EFFECT OF ROOTZONE COMPOSITION AND CULTIVATION/AERATION TREATMENT ON THE PERFORMANCE OF GOLF GREENS UNDER NEW ZEALAND CONDITIONS

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Doctor of Philosophy in Turfgrass Science
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DECLARATION

This is to certify that the research carried out for my Doctoral thesis entitled "EFFECT OF ROOTZONE COMPOSITION AND CULTIVATION/AERATION TREATMENT ON THE PERFORMANCE OF GOLF GREENS UNDER NEW ZEALAND CONDITIONS" in the Institute of Natural Resources, Massey University, Palmerston North, New Zealand is my own work and that the thesis material has not been used in part or in whole for any other qualification.

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This is to certify that the research carried out in the Doctoral thesis entitled "EFFECT OF ROOTZONE COMPOSITION AND CULTIVATION/AERATION TREATMENT ON THE PERFORMANCE OF GOLF GREENS UNDER NEW ZEALAND CONDITIONS" was done by Cunqi Liu in the Institute of Natural Resources, Massey University, Palmerston North, New Zealand. The thesis material has not been used in part or in whole for any other qualification, and I confirm that the candidate has pursed the course of study in accordance with the requirements of the Massey University regulations.

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CERTIFICATE OF REGULATORY COMPLANCE

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(a) is the original work of the candidate, except as indicated by appropriate attribution in the text and/or in the acknowledgements;

(b) that the text, excluding appendices/annexes, does not exceed 100,000 words;

(c) all the ethical requirements applicable to this study have been complied with as required by Massey University, other organisations and/or committees (the New Zealand Sports Turf Institute), which had a particular association with this study, and relevant legislation.

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ABSTRACT

The performance of golf greens in terms of rootzone physical properties, sward characteristics and playing quality is highly dependent upon the original rootzone composition and subsequent management. Such performance also continuously changes with time under usage. A study to this performance was conducted from April 1998 to January 2003 at the research site of the New Zealand Sports Turf Institute. This thesis reports results of both the field measurements made of rootzone physical properties, sward characteristics and playing quality of five alternative golf green rootzones during the first five years after sowing, and of the simulation modeling of their performance predicted for the first 30 years after sowing. Rootzone treatments were partially amended sand rootzone, soil rootzone, pure sand rootzone, fully amended sand rootzone, and partially amended sand + zeolite rootzone. A split-plot design was superimposed on the rootzone treatments consisting of twice-yearly cultivation/aeration treatments (control, HydroJect, scarification and Verti-drain).

Results showed that performance of golf greens could be objectively, quantitatively and comprehensively assessed and monitored over the long-term at the rootzone level by using an Integrated Rate Methodology (IRM) model through computing the Comprehensive Golf Green Performance Index ($CGGP_I$).

The performance of golf greens showed a gradual improvement during the first two years after sowing. It then deteriorated progressively over the remainder of the 30 years predicted for all rootzone and cultivation/aeration treatments. This general trend was reflected mainly by a gradual decrease with time in water infiltration rate, oxygen diffusion rate, air-filled porosity and deep rooting. Also, there was a gradual increase in green speed, surface hardness, root mass and organic matter content near the surface profiles. By the 14^{th} and 27^{th} year after sowing, the IRM model predicted that the

$CGGP_I$ for all the three amended sand rootzones and the pure sand rootzone were below the minimum acceptable threshold.

The key factor that caused the general deterioration in green performance of all the sand-based rootzones appeared to be excess accumulation of organic matter in the surface of the profiles.

Whilst there were marked differences in the performance of golf greens between the rootzone types, it was only the conventional soil rootzone that consistently performed unacceptably. Quantitative benefits of upgrading from a soil-based to a sand-based rootzone were evident in terms of improved infiltration rate, increased oxygen diffusion rate and macroporosity, reduced organic matter accumulation near the surface, better root growth and distribution, more stable turfgrass sward, lower weed cover and less fluctuation with seasons in surface hardness.

Among the four sand-based rootzones, the pure sand rootzone had the highest incidence of dry patch disorder, poorest turf visual quality, greatest changes over time in the relative balance of *Festuca* and *Agrostis*, and largest fluctuation with seasons in surface hardness. However, it contained the best root growth distribution. After the fifth year from sowing, the green performance of the pure sand rootzone remained significantly better than the three amended sand rootzones.

There was negligible difference in the performance of golf greens between the three amended sand rootzones on all measured or predicted occasions. The supposed benefits of burying a zeolite-amended sand layer at 100-200 mm depth, ostensibly for encouraging deep rooting, were not apparent under the experimental conditions used, possibly because the experimental plots were never managed under nutrient or moisture stress conditions.

Beneficial effects of twice-yearly cultivation/aeration treatments on rootzone physical properties, sward characteristics and playing quality were evident, although these effects were extremely short-lived. Verti-drain treatment with hollow tines tended to be most effective in controlling surface organic matter accumulation and the resultant rootzone physical deterioration. In contrast, the scarification treatment gave variable response, reducing root mass, hence organic matter accumulation, near the surface on the one hand, but on the other decreasing infiltration rate and turfgrass cover.

HydroJect treatment, although tending to induce a higher incidence of disease and pest damage, appeared particularly effective in minimizing the occurrence of dry patch disorder on sand-based rootzones when used in conjunction with a proprietary wetting agent. None of the cultivation/aeration treatments could effectively halt the general deterioration with time in the performance of golf greens under the twice-yearly treatment frequency used. It was concluded that:

(a) The performance of sand-based rootzones for golf greens will be limited in the long term by excess accumulation of organic matter near the surface of the profile;

(b) Cultivation/aeration treatments will need to commence immediately after full turf establishment and should be carried out more than twice per year on golf greens under New Zealand conditions;

(c) HydroJect treatment, when used in conjunction with wetting agent application, is an effective management tool for prevention of dry patch disorder on sand-based golf greens; while scarification should not be used in isolation of other physical cultivation;

(d) Upgrading from a conventional soil rootzone to a high-grade, sand-based rootzone will greatly improve golf green performance;

(e) The practice of constructing only the top 100 mm of the sand rootzone with organic-amended sand is an alternative method that can be used successfully for putting green construction instead of the fully amended, standard USGA-type profile; the pure sand rootzone system is also an appropriate alternative for rootzone construction of golf greens, provided the initial establishment can be managed successfully;

(f) The integrated rate modeling approach is potentially an effective decision-making tool for rootzone upgrading, surface preparation planning, performance assessment and monitoring, professional consultancy, and seasonal management of golf greens.

KEYWORDS: Comprehensive Golf Green Performance Index ($CGGP_I$), compost, golf green construction, HydroJect, Integrated Rate Methodology (IRM) model, playing quality, pure sand, rootzone physical properties, sward characteristics, scarification, Verti-drain and zeolite.

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STRUCTURE OF THESIS

All chapters in this thesis, except Chapter One (Introduction), Two (Review of the Literature), Three (Materials and Methods), Eight (General Discussion) and Nine (Conclusions), are based on a series of papers that have been published or submitted for publication. The two papers in Chapter Seven (model section), which have been submitted for publication, are presented here as scientific papers but in thesis format. These two submitted papers are saved in the supplied disc in the appendix. The references relevant to individual chapters are at the end of each chapter. All the materials and methods used in this research are integrated into one chapter (Chapter Three) due to the similarity. The results are discussed in detail in each experimental chapter and integrated into a general discussion in Chapter Eight. The main findings from the research in this thesis are summarized separately in Chapter Nine.

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