Research was carried out on 10-year-old Penn A4 practice putting greens at Independence Golf Club (Richmond, Virginia) with various combinations of small tines, big tines and verticutting imposed to provide a range of seasonal surface removal from 0-26.6 per cent

Organic matter dilution programmes for sand-based greens

US researchers investigated several spring and autumn cultivation treatments to minimise both organic matter in the thatch/mat layer and recovery time of bentgrass putting green turf from renovations.

USGA-sponsored research by Dr. Bob Carrow and his colleagues at the University of Georgia in the 1990s provided data for cultivation and topdressing recommendations for sand-based greens commonly known as 'organic matter dilution' programmes. O'Brien and Hartwiger (2003) summarised the details of this approach recommending annual cultivation practices that removed 15-20 per cent surface area and incorporated 40-50ft^3 sand/1000ft^2 (1.2-1.5m^3/100m^2), with the ultimate goal of maintaining surface rootzone organic matter at 4 per cent or less.

Aggressive organic matter dilution programmes are intended to slow loss of aeration porosity and subsequent infiltration rates, thereby allowing superintendents to more easily manage their putting greens and lessen the effects of summer decline.

In March 2008, researchers at Virginia Tech embarked on a three-year project to compare various cultivation approaches that removed between 10-27 per cent surface area and determined treatment effects on agronomic performance of a mature bentgrass putting green. The ultimate goal was to determine which organic matter dilution programme maintained mat layer organic matter at less than 4 per cent while providing the fewest days of putting quality disruption each year.

MATERIALS AND METHODS

Research was done on 10-year-old Penn A4 practice putting greens at the Independence Golf Club, near Richmond, the state capital of Virginia, which has a humid subtropical climate characterised by hot, humid summers and mild to cool winters.

Prior to starting the research project, analysis of four randomly selected cup-cutter cores revealed a thatch/mat layer (0-2" deep) with 5.8 per cent organic matter. Various combinations of small tines (¼" inside diameter), big tines (½" inside diameter) and verticutting (3mm blade) were imposed in late March (Northern Hemisphere spring) and early September (Northern Hemisphere autumn) to provide a range of seasonal surface removal from 0 per cent to 26.6 per cent (Table 1). The seven treatments were:

- **Treatment 1:** Control (sand-only);
- **Treatment 2:** ¼" coring, two passes (spring and autumn);
- **Treatment 3:** Verticutting (3mm blade) (spring and autumn);
- **Treatment 4:** ¼" coring + verticutting (3mm blade) (spring); ¼" coring (autumn);
- **Treatment 5:** ½" coring (spring); ¼" coring, two passes (autumn);
- **Treatment 6:** ½" coring (spring and autumn);
- **Treatment 7:** ½" coring (spring); verticutting (3mm blade) + ¼" coring, two passes (autumn);

Verticutter blade spacing was 1 inch and depth 0.75 inches. Coring tine spacing was 1.33x1.5 inches, with a coring depth of 2 inches. Heavy sand topdressing of about 12ft^3/1000 ft^2 (0.4m^3/100m^2) was applied on both days of cultivation, supplemented by four light topdressings (0.004m^3/100m^2) every 4-6 weeks between cultivations, for a seasonal total of 24.6ft^3/1000ft^2 (0.75m^3/100m^2).

Cultural management of these greens was identical to all others on the golf course, receiving preventive pesticide applications, daily mowing at 0.125 inches (3.175mm) and annual nitrogen fertilisation of 4.4, 3.3 and 4.3lbs N/1000ft^2 (2.15, 1.6 and 2.1kg/100m^2) in 2008, 2009 and 2010 respectively.

To track per cent cover or recovery rate following cultivation treatments in 2009 and 2010, digital images were taken every 7-14 days with a light box and analysed with SigmaScan software. Linear regression was then used to predict the number of days required for each treated plot to return to 99 per cent cover or a non-disrupted putting surface.

RESULTS

The focus is on measurements of per cent organic matter (from loss on ignition tests) in the thatch/mat layer at the end of each season as affected by the various cultivation treatments, and on estimates (from digital image analysis) of days required to achieve 99 per cent turf cover following cultivation treatments.

At the end of 2008, only those coring treatments that removed 14.8 per cent to 19.6 per cent (treatments 5 and 6) significantly reduced per cent organic matter compared to the topdressed control (Table 1). Use of smaller tines alone (treatment 2), verticutting alone (treatment 3) or combinations of the two (treatment 4), failed to reduce per cent organic matter in 2008.

At the end of 2009, all treatments, except verticutting alone, significantly decreased per cent organic matter in the thatch/mat layer compared to the topdressed control (Table 1). Coring spring and autumn with ½" tines on a tight spacing to remove about 9.8 per cent surface area to a depth of 2 inches (treatment 5) resulted in the least organic matter (3.1 per cent) over the three years. Data also suggest that verticutting to 0.75 inches does not remove enough material for adequate organic matter dilution, even though this procedure removes a large amount of surface area (11.8 per cent) with each pass.

Very little change in per cent organic matter was measured due to treatments between 2009 and 2010. The only changes of note from 2009 to 2010 were an increase from 3.7 to 4.5 per cent in treatment 4 (verticutting + small tine cultivation) and a slight increase (3.4 to 3.8 per cent) in treatment 2 (small tines, twice over). Only where large tines were used to remove 14.8 per cent or greater surface area (treatments 5-7) was it observed that per cent organic matter levels were kept at significantly lower levels (3.1 to 3.3 per cent) compared to the topdressed control (Table 1).

Fastest spring recovery (averaged over 2009 and 2010) of 29.5 days was measured for treatment 3 (verticutting) (Table 2). Large diameter coring (treatments 5-7) or small diameter coring + verticutting on the same day (treatment 4) required 35.5 to 40 days for spring recovery (Table 2). Late summer/early autumn recovery data were very similar for cultivation treatments that remained the same as their spring counterpart. In particular, treatment 3 (verticutting) recovered in only 25.5 days (Table 2), while large diameter coring alone (treatment 6) required six fewer days of recovery (34 days versus 40 days) in the autumn compared to the spring coring. Fastest autumn recovery of 8.5 days was observed with treatment 4 where only 2.5 per cent surface removal occurred.

Data interpretation for treatments 2, 5, and 7 is confounded by irregularities in how the treatments were applied. For treatments 2 and 5, when the second ¼" coring pass was made, surface tearing and furrowing occurred, causing a higher per cent

TAKE-HOME POINTS

- The control plots finished with the greatest thatch/mat organic matter (4.3 per cent), but this 0.5 to 1 per cent increase compared to more aggressive treatments did not result in lower visual quality.
- At the end of 2008, only those coring treatments that removed 14.8 per cent to 19.6 per cent significantly reduced per cent organic matter compared to the topdressed control.
- At the end of 2009, all treatments, except verticutting alone, significantly decreased per cent organic matter in the thatch/mat layer compared to the topdressed control.
- Using large tines (0.5") at a close spacing both spring and autumn each year (19.6 per cent surface removal) worked best in terms of reducing final organic matter at 3.1 per cent, but required approximately 5-15 extra days of each season for recovery compared to the small tine and/or verticutting treatments.
- Annual removal of 15 to 20 per cent surface area should be the goal for adequate dilution of organic matter in creeping bentgrass greens.

TABLE 1. TREATMENT DETAILS AND ORGANIC MATTER PERCENTAGE

	Treatments	Surface Area Removed (%)			Thatch/Mat (%OM)		
		March	Sept	Total	Nov 2008	Nov 2009	Nov 2010
1	Control (sand-only)	0	0	0	5.2^{a}	4.3^{a}	4.3^{ab}
2	¼" coring, two passes (S+A)	5	5	10	4.9^{ab}	3.4^{c}	3.8^{cd}
3	Verticutting (3mm blade) (S+A)	11.8	11.8	23.6	5.0^{ab}	3.9^{ab}	4.0^{bc}
4	¼" coring + verticutting (3mm blade) (S); ¼" coring (A)	2.5+11.8	2.5	16.8	5.2^{a}	3.7^{bc}	4.5^{a}
5	½" coring (S); ¼" coring, two passes (A)	11.8	5	14.8	4.8^{b}	3.3^{cd}	3.3^{de}
6	½" coring (S+A)	9.8	9.8	19.6	4.8^{b}	3.0^{d}	3.1^{e}
7	½" coring (S); verticutting (3mm blade) + ¼" coring, two passes (A)	9.8	5+11.8	26.6	5.1^{ab}	3.3^{cd}	3.2^{e}
				LSD(0.05)	0.38	0.42	0.49

NB: Table shows surface area removed (%) and organic matter content (%, wt/wt, loss at ignition) of A4 creeping bentgrass as affected by various cultivation treatments. Tine size shown is inside diameter. S= spring, A=autumn, S+A=spring and autumn. Values with the same letters are not statistically different. March is Northern Hemisphere spring; Sept is Northern Hemisphere autumn

Prior to start of the study, analysis of four randomly selected cores revealed a thatch/mat layer 0-2" deep with 5.8 per cent organic matter

surface damage than the calculated 5 per cent. Our plots were in 6 foot wide (1.8m) lanes that did not allow us to run our second coring pass at an angle to the first pass. Thus, many holes were being hit twice.

Interpretation of the recovery time for treatment 7 should be tempered by the fact that verticutting could not be completed over the top of plots that received two passes of the ¼" tines. Undue sod heaving was occurring, so verticutting was delayed until three to four weeks after coring, greatly extending the time required for recovery.

Visual quality ratings at various dates in 2008 and 2010 (Table 3) show that the control plots (sand topdressed only) did not suffer summer decline as might be expected without core aeration or deep verticutting for three consecutive years. Statistically, the control plots finished with the greatest thatch/mat organic matter (4.3 per cent), but this 0.5 to 1 per cent increase compared to more aggressive treatments, did not result in lower visual quality.

These results point to the importance of sand topdressing in diluting organic matter and maintaining a high quality putting green. Would only applying sand topdressing of at least 24ft^3/1000 ft^2/yr (0.75m^3/100m^2/yr) continue to provide acceptable putting green quality at this site for another one, three, or five years? Unfortunately this information is unavailable and this data cannot be used to confidently predict if this would be the case. These results demonstrate the need for conducting long-term (5-15 year) field research trials.

The ultimate goal was to determine cultivation treatments that are sufficient to adequately reduce thatch/mat per cent organic matter, while also disrupting putting surface quality for the least amount of time.

The least disruptive treatment in terms of per cent surface removal (treatment 2, 10 per cent) healed relatively quickly (32 days) and reduced thatch/mat organic matter to an acceptable level of 3.8 per cent after three years. However, the fact that ground was lost between 2009 (3.4 per cent) and 2010 (3.8 per cent) may point to this practice not being sufficient in the long-term.

Verticutting alone each spring and autumn (treatment 3) resulted in the second fastest recovery of any treatment (27.5 days), but failed to significantly reduce organic matter to a level below the untreated. Treatment 4 resulted in the fewest average days of disruption over the season (22), but finished 2010 with the same amount of organic matter (4.5 per cent) as the topdressed control. Verticutting and small tine coring may heal fast, but appears to be insufficient for organic matter dilution.

Using large tines (½") at a close spacing both spring and autumn each year (19.6 per cent surface removal, treatment 6) worked best in terms of minimising final organic matter at 3.1 per cent, but required approximately 5-15 extra days each season for recovery compared to the small tine and/or verticutting treatments.

Finally, being very aggressive by removing 26.6 per cent surface area (treatment 7) per year did not work in this trial. Recovery time was significantly delayed without achieving greater organic matter dilution compared to treatments that removed 15-20 per cent surface area.

In summary, three years of data indicate that various coring approaches can be combined with verticutting and consistent sand topdressing to achieve the goal of organic matter dilution. Annual removal of 15-20 per cent surface area should still be the goal for adequate dilution of organic matter in creeping bentgrass greens. While verticutting alone provides fast healing, data from this project indicates that it needs to be combined with at least one annual 10 per cent coring for adequate organic matter dilution.

TABLE 2. AVERAGE DAYS OF DISRUPTED PUTTING QUALITY (2009 AND 2010)

Treatments	Spring % removal	Days to 99% cover	Autumn % removal	Days to 99% cover	Total % removal	Disrupted Days
1 Control (sand-only)	0	0	0	0	0	0
2 ¼" coring, two passes (S+A)	5	32.5[1]	5	31[1]	10	32
3 Verticutting (3mm blade) (S+A)	11.8	29.5	11.8	25.5	23.6	27.5
4 ¼" coring + verticutting (3mm blade) (S); ¼" coring (A)	2.5 + 11.8	35.5	2.5	8.5	16.8	22
5 ½" coring (S); ¼" coring, two passes (A)	9.8	38.5[1]	5	30.5[1]	14.8	34.5
6 ½" coring (S+A)	9.8	40	9.8	34	19.6	37
7 ½" coring (S); verticutting (3mm blade) + ¼" coring, two passes (A)	9.8	38.5	5 + 11.8	41.5	26.6	40

NB: Table shows total estimated days of disrupted putting quality in 2009 and 2010 (averaged) as affected by per cent surface removal by various core cultivation and verticutting treatments. [1]Two passes with the ¼" tines resulted in undue tearing, hole overlap, and furrowing on the putting surface that served to delay recovery in treatments 2 and 5 in Autumn.

Organic matter sampling was carried out over a three year period. Using large tines (½") at a close spacing both spring and autumn each year worked best in terms of reducing final organic matter at 3.1 per cent, but required longer to recover

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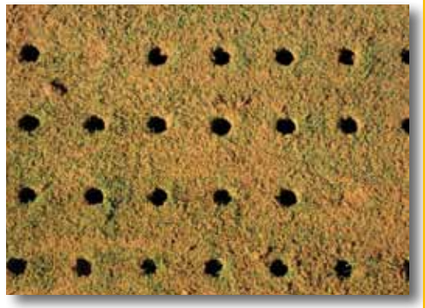

Annual removal of 15-20 per cent surface area should still be the goal for adequate dilution of organic matter

TABLE 3. RATINGS OF PUTTING GREEN VISUAL QUALITY

Treatments	Total % removal	Visual Quality Rating[1]			
		July '08	Sept '08	Aug '10	Nov '10
1 Control (sand-only)	0	6.5^{ab}	7.5^{ab}	7.1^{ab}	7.8^{a}
2 ¼" coring, two passes (S+A)	10	6.3^{b}	6.9^{c}	6.8^{b}	7.8^{a}
3 Verticutting (3mm blade) (S+A)	23.6	6.3^{b}	7.1^{bc}	6.6^{b}	7.5^{ab}
4 ¼" coring + verticutting (3mm blade) (S); ¼" coring (A)	16.8	6.3^{b}	7.3^{abc}	7.3^{a}	7.6^{ab}
5 ½" coring (S); ¼" coring, two passes (A)	14.8	6.5^{ab}	7.8^{a}	6.6^{b}	7.5^{ab}
6 ½" coring (S+A)	19.6	6.1^{b}	7.1^{bc}	6.8^{b}	7.5^{ab}
7 ½" coring (S); verticutting (3mm blade) + ¼" coring, two passes (A)	26.6	6.8^{a}	7.8^{a}	6.8^{b}	7.4^{b}
	LSD (0.10)	**0.4**	**0.5**	**0.4**	**0.3**

[1] 1-9 (where 1 = poor, 9 = best). These ratings represent putting green quality either before cultivation treatments or after complete recovery from cultivation