TRIALS OF TURFGRASS WEAR TOLERANCE AND ASSOCIATED FACTORS A SUMMARY OF PROGRESS 1975 - 1977

By P. M. CANAWAY

INTRODUCTION

"Wear tolerance" of turfgrasses is defined as the ability to withstand wear and it is well known that different turfgrass species possess differing degrees of wear tolerance, e.g. Beard (1973), Shildrick (1975), Shearman and Beard (1975a). Many factors are thought to influence wear tolerance such as shoot density, leaf structure, succulence and the age and vigour of the sward (Beard 1973) but the experimental evidence is very limited and it is only recently that work has been undertaken to investigate this problem. Shearman and Beard (1975b) found that wear tolerance was closely correlated with the amounts of various cell-wall constituents i.e. fibre (in the biochemical sense of the term) present in the seven different species studied. In the same series of experiments Shearman and Beard (1975c) also studied a number of other factors (verdure, shoot density, leaf width, load bearing capacity, leaf tensile strength, moisture content, relative turgidity) but found no significant correlations between wear tolerance and any of these factors tested individually. Shearman and Beard (1975c) also compared the leaf anatomy of *Festuca arundinacea* (the most wear tolerant in their trial) with that of *Poa trivialis* (least wear tolerant) and found large differences in the amounts of sclerenchyma and lignified cells. This provided a little further evidence suggesting the importance of fibre in wear tolerance.

This article summarises in brief form the results of two trials at Bingley. Trial 1, a pilot trial, made use of turfed material in order to obtain some preliminary results as quickly as possible while Trial 2, a sown trial, was establishing. The main objective of both trials was to measure the wear tolerance of six turfgrass species using the D.S.1 wear machine (Canaway 1976) and to attempt to relate this to a number of factors, including fibre, biomass and turf strength measured before wear. In Trial 2 the effect of wear on infiltration rate and soil compaction was also studied.

MATERIALS AND METHODS

A. Trial details

Establishment

In July 1975 the land for both trials was sterilized with methyl bromide and then limed, fertilized and prepared ready for laying out of the trials in September 1975. Both trials were laid out in six randomised blocks. In Trial 2, in addition, a separate block which remained unworn was also sown. Plot size was 1·5 m × 1·5 m in both trials.

Trial 1 was established in September 1975 from turf of six species lifted from other parts of the trial ground. After the turf was laid, the plots were top dressed with sand to correct levels. Because the 1973 - sown *Festuca rubra* turf (and to a lesser extent that of *Agrostis tenuis*) was rather thin and weak, further material sown in 1971 was also used giving a total of eight types of turf. All the turf was unfortunately contaminated with *Poa annua,* some species being contaminated more than others.

Trial 2 was sown on an adjacent area using the same species as in Trial 1. Table 1 lists details of the species and cultivars used in the two trials and also, for Trial 1, the original sowing date and previous mowing height of the turf.

TABLE 1
Details of species and cultivars used in wear tolerance trials

	Trial 1 laid Sept. 1975			Trial 2 sown Sept. 1975
Species	Cultivar	Original sowing date of turf	Previous mowing height (mm)	Cultivar
Lolium perenne L.	Aberystwyth S.23	Sept. 1973	25	As in Trial 1
Poa pratensis L.	Sydsport	Sept. 1973	25	Baron
Phleum pratense L.	Aberystwyth S.48	Sept. 1973	25	As in Trial 1
Agrostis tenuis Sibth.	Highland	Sept. 1973 & June 1971	8	As in Trial 1
Festuca rubra L.	Highlight	Sept. 1973 & June 1971	8	Highlight & Canadian (50-50 mixture)
Poa annua L.	(from S.T.R.I. cuttings)	April 1973	8	As in Trial 1

Wear treatments

Wear treatments were carried out with the D.S.1 wear machine set to a speed-ratio of 1·33:1 between the front and rear rotors except that, in the later stages of Trial 1, a speed-ratio of 1·67:1 was used to produce a more severe wear treatment. The wear treatments were concluded when the plots of *F. rubra* and *A. tenuis* had been reduced almost to bare ground. The details of the wear treatments are summarised in Table 2.

TABLE 2
Summary of wear treatments

	Trial 1	Trial 2
1st month's wear	29 Mar. - 26 Apr. 1976	9 Feb. - 7 Mar. 1977
2nd month's wear	27 Apr. - 21 May 1976	8 Mar. - 3 Apr. 1977
Total No. passes in 1st month	32	20
Total No. passes in 2 months	70*	40

* includes 8 passes with 1·67:1 speed ratio

The total number of wear treatments required to reach a similar end point was much greater in Trial 1 than in Trial 2. There seemed to be three main reasons for this: 1) the turf used in Trial 1 was mature and well-knitted whereas that used in Trial 2 was relatively young; 2) the wear treatments in Trial 1 were applied later in the season than in Trial 2 and thus the grass showed a marked degree of short-term recovery between wear applications, especially during the second month's wear; 3) a relatively dry winter in 1975/6 left the ground in a firm condition as compared to the wet winter of 1976/7.

Trial maintenance

The trials were mown at 25 mm with the cuttings removed. Fertilizer applications consisted of a complete dressing (15:10:10) applied at 350 kg/ha in spring and autumn and two summer dressings of nitro-chalk applied at 250 kg/ha. Disease problems occurring in Trial 2 were treated appropriately as they arose; most serious was attack of *Poa pratensis* by *Drechslera poae.*

B. Data collection

In Table 3 the characters assessed and method of assessment are summarized. Wear tolerance of the species was assessed from the amount of grass ground cover remaining after wear expressed as a percentage of the pre-wear value.

RESULTS AND DISCUSSION

For conciseness in the description of the results sub-species and cultivar names have been omitted but this is not intended to imply generalisation of the results to include sub-species and cultivars other than those used.

Wear tolerance

The mean values for wear tolerance of the six species in the two trials are given in Table 4, where wear tolerance is represented by ground cover remaining after wear expressed as a percentage of the pre-wear value.

TABLE 3
Summary of characters assessed and methods of assessment

Character assessed	Trial 1	Trial 2	Assessment procedure
Pre-wear			
1) Ground cover and contamination by other species	√	√	Ten-pin frame point quadrat, 100 points per plot
2) Above ground biomass	√	√	Dry weight of samples clipped to ground level in each plot
3) Fibre content	√	√	Modified acid detergent fibre method (M.A.D. Fibre)
4) Turf strength	√	√	Directly with football-stud disc (for details see Canaway 1975)
5) Root and other organic matter	√		Loss on ignition of 3·5 cm diameter, 5 cm deep soil cores (5 cores from each plot)
After 1 month's wear			
1) Ground cover etc.	√	√	As above
At fortnightly intervals during period of wear			
1) Growth rate	√	√	Dry weight of samples clipped to ground level in unworn plots
2) Soil compaction		√	Bulk density and air filled porosity by taking 3·5 cm diameter, 5 cm deep soil cores from paths (10 cores on each occasion of measurement)
After 2 months' wear			
1) Ground cover etc.	√	√	As above
2) Infiltration rate		√	Direct measurement over 22 hours
3) Turf strength		√	As above
After 2 months' recovery			
1) Ground cover etc.	√	√	As above

TABLE 4

Mean wear tolerance (percentage ground cover remaining) for six turfgrass species in the two trials (%)

Species	Trial 1		Trial 2	
	After 1 month's wear (32 passes)	After 2 months' wear (70 passes)	After 1 month's wear (20 passes)	After 2 months' wear (40 passes)
Poa annua	95·4a	72·3a	76·1a	75·1a
Lolium perenne	74·8b	36·2c	62·4b	44·5b
Poa pratensis	79·7b	46·0b	54·6c	39·1c
Phleum pratense	70·2b	20·5d	67·8b	38·0c
Festuca rubra (1971)*	33·8c	6·8e	26·6d	5·7d
Festuca rubra (1973)	23·5d	1·2f	**	**
Agrostis tenuis (1971)	20·8d	1·7f	29·7d	4·4d
Agrostis tenuis (1973)	20·4d	1·3f	**	**

*1971 and 1973 refer to dates of original sowing in Trial 1 only.
**In Trial 2 *F. rubra* and *A. tenuis* not duplicated as in Trial 1 hence space in Table.

N.B. Means in each column without a common letter are significantly different at $p < 0{\cdot}05$ using Duncan's multiple range test. Comparison can not be made between columns.

Considering the differences between the two trials in age, maturity and manner of establishment of the turf the ranking of the species is very similar, although there are minor differences. For example, *Lolium perenne* exceeded *Poa pratensis* in Trial 2 but not in Trial 1, the latter species suffering disease attacks by *Drechslera poae* in Trial 2. The difference in wear tolerance between the *Festuca rubra* plots of different ages in Trial 1 appears to reflect the rather poor quality of the 1973 - sown material.

The overall pattern of wear tolerance in the species tested agrees well with other published work and observation in practical situations. For comparison, the wear tolerance rankings given by the S.T.R.I. (1978) and the Dutch I.V.R.O. (1978) are given in Table 5 below.

TABLE 5

Rankings for wear tolerance ratings of turfgrass species from published sources

Species (listed in the same order as in Table 4)	Source	
	S.T.R.I. (1978)	I.V.R.O. (1978)
*Poa annua**	1 =	No Data
Lolium perenne	1 =	1
Poa pratensis	3 =	2
Phleum pratense	3 =	3
Festuca rubra	5	4 =
Agrostis tenuis	6	4 =

*S.T.R.I. rankings indicate considerable variability in *P. annua* wear tolerance.

Correlations of wear tolerance with other attributes measured

In Trial 1 a significant correlation was found between percentage fibre and wear tolerance both after one month's wear ($r = 0{\cdot}58$ $p < 0{\cdot}01$) and after two months' wear ($r = 0{\cdot}52$ $p < 0{\cdot}001$[†]). None of the other attributes measured before wear was correlated with wear tolerance. The fibre result, although suggestive, should be interpreted cautiously since Trial 1 possessed a number of serious limitations: 1) the turf used was of different ages and this in itself could have influenced fibre content; 2) the sand top dressing used to correct levels after laying the turf was found to have influenced other measurements, notably turf strength, by the presence of different amounts of sand on plots of different species, this could also have influenced the manner in which samples were taken for fibre analysis; 3) only six winter months passed between laying the turf and starting wear treatments and therefore it was possibly incompletely rooted.

In Trial 2 after one month's wear no correlations were found between the attributes measured before wear and the observed wear tolerance. After two months' wear however, significant correlations were found both with biomass (i.e. the amount of plant material below the cutting height and above the soil surface, $r = 0{\cdot}42$, $p < 0{\cdot}01$) and with fibre expressed per unit area ($r = 0{\cdot}42$, $p < 0{\cdot}01$) in apparent confirmation of the work of Shearman and Beard (1975b) who found a similar result. In the present case the correlation between fibre per unit area and wear tolerance was largely due to differences in biomass among the species (since fibre per unit area = biomass per unit area × % fibre) the differences in percentage fibre being very small as compared with the differences in biomass. In the work of Shearman and Beard (1975b) biomass may also have been a determining factor in their obtaining a significant correlation between fibre per unit area and wear tolerance but their estimates of wear tolerance depended on biomass and therefore such a correlation would have constituted a circular argument. In Trial 2 the value of the two significant correlation coefficients obtained ($0{\cdot}42$) is low indicating that the correlations are weak. If the data for biomass are re-analysed omitting *P. annua* the correlation between wear tolerance and biomass disappears completely ($r = -0{\cdot}074$ N.S.) which means that although biomass may be important, the trial does not supply the hard evidence needed, and further work is required.

Effects of wear on infiltration rate and soil compaction in Trial 2

The effect of wear on infiltration rate is dramatic, the value for the worn area being about 1/20 of that on the unworn area (Table 6).

† The apparent discrepancy between the significance levels for the correlation coefficient obtained after one month's wear and that after two months' wear is due to the fact that only three blocks were sampled for wear tolerance after one month's wear, thus reducing the number of degrees of freedom available.

TABLE 6

Infiltration rates (measured after 2 months' wear) of worn and unworn plots pooled over all species

	Infiltration rate (mm/hr)
Unworn	45·6
Worn	2·6

The difference between the worn and the unworn plots was significantly different at $p < 0{\cdot}001$ (*d* test). The low infiltration rate on the worn area is due to soil compaction and smearing of surface soil structure. The species tested individually showed no significant differences in infiltration rate.

Although the effect of wear on infiltration rate was so large, the observed value for the infiltration rate of the worn plots would be sufficient to allow all but the heaviest rain to drain away as it fell on the naturally free draining sandy-loam soil at Bingley.

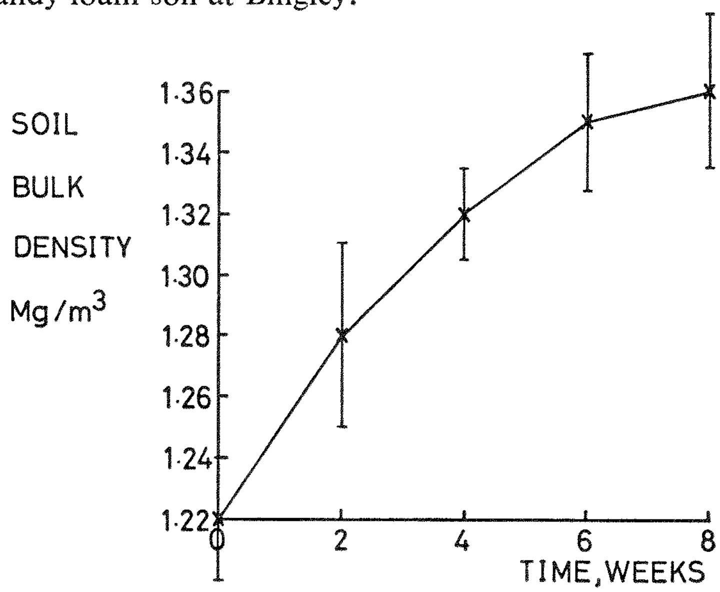

Figure 1. Increasing soil compaction takes place as a result of the continuing wear treatments. Vertical bars represent the standard errors of the means at the different sampling dates.

The effect of increased soil compaction during the wear treatments is illustrated by Fig. 1 which shows the increase in soil bulk density as the trial progressed. Since the measurements were taken on path areas receiving only half the number of wear applications as the plots, the trial plots presumably suffered worse compaction. At a given moisture content, compaction results in a progressive reduction in air-filled pore space. The values at each sampling date for percentage air-filled porosity are given in Table 7 and as can be seen there is a progressive reduction during the trial.

TABLE 7

Mean values of air-filled porosity taken at fortnightly intervals

Sampling date (1977)	Air-filled porosity (%)	Standard error
8 Feb.	10·3	1·34
24 Feb.	7·3	1·86
10 Mar.	6·3	0·83
24 Mar.	4·1	1·16
7 Apr.	3·9	0·98

ACKNOWLEDGEMENTS

Thanks are due to Mr. A. R. Woolhouse for his help in computer programming. The data analysis was carried out at Bradford University computing laboratory and fibre analysis by M.A.F.F. Agricultural Advisory and Development Service, Leeds. The work was carried out as part of a contract with the Natural Environment Research Council to whom a fuller report on the above has been submitted.

REFERENCES

Beard, J. B. (1973). *Turfgrass: Science and Culture,* Prentice-Hall Inc., Englewood Cliffs, New Jersey, U.S.A.

Canaway, P. M. (1976). A differential slip wear machine (D.S.1) for the artificial simulation of turfgrass wear. *J. Sports Turf Res. Inst.* 52, 92-99.

I.V.R.O. (1978). *53e Beschrijvende Rassenlijst voor Landbouwgewassen 1978.* Leiter Nypels, Maastricht, The Netherlands.

Shearman, R. C. and Beard, J. B. (1975a). Turfgrass wear tolerance mechanisms: I. Wear tolerance of seven turfgrass species and quantitative methods for determining turfgrass wear injury. *Agron. J.* **67**, 208-211.

Shearman, R. C. and Beard, J. B. (1975b). Turfgrass wear tolerance mechanisms: II. Effects of cell wall constituents on turfgrass wear tolerance. *Agron. J.* **67**, 211-215.

Shearman, R. C. and Beard, J. B. (1975c). Turfgrass wear tolerance mechanisms: III. Physiological, morphological, and anatomical characteristics associated with turfgrass wear tolerance. *Agron. J.* **67**, 215-218.

Shildrick, J. P. (1975). Turfgrass mixtures under wear treatments. *J. Sports Turf Res. Inst.* 51, 9-40.

S.T.R.I. (1978). Choosing Turfgrass Seed in 1978.