THE EFFECTS OF FYTOGREEN FOAM ON MOISTURE RETENTION AND TURF QUALITY FOR SPORTS TURF ROOTZONES

FIELD AND GREENHOUSE STUDY

Final Report

For

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SUMMARY

- A field trial was conducted to monitor the performance of rootzones amended with Fytogreen foam, to test whether the foam would enhance germination and establishment of a healthy turf sward.

- Following the field trial, a greenhouse dry-down experiment was carried out using the same rootzones to determine the response of turf swards to moisture stress, in order to examine whether Fytogreen foam improved moisture retention and offered benefits for turf quality

- Six rootzones were tested, comprising sand, a sand/soil mix and a sand/peat mix and each of these mixes with Fytogreen foam incorporated. In the dry-down phase, three different irrigation regimes were administered, namely 0, 5 mm and 10 mm of water per week.

- Fytogreen foam was found to improve grass germination, with the greatest effect on sand rootzones. On sand rootzones germination was improved to a level comparable with soil amended rootzones. Considerable improvements in germination rate were also observed on soil rootzones amended with Fytogreen

- Pure sand rootzones were found to support turf of particularly poor quality. Major improvements were observed on sand plots with Fytogreen incorporated in the rootzone; these rootzones performed at a level comparable with rootzones amended with soil and peat. Turf quality was improved on soil amended plots when Fytogreen is added. There were no appreciable improvements on peat amended rootzones.

- Fytogreen improved water retention for all treatments during the first three weeks of the greenhouse dry-down phase. Fytogreen foam prevented rapid moisture loss in unwatered lysimeters and in lysimeters watered with 5 mm per week. Fytogreen accounted for some increase in water retention for all rootzones, although the effect was most pronounced and of the greatest duration for sand rootzones.

- Turf quality measurements during the dry-down period indicate that Fytogreen slowed the deterioration of turf swards under moisture stress. The greatest improvements were recorded for unwatered swards and, in terms of rootzone material, for sand rootzones. Turf quality could be preserved at an acceptable condition for approximately one week longer when Fytogreen was added. Fytogreen accounted for only very minor improvements in the response to drought stress of soil and peat amended rootzones.

- The results of this trial suggest Fytogreen has considerable potential as an alternative rootzone amendment for sports turf surfaces, in terms of the improvements it offers in grass germination and turf establishment, and the benefits observed in preserving turf quality under conditions of moisture stress.

INTRODUCTION

Rootzone materials for sports surfaces are required to be free draining, yet must also have the capacity to retain enough water to sustain healthy turfgrass growth. Sand is the principal component of most rootzones as its relatively coarse particle size characteristics permit free drainage, even after compaction. To increase water and nutrient retention, rootzones are typically amended by the addition of material from an organic source such as peat. However, peat extraction is not a sustainable operation, and is thus a source of increasing environmental concern. Consequently, research is needed to examine alternative materials with properties that offer the same hydrological advantages as traditional amendments.

Fytogreen foam is a biodegradable foam product manufactured by Fytogreen B.V. As a rootzone amendment, it is claimed that the foam can enhance drainage properties, improve aeration and soil structure, and increase water retention capacity. It is also reported that the foam also has a positive effect on germination, rooting, nutrient mobilisation and resilience.

A laboratory study (STRI report 0066/3) conducted at the STRI examined the soil physical properties of rootzones amended with Fytogreen foam. The addition of Fytogreen foam was found to increase capillary porosity and water retention capacity and decrease hydraulic conductivity and total and air-filled porosity. The study indicated that Fytogreen foam has potential for inclusion in rootzones that conform to USGA limits for physical performance. A field and greenhouse trial was then established to monitor the performance of rootzones amended with the foam, with two main aims: firstly, to determine rates of grass establishment and test whether the rootzones containing Fytogreen foam could maintain a healthy sward; secondly, to examine the effect of Fytogreen foam during a controlled greenhouse dry-down phase, to simulate the response of turf swards to drought conditions. This report describes the methodology of the field and greenhouse trial and presents the results and interpretations of the measurements that were taken.

MATERIALS AND METHODS

Field study

The field trial was conducted on the STRI trial grounds, Bingley, U.K. There were six experimental treatments, comprising:

1) Medium sand with no Fytogreen foam
2) Medium sand with 20% Fytogreen foam (by volume)
3) 85: 15 Medium sand to peat mix with no Fytogreen foam
4) 85: 15 Medium sand to peat mix with 15% Fytogreen foam (by volume)
5) 85: 15 Mix of medium sand and sandy loam topsoil with no Fytogreen foam
6) 85: 15 Mix of medium sand and sandy loam topsoil mix with 15% Fytogreen foam (by volume)

The rates of Fytogreen incorporation were based on the results of the laboratory study (document R0066/3). The sand type used in this study was a 50:50 mix of medium (Rufford 1742) and medium-coarse (Chelford 30); the particle size distributions of the materials are shown in Table 1. The soil amendment was a sandy loam topsoil (16% clay, 23% silt, 61% sand) taken from the STRI trial grounds at Bingley. The peat amendment was a commercially available *Sphagnum* moss peat.

TABLE 1

Particle size distribution (%) and organic matter content (%) of the rootzone mixes

Rootzone Mix	Very coarse sand (2-1 mm)	Coarse sand (1-0.5)	Medium sand (0.5-0.25)	Fine sand (0.25-0.125)	Very fine sand (0.125-0.05)	Silt and clay (<0.05)	Organic matter (%)
Pure sand	trace	17	72	11	trace	trace	0.0
80:20 Sand:Soil†	1	17	63	11	2	6	1.2
80:20 Sand:Peat	trace	20	68	10	1	2	2.4

† 0.6 % was > 2 mm (i.e. gravel)

The experimental treatments were set out in a factorial randomised block design with four replications. Each plot was 1 m x 1 m and contained 250 mm of the rootzone over a gravel drainage layer. Six pots (230 mm diameter) were filled with the respective rootzone material and placed *ca.* 5 mm below the surface in each plot (Plate 1), to be used as weighing lysimeters in the dry-down phase. The trial was sown on 10 August 1999 with perennial ryegrass (*Lolium perenne*) at 35 g/m^2, comprising equal quantities of three cultivars: Aberelf, Barlinda and Barcrown. The maintenance procedures are summarised in Table 2. Plates 1 and 2 show general views of the trial.

Field measurements

The following measurements were carried out in accordance with the STRI standard operating procedures (SOP) given in Appendix I.

- Visual assessment of grass establishment: measured weekly for the first four weeks (SOP 301598).
- Visual assessment of ground cover: measured after 0.5, 1, 2, 3 and 9 months after sowing (SOP 1B1199).
- Reflectance ratio: measured after 0.5, 1, 2, 3, 6 and 9 months after sowing – four readings per plot (SOP 301499).

Rainfall and temperature data coinciding with the trial period are presented in Appendix II.

Dry-down phase

The weighing lysimeters were removed from the trial and set up in the greenhouse on 5 June 2000. Plate 3 shows the lysimeters in position in the greenhouse. The following three irrigation treatments were administered to the six lysimeters from each plot (allowing two replicates): 0 mm (i.e. no irrigation), 5 mm and 10 mm per week. The allotted amount of water was applied on two separate occasions in each week. A rotation scheme was established whereby, on each block, every lysimeter was rotated by one row and one column each week. This was integrated into the design to ensure that any effect of spatial arrangement (due to potential variations in receipt of sunlight) would be kept to a minimum. Temperature data for the greenhouse during the drought stress experiment is given in Appendix II. Because of the very high temperatures in the greenhouse on the weekend of 17-

18 June all plots received a light syringing of water (approximately 2 mm) to reduce temperatures by evaporation.

TABLE 2

Summary of trial maintenance procedures during the trial

Fertiliser	Fertiliser applications were as follows: 10 Aug 1999: 12:6:6 @ 35 g m^{-2} 7 September 1999: 12:0:9 @ 20 g m^{-2} 21 September 1999: 12:6:6@ 30 g m^{-2} 15 October 1999: Maxicrop 6 @ 4 ml m^{-2} 1 December 1999: Maxicrop 6 @ 4 ml m^{-2} 2 February 2000: Maxicrop 6 @ 4 ml m^{-2} 14 March 2000: 12:6:6 @ 35 g m^{-2} 5 May 2000: 12:6:6 @ 25 g m^{-2} 23 May 2000: 12:6:6 @ 25 g m^{-2}
Irrigation	Surface was heavily watered on nine dates during the establishment phase, between 31 August and 17 September 1999.
Mowing	The trial was mown at 35 mm on the 7 and 13 September 1999. The trial was then mown approximately every 4 days from 17 September at 30 mm until 29 November. Mowing was then carried out on only one occasion per month in February and March 2000. Through the spring (April and May 2000) the trial was mown twice weekly at 30 mm. Clippings were removed each time the trial was mown
Other maintenance	The trial was rolled with a 250 kg roller on 31 August and 7 September 1999 to firm the surface. Sand plots and sand and Fytogreen plots were oversown at 30 g m^{-2} on 13 September 1999.

Measurements for dry-down phase

The following measurements were carried out on all the lysimeters on a weekly basis for eight weeks. The standard operating procedure for each method is given in Appendix I.

- Reflectance ratio: two readings per lysimeter (SOP 301499).
- Visual appraisal of turf quality: measured where appropriate to supplement the data set – mean of two assessors (SOP 1B0798).
- Moisture loss: determined by weighing the lysimeters. Gravimetric water content was calculated from a sample taken on the final sampling date (27 July 2000), which was then combined with the weight data to plot the change in soil moisture of each pot over time.

Statistical analysis

All data underwent an analysis of variance test (ANOVA). Where appropriate the least significant difference (LSD) at the P=0.05 level was calculated to indicate differences between treatment means.

RESULTS

Field study

Germination

There were highly significant effects on germination rate of both amendment material and Fytogreen application (Table 3). Amendment had a major influence, with germination occurring fastest on the peat amended rootzones and slowest on the sand rootzones (Figure 1).

The influence of Fytogreen was apparent across the range of amendments; on the sand rootzones it caused an increase in germination rate from the first assessment date and resulted in considerable improvement over the next three occasions when germination was measured. The effect of Fytogreen was minor for the sand/peat rootzones. For sand/soil mixes, there was no early effect , but major improvements in germination rate were recorded on 1 and 9 September 1999 (Figure 1). On these occasions the soil amended plots with Fytogreen out-performed all other treatments.

TABLE 3
Summary of statistical analysis results from field trial showing effect of amendment and effect of Fytogreen (both averaged over other factors)

Date	Germination		%Ground cover		Reflectance Ratio	
	Amendment	Fytogreen	Amendment	Fytogreen	Amendment	Fytogreen
18 Aug 99	***	***	***	**	NS	NS
24 Aug 99	***	***				
1 Sep 99	***	**	***	**	**	**
9 Sep 99	***	***				
7 Oct 99			***	***	*	**
4 Nov 99			***	***	*	***
1 Feb 00			***	***	NS	NS
5 May 00			***	***	NS	*

(Shading refers to dates when the specified measurement was not taken)

*** P < 0.001
** P < 0.01
* P < 0.05
NS Not Significant

Ground cover

Significant effects of Fytogreen and amendment material were recorded throughout the trial (Table 3). For the amendment material there was a marked difference between treatments, with sand rootzones consistently having the poorest ground cover (Figure 2). There was less of a distinction between soil and peat amended rootzones, although rootzones containing peat consistently produced the highest level of sward cover.

Highly significant effects of Fytogreen were observed (Figure 2). Sand rootzones experienced the greatest improvement in ground cover when Fytogreen was incorporated, an increase of *ca.* 20 percentage points on the latter four sampling occasions. This improvement resulted in the sand rootzones amended with Fytogreen out-performing the soil amended mixes and approaching the cover observed on plots with peat amended rootzones. Soil and peat amended rootzones were also improved throughout the trial by the incorporation of Fytogreen, most notably in the case of the soil amended rootzones. In week 2 (1 September 1999) Fytogreen accounted for a doubling in ground cover for the soil amended rootzones, and the improvement averages eight percentage points thereafter.

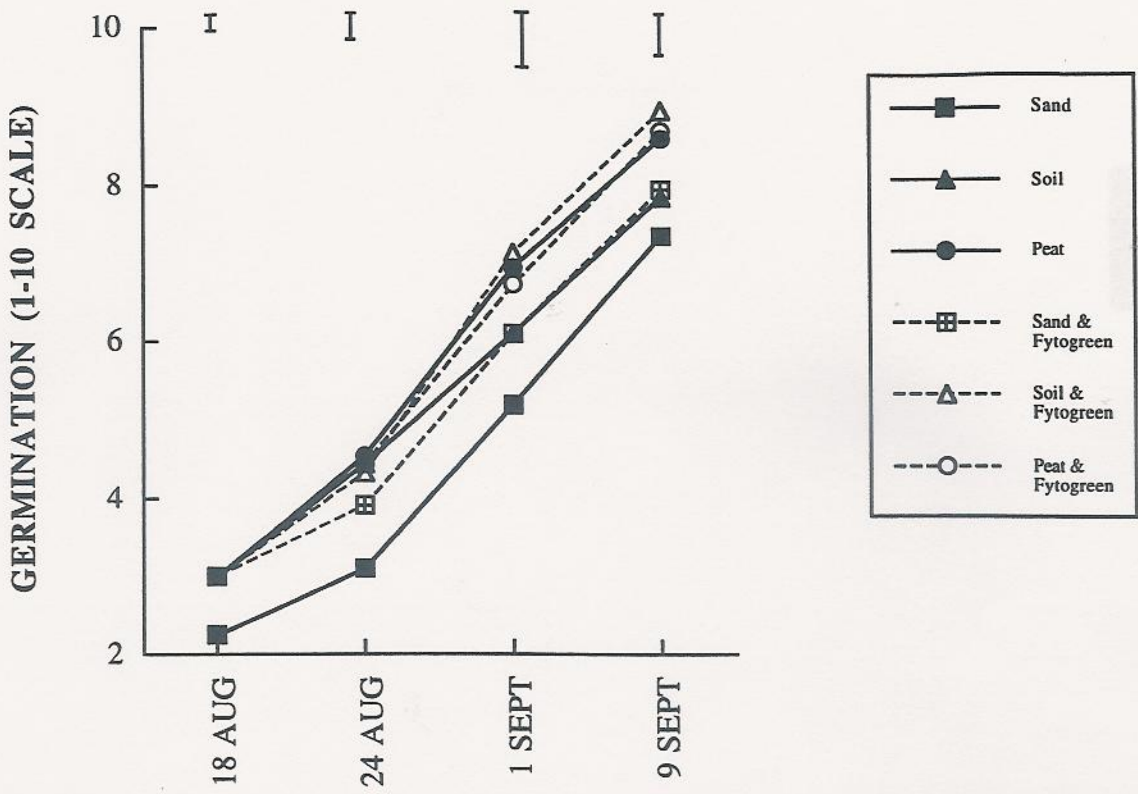

FIGURE 1. Germination rate (1-10 Scale, 10 = most advanced development) for rootzone mixes over the course of the field trial. Vertical bars show LSD (5%).

Reflectance ratio

The results of the reflectance ratio measurements are more variable, yet still indicate a statistically significant effect over the middle period of the trial, when grass cover was increasing rapidly (Table 3). The effect of amendment was greatest on 1 September 1999, early in the establishment stage (Figure 3). On this date, the effect of Fytogreen was very prominent for the sand and soil amended rootzones, but it was minor for peat amendments Throughout the remainder of the trial, the contrast between treatments was less pronounced, with the exception of the sand rootzones which performed consistently poorly (Figure 3). The effects of Fytogreen were most dramatic on sand rootzones; whilst sand only rootzones yielded the lowest reflectance scores throughout, the sand plots containing Fytogreen had the highest reflectance ratio values on three occasions between 7 October 1999 and 1 February 2000. The influence of Fytogreen was less pronounced for rootzones containing soil and appears to be very minor for peat amendments (Figure 3).

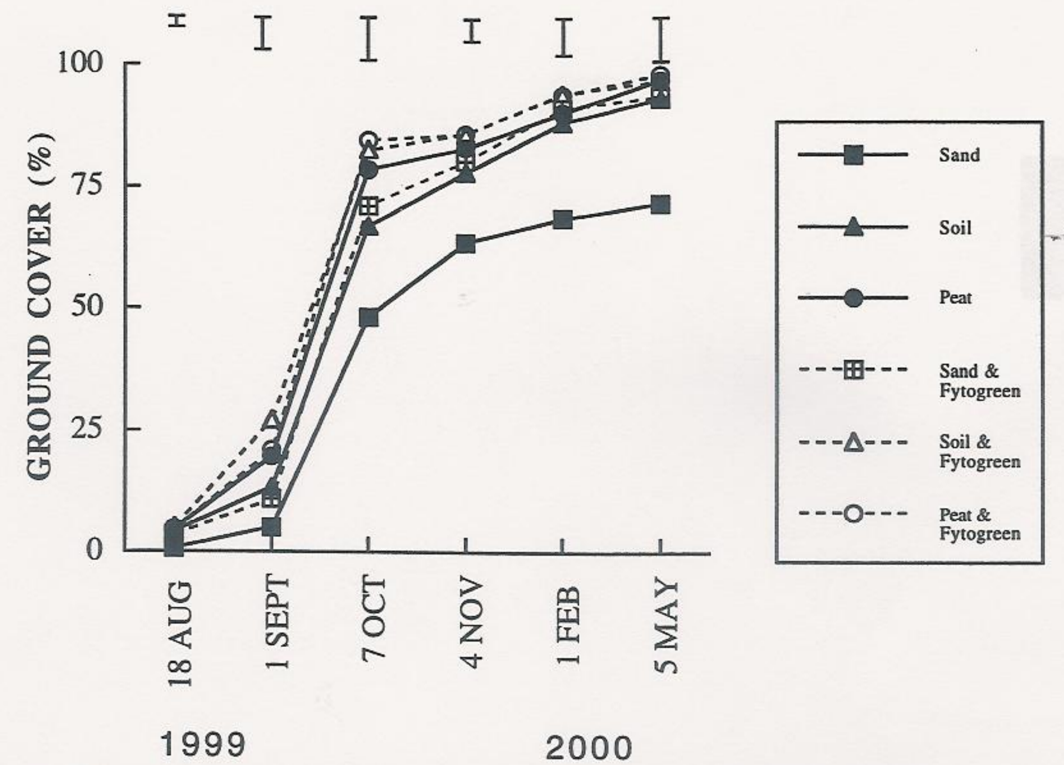

FIGURE 2. Ground cover for rootzone mixes over the course of the field trial. Vertical bars show LSD (5%).

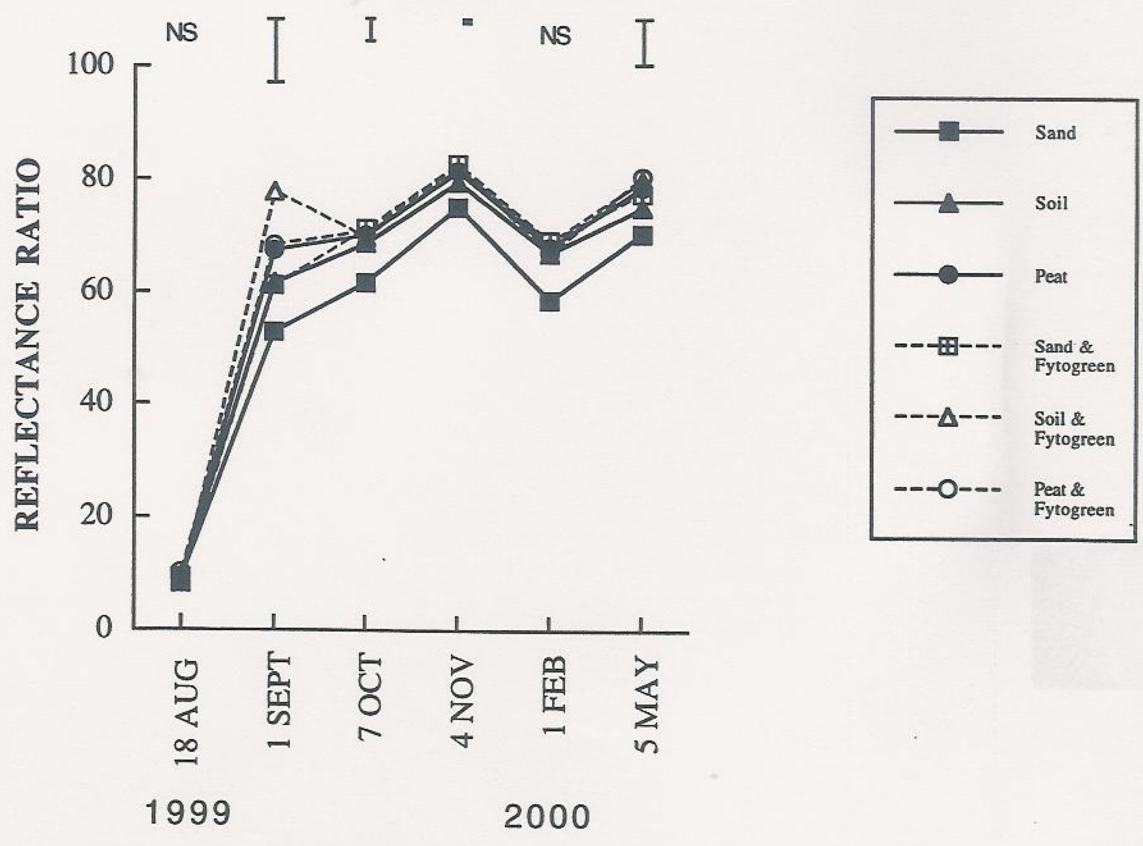

FIGURE 3. Reflectance ratio for rootzone mixes over the course of the field trial. Vertical bars show LSD (5%). NS = Not Significant.

Dry-down phase

Moisture retention

Irrigation input was obviously a major control on water content throughout the period of drought stress (Table 4), except the first week (08 June 2000). On this occasion the lysimeters had only just been removed from the field trial, and were therefore of relatively similar moisture content. Moisture content decreased through the dry-down, with the rate of decrease inevitably being most rapid for the unwatered lysimeters (Figure 4).

Significant effects of Fytogreen were recorded in the first three weeks. Inclusion of Fytogreen foam was found to increase water retention in the early stage of the dry-down period, most notably on unwatered lysimeters and those receiving 5 mm of water per week, whilst the effect on 10 mm per irrigation regime was found to be minor (Figure 4). In terms of rootzone treatments, the different responses were most striking in the first three weeks (Figure 5). There was a major amendment effect, with peat rootzones holding most water and sand holding least; moreover, for each rootzone type, moisture content was considerably higher and decreased at a slower rate when Fytogreen was added (Figure 5).

To account for any influence of the contrasting densities of the rootzone materials on gravimetric moisture content calculations, a further analysis was carried out the volume of water contained in the lysimeters on each measurement date (each lysimeter had a volume of approximately 6.89 litres. The volume of water was calculated from the weight of the lysimeter minus the oven-dry soil weight and the weight of the plastic container. The total weight was converted to total volume using a water density of 1 kg l^{-1}. The statistical analysis confirmed that the significance of the various effects on each date was identical to the outcome of the gravimetric data analysis. A summary table of this data is presented in Table 4.

TABLE 4
Volume of water retained in each lysimeter, giving mean values (in litres) for each treatment, averaged over other effects, and LSD's at P <0.05

	Amendment				Fytogreen			Irrigation			
	Sand	Soil	Peat	LSD	Fytogreen	No Fyto	LSD	0 mm	5 mm	10 mm	LSD
08-Jun-00	1.27	1.43	1.79	0.114	1.64	1.35	0.093	1.50	1.48	1.51	NS
15-Jun-00	0.90	1.08	1.35	0.131	1.23	0.99	0.107	0.90	1.08	1.34	0.098
22-Jun-00	0.57	0.72	0.94	0.127	0.80	0.69	0.104	0.38	0.69	1.17	0.119
29-Jun-00	0.45	0.53	0.73	0.123	0.60	0.54	NS	0.15	0.42	1.14	0.120
06-Jul-00	0.56	0.61	0.80	0.111	0.68	0.64	NS	0.14	0.46	1.37	0.139
13-Jul-00	0.52	0.54	0.77	0.143	0.65	0.58	NS	0.12	0.32	1.40	0.143
20-Jul-00	0.33	0.34	0.49	0.100	0.38	0.39	NS	0.08	0.17	0.92	0.118
27-Jul-00	0.35	0.33	0.50	0.081	0.39	0.40	NS	0.07	0.21	0.90	0.118

Visual Appraisal

Significant differences were observed between the visual quality of the swards in terms of irrigation, amendment material and Fytogreen (Table 5; Figures 6 and 7). The impact of moisture stress is clearly apparent; the irrigation treatment effect was highly significant throughout the experiment, with the exception of the first two weeks when moisture stress

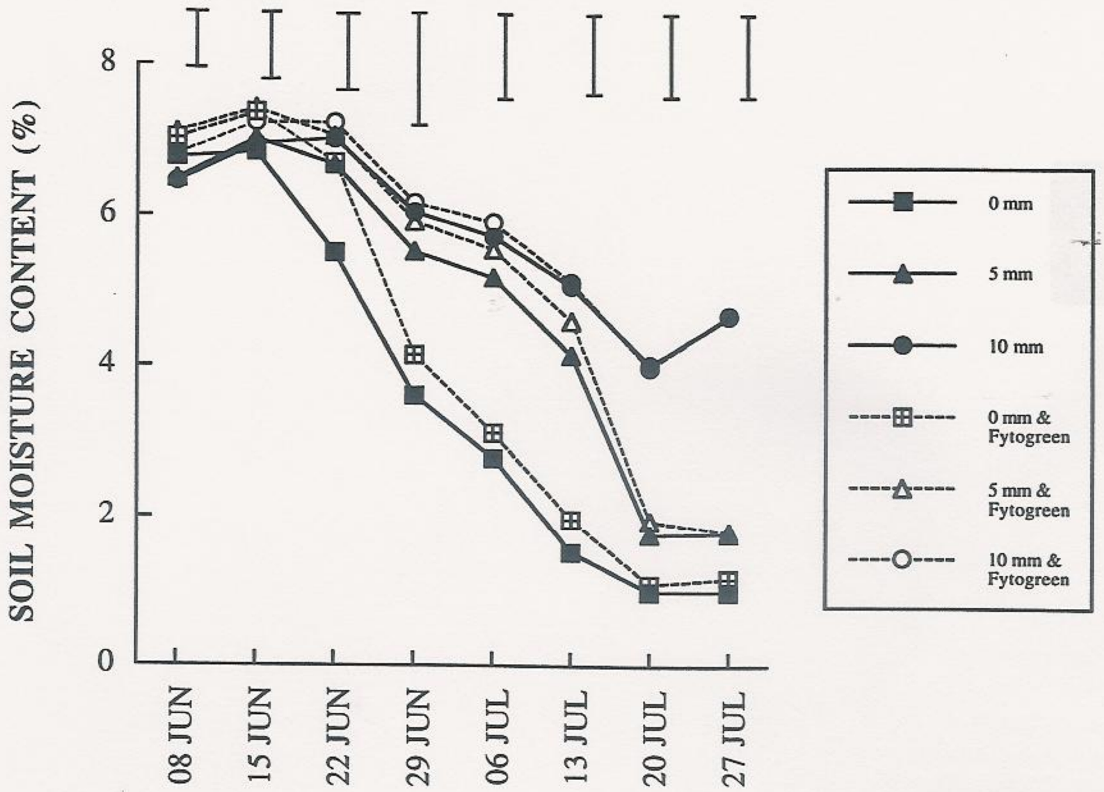

FIGURE 4. Soil moisture content for irrigation treatments over the course of the dry-down period. Vertical bars show LSD (5%).

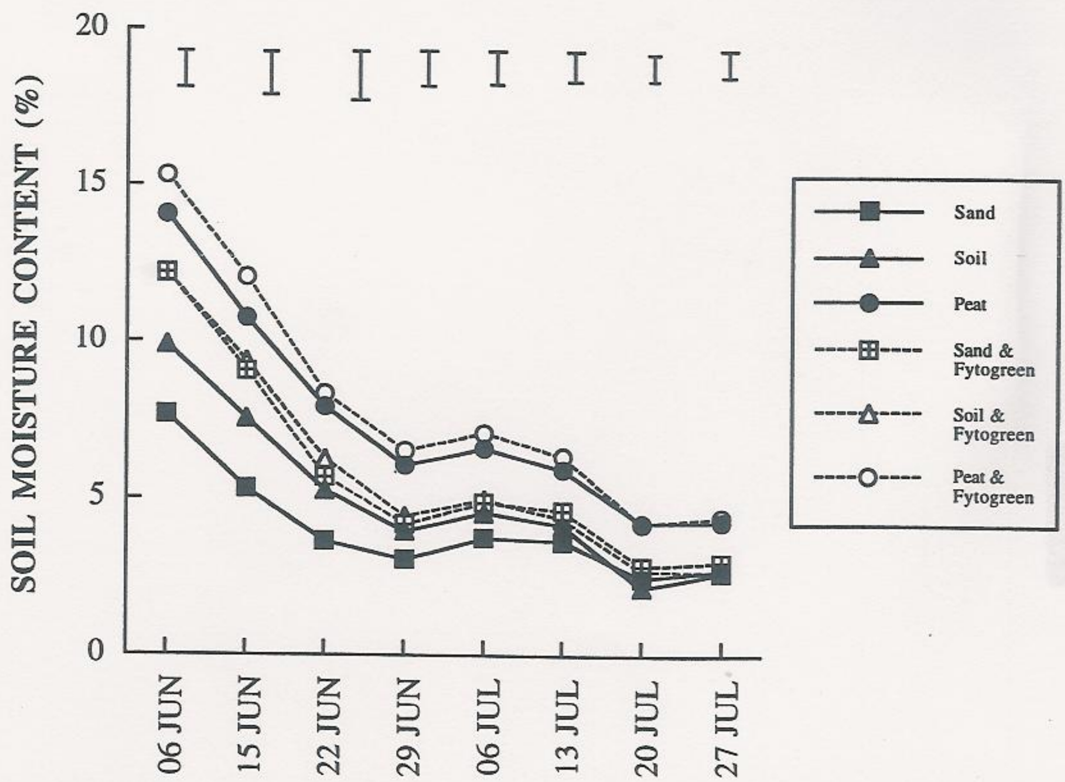

FIGURE 5. Soil moisture content for rootzone mixes over the course of the dry-down phase. Vertical bars show LSD (5%).

had not begun to take effect. The visual merit score declined throughout the dry-down period as moisture stress began to set in and swards began to become impoverished and die off. Irrigation regime was obviously a crucial factor in maintaining the sward; the decline in quality over the dry-down was rapid and severe for the unwatered swards, whilst those irrigated with 5 mm per week were of reasonable visual merit until the last two weeks (Figure 6). The lysimeters with the 10 mm per week treatment retained a sward that at the end of the experiment was only just below the level of what is regarded as acceptable on the visual appraisal scale (SOP 1B0798, see Appendix I). The effect of Fytogreen on the response of lysimeters with different irrigation regimes was evident (Figure 6). The largest effect occurred on the unwatered lysimeters, where Fytogreen prevented the turf from deteriorating so rapidly. Lysimeters watered with 5 mm per week displayed an appreciable difference due to Fytogreen, but the effect on the 10 mm treatments was negligible, a similar pattern to the moisture retention characteristics previously discussed. Plates 4-6 are views of turf swards at the end of the dry-down; the contrast in visual quality between irrigation treatments is clear, for each of the amendments.

TABLE 5
Summary of results of statistical analysis for dry-down, showing effects of Fytogreen, amendment materials and irrigation regime

	Moisture content			Visual merit			Reflectance ratio		
Date	Irrigation	Rootzone	Fytogreen	Irrigation	Rootzone	Fytogreen	Irrigation	Rootzone	Fytogreen
08 Jun 00	NS	***	***	*	**	**	NS	NS	NS
15 Jun 00	***	***	***	NS	**	*	*	*	NS
22 Jun 00	***	***	**	***	***	***	***	*	*
29 Jun 00	***	***	NS	***	*	*	***	**	**
06 Jul 00	***	***	NS	***	***	*	***	NS	*
13 Jul 00	***	***	NS	***	*	*	***	**	*
20 Jul 00	***	**	NS	***	**	NS	***	**	NS
27 Jul 00	***	**	NS	***	**	NS	***	NS	NS

There was a significant effect of Fytogreen and of amendment material through most of the dry-down phase, although the difference associated with Fytogreen was not significant on the last two measurement dates. In terms of amendment effects, swards with the peat amendment had the highest scores (Figure 7) whilst the sand rootzones supported swards of much poorer quality. The effects of Fytogreen were substantial. The largest effect was again upon sand rootzones, with smaller and inconsistent improvements occurring for the amended rootzones (Figure 7). Plates 4-6 clearly illustrate the effect of Fytogreen on visual quality of swards at the end of the trial, for each of the rootzones. The lack of significant effect of Fytogreen in the last two weeks can be attributed to the fact that by this time most of the swards were under extreme moisture stress and were thus discoloured and becoming patchy. Consequently, the differences between lysimeters were becoming less distinct. The amendment effect was still relatively strong owing to the substantial difference in quality between the peat rootzones and the other rootzones at this late stage (Figure 7).

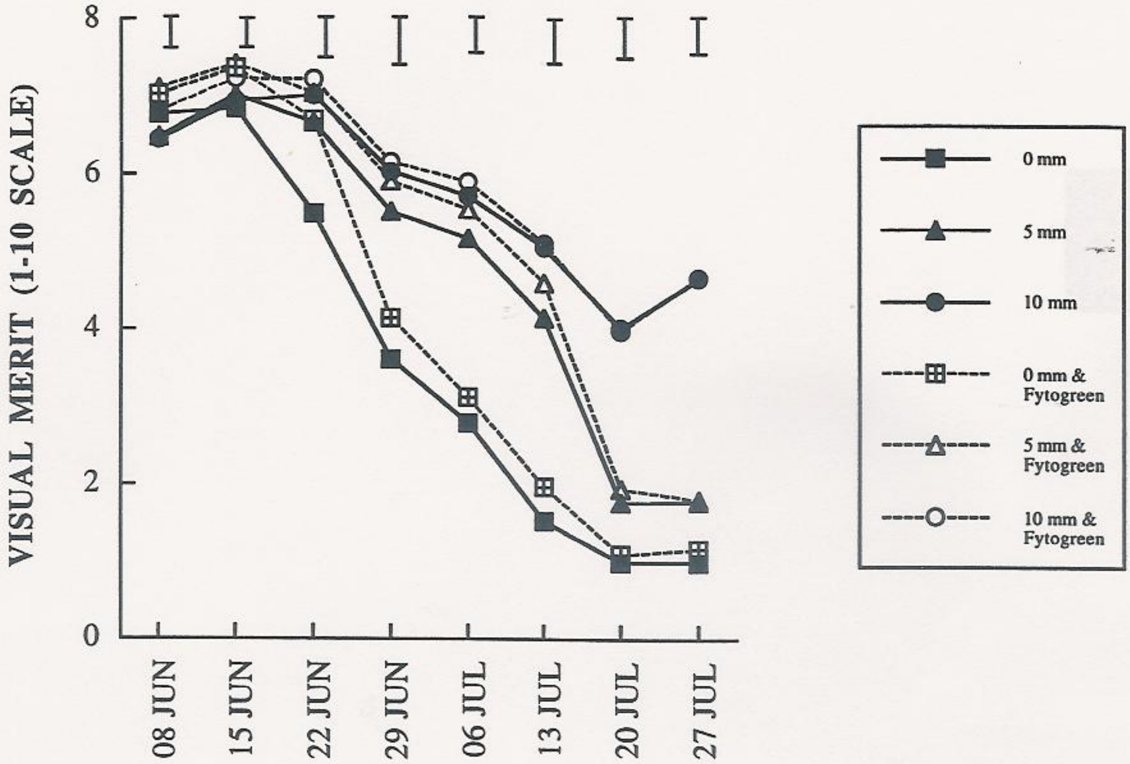

FIGURE 6. Visual Merit Score (1-10 Scale, 10 = best) for irrigation treatments over the course of the dry-down period. Vertical bars show LSD (5%).

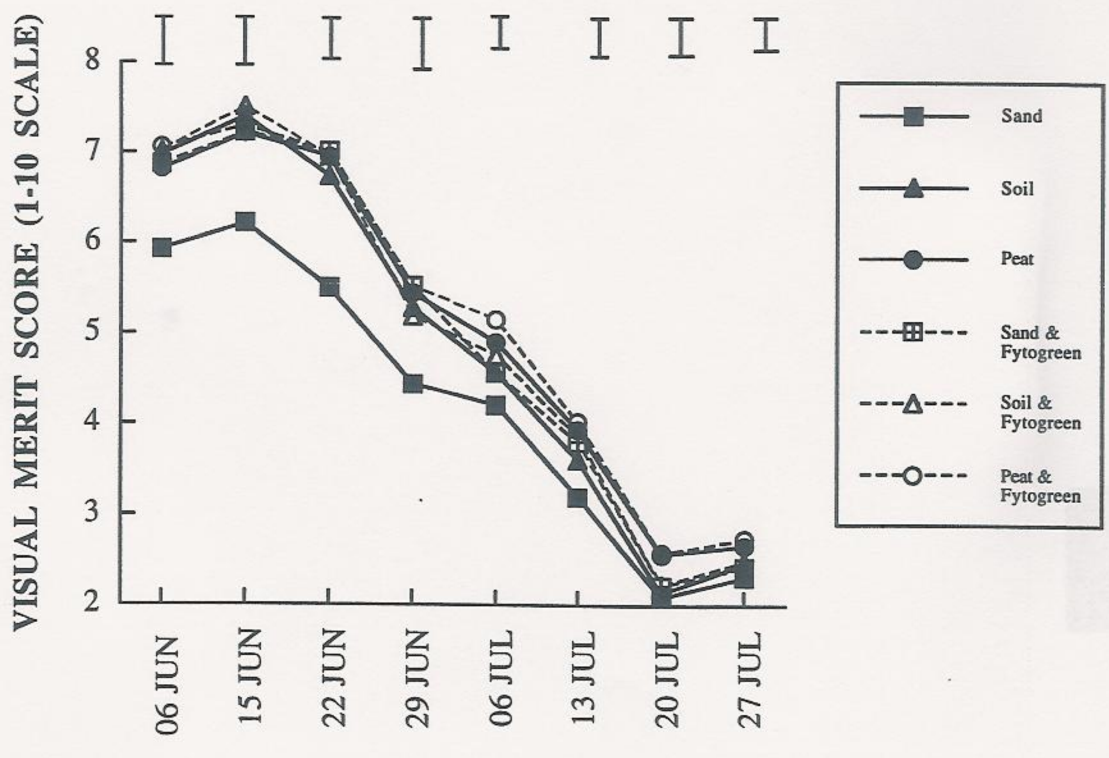

FIGURE 7. Visual Merit Score (1-10 Scale, 10=best) for rootzone mixes over the course of the dry-down period. Vertical bars show the LSD (5%).

The visual merit data can be used to estimate how long the condition of a sward can be prolonged to a particular standard by the addition of Fytogreen foam. A value of five on the visual merit scale is regarded as the lower limit of acceptable turf quality. At this level, the time difference between the response curves (from Figures 6 and 7) gives an estimate of the amount of extra time that a rootzone amended with Fytogreen will maintain a sward under drought stress relative to an unamended rootzone. In terms of rootzone medium, this value was one week for sand rootzones and *ca.* 2-2.5 days for peat rootzones. No extra time was apparent at this level for the soil rootzones.

Reflectance ratio
The fundamental importance of irrigation regime was again apparent in the reflectance ratio data, being highly significant on all occasions except the first two weeks, before the effects of moisture stress set in. There was a decline in reflectance ratio over the experiment as moisture stress affected the swards. This decline was strongly influenced by irrigation and by Fytogreen incorporation (Figure 8). Fytogreen had most influence on turf quality for the lysimeters receiving no water, a similar response to that found in the visual merit data, and there was also some effect on lysimeters watered with 5 mm per week.

Significant results were recorded for amendment and Fytogreen treatments through the middle period of the dry-down phase (Table 5). The non-significant results at the end reflect the relative uniformity that occurs when most swards are undergoing extreme moisture stress. The familiar pattern of rootzone effects on turf quality emerges from the data; the sand rootzones performed characteristically poorly, with rapid deterioration after the second week (Figure 9). The sand lysimeters amended with Fytogreen fared much better, with considerably slowed deterioration. Rootzones amended with peat maintained the healthiest swards, although there was only a minor improvement when Fytogreen was added. Soil amended rootzones scored intermediately, and were slightly improved by Fytogreen on most dates.

DISCUSSION & CONCLUSIONS

Table 6 provides summary data for each of the measurements over the course of the field trial, showing a comparison between plots with Fytogreen and those with no Fytogreen, averaged over the other amendments. Fytogreen was found to improve grass germination (Table 6). It promoted germination on unamended sand rootzones to a level approaching those amended with soil. On plots containing soil amendment, it further stimulated germination by a significant amount. Fytogreen foam improved turf quality throughout the field trial, as measured by both visual appraisal and reflectance ratio (Table 6). Pure sand rootzones were found to score very poorly for all turf characteristics, and underwent a substantial improvement when Fytogreen foam was added. The incorporation of Fytogreen improved turf quality to level comparable to those measured when soil amendments were added, and in several cases surpassed these. Sand and Fytogreen mixes approached (and with regard to reflectance ratio, exceeded) the level of quality found with peat amendments, which is a major improvement given the poor performance of pure sand rootzones. There was typically a considerable improvement when Fytogreen is added to soil amended rootzones, whilst the effect on peat amended rootzones was generally the least pronounced.

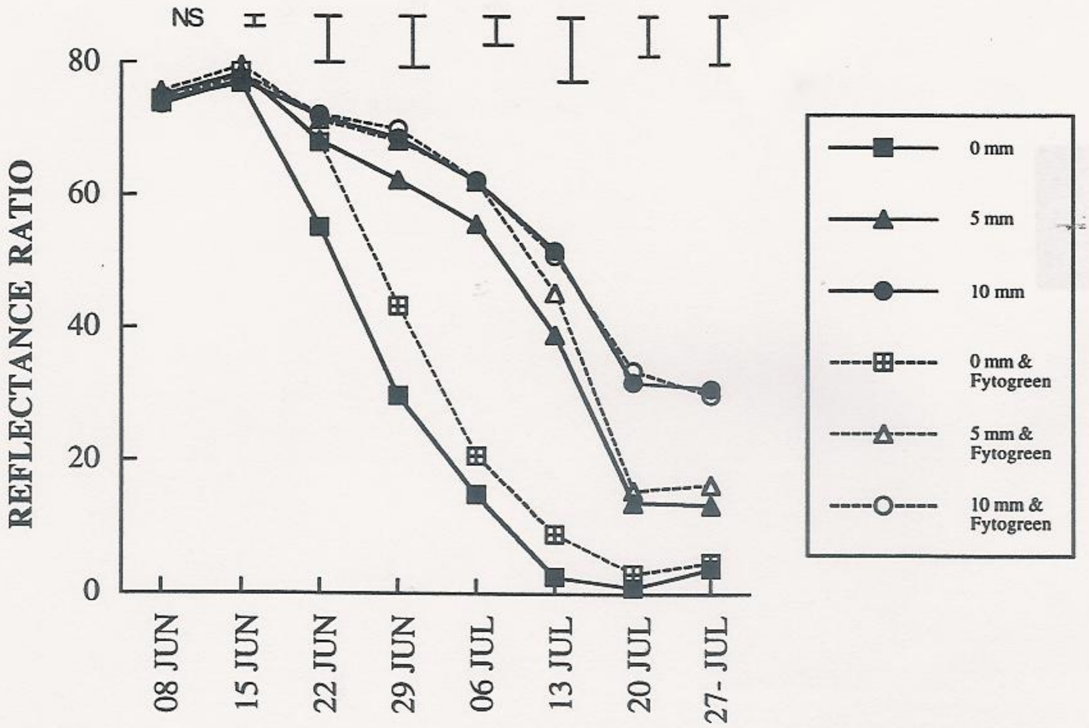

FIGURE 8. Reflectance ratio for irrigation treatments over the course of the dry-down period. Vertical bars show LSD (5%). NS = Not Significant.

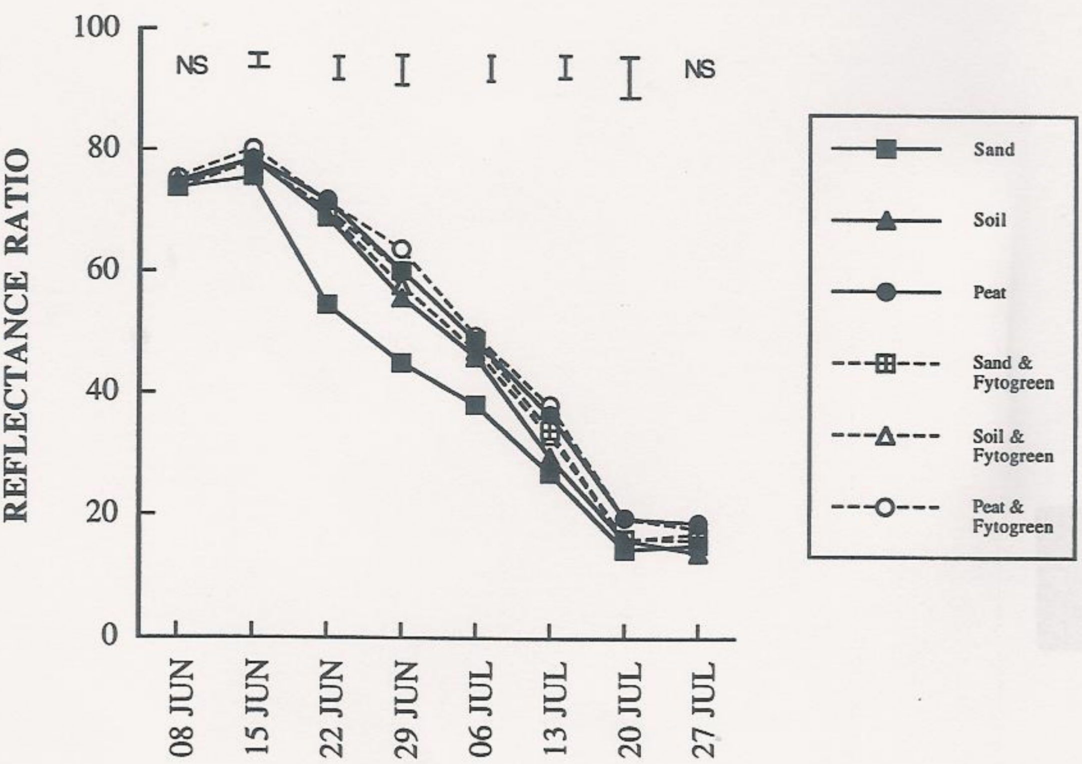

FIGURE 9. Reflectance ratio for rootzone mixes over the course of the dry-down period. Vertical bars show LSD (5%). NS = Not Significant.

TABLE 6

Summary table comparing mean values for plots with Fytogreen incorporated and plots with no Fytogreen; values averaged over other amendments. LSD = least significant difference calculated for the effect of Fytogreen at the P < 0.05 level

Date	Germination			Ground cover (%)			Reflectance ratio		
	Fytogreen	No Fyto	LSD	Fytogreen	No Fyto	LSD	Fytogreen	No Fyto	LSD
18 Aug 99	3.0	2.7	0.10	4.5	3.2	0.65	9.4	9.1	NS
24 Aug 99	4.3	3.9	0.16						
1 Sep 99	6.6	6.1	0.33	19.7	12.7	3.84	69.1	60.8	5.31
9 Sep 99	8.5	7.9	0.21						
7 Oct 99				79.3	64.5	5.18	70.7	66.9	2.43
4 Nov 99				83.8	74.7	2.80	82.4	78.8	1.58
1 Feb 00				92.9	82.3	3.98	68.4	64.7	NS
5 May 00				96.1	87.2	4.77	79.4	74.8	3.72

Table 7 gives summary data showing the effect of Fytogreen foam for each of the measurements made during the dry-down period. Fytogreen foam was found to increase water retention in the first half of the drought phase. During the period, Fytogreen foam enhanced water retention properties for all treatments, with the greatest improvement occurring when added to sand. Inclusion of the foam prevented rapid moisture loss in unwatered lysimeters and those watered with only 5 mm per week. The patterns that emerge in the soil moisture data are reflected in the turf quality tests. The results of these tests indicated that Fytogreen slowed down the deterioration of swards under moisture stress. This is particularly the case for the sand rootzones, although the ameliorative properties are apparent for soil amended rootzones. Significant results were found for both reflectance ratio and visual appraisal data sets, and the greatest response was found in swards under the most moisture stress. The data indicate that addition of Fytogreen can prolong the quality of swards under drought stress; for sand rootzones, quality could be preserved at an acceptable condition for one week longer when Fytogreen was incorporated.

TABLE 7

Summary table comparing mean values for lysimeters with Fytogreen incorporated and lysimeters with No Fytogreen; values averaged over other amendments. LSD = least significant difference calculated for the effect of Fytogreen at the P < 0.05 level

Date	Soil Moisture (%)			Visual appraisal			Reflectance ratio		
	Fytogreen	No Fyto	LSD	Fytogreen	No Fytogree n foam	LSD	Fytogreen	No Fyto	LSD
08 Jun 00	13.2	10.5	0.64	7.0	6.6	0.29	74.4	74.4	NS
15 Jun 00	10.2	7.9	0.71	7.3	6.9	0.29	78.8	77.6	NS
22 Jun 00	6.8	5.6	0.77	6.9	6.4	0.27	70.5	65.1	4.79
29 Jun 00	5.1	4.4	NS	5.4	5.1	0.30	60.5	53.6	4.16
06 Jul 00	5.7	5.0	NS	4.8	4.6	0.23	48.4	44.2	4.05
13 Jul 00	5.1	4.6	NS	3.9	3.6	0.24	35.0	31.1	3.02
20 Jul 00	3.3	3.2	NS	2.3	2.3	NS	17.3	15.5	NS
27 Jul 00	3.4	3.2	NS	2.6	2.5	NS	17.0	16	NS

In relation to the aims of this study it can be concluded that, in the case of this trial, rootzones containing Fytogreen foam established and maintained a healthy sward over a period of time, with the improvements to unamended sand rootzones being particularly substantial. Secondly, that Fytogreen foam application brought about significant improvements in the preservation of turf quality under conditions of drought stress. For the turf properties measured in this study, Fytogreen performed at a level comparable to traditional amendments. Overall, the field and greenhouse trials described in this report have demonstrated that Fytogreen foam has considerable potential as an alternative rootzone amendment.

QUALITY STATEMENT

We confirm that this report is a true representation of the original data collected and that the Standard Operating Procedures referred to in the STRI Manual of Standard Operating Procedures, and those relevant to data collection, data preparation, archiving of data and preparation of reports have been implemented in full.

Prepared by: 5/10/00 (Signature and date)

Final version checked and reviewed by: Stephen Baker 5/10/00 (Signature and date)

POLITE REMINDER

Please ensure that your Sales/Marketing Department is aware that this research has been carried out under contract and that the consent of the STRI must be obtained where information contained in the report is to be used in advertising or promotional literature.

APPENDIX I

STRI STANDARD OPERATING PROCEDURES RELEVANT
TO FIELD AND GREENHOUSE TRIAL

STRI
BINGLEY

STANDARD OF OPERATING PROCEDURE NO. 301598 (1 page)

ASSESSMENT OF EARLY ESTABLISHMENT OF TURF

[1] Scope

This standard operating procedure describes the method for assessing early establishment of turf swards.

[2] Procedure

Germination and subsequent establishment are scored on a 1-10 scale. In this scale 1 = no shoots visible, 2 = a few shoot tips visible on close inspection, 3 = shoot tips visible in the majority of the plot on close inspection, 4 = shoots visible when standing and looking down on the plot, 5 = 1 leaf visible (but not necessarily fully emerged, on 10 randomly selected plants), 6 = 1.3 to 1.7 leaves visible per shoot, 7 = 1.8 to 2.2 leaves visible, 8 = 2.3 to 2.7 leaves visible, 9 = 2.8 to 3.2 leaves visible and 10 = 3.3 or more leaves visible. Note, the number of leaves on the 10 selected plants will have to be recorded and the average calculated before individual plot scores above 5 can be determined.

STANDARD OPERATING PROCEDURE (SOP) PREPARED BY: A. Newell						
SOP CHECKED BY:	SWB.....	DJB.......	DML.....	AJN......	FC.........	CAE ✓
AGREED AS SOP BY: P.M. Canaway (CHIEF EXECUTIVE)						
TO BE EFFECTIVE FROM: NOV 1998						
TOTAL NUMBER OF PAGES IN SOP: 1						

STANDARD OPERATING PROCEDURE NO. 1B1199 (4 pages)

DETERMINATION OF GROUND COVER

FOREWORD

This standard operating procedure is based upon a draft European Standard in preparation by Technical Committee CEN/217, Surfaces for sports areas.

[1] Scope

This standard operating procedure specifies three methods of test for the determination of ground cover of natural turf.

[2] Terms and Definitions

The proportion of ground cover occupied by the perpendicular projection of live grass material above it.

[3] Principle

Three methods of test are given. Method A is a visual subjective assessment of ground cover using no measuring device. Method B uses a sampling grid to give a more systematic assessment of ground cover. Method C uses a point quadrat for when objective data are required or where a detailed assessment of species composition is needed.

In all three methods, an observer assesses the proportion of ground cover including:

a) live grass, (this includes healthy (green) and senescent (yellow) leaf tissue together with the living stem material, which can be a variety of colours depending on the grass species).

b) weeds;

c) moss;

d) dead matter and bare ground;

The procedure can be used to measure the live grass ground cover and/or ground cover for individual plant species.

[4] Procedure

Ensure that the sward height is within the range appropriate for the given sport.

Note: The amount of cover which is recorded is dependent on the length of grass. If the sward height is higher than the value for the given sport, mow the turf before assessment. On longer turf and if the grass blades are lying in a procumbent position because of mowing or rolling, brush the test area to achieve a more usual upright position for the grass blades. If the sward height is lower than the value for the given sport, do not proceed with the determination.

[4.1 Method A. Visual assessment of ground cover

4.1.1 Procedure

With the observer standing upright directly adjacent to the test area, estimate by eye the proportion of sports surface occupied by living plant tissue, dead matter and the bare ground and if required, the proportion covered by particular plant species. Record only living plant tissue as ground cover. Record dead matter and bare ground separately, if required. Estimate the cover visible by the upright observer. Disregard overlap of living plant tissue, i.e. do not multiple count.

Note: An area quadrat (similar to that described in Method B (below), but not necessarily many subdivisions), may be used to define the sampling area.

Unless otherwise specified, assess at least five randomly chosen sampling test areas on sports surfaces of less than 100 m², assess 5–10 test areas as appropriate on sports surfaces of 100 m² to 1000 m² and assess 10-15 test areas on sports surfaces of 1000 m² to 5000 m². Subdivide larger sports areas and test each as above.

4.1.2 Expression of results

Express the results as the estimated percentages of live grass tissue and, if required, give the estimated ground cover for individual plant species.

4.2 Method B. Assessment of ground cover by frame quadrat

4.2.1 Apparatus

Frame between 0.75 m x 0.75 m and 1.0 m x 1.0 m internal dimensions divided into 100 smaller squares (each subdivision representing 1% of the total area) using string, cord or thin wire as shown in Fig. 1.

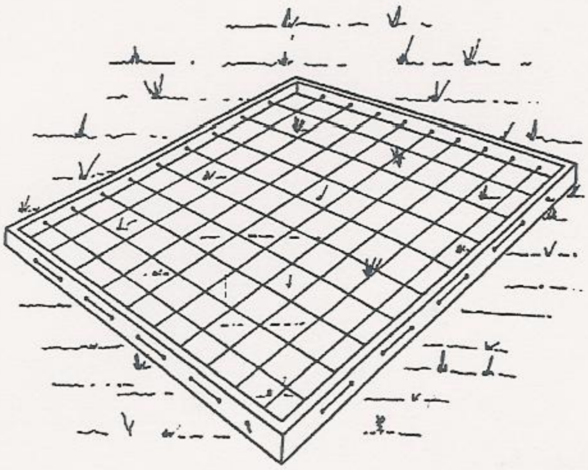

FIGURE 1. Frame for estimating ground cover.

4.2.2 Procedure

Depending on whether the cover components to be counted are smaller or larger than the frame subdivisions, refer to 4.2.2.1 or 4.2.2.2. With the observer standing upright, directly adjacent to the test area, estimate by eye the proportion of sports surface occupied by living plant tissue, dead matter and bare ground. Estimate the percentage of small weed plants or scattered spots of bare ground by the method described in 4.2.2.1. Assess the general distribution of plant cover as compared with extensive bare areas or the areas occupy by large weeds, moss patches, etc. as described in 4.2.2.2.

4.2.2.1 Cover components less than subdivision size

Estimate how many components would be required to fill a subdivision (1% of the frame), then count the number of cover components in the whole area being examined (making due estimation for any overlap which occurs) and from that, calculate the total percentage within the frame.

4.2.2.2 Cover components of subdivision size or larger

Count how many subdivisions in the frame are wholly or more than half filled by the component being assessed. All subdivisions less than half-filled are ignored as 'empty'. With 100 subdivisions the 'full' and 'empty' subdivisions are assumed to balance out with adequate accuracy, so that 'full' subdivisions can be used as a basis for the required percentage figure.

4.2.2.3 Number of frame placings

Unless otherwise specified, make at least five random placings of the frame on areas of less than 100 m², take 5–10 placings as appropriate on areas of 100 m² to 1000 m² and take 10-15 placings at random for areas of 1000 m² to 5000 m². Large areas should be subdivided into two or more areas for testing.

STRI BINGLEY

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STANDARD OF OPERATING PROCEDURE NO. 301499 (1 page)

ASSESSMENT OF REFLECTANCE RATIO

[1] Scope

This standard operating procedure specifies the method of assessment of reflectance ratio.

[2] Apparatus

Reflectance Ratio Meter

The meter operates on the principle that the spectral reflectance of bare soil and green vegetation differ. The reflectance ratio meter measures the relative intensities of the reflected light at wavelengths of 650 and 750 nm.

As green vegetation affects the reflectance of light in the 650 nm wave band but not in the 750 nm band, the ratio of the reflected light at these two wave lengths is proportionally affected by the amount of vegetation in the field of view.

[3] Procedure

The machine shall be set to zero using a clean soil area or a black reflective surface. The maximum range should then be set using an area of healthy turf. The range chosen should be in the order of 0 (bare soil) to 80 or 90 for the upper end of the area on which measurements are to be made. Care should be taken to ensure that the upper range does not exceed 100. Measurements on the experimental plots can then be made. It should be noted that changes in ambient light levels can affect the readings made and as such measurements made under light conditions which vary between cloud and direct sunlight will be of little value.

Where there is only small variation in ground cover the ratio may more strongly reflect variation in colour.

[4] References

Haggar, R.J. and Isaac, S.P. (1985). The use of a reflectance ratio meter to monitor grass establishment and herbicide damage, *Grass and Forage Science*, Vol. 40, 331-334.

Haggar, R.J., Stent, C.J. and Isaac, S. (1983). A prototype hand-held patch sprayer for killing weeds, activated by spectral differences in crop/weed canopies, J. Agric. Engng Res. 28, 349-358.

Haggar, R.J., Stent, C.J. and Rose, J. (1984). Measuring spectral differences in vegetation canopies by reflectance ratio meter, *Weed Research*, Vol. 24, 59-65.

Steven, M.D., Biscoe, P.V. and Jaggard, K.W. (1983). Estimation of sugar beet productivity from reflection in the red and infrared spectral bands, *Int. J. Remote Sensing*, Vol. 4, No. 2, 325-334.

STANDARD OPERATING PROCEDURE (SOP) PREPARED BY: A.N...........

SOP CHECKED BY:	SWB.....	DJB.......	DML.....	AJN......	FC.........	CAE...

AGREED AS SOP BY: .... (CHIEF EXECUTIVE)

TO BE EFFECTIVE FROM: AUG 1999

TOTAL NUMBER OF PAGES IN SOP: 1

STRI

STANDARD OF OPERATING PROCEDURE NO. 301499 (1 page)

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Haggar, R.J. and Isaac, S.P. (1985). The use of a reflectance ratio meter to monitor grass establishment and herbicide damage, *Grass and Forage Science*, Vol. 40, 331-334.

Haggar, R.J., Stent, C.J. and Isaac, S. (1983). A prototype hand-held patch sprayer for killing weeds, activated by spectral differences in crop/weed canopies, J. Agric. Engng Res. 28, 349-358.

Haggar, R.J., Stent, C.J. and Rose, J. (1984). Measuring spectral differences in vegetation canopies by reflectance ratio meter, *Weed Research*, Vol. 24, 59-65.

Steven, M.D., Biscoe, P.V. and Jaggard, K.W. (1983). Estimation of sugar beet productivity from reflection in the red and infrared spectral bands, *Int. J. Remote Sensing*, Vol. 4, No. 2, 325-334.

STANDARD OPERATING PROCEDURE (SOP) PREPARED BY:..............

SOP CHECKED BY:	SWB.....	DJB.......	DML.....	AJN......	FC.........	CAE.....

AGREED AS SOP BY.................. (CHIEF EXECUTIVE)

TO BE EFFECTIVE FROM AUG 1999

TOTAL NUMBER OF PAGES IN SOP: 1

APPENDIX II

WEATHER DATA DURING FIELD TRIAL AND GREENHOUSE TEMPERATURES DURING DRY-DOWN PHASE

APPENDIX II

a) Weekly temperature and rainfall figures from the STRI trials ground for the period May 1999 to June 2000, when the field trial was in progress

Week commencing	Maximum temp (°C)	Minimum temp (°C)	Rainfall (mm)
02/05/99	15.9	6.6	54
09/05/99	15.7	8.6	27.6
16/05/99	15.1	6.6	0
23/05/99	17	8	14.65
30/05/99	14.9	9	25.9
06/06/99	14.1	7.1	20.85
13/06/99	19.1	10.2	3.3
20/06/99	18.1	8.3	1.05
27/06/99	17.8	8.3	24.45
04/07/99	22.4	14.1	7.6
11/07/99	20	11.5	0.16
18/07/99	18.4	11.9	6.55
25/07/99	20.8	10.4	0
01/08/99	24.8	13.9	20.26
08/08/99	16.7	10	10.25
15/08/99	15.8	9.7	23.3
22/08/99	17.8	11.9	6.3
29/08/99	21.5	12.4	2.85
05/09/99	21.8	10.5	7.65
12/09/99	16.9	7.7	2.35
19/09/99	17.8	9.4	56.15
26/09/99	14.3	9.3	80.65
03/10/99	12.6	4.5	14.15
10/10/99	13.5	5.9	2.45
17/10/99	11.2	5.8	18.55
24/10/99	13.3	6	11.05
31/10/99	12.8	7.4	25.55
07/11/99	10.1	3.8	0.85
14/11/99	6.6	2	2.9
21/11/99	9.9	5	6.65
28/11/99	9	3.8	44.1
05/12/99	8.1	2.5	63.4
12/12/99	5.3	-0.1	46.1
19/12/99	5.1	-1.2	16.9
02/01/00	8.65	2.4	7.05
09/01/00	7	2.1	33.9
16/01/00	5.9	-0.03	0.1
23/01/00	5.83	1.6	3.95
30/01/00	9.63	5.2	38.75
06/02/00	9.2	2.1	22.35
13/02/00	6.9	1	36.9
20/02/00	8	0.9	4.55

Week commencing	Maximum temp (°C)	Minimum temp (°C)	Rainfall (mm)
27/02/00	8.3	1.6	41.8
05/03/00	11.6	8	26.2
12/03/00	10	3.6	1.15
19/03/00	10.6	2.2	5.25
26/03/00	8.9	0	8.65
02/04/00	8.4	-0.4	16.65
09/04/00	8.4	0.8	38
16/04/00	12	3.3	35.3
23/04/00	14	6.7	23.6
30/04/00	12.8	5.2	0
07/05/00	17	7.3	0
14/05/00	18	6.9	17.2
21/05/00	14.2	4.9	37.4
28/05/00	15.4	7.4	66.7
04/06/00	15.8	7.7	7.25

APPENDIX II

b) Temperature data from the greenhouse during the dry-down phase

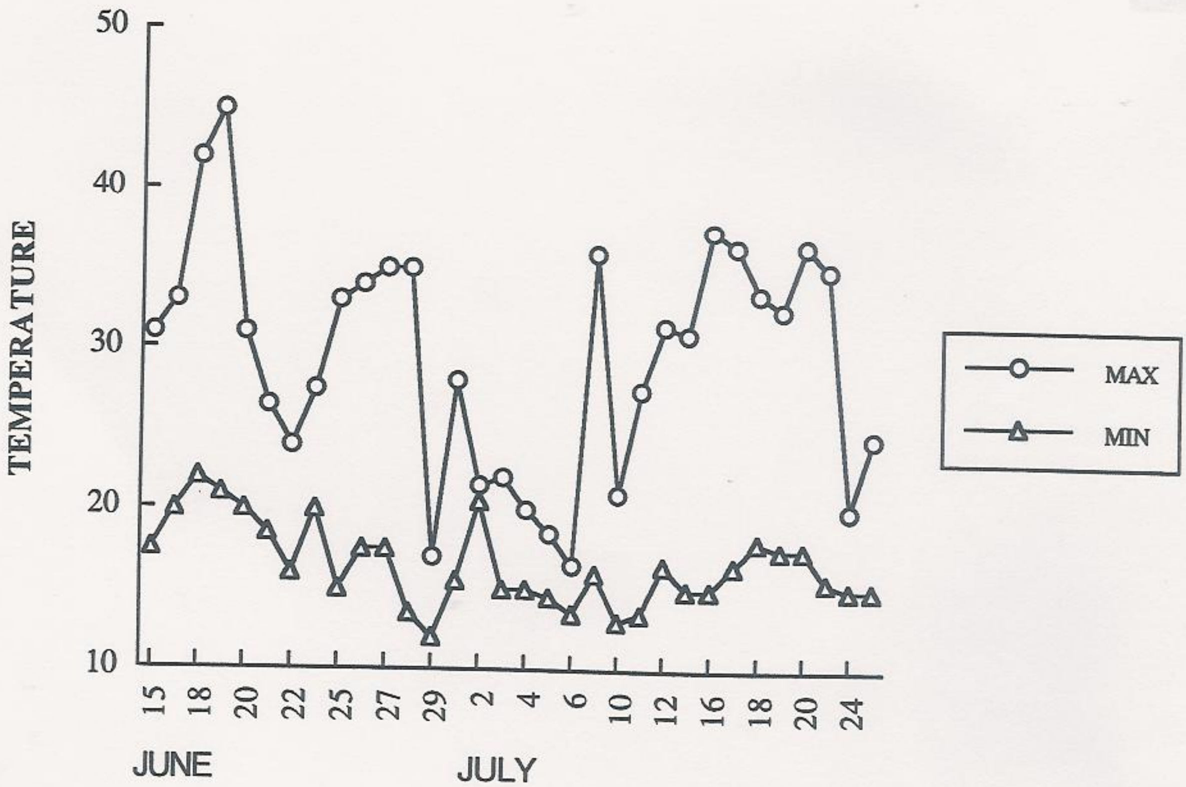

PLATE 1
Installation of the lysimeter pots during the trial construction

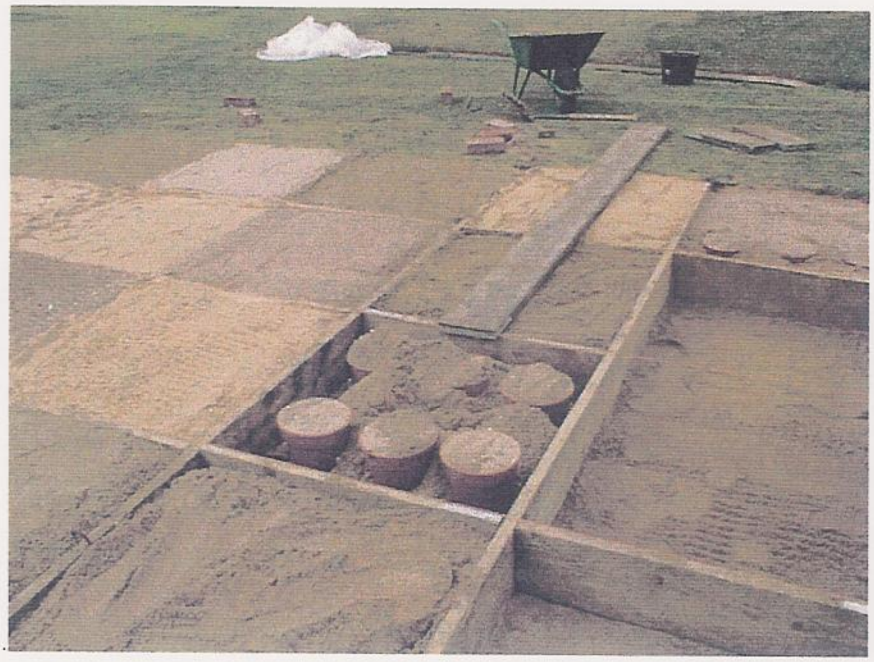

PLATE 2
View of trial during establishment, showing contrasting stages of germination between plots

PLATE 5
Four lysimeters with soil amended rootzones, illustrating the contrast between swards with and without Fytogreen amendments and between irrigation regimes on 30th June 2000 (please note pot positions are not the same as for Plate 4, refer to plate labels).

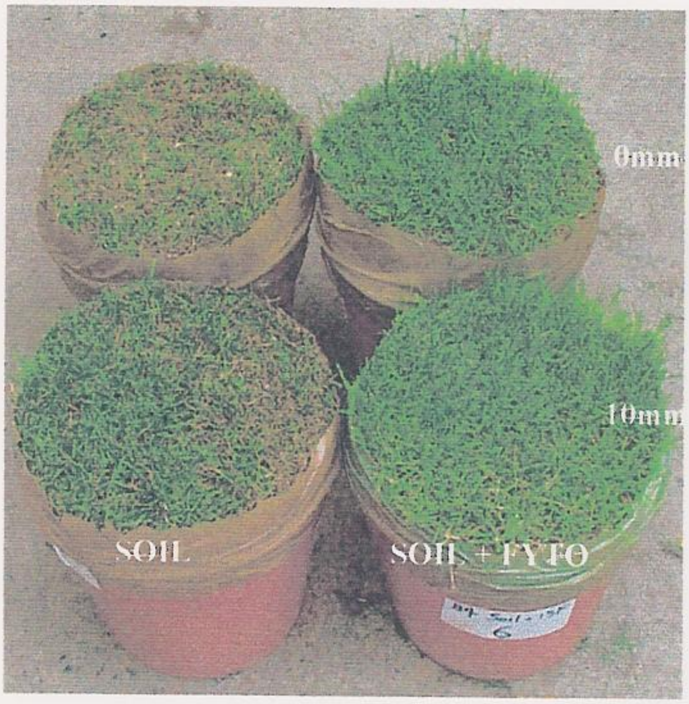

PLATE 6
Four lysimeters containing peat amended rootzones, illustrating the contrast between swards with and without Fytogreen and between irrigation regimes (30 June 2000).

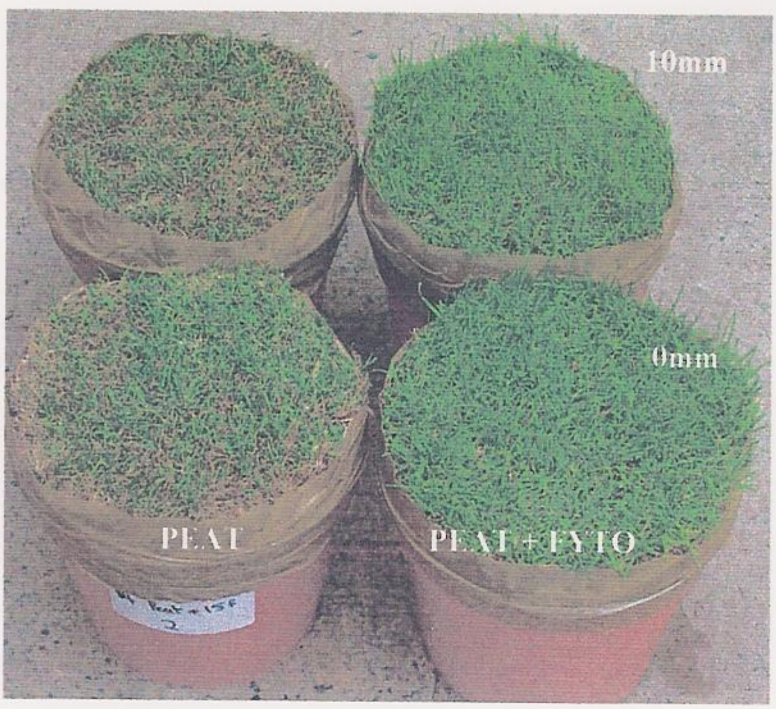

PLATE 3
View of lysimeters in greenhouse during dry-down phase

PLATE 4
Four sand rootzone lysimeters illustrating the contrast between swards with and without Fytogreen amendments and between irrigation regimes (30 June 2000). Top row =10mm irrigation, bottom row =0mm irrigation. Left column= no Fytogreen, right column = Fytogreen