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# TURFGRASS TRENDS

## BENTGRASS AND TOLERANCE

### What Makes Some Bentgrass Species More Wear Tolerant?

By Scott Ebdon and Michelle DaCosta

Traffic can be broken down into two stresses: wear and soil compaction. Recent studies show that injury caused by wear is the principal stress under traffic accounting for 90 percent of the injury compared to soil compaction. Creeping bentgrass (*Agrostis stolonifera* L.) and velvet bentgrass (*Agrostis canina* L.) are important turfgrasses for golf putting greens. Velvet bentgrass reportedly performs better under traffic than creeping bentgrass does. Investigations into wear tolerance mechanisms (plant factors) are limited in both velvet and creeping bentgrass, and knowing this would help in selecting and breeding wear tolerant genotypes.

Various anatomical and morphological plant characteristics have been identified to be important in wear tolerance of cool season turfgrasses. Cool season species with superior wear tolerance have been associated with plant characteristics, including greater total cell wall content (thicker cell walls), wide leaf width (coarse leaf texture), greater leaf tensile strength, and high shoot density. Also, more recent research has shown the importance of plant morphology such as leaf angle in imparting better tolerance to wear.

Increased shoot density provides more tissue for cushioning that is available to absorb the impact of the injury caused by traffic. Greater total cell wall components enable plants to withstand pressure (bending and crushing) compared to thinner-walled plants. Biologically, leaf angle in wear tolerance is significant because genotypes with a more upright leaf orientation will have less tissue exposed to the vertical forces present in wear stress compared to leaf tissue on a horizontal plane.

The objective of our research was to investigate genetic variation in creeping and velvet bentgrasses' anatomical, morphological and physiological characteristics and relate them to wear tolerance in the field.

#### Genotype selection and wear tolerance

Fourteen genotypes were selected from the 2003 National Turfgrass Evaluation Program (NTEP) bentgrass trial located at the Joseph Troll Turf Research Center, South Deerfield, MA, University of Massachusetts Amherst. Seven velvet bentgrass genotypes were evaluated, including Greenwich, Legendary, SR-7200, Venus, Vesper, Villa and an experimental entry. Seven creeping bentgrass genotypes also were

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**TABLE 1: WEAR TOLERANCE**

GENOTYPES	TCW	LEAF ANGLE <sup>§</sup>	TILLER ANGLE <sup>§</sup>	TILLER DENSITY
<b>Creeping bentgrass</b>	%	----1 to 4----	----1 to 4----	Tillers dm <sup>-2</sup>
Authority	54.2c <sup>‡</sup>	1.7e	1.5d	1683de <sup>§</sup>
Bengal	53.5cd	2.6d	1.3d	1783de
CY-2	48.5e	3.2c	2.2c	1616de
Declaration	51.5c-e	2.3d	2.2c	1917de
Independence	51.1c-e	1.8e	2.2c	1016e
Penn A-1	50.1de	2.4d	1.8cd	1500e
Penncross	53.7cd	2.3d	1.2d	1033e
Creeping mean	51.8	2.3	1.8	1500
<b>Velvet bentgrass</b>	%	----1 to 4----	----1 to 4----	Tillers dm <sup>-2</sup>
Experimental	61.7ab	3.3c	4.0a	3150bc
Greenwich	61.4ab	3.6a-c	3.8ab	3683bc
Legendary	60.4ab	3.8ab	3.8ab	5000a
SR-7200	58.7b	2.6d	3.2b	2683cd
Venus	63.5a	3.4bc	3.3b	3900b
Vesper	61.8ab	3.3c	3.7ab	3300bc
Villa	58.7b	3.9a	3.8ab	3983ab
Velvet mean	60.9	3.4	3.7	3667

‡ Numbers within the same column followed by the same letter(s) are not significantly different (SD=0.05).  
§ Rating: 1= horizontal, 2 = semi horizontal, 3 = semi-vertical, 4 = vertical.

*Genotype means for total cell wall (TCW) content, leaf and tiller angle, and total density in Agrostis species established as space plants in the greenhouse from vegetative plantings from field plots (2-year averages for 2006 and 2007 are shown).*

*Continued from page 33*  
included in the test, including Authority, Bengal, CY-2, Declaration, Independence, Penn A-1 and Penncross.

Wear treatments were applied using 50 passes with a Toro Greensmaster Flex 21 fitted with a grooming brush. The brush was adjusted in a free floating position in contact with the turf canopy. This method of simulating wear was chosen because of its ability to create scuffing, crushing and brushing action to the plant while minimizing pressure to the soil and limiting soil compaction and disruption of the putting surface. All plots were mowed at the 0.125 inch height of cut prior to the application of grooming brush wear.

Four wear events were conducted – on October 27, 2005; June 16, 2006; October 25, 2006; and June 15, 2007. Ratings for wear tolerance following grooming brush injury were visually recorded as the percentage of leaf surface area retaining green color using a scale of 1 to 9 (9 = no injury or 100 percent green color, 1 = no green, 100 percent necrotic).

Velvet bentgrass consistently outperformed creeping bentgrass entries in wear tolerance on all evaluation-rating dates (Fig. 1). Velvet bentgrass clearly exhibited superior wear tolerance to creeping bentgrass during the spring and fall periods. Wear tolerance among all bentgrass genotypes was better under the more favorable growing conditions for shoot vigor of spring when compared to

the fall period. Similar results have also been observed in Kentucky bluegrass (*Poa pratensis* L.) between the spring and summer-to-fall period (5).

Little difference was observed in wear tolerance among the different genotypes within the same species. However, SR-7200 was consistently lower in wear tolerance than other velvet bentgrass genotypes (Table 1). SR-7200 tolerance to wear, however, was better than all other creeping bentgrass entries. These results are consistent with those reported by other researchers.

Most velvet bentgrass genotypes exhibited acceptable wear tolerance (ratings > 6 on the 1 to 9 rating scale) with the exception of SR-7200, while no single genotype of creeping bentgrass afforded acceptable wear tolerance. These differences in wear tolerance can be explained by anatomical and morphological properties among the species.

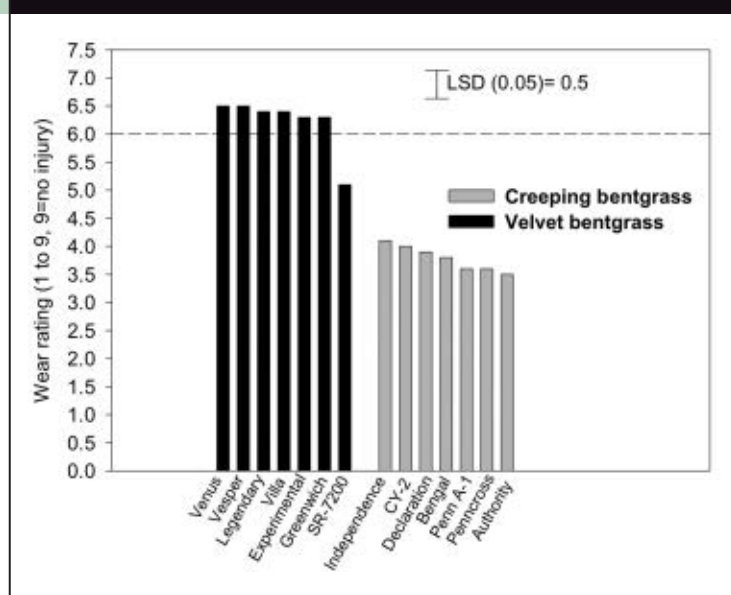
## Genotype and plant factors

Samples were taken from field plots during the same period when wear was applied in order to assess various anatomical and morphological characteristics. Velvet bentgrass tolerance to wear was due in large part to its leaf tissue exhibiting greater total cell wall (TCW) content than creeping bentgrass. Greater cell wall thickening imparts better resistance to bruising injury under traffic. In addition, the more upright "vertical" growth habit due to leaf orientation and tiller orientation of velvet bentgrass was associated with better tolerance to wear. The more horizontal growth habit of leaves and tillers in creeping bentgrass may expose aerial shoot tissue to greater wear injury.

The lower wear tolerance exhibited by SR-7200 velvet bentgrass may be a combination of its lower cell wall content and horizontal growth habit (leaf and tiller), which combined less durable aerial shoots with greater exposure to wear stress. Velvet bentgrass genotypes exhibited a 2.5 fold greater tiller (shoot) density over creeping bentgrass. Wear intolerant SR-7200 velvet bentgrass was consistently lower in shoot density among velvet genotypes.

SR-7200 was lowest in wear tolerance among velvet bentgrass and exhibited lower cell wall components, lower shoot density

**FIGURE 1: WEAR TOLERANCE COMPARISON**



**Wear tolerance comparison (2-year average): Velvet (*Agrostis canina*) and creeping (*Agrostis stolonifera*).**

and a more horizontal tiller (and leaf) angle, which was consistent with the lower responses observed in creeping bentgrass. Breeders can improve overall wear tolerance in bentgrass species by giving priority to breeding for greater shoot density and cell wall content as well as by breeding for a more upright growth habit (tiller and leaf).

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# Macronutrient Interactions on Turf Absorption and Distribution

THIRD IN A SERIES

By Richard J. Hull & Haibo Liu

In the first article of this series (Hull & Liu, October, 2010), we introduced nutrient interactions in turf management from a compartmental perspective. In the second article (February 2011), we looked at the interaction of mineral nutrient ions within the cell wall phase of plant roots and how it is influenced by the composition of soil water.

This article examines the competition among nutrient ions for carrier sites that deliver nutrients across plasma membranes into living cell protoplasts. Some interactions among these nutrient ions within turfgrass plants also will be considered.

## Macronutrient interactions

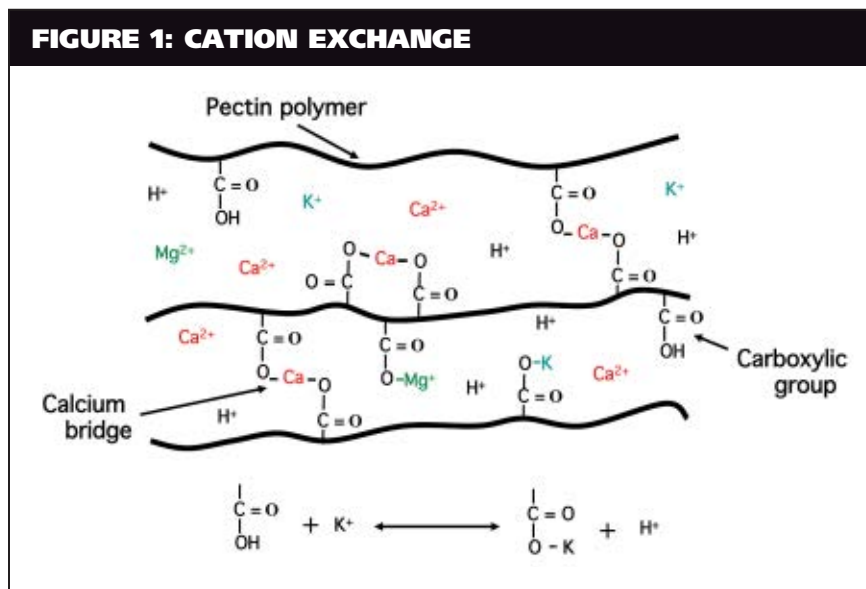
In the apoplast of roots, nutrient ions not bound to exchange sites can be attracted to transport proteins that span the cell's plasma membrane. There are four types of transporters (carriers): primary ATP hydrolyzing pumps; cation/H<sup>+</sup> cotransporters; cation/

anion antiporters; and ion channels (Fig. 1).

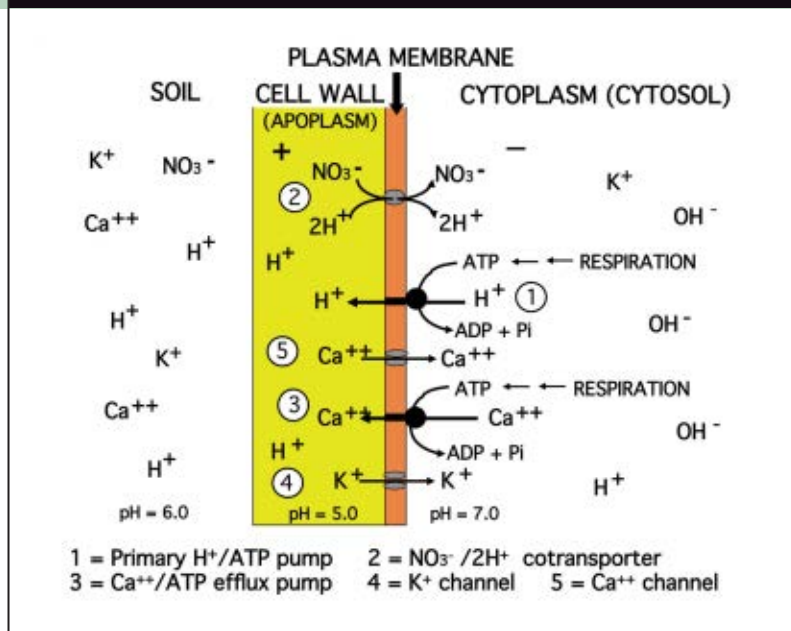
Most nutrient ions are more concentrated in cell sap (cytosol) than they are in the apoplast solution, so nutrient transport across a plasma membrane is normally against a concentration gradient. For such transport to occur, a source of energy must be provided. Nutrient absorption derives its energy from ATP, the universal energy currency generated through respiratory metabolism and photosynthesis. In roots, ATP is generated from respiration centered in mitochondria.

ATP directly powers two primary pumps in a cell's plasma membrane. The most important such pump is the primary H<sup>+</sup> transporting ATPase. At the inner membrane surface, an ATP is hydrolyzed to H<sub>2</sub>PO<sub>4</sub><sup>-</sup> and ADP with an H<sup>+</sup> driven through the pump protein into the apoplast. As this pump operates utilizing ATPs, H<sup>+</sup>s accumulate in the apoplast and become less concentrated in the cytosol. This creates an H<sup>+</sup> gradient across the plasma membrane that can be measured as a pH gradient (ΔpH). Because each H<sup>+</sup> carries a positive charge, the ΔpH also generates an electrical potential across the membrane with the apoplast becoming positive and the cytoplasm negative. This pH gradient is the energy source that transports nutrient ions into root cells.

Apoplastic K<sup>+</sup> being a cation is attracted to the negative protoplast compartment and can cross the plasma membrane passively via K<sup>+</sup> channels. The same holds for Ca<sup>2+</sup> except its Ca<sup>2+</sup> channels are normally blocked and open only in response to stress signals. Nitrate being an anion, would be repelled by the negative protoplast compart-



Cation Exchange within Pectin Region of Apoplast

**FIGURE 2: TRANSPORTERS**

### Nitrate, Potassium & Calcium Transporters in Roots

ment but can enter via a NO<sub>3</sub><sup>-</sup>/2H<sup>+</sup> co-transporter. Nitrate enters with two H<sup>+</sup>s that are strongly attracted to the negative cytoplasm. Calcium ions normally are excluded from the cytosol and most Ca<sup>2+</sup>s that do get inside are pumped back into the apoplast by a primary Ca<sup>2+</sup>/ATP efflux pump. Here the energy of ATP hydrolysis is expended in driving a Ca<sup>2+</sup> through a transport protein into the cell wall apoplast or across a tonoplast membrane into cytoplasmic vacuoles. It is important to keep the Ca<sup>2+</sup> concentration in the cytosol very low (~0.1-0.2 μM = 0.006 ppm) to prevent it from precipitating phosphate ions that are critical for essential metabolic reactions. Most of the Ca in plant tissues is bound onto cell wall exchange sites or sequestered in vacuoles or other cytoplasmic organelles.

Competition for transport proteins is a major source of nutrient interaction in turf. The competition between K<sup>+</sup> and NH<sub>4</sub><sup>+</sup> for a common trans-membrane channel has often been cited as an example of nutrient competition (Marschner 1995). However, this has rarely been regarded as having much practical significance given the low concentration of NH<sub>4</sub><sup>+</sup> in most soil solutions. If NH<sub>4</sub><sup>+</sup> is in fact accountable for as much as fifty percent of the N absorbed by turf, as we have suggested (Hull and Liu 2005), competition between these two ions could cause an availability interaction especially when one is in short supply. That condition may be unlikely since both ions have equal affinity for both soil and apoplastic cation exchange sites.

When NO<sub>3</sub><sup>-</sup> is the major source of available N, a steady supply of K<sup>+</sup> is essential because within turf roots, K<sup>+</sup> is needed as a companion ion for NO<sub>3</sub><sup>-</sup> transport from roots to leaves within the xylem. This nutrient interaction would appear to justify applying K with N when fertilizing greens or other turf growing on a medium of low CEC. In calcareous sand greens, the abundant Ca<sup>2+</sup> would so dominate the apoplastic CEC that both K and N would be free to bind with their respective transport proteins and be absorbed readily. Potassium is absorbed efficiently by

roots and generally requires low soil solution concentrations to satisfy plant needs.

Because Ca<sup>2+</sup> binds strongly to apoplastic CEC sites and plays a critical role in stabilizing the structural integrity of plasma membranes, it is unlikely that there is much direct competition between Ca<sup>2+</sup> and K<sup>+</sup> for binding sites on their respective transport proteins. However, the low binding energy of Mg<sup>2+</sup> with exchange sites makes it likely that both Ca<sup>2+</sup> and K<sup>+</sup> would be effective inhibitors of its absorption by roots. When Mg, Ca and K were present at equivalent concentrations in a nutrient solution, Mg absorption by barley roots was reduced by 90% [Schimansky (1981) in Marschner (1995)]. Magnesium deficiency is likely in the presence of Ca and K making foliar applications of Mg more effective than soil treatments. Manganese ions (Mn<sup>2+</sup>) also are especially strong competitors for Mg<sup>2+</sup> transport proteins. Fortunately free Mn<sup>2+</sup> is rarely present at significant levels in the solution phase of most soils.

### Micronutrient interactions on absorption and distribution in turf

Interactions among micronutrients during absorption, distribution and metabolism are numerous and few are generally appreciated in turf management. One curious observation reported from Japan (Kobayashi et al.

*Continued on page 38*

*Continued from page 37*  
 2003) is that tobacco plants deficient in iron (Fe) exhibit classic deficiency symptoms, mainly highly chlorotic young leaves and reduced growth. However, if zinc (Zn) and manganese (Mn) are deficient as well as Fe, leaf chlorosis is much less evident and growth is near normal. This masking of deficiency symptoms occurs with no increase in tissue Fe concentrations. Clearly the nutrient imbalance of Fe being deficient while Zn and Mn are not is what triggers the expression of deficiency symptoms.

Later research from Iran (Ghasemi-Fasaei & Ronaghi 2008) explored the frequent failure of Fe applications to deficient wheat plants to restore normal growth and sometimes even to exacerbate Fe deficiency. Here wheat was grown in calcareous soils that tend to reduce the availability of cationic micronutrients and promote deficiency symptoms. They grew wheat on such a soil and applied an Fe-chelate to the soil or FeSO<sub>4</sub> to the foliage. Neither Fe application increased growth. While tissue levels of Fe increased in response to treatment, tissue levels of Zn, Mn and Cu decreased increasing the ratio of Fe to other cationic micronutrients individually and combined. This imbalance was attributed to an antagonistic effect of Fe on the absorption of other nutrients and the practice of applying Fe to correct its deficiency in grasses growing on calcareous soils was questioned.

While the relevance these studies to turfgrass nutrient management on non-calcareous soils or sand is not immediately obvious, it is evident that a proper balance of nutrients is critical for optimum grass performance. This balance can be disturbed by imbalanced nutrient supply or by nutrient antagonisms during absorption by roots or partitioning within the plant.

A more obvious lesson can be drawn from a very recent report from Italy (Astolfi et al. 2010) that described an interaction of sulfur (S) availability with Fe nutrition in barley. They noted that improvements in air quality and the use of fertilizers of greater purity seemed to be related to increased incidences of Fe deficiency in grain crops. When S was withheld from barley plants, Fe deficiency

symptoms increased sharply. This was shown to be related to a failure by plant roots to release a chelate into the soil when confronted with an Fe shortage. These chelates called phytosiderophores (PS), bind Fe<sup>3+</sup> very efficiently and allow it to be captured and absorbed by roots. PS synthesis is induced by low Fe availability and depends upon a ready supply of S since they are made from the S-containing amino acid methionine. In this case, a micronutrient (Fe) becomes seriously deficient because a macronutrient (S) was insufficient to permit a normal plant response to the deficiency stress.

Only a few of the many nutrient interactions known to be critical for normal turf growth and performance have been discussed in these two articles. There are undoubtedly many other such interactions that are not recognized and may be responsible for some most perplexing management problems, such as interactions with pesticides and surfactants in the soil or on the turf leaf surface. It is evident that maintaining basic nutrient balances and beneficial interactions can be added to the long list of grass requirements with which the turf manager must be familiar. However, such knowledge must be based on sound research of nutrient interactions conducted on turfgrass species. Those funding turf research should be encouraged to devote greater attention to this critical aspect of turfgrass nutrition.

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## The Winds of Change

**T**he finest legal minds not charging \$700 an hour recently reached agreements on tweaks to the Rules of Golf. While I know *Golfdom* readers have already committed the vagaries of Decision 4-4a/6 to memory, it may be worth considering one of the big changes and what it means to the world of maintenance.

At first glimpse, the change to Rule 18-2b does not sound like it'll be a life changer for the turfgrass world. To refresh your memories, again, because I know you've been enraptured nightly by reading the 3-inch thick Decisions book before bed: in the past, the Rules deemed a player had caused a ball to move after they addressed it by placing their putter behind the ball, whether they had moved the ball or not. Wind and tightly mown greens were usually the culprit, but that didn't matter to the frosty Rules of Golf which invoked a penalty if anyone saw it, or as was the case with many golfers, they called it on themselves.

Well, the bluecoats got together and did something after several high profile episodes where HD television-aided viewers phoned in violations when balls moved and players had done nothing wrong other than place their putter behind the pellet on a windy day. The dirty little secret we all knew: this is as much a product of the green speed chase as it is a windy day. On a fast, firm green cut to 1/8" it's not easy to get your ball to hold still.

The 2012 version of the Rules fixes the problem with an exception

THE RULEMAKERS HAVE ACTUALLY MADE  
THE PUTTING SURFACE JUST A LITTLE LESS  
SACROSANCT AND PRECIOUS IN THE EYES OF  
THE OH-SO PRECIOUS RULES.

BY GEOFF SHACKELFORD



that says players haven't addressed the ball by taking their stance if it's clear wind moved the ball. Now they just play the ball where it lies after the wind has done its thing.

What do I love about this change? Well instead of asking the players to replace the ball, the bluecoats said, just move a bit and play the ball from where it came to rest. Following years of rules and decisions that have allowed the golfer to fiddle, fudge, touch, re-touch, scrap, slap and in general, fuss too much with their ball and the green, the bluecoats have gone retro by returning to the most fundamental tenet of all: play it as it lies.

Now, this rule change is not going to change the world, but it's one small step backwards for the green. And for a world where the putting surface has taken on entirely too much focus, the maintenance world will take anything it can get.

No, golfers won't be asking greens to get a little bit longer in the blade or bumpier in an homage to late 1800s golf. Nor will Tour pros be any less fussy about... everything. But for the first time since the stymie was

outlawed, the rulemakers have actually made the putting surface just a little less sacrosanct and precious in the eyes of the oh-so precious Rules. More importantly, they've said to the world that we don't need to take this whole nonsense of touching and placing your ball on the green quite so seriously.

Long before our time, greens were much less important. When the stymie — that's when players left their balls down on the greens and had to play around them strategically — golf entailed much less touching of the ball when it was on the area known as the green. Golf was probably a lot more interesting then and certainly less expensive and faster. Mostly because of the Rules and advancement in agronomy, we know the green has taken on too much importance. And for a change, it seems the rulemakers have taken notice.

Now, about those guys bracing putters against their bellies...

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