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End of Project
Report

Project 4081

DEVELOPMENTS OF SPORTS TURF SYSTEMS SUITABLE FOR IRISH CONDITIONS

PHOTO

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Series No. 12

DEVELOPMENTS OF SPORTS TURF SYSTEMS SUITABLE FOR IRISH CONDITIONS

Project 4081

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SUMMARY

The principal objective of the study was to establish scientific data in relation to the nutritional requirements and best management practice for golf greens constructed to the United States Golf Association (USGA) 1973 specification under Irish conditions.

The game of golf is one of the biggest sports industries in the world. Income from golf tourism in Ireland has increased from £73 million in 1994 to £180 million in 1998. Good quality turfgrass is required to underpin the promotion of golf tourism.

Traditionally, golf greens on Irish golf courses were constructed from local materials and vary from green to green within a given golf course and also between different golf courses. In recent years there is a perception that the quality of putting surfaces is superior on greens constructed to the USGA specification. In addition, greens constructed to this specification are similar one to the other and location to location. The principal features of the USGA 1973 specification could be summarised as follows: (1) A network of drainage pipes installed in the underground soil covered with a carpet of peat gravel; (2) A blinding layer of specifically graded sand placed on the peat gravel; (3) A root zone mixture of graded sand (80%) and graded peat moss (20%) by volume. The particle size of the component layers must comply to the exact specification in terms of size, diameter and shape. As sands contain no nutrients, the management of greens constructed mainly of sand is more exacting than the traditional soil constructed greens. The results from this project confirmed this assumption.

Three major objectives were researched in this project: (a) the effect of micro nutrients, when applied or omitted, on the quality and growth of grass on a green surface; (b) the encroachment of *Poa annua* (annual meadow grass) onto the green; and (c) the comparison of two nitrogen top dressing programmes on sand greens. The detailed results are given in the text and in the conclusions of this report.

INTRODUCTION

Golf, as we know it today, started in Scotland. The first golf courses were developed on links lands and on sand dunes along the coastal strip. Fine *Fescue* and *Agrostis* grasses grow naturally on these sandy loams (Beard, 1982). In Ireland, golf courses were constructed around centres of population. Where sand dunes or links-type sandy soil was available, golf courses were constructed as a first choice on these sites. These are commonly termed 'links courses'. In areas away from the coast, golf courses were constructed on naturally free draining parkland locations. The greens on these parkland courses were constructed of a mixture of sandy loam, organic matter and generally from materials which were obtained in the locality. The golf greens built on these parkland courses were commonly termed 'push-up' greens. These push-up greens were not constructed to any set specifications and, as such, there was a lack of uniformity from green to green within a course and major differences also existed between the types of green found on different golf courses. This lack of uniformity was first recognised by the United States of America Golfing Association (USGA). Research was undertaken by the USGA in the late 1960s to develop a standard construction specification for golf greens. This research culminated in the development of a set of specifications commonly termed *USGA Specification for a method of Putting Green Construction*.

In the early 1990s a number of Irish golf clubs proceeded to build sand-based greens constructed to the broad guidelines of the USGA specification. In the majority of cases, the grass established on the sand greens was less than satisfactory for good golfing conditions. The reasons or causes for the poor grass growth, and its failure in many instances, were not clearly understood. To address this lack of scientific information, Teagasc Kinsealy Research Centre initiated a research programme to identify best management practices and nutritional requirements for greens constructed to the USGA specification. Materials used to construct a USGA green must conform to an exact set of specifications. Greens so constructed could be expected to have identical physical properties, eliminating inconsistencies, reducing compaction and waterlogging, and thereby enabling play to continue for a greater part of the year, other than in conditions of freezing. It is also considered that the putting surface on USGA greens is superior to that of the traditional Irish push-up green.

Three specific studies were carried out on the USGA greens at Kinsealy as follows: on Greens A and B: the effects of four micronutrients on sward colour, the incidence of disease and the rate of invasion of *Poa annua* into the sward, were studied; on Green C: the influence of two nitrogen formulations on the growth and colour of *Agrostis stolonifera* was investigated. In the course of the trial some interesting matters in relation to the total nutrient requirement of USGA greens were observed. In addition, it was noted that the element potassium became a problem in the late spring/summer. This was corrected but failure to observe and take corrective action could lead to serious growth problems (see **Discussion**).

Trace elements are plant nutrients which are essential for the survival of plants but which are required only in minute quantities (MacNaeidh, 1997, Pers. Comm.). The principal micronutrients required for grass are considered to be Boron, Copper, Manganese and Zinc. Information in the scientific references is very limited on the interaction of micronutrients and fine turf growth. The exact function of Boron in plant growth and development is not well understood but is thought to work in calcium utilisation (Beard, 1973), with a deficiency resulting in poor colour (Deal and Engel, 1965), and poor vascular strand development causing sensitivity to water stress. Copper is a component of several enzyme systems and is needed in the synthesis of certain plant growth promoting substances, with a deficiency leading to death of the auxiliary buds in the apical meristem of turfgrass (Beard, 1973). Manganese functions in chlorophyll synthesis and is a factor in a number of plant enzyme systems (Beard, 1973), with a deficiency causing discoloration of turf. The actual role of Zinc is not well documented, but reported functions include a constituent of certain plant enzymes such as carbonic anhydrase and a co-factor in the synthesis of certain plant food hormones and auxins such as idoleactic acid, with a deficiency resulting in the restriction of leaf development (Beard, 1973).

The literature review revealed that there was very little information on the specific effects of micronutrients and their interaction with grass growth, colour and texture on sand dominated root zone greens. In Ireland, a number of commentators who had failures with USGA type greens felt that lack of minor nutrients could be a contributory factor. The aim of the first trial was to identify the effects of four micronutrients on the growth of fine turfgrass mixtures when grown on USGA constructed greens. Nutrient application is the practice by which essential plant foods are supplied as part of a turfgrass cultural management programme and ranks alongside mowing and irrigation as a primary determinant of turfgrass persistence and quality (Turgeon, 1991).

Poa annua (annual meadow grass) is a natural occurring grass found on all golf courses in Ireland examined by the authors. The predominant grass used on USGA seeded greens is an

Agrostis species. *Poa annua* encroached onto all of the greens at Kinsealy and had to be removed by hand. The pattern of development and encroachment was studied as a secondary issue in these trials on Greens A and B.

The influence of nitrogen formulation on the growth of *Agrostis stolonifera* was undertaken on 'Green C'. A slow release nitrogen-type, which was applied to the green surface every six weeks, was compared with a soluble form of nitrogen which was applied at one sixth of the quantity but on a weekly basis in the form of sulphate of ammonia and potassium nitrate. Potassium nitrate is a fertiliser which increases pH in the soil (Turgeon, 1991).

The general performance of urea formaldehyde in cool temperature climates has been poorer than other nitrogen sources (Moberg *et al.* 1970; Waddington *et al*. 1976; Kavanagh *et al*. 1980; Hummel and Waddington 1981, 1984; Landschoot and Waddington, 1987). The type of methyleneurea used in this trial was supplied from the USA and was considered to be superior to earlier formulations supplied to the turfgrass industry. The suppliers advised that the formulation to be tested should perform in a similar way to other nitrogen sources but releasing the nitrogen over a five to seven week period.

MATERIALS AND METHODS

The studies were conducted on three greens, A, B and C, constructed at Kinsealy Research Centre. The greens were constructed in accordance with USGA Greens Section "Recommendations for the Construction of a Putting Green, 1973". Greens A and C had a root zone mixture comprising of 80% graded silica sand and 20% graded Bord na Mona Sphagnum peat moss. Green B had a root zone mix comprising of 80% graded silica sand and 20% graded sandy loam. The soil was used to increase the clay fraction and thus increase the cation exchange capacity (CEC) of the root zone (Miller and Donohue, 1990). The greens were firmed and levelled and allowed to settle for two weeks prior to sodding Greens A and B and seeding Green C. A fertiliser mixture comprising of macronutrients N, P, K, Mg, and micronutrients (**Table** I) was applied to the root zone and raked into the top 50mm two days prior to laying the sod or seeding.

Table 1 : Macronutrient and micronutrient application rates prior to sowing and the micronutrient mixture applied to plots on Greens A and B

Nutrient	Fertiliser Type	Composition	Rate of Fertiliser applied (g/m^2)

Macronutrients			
Nitrogen (N)	Sulphate of Ammonia	21% N	17.0
Phosphorus (P)	Superphosphate	8% P	25.0
Potassium (K)	Sulphate of Potash	44% K	25.0
Magnesium (Mg)	Kieserite	16% Mg	43.0
Micronutrients			
Boron * (B)	Borax	11% B	0.6
Copper * (Cu)	Copper Sulphate	25% Cu	0.6
Iron (Fe)	Iron Chelate		1.8
Manganese * (Mn)	Manganese Sulphate	32% Mn	0.8
Molybdenum (Mb)	Sodium Molybdenate	39% Mb	0.02
Zinc * (Zn)	Zinc Sulphate	23% Zn	0.8

* *denotes trace elements and rates which were also applied at monthly intervals March-September on Greens A and B.*

Construction of Greens

The basic structure of the greens consisted of four separate layers, subgrade and drainage layer, a gravel drainage layer, a blinding intermediate layer, and a root zone layer. The USGA specification utilises a perched water table principle whereby there is a discontinuity of pore space throughout the layers. In effect, this gives the USGA green a reasonable water holding capacity without conceding any of the free drainage properties of a sand green. The total porosity should range between 35/55%, the air filled porosity between 15/30%, the capillary porosity between 15/25%, and the saturated conductivity between 15 and 30cm/hr. It must be emphasised that for greens to perform as intended by the USGA, the exact construction specifications must be adhered to (**Fig. 1:** Cross section of USGA green).

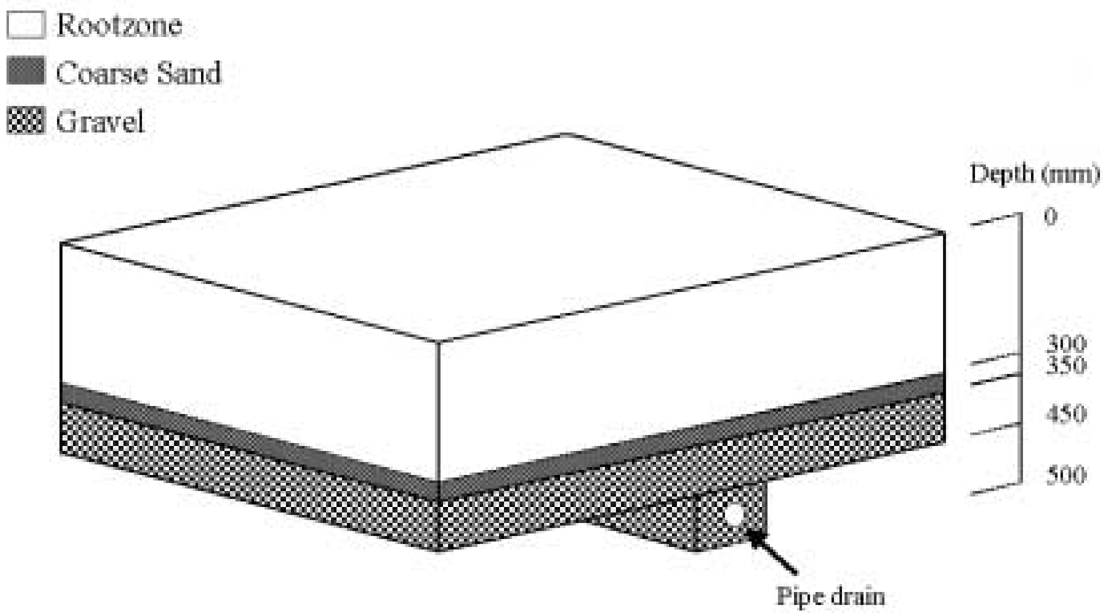

Fig. 1 : Cross section of USGA green

Experimental Design

Greens A and B

A mixture of four trace elements as set out in **Table** 1 were applied to half the plots on Greens A and B at monthly intervals from March to October each year. Nitrogen, Potassium, Magnesium and Phosphorus were applied at regular intervals throughout the year based on the chemical analysis of the root zone, and the total elemental N, P, K, Mg applications for the four years of this trial are set out in **Table** 2.

Table 2 : Greens A and B - total application of N, P, K, Mg, kg/ha in years 1994 - 1997

Year	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Magnesium (Mg)
1994	330	100	465	-
1995	520	35	417	70
1996	423	53	315	15
1997	462	34	554	136

Greens A and B were divided into experimental plots 2m x 1.2m and were sodded with a turf with a grass composition Type I, II or III, as per experimental design (as set out in **Table** 3).

Table 3 : Turf type composition

Type	Species Composition

I	80% *Agrostis tenuis* 20% *Festuca rubra ssp. Commutata*
II	40% *Festuca rubra ssp. Commutata* 40% *Festuca rubra ssp. Litoralis* 20% *Agrostis tenuis*
III	60% *Festuca rubra ssp. Litoralis* 20% *Festuca rubra ssp. Rubra* 20% *Agrostis tenuis*

Green C

This green was seeded with *Agrostis stolonifera var.* "Pencross" at a rate of 8gm^{-2}. The surface of the green was not allowed to dry out during day time until the seed was well established. Green C was divided into fifteen plots, each plot measuring 3.5 x 3.5m. The plots were completely randomised and assigned treatments. There were two nitrogen treatments investigated, termed Treatment 1 and Treatment 2. Treatment 1 consisted of alternate weekly applications of ammonium sulphate (21% N) and potassium nitrate (13% N, 38% K) from March to 19th September. Thereafter, two applications of ammonium sulphate and four applications of potassium nitrate at half rate were applied to take cognisance of the falling temperature and the reduced turfgrass growth rate. At each application of ammonium sulphate or potassium nitrate the actual nitrogen applied was 0.96gm^{-2}. Potassium nitrate was applied at 2.7gm^{-2}. The total nitrogen applied was 25.85gm^{-2} and 37.58gm^{-2} of potassium for the duration of the trial.

Treatment 2 consisted of applications of methyleneurea (40% N) at six-week intervals beginning 11th April and ending 19th September. The last application was one half the regular rate, taking cognisance of the reducing growth rate of the turfgrass. The methyleneurea was applied at a rate which equalled the amount of nitrogen applied in Treatment 1 over the same six-week period of 5.76gm^{-2}. In addition, potassium was applied to compensate for the same amount of K applied in Treatment 1. The total amount of nitrogen N applied was 25.7g and 37.59g of potassium.

Phosphorus, Magnesium and microelements Boron, Copper, Manganese and Zinc were applied based on root zone chemical analysis. The total amount of fertilisers applied to both treatments was identical and is summarised in **Table** 4.

Table 4 : Green C- total application of N, P, K, Mg, kg/ha in 1997

Treatment	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Magnesium (Mg)
1	258	27	376	49
2	258	27	376	49

All greens were managed throughout the duration of these trials in accordance with best greenkeeping practices. Irrigation was applied through an automatic system from April to September, based on visual observation of the turfgrass and on meteorological data. Irrigation was also used to wash in fertilisers, particularly potassium, to avoid grass scorching. The greens were cut a minimum of five times per week from April to September at a mowing height of 5mm. Top dressing consisting of the root zone mix was applied on six occasions during the growing season at a rate of 1kg per metre squared.

PHOTO

Fig. 2 : Constructing USGA green at Teagasc Kinsealy Research Centre

Data Collection

Root zone samples were taken from each plot at the start of each month and analysed for levels of all major and the four micronutrient levels. The pH level for each plot was measured using a glass electrode pH metre placed in a suspension of sieved dried root zone material and distilled water.

The plots were scored at regular intervals for colour on an index of 1 to 9 where 9 was the best registration for colour. *Poa annua* was measured as individual seedlings in Years 1 and 2 but this was changed to the area in centimetres squared thereafter as it was not possible to discern individual seedlings (on Greens A and B only).

RESULTS

Greens A and B - Studies on factors associated with micronutrients, pH and *Poa annua* were investigated on these greens.

Micronutrients in the root zone

There was a consistent difference between the levels of B, Cu, Mn and Zn in the root zone of plots receiving monthly applications compared to those not receiving trace elements. The plots receiving trace elements gave a higher reading on each analysis date for the four elements. The cumulative means for the 1995/96 seasons are set out in **Table** 5.

Table 5 : Mean readings for B, Cu, Mn, and Zn mg/kg in the root zone

mg/kg	+ trace elements	+ trace elements	- trace elements	- trace elements
	1995	1996	1995	1996
Boron	0.85	1.38	0.43	0.67
Copper	4.82	8.90	3.03	3.50
Zinc	3.02	9.00	1.50	2.40
Manganese	31.00	27.50	25.00	18.40

\+ = plots getting trace elements
\- = plots not getting trace elements

Colour of Grass

Except for the May 1995 readings, when the colour was significantly better on the plus-trace element plots, the trace element treatment did not significantly affect the colour of the turf on any other recording dates during the three years of this trial. No deficiency or toxicity symptoms were recorded for any of the trace element treatments for the duration of this trial.

Table 6 : Mean reading of colour for plots with and without trace elements - 1995

Date	+ Trace elements	- Trace elements	S.E. (df=60)
May *	4.60	5.43	0.14
June	7.48	7.60	0.12
July	7.00	6.90	0.12
September	6.08	6.20	0.14
November	5.45	5.53	0.07

* denotes significant difference

Table 7 : Mean reading of colour for plots with and without trace elements - 1996

Date	+ Trace elements	- Trace elements	S.E. (df=60)
February	5.50	5.55	0.08
April	5.80	5.83	0.11
June	5.83	5.75	0.12
September	6.15	6.03	0.11
November	5.73	5.85	0.09

Root zone pH analysis

The pH of the root zone material ranged from 5.6 and 6.3 for Greens A and B respectively at the beginning of the experiment, to 5.4 and 5.5 for the same greens after three years. The mean reading for plots are shown in **Fig**. 3. The nitrogen was applied as sulphate of ammonia up to Month 32. This was changed in Month 33 to potassium nitrate $KN0_3$ and sulphate of ammonia applied in alternate weeks. The value for the pH increased after Month 32 arising from the use of potassium nitrate. This could be attributed to the use of potassium nitrate in the nitrogen programme (Turgeon, 1991).

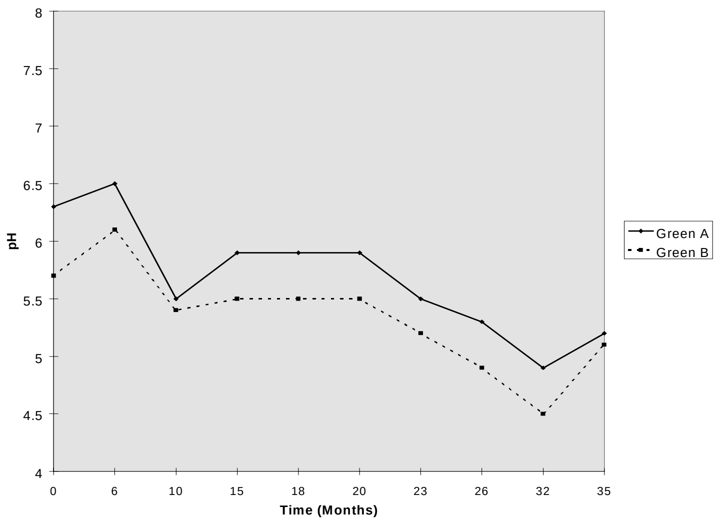

Fig. 3 : Root zone pH of Greens A and B, 1995 to 1997

Green A- Rootzone mix 80% silica sand, 20% graded sphagnum peat.
Green B- Rootzone mix 80% silica sand, 20% graded mineral soil.
* Nitrogen at Sulphate of Ammonia to month 32. Thereafter in Nitrate form.

Poa annua (Annual meadowgrass)

In January 1995 *Poa annua* recording commenced in each plot. There were three grass types under test in this trial, as set out in **Table** 3. In 1995 the individual seedlings of *Poa annua* were recorded. In the following season *Poa annua* was recorded as the area cm^2 per plot as it was not possible to isolate individual seedling. The results are set out in **Tables** 8 and 9.

Table 8 : Sod type and *Poa annua* count / plot 1995

Date	Type 1	Type 2	Type 3	S.E. (df=60)

January	3.6	0.2	0.5	2.7
May	13.1	2.4	2.2	2.7
June	3.6	0.8	1.5	3.8
July	4.2	1.0	2.4	4.4
August	13.8	6.5	8.5	9.6
November	2.0	0.5	1.3	3.3

Table 9 : Sod type and *Poa annua* means, cm^2 / plot 1996

Date	Type 1	Type 2	Type 3	S.E. (df=60)
March	20.0	6.0	4.2	2.1
June	27.7	19.2	14.2	2.8
August	36.3	13.0	9.6	2.9
October	67.5	10.0	10.0	4.9
November	48.9	4.6	5.6	3.7

Poa annua on all dates was significantly greater in the Type 1 sod (80% *Agrostis*) than in Types 2 or 3. The area of *Poa annua* in the Type 1 plots increased from March to October, with a decline in the areas for the month of November. It was observed in 1997 that the *Poa annua* was well established and it would not be possible to remove it without the aid of a hole cutter or similar tool. It was also noted that it was difficult to see visual differences between the *Poa annua* and the *Agrostis* ssp. when the *Poa annua* was not in seed, and that only when the *Poa annua* was producing seed heads was it conspicuously unattractive on the putting surface. The use of scarification and spraying with iron sulphate “masked” the presence of the *Poa annua* in the sward.

Pest and disease

Plots were examined at monthly intervals for symptoms of disease and pest. Apart from a small amount of *fusarium* in November 1996 on both greens which was not associated with treatments or sward type, disease or pest was not present at any other time.

Green C - A comparison of two nitrogen top dressing programmes

Colour ratings of plots Treatments 1 and 2

The colour of the plots based on a score rating 1 to 9 (where 9 was the highest and best colour possible) was taken at weekly intervals from the end of March to late December. The mean monthly readings for colour ratings are set out in **Table** 10. Differences between Treatments 1 and 2 were marginal from 27th March to 12th June, although statistically significant differences were recorded on 9th and 16th May where Treatment 1 were superior to Treatment 2. From June to the middle of December, the score readings for Treatment 1 plots were significantly higher than those for Treatment 2. The differences in superiority for Treatment 1 became very noticeable from October through to December. The colour rating on the Treatment 2 plots from late September through to December would not be considered satisfactory in a normal golfing situation.

Table 10 : Mean monthly colour ratings for Green C, Treatments 1 and 2, 1997

Month	Treatment 1	Treatment 2
March	2.4	2.6
April	5.0	5.0
May	7.8	7.5
June	6.3	4.9
July	7.4	5.8
August	8.1	6.2
September	7.3	5.0
October	7.2	3.6
November	7.4	2.9
December	6.9	2.9

Colour ratings on a scale of 1 to 9 where 9 was the best possible score.

Fresh weight yield

In view of the significant differences in colour ratings which were apparent from mid-July, the mean fresh weight of grass mown from Treatments 1 and 2 were recorded on four occasions, as set out in **Table** 11. On three of the dates recorded the fresh weight for Treatment 1 was significantly higher than that obtained from Treatment 2.

Table 11 : Mean fresh weight yields of Treatment 1 and Treatment 2 plots

Date	Treatment 1 g	Treatment 2 g	S.E.D.	Significance of p-value

12.08.97	205.77	78.29	10.840	p<0.001
01.09.97	82.39	81.11	9.025	N.S.
16.10.97	295.56	104.87	9.985	p<0.001
02.12.97	262.56	33.18	24.463	p<0.001

Root zone pH

The pH from samples taken at regular intervals throughout the 1997 growing season are set out in **Table** 12. At the start of the trial, the pH values were 5.4 for both treatments. By the end of April the pH values had dropped to 5.1 and 5.3 for Treatments 1 and 2 respectively, before increasing to a value of 5.7 by early June. The pH levels dropped to 4.9 by the end of August and increased again to 5.7 by the middle of October. Significant statistical differences only occurred on the final two sampling dates when the pH values of Treatment 1 were lower than those of Treatment 2.

Table 12 : Root zone pH of Treatments 1 and 2 plots, Green C, 1997

Date	Treatment 1	Treatment 2	S.E.D.	Significance of f - value
27.03.97	5.7	5.7	0.08	N.S.
29.04.97	5.1	5.3	0.14	N.S.
06.06.97	5.7	5.7	0.02	N.S.
03.07.97	5.7	5.5	0.11	N.S.
08.08.97	5.0	5.9	0.04	N.S.
01.09.97	4.9	4.9	0.10	N.S.
13.10.97	5.4	5.7	0.10	p<0.01
02.12.97	6.0	6.3	0.09	p<0.03

Nitrogen Content of Tissue Samples

The nitrogen tissue content for Treatment 1 ranged from 1.8 at the beginning of the trial in March, to 4.6 on the last sample date in December. The nitrogen value of 1.8 was only observed at the start of the trial date and from May to last sampling, the tissue nitrogen contents never fell below 3.4. The nitrogen content remained above the sufficiency value (2.7%) for the duration of the experiment in relation to Treatment 1. With regard to Treatment 2, by mid-August the nitrogen content of tissue had dropped below the recommended sufficiency value. The nitrogen content had risen to 3.9 by early September but again had declined to 2.0 and 2.1 respectively for the October and the December readings. The readings for nitrogen content Treatments 1 and 2 are set out in **Table** 13.

Table 13 : Nitrogen content of Treatments 1 and 2, Tissue samples N (%) of DM

Date	Treatment 1	Treatment 2	S.E.D.	Significance of f - value
26.03.97	1.8	1.8	0.0	N.S.
08.05.97	4.5	4.6	0.12	N.S.
04.06.97	3.9	4.3	0.25	N.S.
03.07.97	4.0	3.0	0.21	p<0.001
12.08.97	4.4	2.4	0.11	p<0.001
01.09.97	3.5	3.9	0.17	p<0.02
16.10.97	3.8	2.0	0.13	p<0.001
02.12.97	4.6	2.1	0.12	p<0.001

DISCUSSION

Greens A and B

No differences were observed between plots receiving and not receiving trace elements B, Cu, Mn and Zinc. The levels of Boron declined rapidly between October and March and a spring application is advised. There was 25mm of mineral soil attached to the sods used on these two greens and it is possible that sufficient supply of minor elements was available from this source to satisfy good grass growth. On a pure sand green there may be a need to apply annually trace elements to satisfy plant growth conditions.

A mineral sandy loam was used in the root zone mix in Green B, as a substitute for sphagnum peat moss. Literature suggested that the use of mineral soil would be nutritionally superior to peat moss. There was no difference in the performance of the grass on the two root zone types. The findings support the use of graded sphagnum peat moss and not graded soil, in view of the difficulties in obtaining the latter. It was also observed that it was easier to uniformly mix the sphagnum peat with the sand root zone.

The findings conclude that *Poa annua* can invade an *Agrostis* ssp. grass cover sod more easily than that of a predominantly *fetusca* ssp. sward. *Poa annua* was observed in greater numbers in the month of May and in late autumn. These findings would suggest that operations which facilitate seed establishment should be avoided at these times of the year. The study also supports the view that if a policy of removing *Poa annua* from newly seeded sand greens is to be pursued, this must be done while the *Poa* grass is in the seedling stage.

The root zone mixture in a USGA sand green has a very limited cation exchange capacity. This predisposes it to serious risk of nutrient leaching. This was particularly noticeable in relation to potassium. Levels in the root zone depleted to deficiency levels between October and March in each of the three years of this trial (**Fig.** 4). In addition, the uptake of potassium in the period from April to mid-June suggests that extreme care should be taken in the management of potassium on these greens. Sulphate of potash was used at regular intervals to correct and maintain adequate potassium in the root zone. Sulphate of potash can cause serious scorching to grass and correct application procedures must be adhered to. The total amount of nutrients N, P, K, Mg applied in this series of trials were a factor of 2.5 to 3 times greater than would normally be required on a traditional push-up soil green. There is little latitude for mismanagement of the nutritional requirements of a USGA type green, particularly in the establishment years. This type of green should not be permitted to go hungry at any time of the growing season.

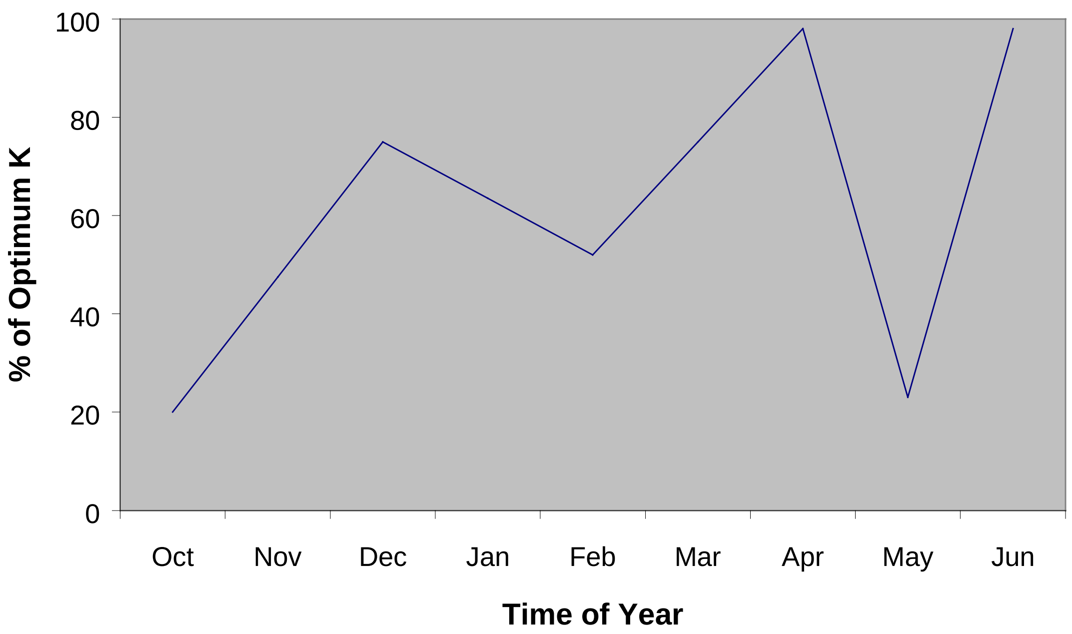

Fig. 4 : Variation in green potassium levels in the root zone

Green C

In this experiment, a policy of applying weekly nitrogen was considered superior to the use of a slow release methyleneurea based nitrogen product. The visual colour and growth of the grass was superior when sulphate of ammonia and potassium nitrate were used. The slow release methyleneurea form of nitrogen did not work satisfactorily on Green C. The type of methyleneurea specifically obtained from the USA was the most suitable form of urea for use under Irish conditions.

Observation of the amount of grass clippings was considered to be a useful guide in determining the nitrogen top dressing policy on USGA greens. The amount of fresh weight clippings gathered from the methyleneurea nitrogen treated plots deteriorated very sharply from late autumn.

PHOTO

Fig. 5 : A training session in progress examining a USGA green at Kinsealy

CONCLUSIONS

USGA sand based greens have a very limited cation exchange capacity. Understanding the nutritional management implications of USGA greens should be determined before a club embarks on the construction of sand based greens.

The nutritional management of potassium is of particular importance on USGA type greens. This is particularly relevant in late spring and early summer. Potassium nitrate was considered a very useful and suitable fertiliser for supplying nitrogen and potassium for sand-based greens. Boron is very easily leached from the root zone.

Our experience to date suggests that the controlled release fertiliser, methyleneurea, as a source of nitrogen could not be considered a suitable material, particularly in the establishment years on a USGA type green.

The application of sulphate of ammonia and potassium nitrate was superior in the colour performance and growth of grass on sand based greens. Potassium nitrate is very useful, particularly in limiting the pH decline.

It was also observed that greens based on USGA specifications can become deficient in nutrients after periods of high precipitation or mis-use of irrigation systems. Sand based greens should not be allowed go hungry at any period of the year.

Poa annua should be removed as a seedling if a policy of maintaining *Poa annua*-free *Agrostis/Festuca* is to be followed.

The trial greens and facilities continue to be used in supporting the Teagasc greenkeeping training programmes and are a major asset in the dissemination of applied skills in the management of United States Golf Association (USGA) greens.

The author suggests that a trial putting green should be built and a knowledge of the particular nutritional requirements be acquired prior to embarking on building USGA greens on the main course.

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