Soccer Pitches Performances as Affected by Construction Method, Sand Type and Turfgrass Mixture

S. Magni, M. Volterrani and S. Miele
Centro Ricerche Tappeti Erbosi Sportive -DAGA
University of Pisa
Italy

Keywords: Winter games, athletic fields, football, drainage, porous sand, growing media

Abstract

During winter, soil compaction and slow turf recovery are the main causes for loss of soccer pitch quality. Sandy materials are commonly used to reduce compaction and improve drainage. Internally porous volcanic sand can provide better growing conditions than silica sand due to higher water holding capacity and nutrient retention. *Festuca arundinacea* is well adapted to Italian climatic conditions and its increased use could improve the quality of sports fields in the Mediterranean area. In a field trial six construction methods, two sandy materials and two cool-season turfgrass mixtures were compared under simulated winter usage. Results showed a progressive increase in ground cover and water infiltration rate according to the following ranking in the complexity of the design: undrained native soil - drainage systems - sand based profile. Soil amendment was not effective in improving drainage. Higher values of ground cover were observed for the mixture containing tall fescue. Good playing quality was recorded for each of the construction method, sand type and turfgrass mixture. Porous sand produced a lower bulk density in the top layer of the rootzone. *Festuca arundinacea* and porous sand appear as promising tools in sport fields construction.

INTRODUCTION

Playing surfaces of good quality are expected to ensure player's enjoyment and safety as well as to provide a pleasant background for spectators. At the beginning of the playing season natural turf surfaces offer good playing conditions. As the number of matches played on a pitch increases ground cover can be lost in heavily trafficked areas, particularly during the wet and cold season. Furthermore when rainfall exceeds evapo-transpiration soil structure is prone to destruction with dramatic reductions in porosity. This produces poor growing conditions for the turf, and low playing quality due to muddy surface and water ponding. For these reasons construction methods for winter games pitches are conceived to improve drainage of excess water and to provide good growing conditions for the whole playing season.

Silica sand is widely used in sports fields construction due to its stable pore system. Low moisture retention and nutrient holding capacity make this material less desirable as a turf rootzone in dry hot climates. Internally porous materials are used for sand amendment in order to enhance both water and nutrient retention (Hummel, 1995). In Italy the large availability of porous volcanic sands, such as lava (lapillus) and pumice allows their use as rootzone materials. Porous volcanic sands have a high infiltration rate and good water retention capacity to cope with both winter rainfall and summer drought.

Playing surfaces quality can be greatly improved also by the use of properly selected turfgrasses. Among cool-season grasses *Festuca arundinacea* has proved to be well adapted to Mediterranean climate nevertheless it is not commonly used for soccer pitches in Italy. Little is known about its behaviour in relation to playing quality and maintenance requirements.

The objectives of the study were: 1) To evaluate different athletic field construction types as influenced by rootzone material and drainage and 2) To evaluate turf mixture performance by adding either *Festuca arundinacea* or *Lolium perenne* to *Poa pratensis*. In the present field trial several construction methods of different complexity, two sand types and two cool-season turfgrass mixtures were compared under simulated winter wear conditions in order to evaluate turf quality, playing quality and soil physical characteristics.

MATERIALS AND METHODS

A soccer pitch field trial was carried out at the experimental station of Dipartimento di Agronomia e Gestione dell'Agroecosistema of Pisa University (43° 40' N, 10° 19' E) on a silt loam soil (31% sand, 52% silt, 17% clay, 21 g kg^{-1} organic matter, pH= 7.7). The research area was laser graded with crown and 1% slope.

The following six construction methods were included in the trial (main treatment): undrained (native soil), amended topsoil (off site mixing of native soil and sand up to a final sand content in the mix of 80% on volume basis. The mix was spread over the native soil and rolled to give a 80 mm topsoil layer), pipe drained (drain trenches 120 mm wide and 400 mm deep, 5 m apart with 60 mm diameter perforated plastic drain pipe; trench backfilling with 200 mm gravel plus 200 mm sand; 20 mm carpet of sand over the whole plot surface), slit drained (pipe drainage as above. Slit trenches 120 mm wide and 200 mm deep added at right angle, 2.5 m apart. Sand backfilling and sand carpet as above), slit drained close spacing (pipe and slit drainage as well as sand carpet installed as above except for pipes and slits spacing: 2.5 m and 1 m respectively) and sand based rootzone (pipe drains 5 m apart at depth of 200 mm, 150 mm gravel drainage layer and 300 mm sand rootzone layer).

Sand and gravel used in the construction were from internally porous or non-porous materials (secondary treatment). As non-porous materials a silica sand meeting USGA specifications and a crushed gravel (size 6-10 mm) were adopted. Pure silica sand was used for soil modification and sand top dressing, while a sand/peat mix (15% sphagnum peat on volume basis) was used as sand rootzone and for drainage trenches and slits backfilling. As porous materials a mix of lava and pumice sands (1/1 v/v), referred to as "volcanic sand", was used in place of silica sand while a lava gravel (size 6-10 mm) was used as coarser material. No peat amendment was adopted for volcanic sand. Bulk density of silica sand and volcanic sand were 1.58 and 1.16 g cm^{-3} respectively.

Sowing was performed on 11 October 1999 with two different cool season turfgrass mixes (tertiary treatment) both containing 25% *Poa pratensis* (cv. 'Midnight' and 'Bartitia') the 75% being *Festuca arundinacea* (cv. 'Eldorado' and 'Barfelix') or *Lolium perenne* (cv. 'Brightstar' and 'Barsportivo').

Irrigation and fertilization were applied to maintain the turf in good growing condition. Mowing height of 30 mm with clippings removal was adopted. Wear treatment started when the ground cover was considered complete by using a Brinkman traffic simulator (Cockerham et al., 1990). From September to December 2000, 4 passes per week were made to obtain a total of 104 passes. At the end of simulated wear treatments, in order to obtain a uniform soil moisture content, a heavy irrigation was performed 3 d before determining the following parameters: ground cover (visual assessment), water infiltration rate (ponded single-ringed infiltrometers of 254 mm diameter: on pipe drained and slit drained plots rings were placed either directly over the slits or midway between two slits and overall infiltration calculated), traction (studded disk apparatus similar to that described by Canaway and Bell,1986), penetration resistance (Eijkelkamp cone penetrograph fitted with 100 mm^2 penetration cone. Registration of the peak value recorded in the top 100 mm of the soil profile), ball rebound resilience (measured releasing from a height of 2 m a football FIFA standard No 5 inflated to 0.9 bar. Data are reported as percentage of rebound on concrete as specified in DIN, 1986), ball roll (distance rolled after releasing the football down a standard ramp from a height of 1 m as specified in BS7044, 1989), bulk density (determined on undisturbed soil cores of 27 mm diameter and 40 mm length collected from the soil top 40 mm).

A split-split-plot design with four replications was adopted. Sub-sub-plots surface area was 12.5 m^2. The data were tested using analysis of variance and the least significant difference for $P \leq 0.05$ was used to detect differences between treatment means.

RESULTS AND DISCUSSION

Ground Cover

Ground cover showed a significant 'construction method × turfgrass mixture' interaction. After 104 passes of the traffic simulator, a 38% value was recorded on native soil plots for the mix containing *Lolium perenne* (Table 1), while, for the mix containing *Festuca arundinacea* the value raised to 63%. Soil amendment produced a positive effect with both mixes if compared to the undrained native soil. A further increase in ground cover was observed where drainage techniques were adopted. Again better results were shown by the *Festuca arundinacea* mix. In the sand based rootzone the mix containing *Lolium perenne* reached a better ground cover with respect to the drained systems while high values of the *Festuca arundinacea* mix didn't show any further increase.

Water Infiltration Rate

Water infiltration rate was significantly affected by the construction system (Table 2). Very high rates were recorded for sand based rootzone (715 mm h^{-1}). The slit drained close spacing treatment showed a value of 190 mm h^{-1}. Differences among the other construction methods were not significant.

Mean water infiltration rate of the mix containing *Festuca arundinacea* showed significantly higher values (204 mm h^{-1}) than the mix with *Lolium perenne* (140 mm h^{-1}) (data not shown in table).

Traction

Significant differences in traction were recorded as mean effect of 'construction method × turfgrass mixture' interaction. Native soil gave the lowest values (37 Nm), the highest being recorded in the sand profile (mean value 66 Nm). Both the construction methods showed a significant difference from all the other systems (Table 1). The turfgrass mix containing *Festuca arundinacea* produced a higher traction than the one containing *Lolium perenne* only on amended soil and slit drainage at close spacing.

The mean effect of sand type produced a significant difference with porous material showing a lower traction (48 Nm) than the non porous one (51 Nm).

Penetration Resistance

Penetration resistance of the sand profile (Tab. 2) was significantly different (2.5 MPa) from that recorded for all other construction methods (average value 1.6 MPa). A significant difference was produced also by the sandy materials, the porous one showing a higher resistance (1.9 and 1.7 MPa for porous and non-porous sand, respectively).

Ball Rebound Resilience

The construction method significantly affected ball rebound. As shown in Table 2 the lowest rebound was recorded in sand profile (68%), the highest in native soil (76%). Significant effects on rebound resilience were observed also for the 'sand type × turfgrass mix' interaction. Average values recorded on the *Festuca arundinacea* mix resulted of 67% rebound while values referring to the *Lolium perenne* mix not only were higher but were also affected by sand type: 75% for non porous and 83% for porous sand.

Ball Roll

Mean effect of construction method and the effect of 'sand type × turfgrass mix' interaction were significant for ball roll. Distance rolled ranged from 6.1 m recorded for pipe drainage, to 8.0 m in the native soil (Tab. 2). For the mix containing *Lolium perenne* ball roll was higher and not affected by the sand type (average 7.3 m), while, for the one containing *Festuca arundinacea* a significant difference was caused by the two materials (6.9 m with non porous sand and 6.5 m with porous sand).

Bulk Density

A significant effect on bulk density was observed for 'construction method × sand type' interaction. Native soil value was 1.39 g cm^{-3} (Tab. 1). In plots where non porous sand was used for construction, a significantly lower bulk density in the top layer was obtained only in the sand based rootzone (1.12 g cm^{-3}). When porous sand was used, bulk density was significantly different from the one recorded in soil test regardless of the construction system. Sand rootzone exhibited the lowest value (0.83 g cm^{-3}).

CONCLUSIONS

Results obtained during the first year of the research show that soil physical characteristics and ground cover improved with the increasing complexity of the construction method. Soil amendment, despite being an expensive practice, was not effective in improving water infiltration rate of native soil. Porous sand produced lower bulk density and traction while penetration resistance was higher.

The *Festuca arundinacea* and *Poa pratensis* turf enhanced ground cover and water infiltration rate while ball rebound an roll were lower on this mix if compared with the values recorded on the mix containing *Lolium perenne*. Ball roll and traction values were in the preferred ranges for good quality surfaces (Baker et al., 1992). Penetration resistance appeared to be high if compared to common values observed in intensively trafficked areas of soccer pitches (van Wijk 1980).

ACKNOWLEDGMENTS

Research funded by the Ministry of Agricultural and Forestry Policies, special project "Inerbimenti e Tappeti Erbosi per la Valorizzazione Agricola, Ricreativa e Sportiva del Territorio". Paper No: 77.

Literature Cited

Baker, S.W., Gibbs, R.J. and Adams, W.A. 1992. Case studies of the performance of different designs of winter games pitches. I. Playing quality and usage. J. Sports Turf Res. Inst. 68:20-32.

British Standard 7044: Section 2.2. 1990. Artificial sport surfaces. Part 2. Methods of test. Section 2.2. Method for determination of person/surface interaction. British Standards Institution. 8p.

Canaway, P.M. and Bell, M.J. 1986. Technical note: an apparatus for measuring traction and friction on natural and artificial playing surfaces. J. Sports Turf Res. Inst. 62:211-214.

Cockerham, S.T., Gibeault, V.A., Van Dam, J. and Leonard, M.K. 1990. Tolerance of several cool-season turfgrasses to simulated sports traffic. In: Schmidt, Hoerner, Milner, Morehouse (eds), Natural and Artificial Playing Fields: Characteristics and Safety Features. Philadelphia PA (USA): ASTM. 85-95.

DIN 18 032 Part 2. 1986. Sports Halls: Halls for Gymnastic and Games. Floors for Sports activities. Requirements, Testing. 25 p.

Hummel, N.W. 1995. Material selection for USGA greens. 65th Michigan Turfgrass Conference. Lansing, 17-19 January 1995. Michigan State University Extension. 133-143.

van Wijk, A.L.M. 1980. A soil technological study on effectuating and maintaining adequate playing conditions of grass sports fields. In: Agriculture Res. Report 903. Wageningen, (NL): Center for Agricultural Publishing and Documentation. 124 p.

Tables

Table 1. Ground cover and traction as affected by the interaction “construction method × turfgrass mixture” and bulk density as affected by the interaction “construction method × sand type”.

Construction method	Ground cover *Fa*[1]	Ground cover *Lp*[2]	Traction *Fa*	Traction *Lp*	Bulk density Non-porous	Bulk density Porous
	— (%) —		— (N m) —		—— (g cm^{-3}) ——	
Undrained	63	38	37	37	1.39	1.39
Amended topsoil	80	46	55	45	1.44	1.09
Pipe drained	88	60	47	48	1.34	1.07
Slit drained	92	62	45	46	1.34	1.04
Slit drained close spacing	91	61	54	47	1.31	1.12
Sand based root zone	91	77	65	66	1.12	0.83
$LSD_{0.05}$	*4*		*6*		*0.12*	

[1] *Festuca arundinacea* + *Poa pratensis* mix
[2] *Lolium perenne* + *Poa pratensis* mix

Table 2. Water infiltration rate, penetration resistance, ball rebound resilience and ball roll as affected by the mean effect of construction method.

Construction method	Water infiltration	Penetration resistance	Ball rebound resilience	Ball roll
	(mm h^{-1})	(kPa)	(%)	(m)
Undrained	10	1.5	76	8.0
Amended topsoil	3	1.7	73	6.9
Pipe drained	23	1.6	74	6.1
Slit drained	91	1.7	72	6.9
Slit drained close spacing	190	1.7	73	6.7
Sand based root zone	715	2.5	68	7.5
$LSD_{0.05}$	*104*	*0.3*	*4*	*0.3*