PAPER V

Soil conditions and turf quality on soccer fields and golf courses in Norway

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Abstract

Soccer fields and golf courses in Norway are reported to have poor playing surfaces. This study was conducted to determine the rootzone composition and the turf quality on sports areas exposed to compaction and wear. Thirty-nine soccer fields were investigated in August/September of 1990, and further eighteen fields and nineteen golf courses in the late summer of 1993. Non-acceptable turf quality was observed on 33% of the soccer fields, while 3.5% of the playing surfaces were excellent. There was a tendency of increased proportion of annual bluegrass as the overall quality ratings decreased. A combination of fine-textured rootzone material, and high gravel and organic matter content, was found independent of the turf quality ratings. On the golf courses, 64% of the tees and 26% of the greens did not have acceptable playing surfaces. Both golf tees and greens had more sandy and uniform rootzones with a lower organic matter content than the soccer fields.

Introduction

There is an increasing demand to have high-quality playing surfaces on turfgrass areas used for sports. The quality required on soccer fields and golf courses dictates a need for optimal rootzone constructions, requisite maintenance practices, and reasonable use during the playing season. In recent years more attention has been focused on sports areas as potentially groundwater contaminators of nutrients and pesticides due to their sandy structures and intensive fertilization and irrigation practices.

Many soccer fields in Norway are reported to have a bad turf cover, where annual bluegrass (*Poa annua* L.) is the dominant turf species (Håbjørg, 1988). The playing surface is uneven with difficult playing conditions in most periods (Engelsjord, 1990). These problems are mainly associated with poor drainage and aeration within the rootzone layer and the time and frequency of use. Engelsjord (1990) found a very high content of soil organic matter, clay and silt, as well as soil particles > 2 mm in the rootzone layer in 18 soccer fields. The soil had a compacted rootzone with high penetration resistance (> 2.0 MPa) and low water infiltration (< 10 mm/hour). These conditions in the field resulted in excessive wetness during heavy rainfall and in excessive hardness of the surface during dry weather periods. Vigerust (1988) reported similar results from soccer fields in the western coast of Norway. In addition, low water infiltration due to high colloidal content and compacted soil material may give a wet and cold rootzone. Under such circumstanses the increase and drop in soil temperature becomes low. This may result in delay in spring growth and slower and poor hardening in the fall.

The main effect of poor soil conditions on sports areas very often is an end of seeded grass species like Kentucky bluegrass (*Poa pratensis* L.) and perennial ryegrass (*Lolium perenne* L.) on soccer fields and golf tees, and bentgrasses (*Agrostis* spp.) and red fescues (*Festuca rubra* L.) on golf greens. Annual bluegrass is the most likely turfgrass to invade because it can grow better under low soil aeration and wet soil conditions than do other grass species (Beard, 1973; Anonymous, 1982). Such soil conditions often result in a very short root system and an annual bluegrass turf with low stability. These stands are often exposed to divots, giving an unpredictable ball roll and ball bounce. The control of annual bluegrass is difficult because frequent use, close cutting, fertilization and irrigation practices may favour the growth of this species. When large proportion of annual bluegrass are present on golf greens, it may produce slow putting surfaces due to enormous seed-head production (Anonymous, 1982). In addition, annual bluegrass may not survive under cold winter climate and may show brown turf cover in the spring when the soccer league and golf season are starting.

Soil compaction on athletic fields is a serious problem for turfgrass managers, and as observed in different turfgrass studies, overall turf quality, vigor and growth will decline with increased compaction (Beard, 1973; Carrow, 1980; van Wijk, 1980a; O'Neil and Carrow, 1982). Soil compaction does not directly reduce plant activity, but it influences other growth factors such as soil aeration, soil strength, plant and soil moisture relationships and soil temperature (Carrow and Petrovic, 1992).

Sills and Carrow (1983) reported that due to compaction problems many turf managers may attempt to improve visual turf quality by adding high amounts of nitrogen. This may, however, result in further restriction of the turfgrass rooting. To minimize the effect of compaction during practice and match, as well as to facilitate the infiltration rate in periods of heavy rainfall, it is now recommended to use sandy rootzone layers with an uniform particle size distribution (Madison, 1971; van Wijk, 1980b; Adams, 1986; Baker and Isaac, 1987; Taylor et al., 1987; Petersen, 1988; Adams and Gibbs, 1994). However, sandy textured soils with low organic matter content (OM) and low cation exchange capacity (CEC) have greater leaching potentials. Intensive fertilization and irrigation practices (or heavy rainfall) on such growth medium may increase the transportation of nutrients to the groundwater (Petrovic, 1990; Walker and Branham, 1992).

Like soccer fields, minimum compaction, good water infiltration and percolation rates giving high playability in most of the season, are also recommended for the golf course areas (Beard, 1982). An exponential increase in the number of golf players in Norway in the last 30 years has created the need for sandy rootzones which can tolerate heavy traffic. The rootzone composition has an important effect on the hardness of the green and its holding power (Adams and Gibbs, 1994), and on the tee surface resiliency (Beard, 1982).

Properties of both the soil and the turfgrasses are important in establishing and maintaining a quality surface for sport but failure to construct proper rootzones may create problems that are more difficult and expensive to correct. To get more information about the playing conditions on soccer fields and golf courses in Norway, visual assessments of the turf cover and mechanical analysis of the rootzone layer were made in this study.

Materials and Methods

Soccer fields

In August/September of 1990, thirty-nine soccer fields in Norway were examined for mechanical and botanical composition. Three years later, further eighteen fields were evaluated for the same properties (Table 1). The playing surfaces were located from Halden (59°N, 11°E) to Setermoen (68°N, 18°E) in the south-north directions, and under coastal (Bergen) and more continental conditions (Alvdal).

The turfgrass quality was separated into two characteristics; coverage and overall quality (general impression). The turf quality was estimated visually at twelve sites at one half of the field, standing directly adjacent to a quadratical test area (1 m^2). While turf coverage ratings were based on a 0-100 scale (percent of the test area covered by grass), the visual assessments of the overall turf quality was made on a 0-9 scale. Overall quality is a total measure of the playing surface quality, including subjective reflections on smoothness, firmness, density and uniformity. The highest number was always representing the best quality. Botanical composition of the turfgrass cover was determined for all the sites on a 0-10 scale. A more detailed description of these scales are presented in Table 3.

Soil samples were taken from the 0-12 cm rootzone layer, using a soil sampling probe from Eijkelkamp (Agrisearch Equipement, ZG Giesbeek, The Netherlands). Samples from each of the twelve 1 m^2 sites were mixed and analysed for particle size distribution using a combination of dry sieving, wet sieving and the pipette method (Elonen, 1971). The particle fractions were grouped according to Atterbergs scale; d < 0.002 mm (clay), 0.002-0.006 mm (fine silt), 0.006-0.02 mm (medium silt), 0.02-0.06 mm (coarse silt), 0.06-0.2 mm (fine sand), 0.2-0.6 mm (medium sand), 0.6-2 mm (coarse sand) and d > 2 mm (gravel). The organic matter content was determined by ignition. Soil particles < 2 mm in diameter were ignited in a furnace at 550°C. Prior to the ignition, the soil material was dried at 105°C for 24 hours (Øien and Krogstad, 1987) for the determination of oven dry weight.

Golf courses

Four tees and four greens were examined in August/September of 1993 on fourteen and nineteen golf courses, respectively. Four different visual examinations of each golf site were made of the turf cover. Data for turf coverage, turf composition and overall quality were recorded as described for soccer fields. Four to six subsamples in the 0-12 cm rootzone layer were taken randomly from each tee and green, mixed into one sample for each of the golf sites, and analysed according to Elonen (1971) for mineral material and for organic matter content according to Øien and Krogstad (1987). The golf courses were basically located on both sides of the Oslo Fjord (Table 2).

Data processing

The data material was analysed statistically using an analysis of variance procedure. A Ryan-Einot-Gariel-Welsch Multiple Range test (REGWQ) was used with a significance level of p=0.05 using GLM procedure of SAS (SAS Institute Inc., 1987).

Results and Discussion

Soccer fields

Turfgrass quality

The mean overall turf quality was 6.2. Thirty-three percent of the surfaces did not have an acceptable quality (ratings < 6.0), whereas 3.5% of the turfgrass covers were excellent (> 8.0). This was somewhat different than the results presented by Håbjørg (1988). He found 8.3% with excellent and 63% with not acceptable turfgrass quality while examinating 60 soccer fields. Differences in soil construction, maintenance levels and time of the year for data recording, may explain some of the differences between the two studies. More intense use during wet and cold weather conditions may also be more likely to occur today, due to an extended playing season. Subjective ratings from different persons explain some of the differences as well.

Turf coverage was strongly related to overall quality (Table 3). Soccer fields with very good playing surfaces had a mean turf coverage of 98%, while the worst classified surfaces only had a turf coverage of 77%. Reduction in root growth, and in shoot growth and density due to compaction, substantial wear, and low maintenance practices, are the most likely explanation of the differences found. Mean turf coverage for all the the fields examined was 90%. It needs to be mentioned that the goal areas were not included in the visually ratings and that the relatively high turf coverage score is a result of this.

There was a tendency of increased content of annual bluegrass with a decrease in the overall turf quality, while the content of Kentucky bluegrass showed an opposite trend. The content of annual bluegrass varied from 24% to 61%, whereas the Kentucky bluegrass content changed from 76% to 19%. Very similar results are reported in studies by Håbjørg (1988). In present study there was a tendency to higher content of red fescue and weeds on soccer fields having very poor playing surfaces, while perennial ryegrass did not seem to have any significant role for the overall turf quality. However, playing surfaces containing more than 50% perennial ryegrass always showed better quality.

Fifty-one percent of the fields had more than 50% annual bluegrass in their turf cover, while Kentucky bluegrass dominated in 21% of the fields. Perennial ryegrass, mainly used in over-seeding and renovation processes, was found in 56% of the playing surfaces, and generally in low percentages. Red fescue was not any significant species in the present study, although most of the fields were initially seeded with a bluegrass/fescue mixture. This is in agreement with Gore et al. (1979) who found a decrease in relative proportion of red fescues in 16 different turfgrass stands exposed to heavy traffic.

The most common broadleaf weeds were dandelion (*Taraxacum officinale* Weber.), broadleaf plantain (*Plantago major* L.), prostrate knotweed (*Polygonum aviculare* L.) and common chickweed (*Stellaria media* L.). White clover (*Trifolium repens* L.) and other grasses were represented in some playing surfaces as well. On average, a typical soccer field was covered by approximately 50% annual bluegrass, 25-30% Kentucky bluegrass, 10-15% perennial ryegrass, 0-5% red fescue, and 5-10% of weeds.

Rootzone composition

Eighty-four percent of the soccer fields had more than 10% (by weight) clay plus silt in the topsoil (data not shown). The highest values were found at Jorekstad Stadium (72%) and Nedre Eiker Stadium (49%). Åråsen Stadium had nearly 30% clay in the upper 12 cm, which may give serious soil physical problems under intense use. The clay and silt content is much higher than the recommendations given by Madison (1971), van Wijk (1980b), Adams (1986), Baker and Isaac (1987), Taylor et al. (1987), Petersen (1988) and Adams and Gibbs (1994). In addition to a very high content of particle sizes < 0.06 mm, the gravel fraction (diameter > 2 mm) was > 10% for more than half of the rootzones analysed.

Present study also showed that the content of organic matter varied significantly among the fields (1.1 to 14.8%), and that the values were generally high. Seventy percent of the rootzones contained more than 5% (by weight) organic matter. Together with the high content of clay and silt, the soil physical problems become severe. There were no significant differences between overall turf quality and the rootzone particle fractions (Table 4), indicating that in this kind of study level and frequency of fertilization, cultivation practices, repair of divots after practice/match, and frequency of use, play an important role for the surface quality. Some of the sandbased rootzones showed a very poor playing surface. The main reason seems to be an infrequent supply of nutrient and water. Due to low usage and an intense maintenance programme, many soccer fields with loamy rootzones showed an acceptable standard. The average particle size distribution was 5% clay, 20% silt, 62% sand and 13% gravel. In addition to the fine-textured mineral material, the rootzone mixture contained 7% organic matter.

Golf courses

Turfgrass quality

The mean overall turf qualities were 5.1 and 6.4 for tees and greens, respectively. Only one tee (Table 5) and two golf greens (Table 6), representing 7% and 10%, had excellent quality, whereas 64% of the tees and 26% of the greens did not have acceptable playing surfaces. The best tees were found at Oppdal, mainly due to very low frequency of use and a fairly new established course. The highest green quality was found at Nes (creeping bentgrass) and Bogstad (annual bluegrass). Sampling time is, however, of major influence for these results, and visual assessments during the late summer/early fall season are most favourable for the annual bluegrass greens.

Divots and low turfgrass recuperation were the main explanation of the low tee quality on most of the courses. The turfgrass coverage varied from 98% to 77%, with a mean of 85%. Corresponding value for the putting greens was 95%, showing that these areas are prone to thinning. There are various reasons for this, including compaction, water and nutrient deficiencies, and diseases. Another problem resulting in poor putting green quality on many courses in the present study was ball marks.

Even though there was variations in botanical composition among the golf greens, no significant differences were found between the five quality classes. On golf tees, however, there was highest Kentucky bluegrass content on playing surfaces with quality rating > 7.0.

Thirty-two percent of the golf greens were red fescue/colonial bentgrass dominated, and 37% were creeping bentgrass surfaces. Annual bluegrass was represented at 95% of the greens, but dominating at only 20% of them. Weeds were not any significant problem on greens.

On golf tees > 50% annual bluegrass was measured at 21% of the courses, whereas Kentucky bluegrass plus red fescue dominated at 2/3 of the tees. Creeping bentgrass (*Agrostis stolonifera* L.) was not presented on norwegian golf tees, unlike these areas in many other countries. On average, a typical golf tee was covered by 25-30% annual bluegrass, 30-35% Kentucky bluegrass, 0-5% perennial ryegrass, 25-30% red fescue, and 0-5% of weeds.

Rootzone composition

The golf tees and greens were more uniform and sandy than the soccer fields, making them less prone to compaction and low water infiltration. The sand content on the tee rootzones varied between 82% and 94% (mean of 85%) within the five turf quality classes (Table 7). The mean clay plus silt and gravel content were 11% and 6%, respectively. Corresponding values for the green rootzones were 78% to 87% sand (mean of 81%), 12% clay plus silt and 4% gravel (Table 8). The mean organic matter content was 3.7% on tees and 3.5% on greens. Except for the gravel content in greens, no significant differences in particle size fraction and organic matter content were found between excellent and very poor tee and putting green surfaces. This supports the data from the soccer fields that in this kind of studies, several factors play an important role for the turf quality, especially the maintenance programme and the frequency of use.

Conclusions

One-third of the soccer fields did not have an acceptable playing surface. These were dominated by annual bluegrass and weeds. Kentucky bluegrass was the major turfgrass species on fields with very high surface quality. No significant differences were found in the rootzone composition between very good and less acceptable playing surfaces, showing that maintenance practices and use play an important role for the turf quality. Generally there were > 5% organic matter, > 10% clay plus silt, and > 10% gravel in norwegian soccer fields.

The botanical composition did not play any role for the golf green and golf tee qualities. Both pure stands of annual bluegrass, creeping bentgrass as well as red fescue/colonial bentgrass mixtures showed variations in overall quality. Despite a low number of courses examined, 26% of the greens and 64% of the tees did not have acceptable playing surfaces. The rootzones on tees and greens were similar, with > 80% sand, low content of organic matter (3-4%), and 4-6% gravel.

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Table 1. Name and localization for the 57 soccer fields examined in 1990 or 1993.

County	Name of the soccer field[1] (*localization*)
Østfold	Halden (*Halden*), Råde Sportspark (*Råde*), Rygge (*Rygge*), Melløs (*Moss*), Askim (*Askim*)
Akershus	Strømmen (*Strommen*), Åråsen (*Lillestrom*), Storebrand (*Ås*), Ås (*Ås*)
Hedmark	Briskeby (*Hamar*), Steimoegga II (*Alvdal*)
Oppland	Jorekstad (*Fåberg*)
Buskerud	Nedre Eiker (*Mjøndalen*)
Telemark	Åmot (*Åmot*), Seljord (*Seljord*)
Hordaland	Voss Sportspark (*Voss*), Brann (*Bergen*), Krohnsminde (*Bergen*), Stemmemyren (*Bergen*)
Sogn and Fjordane	Sandane (*Sandane*),Vik (*Vik*)
Møre and Romsdal	Halsa (*Halsa*), Bæverfjord (*Bæverfjorden*), Sande (*Sunndalsøra*), Molde (*Molde*), Kråmyra (*Ålesund*), Høddvoll II (*Ulsteinvik*)
Trøndelag (south)	Dalgård II (*Trondheim*), Lerkendal (*Trondheim*), Lade IV (*Trondheim*), Berkåk (*Rennebu*), Oppdal (*Oppdal*)
Trøndelag (north)	Øverlands Minde (*Stjørdal*), Sparbu (*Sparbu*), Gulbergaunet (*Steinkjer*), Grong (*Grong*), Rørvik (*Rorvik*), Svenningmoen I (*Overhalla*), Svenningmoen II (*Overhalla*)
Nordland	Kippermoen I (*Mosjoen*), Kippermoen II (*Mosjoen*), Sagbakken (*Mo*), Fauske (*Fauske*), Stranda (*Svolvær*), Ramberg (*Svolvær*), Melbu (*Melbu*), Sortland (*Sortland*), Folkvang (*Sortland*), Bleik (*Andenes*), Lødingen (*Lodingen*), Narvik (*Narvik*), Beisfjord (*Beisfjorden*), Radåsmyra (*Sandnessjoen*), Brønnøysund (*Bronnoysund*)
Troms	Setermoen (*Bardu*)
Oslo	Bislett (*Oslo*), Voldsløkka (*Oslo*)

[1] For some of the soccer fields another name may be registrated in the Norwegian Football Federation card index

Table 2. Name and localization for the 19 golf courses examined in 1993.

County	Name of the golf course[1)] (*localization*)
Østfold	Hevingen (*Skjeberg*), Borregaard[2)] (*Sarpsborg*), Onsøy (*Fredrikstad)*
Akershus	Lommedalen (*Bærum)*, Oppegård (*Oppegård*), Krokhol (*Siggerud*), Drøbak (*Frogn*), Nes (*Vormsund*), Kjekstad (*Asker*)
Hedmark	Sorknes (*Rena*), Hedmark (*Elverum*)
Vestfold	Vestfold (*Vear*), Borre (*Borre*), Rød (*Tjøme*), Fritzøe (*Larvik*)
Trøndelag (south)	Sommerseter (*Trondheim*), Oppdal (*Oppdal*)
Oslo	Bogstad (*Oslo*), Groruddalen (*Oslo*)

[1)] For some of the courses another name may be registrated in the Norwegian Golf Federation card index
[2)] Underlined courses are registrated only on greens

Table 3. Turf coverage and botanical composition in relation to the overall turf quality on 57 soccer fields in Norway. Mean of 12 assessments on each field.

	Overall turf quality[1)] (0-9)				
	≥ 8.0	7.9-7.0	6.9-6.0	5.9-5.0	< 5.0
Number of fields	2	14	22	10	9
Turf coverage (0-100)	98 a[3)]	97 ab	94 ab	90 b	77 c
Kentucky bluegrass (0-10)	7.6 a	4.5 ab	2.5 b	1.4 b	1.9 b
Annual bluegrass (0-10)	2.4 b	3.1 ab	5.6 ab	6.0 a	6.1 a
Perennial ryegrass (0-10)	0 a	2.1 a	1.1 a	1.4 a	+ a
Red fescue (0-10)	0 a	0 a	0.1 a	0.2 a	0.7 a
Weeds[2)] (0-10)	+[4)] a	0.3 a	0.7 a	1.0 a	1.3 a

[1)] ≥ 8.0 = very good, 7.9-7.0 = good, 6.9-6.0 = acceptable, 5.9-5.0 = poor, < 5.0 = very poor
[2)] Broadleaf weeds + clover + other grasses
[3)] Means with the same letter within a row are not significantly different at p=0.05
[4)] + = values < 0.1

Table 4. Particle size distribution and organic matter content in relation to the overall turf quality on 57 soccer fields in Norway (in weight-%).

		Overall turf quality[1)] (0-9)				
		≥ 8.0	7.9-7.0	6.9-6.0	5.9-5.0	< 5.0
Number of fields		2	14	22	10	9
Gravel		15 a[2)]	17 a	15 a	13 a	8 a
Sand	coarse	15 a	22 a	13 a	13 a	14 a
Sand	medium	23 a	27 a	22 a	25 a	37 a
Sand	fine	20 a	13 a	23 a	20 a	23 a
Silt	coarse	14 a	9 a	13 a	12 a	8 a
Silt	medium	7 a	4 a	6 a	7 a	4 a
Silt	fine	1 a	3 a	3 a	4 a	3 a
Clay		5 a	5 a	5 a	6 a	3 a
Organic matter		7.7 a	6.7 a	6.5 a	8.0 a	7.7 a

[1)] ≥ 8.0 = very good, 7.9-7.0 = good, 6.9-6.0 = acceptable, 5.9-5.0 = poor, < 5.0 = very poor
[2)] Means with the same letter within a row are not significantly different at p=0.05

Table 5. Turf coverage and botanical composition in relation to the overall turf quality of the tees at 14 golf courses in Norway. Mean of 16 assessments on each course.

	Overall turf quality[1)] (0-9)				
	≥ 8.0	7.9-7.0	6.9-6.0	5.9-5.0	< 5.0
Number of tees	1	1	3	3	6
Turf coverage (0-100)	98 a[3)]	94 ab	90 ab	88 ab	77 b
Kentucky bluegrass (0-10)	4.5 ab	8.0 a	2.2 b	3.3 b	2.3 b
Annual bluegrass (0-10)	0 a	1.0 a	1.6 a	4.3 a	3.8 a
Perennial ryegrass (0-10)	0.2 a	0 a	0.2 a	0.4 a	0.6 a
Red fescue (0-10)	5.0 a	1.0 a	4.3 a	1.3 a	2.4 a
Colonial bentgrass (0-10)	0.3 a	0 a	0.7 a	0.1 a	0.3 a
Weeds[2)] (0-10)	0 a	0 a	1.0 a	0.6 a	0.6 a

[1)] ≥ 8.0 = very good, 7.9-7.0 = good, 6.9-6.0 = acceptable, 5.9-5.0 = poor, < 5.0 = very poor
[2)] Broadleaf weeds + clover + other grasses
[3)] Means with the same letter within a row are not significantly different at p=0.05

Table 6. Turf coverage and botanical composition in relation to the overall turf quality of the greens at 19 golf courses in Norway. Mean of 16 assessments on each course.

	Overall turf quality[1)] (0-9)				
	≥ 8.0	7.9-7.0	6.9-6.0	5.9-5.0	< 5.0
Number of greens	2	4	8	2	3
Turf coverage (0-100)	99 a[3)]	98 ab	96 bc	93 c	89 d
Creeping bentgrass (0-10)	5.3 a	3.6 a	3.7 a	2.1 a	5.3 a
Colonial bentgrass (0-10)	0 a	3.1 a	2.3 a	3.3 a	0.2 a
Red fescue (0-10)	0 a	1.4 a	1.8 a	2.0 a	0 a
Annual bluegrass (0-10)	4.5 a	1.8 a	2.2 a	2.3 a	4.2 a
Kentucky bluegrass (0-10)	0 a	0 a	0 a	0.1 a	0.2 a
Perennial ryegrass (0-10)	0 a	0 a	+[4)] a	0 a	0 a
Weeds[2)] (0-10)	0.2 a	0.1 a	+ a	0.2 a	0.1 a

[1)] ≥ 8.0 = very good, 7.9-7.0 = good, 6.9-6.0 = acceptable, 5.9-5.0 = poor, < 5.0 = very poor
[2)] Broadleaf weeds + clover + other grasses
[3)] Means with the same letter within a row are not significantly different at p=0.05
[4)] + = values < 0.1

Table 7. Particle size distribution and organic matter content in relation to the overall turf quality of the tees at 14 golf courses in Norway (in weight-%).

		Overall turf quality[1)] (0-9)				
		≥ 8.0	7.9-7.0	6.9-6.0	5.9-5.0	< 5.0
Number of tees		1	1	3	3	6
Gravel		3 a[2)]	4 a	6 a	4 a	7 a
Sand	coarse	21 a	40 a	14 a	13 a	28 a
Sand	medium	47 a	43 a	35 a	44 a	40 a
Sand	fine	18 a	11 a	30 a	25 a	16 a
Silt	coarse	7 a	1 a	5 a	5 a	2 a
Silt	medium	3 a	0 a	3 a	3 a	1 a
Silt	fine	0 a	0 a	2 a	2 a	1 a
Clay		1 a	1 a	5 a	4 a	5 a
Organic matter		1.5 a	2.2 a	3.9 a	4.7 a	3.7 a

[1)] ≥ 8.0 = very good, 7.9-7.0 = good, 6.9-6.0 = acceptable, 5.9-5.0 = poor, < 5.0 = very poor
[2)] Means with the same letter within a row are not significantly different at p=0.05

Table 8. Particle size distribution and organic matter content in relation to the overall turf quality of the greens at 19 golf courses in Norway (in weight-%).

		Overall turf quality[1)] (0-9)				
		≥ 8.0	7.9-7.0	6.9-6.0	5.9-5.0	< 5.0
Number of greens		2	4	8	2	3
Gravel		3 b[2)]	4 b	3 b	3 b	9 a
Sand	coarse	19 a	26 a	24 a	12 a	19 a
Sand	medium	42 a	46 a	45 a	44 a	40 a
Sand	fine	19 a	14 a	18 a	19 a	19 a
Silt	coarse	5 a	3 a	3 a	6 a	7 a
Silt	medium	4	3 a	1 a	5 a	3 a
Silt	fine	3 a	1 a	1 a	3 a	1 a
Clay		5 a	3 a	5 a	8 a	2 a
Organic matter		5.4 a	3.2 a	2.4 a	5.1 a	4.5 a

1) ≥ 8.0 = very good, 7.9-7.0 = good, 6.9-6.0 = acceptable, 5.9-5.0 = poor, < 5.0 = very poor
2) Means with the same letter within a row are not significantly different at $p=0.05$