WEAR TOLERANCE AND SHADE ADAPTATION INVESTIGATION

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Most of the MSU research reports at the summer field days and this winter turfgrass conference emphasize the applied aspects of our turfgrass research program which have immediate application for the professional turfman in the field. However, there is another aspect of our research program that emphasizes the more basic problems associated with turfgrass culture. In this case, long term investigations are required before the results can be utilized by professional turfmen in the field. This type of research receives little attention at adult educational meetings, but is one of the more significant aspects of our research program. For this reason I would like to spend some time at this conference giving you outlines of the objectives and some of the results which have been forthcoming from two recent Ph. D. theses.

TURFGRASS WEAR TOLERANCE: THE ANATOMICAL AND PHYSIOLOGICAL BASIS

This Ph. D. thesis investigation was conducted by Dr. Robert C. Shearman. The research was supported by a financial grant from the United States Golf Association Green Section Research Fund. The objectives were: (1) to develop a turfgrass wear simulator that can be utilized on small experimental plots and that would adequately establish differential wear tolerances within turfgrass species, cultivars, and cultural practices; (2) to determine the relative wear tolerance of seven cool season turfgrasses as well as to develop methods of differentially evaluating wear injury; (3) to determine the anatomical, morphological, and physiological characteristics of turfgrass species that are associated with wear tolerance; and (4) to develop criteria based on the characteristics listed in (3) that could be utilized as selection tools in turfgrass wear tolerance breeding programs.

Traffic has two main effects that need to be differentiated in any research concerning injury resulting from intense traffic. One effect is turfgrass wear which is basically damage associated with the above ground turfgrass plant parts. This is contrasted to the second effect, soil compaction, which involves physically pushing together soil particles into a more dense soil that has reduced aeration and water infiltration rates. Both have very detrimental effects on turfgrass quality. Most of the previous traffic research and simulation studies have involved primarily a soil compaction component with a secondary effect on turfgrass wear. In contrast, this research emphasizes the turfgrass wear aspects. Thus, the first objective was to develop a wear simulator.

An effective wear simulator was developed for small plot use which adequately separated species wear-tolerance differentials. The apparatus simulated both foot and tire wear on turf with a minimum soil compaction effect. Foot traffic was simulated by a lead sled that was pulled in a circular pattern. A pressure of 4 pounds per square inch was applied. The sled also had a sideward, twisting motion typical of foot traffic. The tire traffic simulation was comparable to that involved with a riding greensmower. Turfgrass wear tolerance among turfgrass species was assessed in two ways: (1) to measure the number of revolutions required to reach a predetermined wear point and (2) to superimpose a specified number of rotations over a given area and then measure the quantity of verdure (living green tissue remaining under the cutting height) remaining after the traffic treatment was completed.

A series of turfgrass species plots were established for use in the wear tolerance evaluation work. The seven species were established the year previous to superimposing the wear treatments over the area. Decided differentials in species wear tolerance were obtained as shown in Table 1. The ranking of wear tolerance from most to least was in the order of Manhattan perennial ryegrass, Kentucky 31 tall fescue, Merion Kentucky bluegrass, Pennlawn red fescue, Italian ryegrass, Cascade chewings fescue, rough bluegrass.

A number of anatomical, morphological, and physiological characteristics were investigated in terms of the degree of correlation with the wear tolerance data previously reported. Characteristics not correlated with interspecies wear tolerance differentials included: (1) verdure, (2) shoot density, (3) leaf width, (4) load bearing capacity, (5) leaf tensile strength, (6) leaf succulence, and (7) leaf relative turgidity. Four characteristics were positively correlated with interspecies wear tolerance. They were total cell wall content per unit area, cellulose content per unit area, lignin content per unit area, and sclerenchyma fiber content as a percent of the leaf cross section. The total cell wall contents of the seven cool season turfgrasses previously reported in Table 1 are shown in Table 2. There was a decided relationship between the total cell wall content and wear tolerance. In addition, the total cell wall content was found to increase with plant maturity as did the turfgrass wear tolerance.

Additional studies are needed to complete this investigation. Specifically comparable studies need to be conducted relating the various anatomical, morphological, and physiological characteristics to variations in wear tolerance within a species such as Kentucky bluegrass. Some of the characteristics which were not related to variations in wear tolerance between species may be more important within a species. These experiments will be pursued in the future. The ultimate objective being to provide information as to the specific plant characteristic that can be utilized in a breeding program to select or predict wear tolerance. This means that these characteristics could be evaluated on an individual plant basis and thus greatly speed up the wear tolerance selection program by many years.

MORPHOLOGICAL, ANATOMICAL, AND PHYSIOLOGICAL RESPONSES OF MERION KENTUCKY AND PENNLAWN RED FESCUE TO REDUCED LIGHT INTENSITIES

This Ph. D. thesis investigation was conducted by Dr. James F. Wilkinson. The objective was to study the morphological, anatomical, and photosynthetic-respiratory responses of Merion Kentucky bluegrass and Pennlawn red fescue under reduced light intensities. Through these investigations it is contemplated that the shade adaptive mechanisms of red fescue might be better understood. The light intensity was maintained at five specified levels during these investigations which were conducted in controlled climate chambers. Other potentially confounding factors such as light quality, soil moisture, disease, and tree root competition were either maintained at a constant level or else eliminated. The details of the experiments are too extensive to present in this paper. Thus, only the basic conclusions will be presented. Individuals wishing to read about this shade tolerance research and the previous wear tolerance studies in more detail are referred to the two theses citations at the end of this paper.

Seven of the morphological responses evaluated in terms of reduced light intensity effects were similar for both the Merion Kentucky bluegrass and Pennlawn red fescue. The specific morphological responses involved and the type of response to reduced light intensitites are summarized as follows: (1) leaf length-increased, (2) leaf width-decreased, (3) clipping weight-decreased, (4) leaf moisture content-increased, (5) chlorophyll per unit area-decreased, (6) chlorophyll per unit weight-increased, and (7) root weight-decreased.

Pennlawn red fescue and Merion Kentucky bluegrass also responded similarly to reduced light intensities in terms of the following anatomical responses: (1) stomatal density-decreased, (2) stomatal pore length-no effect, (3) chloroplast density-decreased, and (4) chloroplast distribution-no effect.

There were three physiological responses to reduced light intensities in which no differentials were observed between Pennlawn red fescue and Merion Kentucky bluegrass. They included: (1) net photosynthesis-decreased, (2) light saturation level-lower, and (3) light compensation point-lower.

Pennlawn red fescue produced a higher quality turf than Merion Kentucky bluegrass at low light intensities under the conditions of this experiment in which diseases, moisture stress, and nutrient competition were not factors. Thus, Pennlawn red fescue ranked superior at the lower light intensities in terms of (a) verdure (shoot growth under the cutting height), (b) leaf area under the cutting height, (c) shoot density, and (d) tillering. In addition to the above growth responses, there was one striking effect in terms of leaf and shoot angle relationships. The shoot angle of Pennlawn red fescue at reduced light intensities was more horizontal than that for Merion Kentucky bluegrass which had a more vertical, upright growth habit (Table 3). Thus, red fescue is favored in the shade due to less photosynthetically active tissue being removed by mowing. This characteristic could be quite significant, although not the only factor involved in the superior shade adaptation of red fescue.

Anatomical investigations of the two species showed that the Pennlawn red fescue had better developed vascular tissue and more support tissues than Merion Kentucky bluegrass at low light intensities. The better vascular tissue development could mean improved water, nutrient, and photosynthetic movement, while more support tissue contributes to improved wear tolerance. It has generally been observed that the wear tolerance of many turfgrass species declines decidedly under shaded environments. In other associated studies, it was found that the cuticle development was greater at reduced light intensities for Pennlawn red fescue than for Merion Kentucky bluegrass. The greater cuticle development may contribute to improved disease resistance; thus, enhancing shade adaptation. Finally, a physiological investigation showed that red fescue displayed a decrease in the dark respiration rate at reduced light intensities while Kentucky bluegrass did not respond similarly. Lower respiration may contribute a more positive carbon dioxide balance (more carbohydrates) for the fescue at low light intensities, thus favoring shade adaptability.

In summary, this investigation showed that the primary anatomical, morphological, and physiological factors associated with adaptation to reduced light intensities were (1) shoot density, growth, and leaf area under the cutting height, (2) a more horizontal leaf orientation, (3) better developed vascular and support tissues, (4) greater cuticle formation, and (5) lower dark respiration rates. As in the case of the previous wear tolerance study, this investigation provides information to the turfgrass breeder concerning characteristics that can be used in a turfgrass breeding program to select for shade adapted cultivars. However, as in the case of the previous study, additional investigations need to be conducted within a specific species, such as Kentucky bluegrass or red fescue. Studies are being conducted toward this end.

REFERENCES

1. Shearman, Robert C. 1973. Turfgrass wear tolerance. Ph. D. Thesis, Michigan State University. 87 pp.

2. Wilkinson, James F. 1973. Morphological, anatomical and physiological responses of Poa pratensis L. 'Merion' and Festuca rubra L. 'Pennlawn' to reduced light intensities. Ph. D. Thesis, Michigan State University. 100 pp.

Table 1. Visual ratings of wheel and sled wear injury on seven cool season turfgrass species after 600 revolutions with the wear simulator.

Turfgrass species	Visual rating of injury*	
	Wheel	Sled
Manhattan perennial ryegrass	2.1a	2.9a
Kentucky 31 tall fescue	2.4b	2.9a
Merion Kentucky bluegrass	2.5b	2.9a
Pennlawn red fescue	3.4c	4.0b
Italian ryegrass	3.6d	4.5c
Cascade chewings fescue	4.0e	4.0d
Rough bluegrass	4.6f	5.0d

*(1-no injury and 5-stems only with exposed soil)

Table 2. Total cell wall content of seven cool season turfgrasses before and after 600 revolutions of the wear simulator.

Turfgrass species	Total cell wall content ($g\ dm^{-2}$)	Percent of total cell wall content remaining after 600 rev.
Manhattan perennial ryegrass	1.06ab	85.6a
Merion Kentucky bluegrass	1.17a	76.3b
Kentucky 31 tall fescue	1.12ab	75.2b
Italian ryegrass	0.94bc	66.2c
Pennlawn red fescue	0.61d	57.3d
Cascade chewings fescue	0.98b	48.3e
Rough bluegrass	0.78cd	33.4f

Table 3. Effect of five light intensities on the leaf angle of singly grown Merion Kentucky bluegrass and Pennlawn red fescue plants.

Light intensity	Shoot angle (degrees) to the vertical	
(lux x 10^3)	Kentucky bluegrass	red fescue
2.7	20	38
5.4	25	55
10.7	30	60
21.5	70	70
43.1	75	80