Alternative Tine Entry Angles Make Subtle Impact on Soil

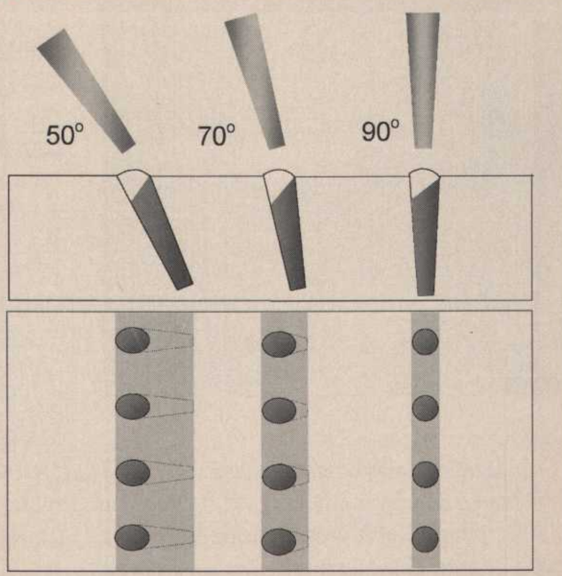
By Christian M. Baldwin, Haibo Liu and Philip J. Brown

Soil compaction involves macropore reduction, where the soil surface is compressed by foot, maintenance equipment or vehicle traffic. Compacted soils are more dense, with less pore space leading to restricted water flow and root growth (Carrow and Petrovic, 1992).

To remedy these problems, cultivation has become a routine practice for turfgrass managers (athletic fields, golf courses and home lawns) because it relieves compaction, reduces localized dry spots and encourages thatch control by replacing a portion of compacted soil and thatch (McCarty, 2005).

Factors affecting cultivation efficiency include soil moisture, tine size, depth of aerification, soil texture, cultivation frequency and equipment type (Guertal and Han, 2002). Different techniques to reduce compaction and thatch for turfgrass managers include linear aerification, which is designed to treat the upper level of the soil to preserve surface diffusion rates (Jones, 2002), vertical mowing (McCarty et al., 2005), deep tine aerification (Guertal et al., 2003) and high-pressure water injection (Murphy and Rieke, 1994). However, effects of cultivation with different tine entry angles on soil hydrophobicity (dry spots) and water infiltration rates have not been investigated.

FIGURE 1



Surface area impacts of core cultivation tine entry angles of 50 degrees, 70 degrees and 90 degrees. The gray areas show the impacted turf surface area with various tine entry angles. Compared to 90-degree tine entry angle, the 50-degree and 70-degree angled tines increased the core surface area by 32.8 percent and 6.1 percent, respectively, regardless of tine diameters. Changing the aerification direction each month will impact a greater area of the soil profile.

The authors hypothesize that aerifying with different tine entry angles (alternating each aerification date) will impact a greater surface area and a greater portion of the soil profile, thereby enhancing water infiltration rates, reducing localized dry spots and enhancing turfgrass quality (TQ). Therefore, the objective of this research was to determine the effects of tine diameter (quarter-inch and half-inch) and entry angle (50 degrees and 70 degrees) on TQ, soil hydrophobicity and water infiltration rates on a creeping bentgrass putting green surface.

Materials and methods

A field study was conducted in 2003 and repeated in 2004 on a Crenshaw creeping bentgrass (*Agrostis stoloniferous* L. var. *palustris* (Huds.) research green constructed in 1997 with an 85:15 sand:peat root zone mix according to United States Golf Association (USGA) recommendations (USGA, 1993) at Clemson University.

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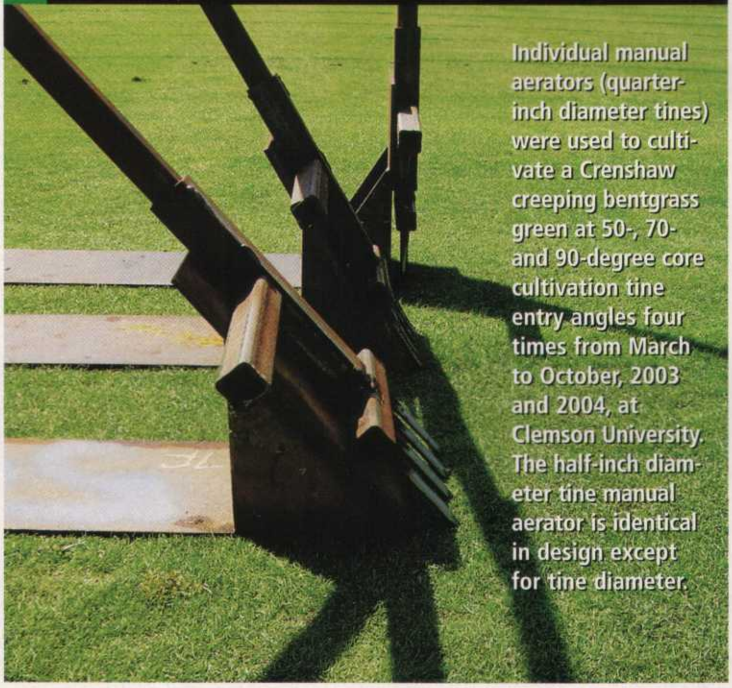
PICTURE 1



Individual manual aerators (quarter-inch diameter tines) were used to cultivate a Crenshaw creeping bentgrass green at 50-, 70- and 90-degree core cultivation tine entry angles four times from March to October, 2003 and 2004, at Clemson University. The half-inch diameter tine manual aerator is identical in design except for tine diameter.

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Cultivation treatments were implemented four times annually in March, May, September and October in both years. During the entire study, treatments included 50-, 70- and 90-degree hollow tine manual aerators plus an untreated without cultivation (Fig. 1).

Manual aerators, consisting of four quarter-inch and half-inch diameter hollow tines 3 inches in length and spaced 2 inches apart (Picture 1), were constructed at the Clemson University maintenance facility department.

Following core removal, topdressing was applied by hand until all holes were completely filled, using USGA specified sand for putting greens. Cultivation direction (North-March, South-May, East-September and West-October) varied with each treatment application.

Data collection

Data collected included TQ, soil hydrophobicity (MED) and water infiltration rates. Turf quality was rated from 1 to 9, with 1 = brown, dead turf, 6 = minimal acceptable turf, and 9 = ideal green, healthy turf.

Soil hydrophobicity was tested using the MED technique. Undisturbed soil core samples (5 inches in depth and one-half inch in diameter) were taken monthly from each plot prior to cultivation treatments and allowed to air dry for 14 days. Droplets containing ethanol (C_2H_5OH) and distilled water solution were

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TABLE 1

Turfgrass Quality†

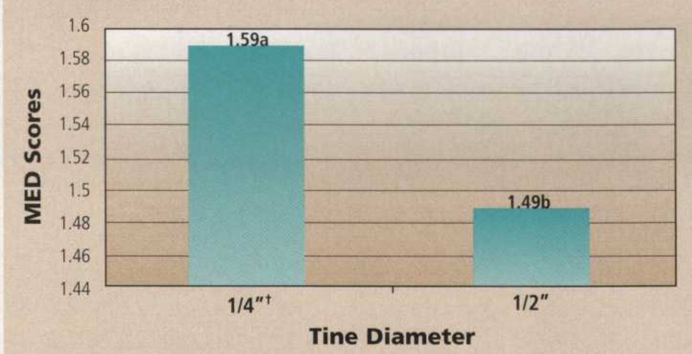
Month		Treatment		Tine Size	
May	6.33b‡	Untreated	6.11b	1/4"	6.27
June	6.54ab	50°	6.22ab	1/2"	6.30
July	6.25bc	70°	6.44a		
August	5.95c	90°	6.39ab		
September	6.70a				
October	5.95c				
LSD	0.36	LSD	0.29	LSD	0.21
p-value	0.01	p-value	0.09	p-value	0.78

†Turfgrass quality based on a scale of 1 - 9, 1 = brown/dead turf, 6 = minimally acceptable turf, 9 = ideal green, healthy turf.

‡Values within a column followed by the same letter are not significantly different at P≤0.10 by protected LSD.

Turfgrass quality of Crenshaw creeping bentgrass influenced by month (May-October), cultivation treatments (50-, 70- and 90-degree core cultivation tine entry angles), plus an untreated plot (no cultivation) and tine size (two hollow tine diameters at a quarter-inch and half-inch) during Year II.

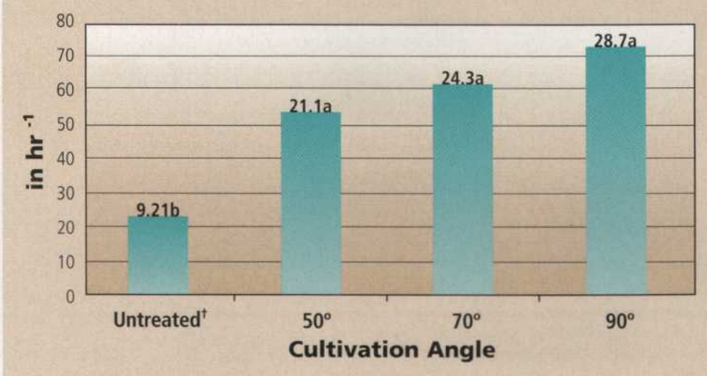
FIGURE 2



Molarity of ethanol droplet test results of Crenshaw creeping bentgrass affected by quarter-inch- and half-inch-diameter tines, pooled across the 50-degree, 70-degree and 90-degree core cultivation tine entry angles, plus an untreated plot (without cultivation).

†Mean data points followed by the same letter are not significantly different at P≤0.01 by protected LSD.

FIGURE 3



Water infiltration rates of Crenshaw creeping bentgrass affected by 50-degree, 70-degree and 90-degree core cultivation tine entry angles plus an untreated plot (without cultivation) pooled across the quarter-inch and half-inch tines.

†Mean data points followed by the same letter are not significantly different at P≤0.01 by protected LSD.

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placed on each soil sample using a pipette.

A scale of 1 to 4, based on the molarity of the ethanol solution tested, was used with 4 being severely hydrophobic (repel water) and 1 being hydrophilic (water loving). If the entire droplet did not completely infiltrate the soil sample within five seconds, the next highest molarity of ethanol/distilled water was applied adjacent to the initial drop until the entire droplet was fully absorbed by the soil sample. Soil hydrophobicity increases as the molarity ethanol/distilled water solution increases, until the droplet completely infiltrates the soil sample within five seconds.

Water infiltration analysis was performed in November following yearly cultivation treatments using a double-ring infiltrometer (model 13a, Turf-Tec International). One sample was taken per plot. The outer ring had a diameter of 4.5 inches and the inner ring 2.5 inches. The infiltrometer was inserted into the turf at a 2-inch depth. Rings were then filled to the top of the infiltrometer (4 inches) with water. After water vacated the center ring, infiltration rates were recorded based on how long the water took to absorb fully into the soil.

Treatments were arranged in a randomized complete block design. All main effects and interaction effects were evaluated using analysis of variance within the Statistical Analysis System (SAS Institute, 2003).

Main effect means for TQ, MED and water infiltration rates are reported because month, treatment and tine size interactions were not significant. Means separation was analyzed using Fisher's LSD test with an alpha of 0.10.

Turf quality

There were no cultivation treatment effects in year I for TQ. However, in year II, the 70-degree tine entry angle provided minimal TQ enhancement (6.4) compared to the control (6.1) (Table 1).

As expected, TQ declined in August (<6) because of summer stress. However, the bentgrass green recovered in September (6.7), when temperatures were moderate. Turfgrass quality declined in October (5.9) because of an outbreak of dollar spot (*Sclerotinia homeocarpa* F.T. Bennett) initiated by high humidity, warm days and cool nights (Belanger et al., 2004), which are typical environmental conditions in the transition zone in late September/early October.

Tine entry angle did not affect MED results; however, the smaller tine diameter (quarter-inch) increased MED 7 percent compared to the half-inch diameter tine (Fig. 2).

Localized dry spots can occur when water infiltration in certain areas is reduced. Use of larger tine diameters, which impact a greater amount of surface area than smaller tine diameters, may possibly reduce LDS's and soil hydrophobicity. Therefore, it may be more beneficial for a superintendent to use a larger tine diameter on a sand-based putting green to minimize unwanted dry patches of turf.

Water infiltration

No water infiltration differences because of tine entry angle were measured for any core cultivated plots. However, without cultivation, water infiltration was reduced 129 percent, 163 percent and 211 percent compared to the 50-, 70- and 90-degree treatments, respectively (Fig. 3).

The decrease in water infiltration is probably indicative of excessive thatch accumulation. These data indicate the importance of aerification to superintendents who manage sand-based creeping bentgrass putting green surfaces. Thatch accumulation is often accelerated in creeping bentgrass cultivars because of their aggressive horizontal growth habits and limited vertical growth, which may quickly develop into thatch in the absence of cultivation.

In another study, McCarty et al. (2005) noted a 188 percent greater infiltration rate with cultivation treatments compared to untreated plots on a sand-based creeping bentgrass putting green.

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Conclusions

Based on results, different core cultivation tine entry angles had minimal statistically significant impacts on parameters measured. However, while not significant, differences were detected between the different angled tines, which may prove to be practical differences for turfgrass managers.

An interesting follow-up study would be to investigate the impacts of different tine entry angles on fine-textured soils (high clay content), which are more prone to compaction.

Finally, deeper tines with different diameters of similar tine entry angles into the soil profile may provide more beneficial results.

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