Transition from cool-season to warm-season grass: environmental effects in a golf course in the North of Italy

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Introduction

Since the beginning of the century, communitarian and regional policies have focused their attention on the sustainability of anthropogenic action, including the management of golf courses. Despite the environmental benefits (BEARD AND GREEN, 1994), also turfgrass has ecological costs related to the greenhouse gases (GHGs) emissions involved in the maintenance operations (BARTLETT AND JAMES, 2001; SELHORST AND LAL, 2011).

A common challenge for maintaining turfgrass surfaces at a high level of quality is the reduction of nitrogen (N) fertilization and the water usage. Several studies focused the attention on the fate of N, regarding the pollution of groundwater aquifer, the increasing of atmospheric N_2O and the scarcity of water (CROCE, 2001; BREMER, 2006)
However another important issue is the assessment of the environmental costs due to fossil fuel emissions regarding turfgrass maintenance activities. In order to guarantee high amenity and playability quality levels, intensive management is frequently considered essential. Nevertheless few approaches cast doubt on this postulate, indicating new possibilities for more sustainable management, without renouncing to high standards. Traditionally, cool-season grasses have been used in Italy for establishing high maintenance turfgrasses (CROCE, 2003). In the last decade some studies demonstrated the adaptability of warm-season grasses to the Italian climate, as far north as the N 45° parallel. The resulting benefits have been experienced by several applications in sport fields, golf courses and residential lawns (MIELE, 2000; CROCE, 2001; DE LUCA, 2008). The use of warm-season grasses reshape the maintenance activities while reducing water consumption, fertilizer inputs, pesticides application, and the frequency of determinate interventions. The reduction of machinery working time implies less CO_2 emissions from fuel combustion, according to the EU policies (IPCC, 2013). The transition from cool-season to warm-season grass has been proposed as an effective strategy in the different Italian temperate climatesfor reducing golf course footprint.
The goal of this study is to assess the environmental effects of two different maintenance approaches in 9 holes of Golf della Montecchia, Padua (Italy).

Materials and methods

Under the Köppen climate classification, most of Italy has a temperate climate (humid subtropical in the North and Mediterranean in the South) that combines cold winters with drought and high temperatures in the summer. Italy, excepted for Sicily, is considered a transition zone for turfgrasses. In these regions cool-season grasses can find good growing conditions during winter and intermediate seasons, while they suffer from heat stress and water limitation in summer. On the contrary warm-season grasses are characterized by winter dormancy and persistent straw-brown color in winter, but they give high quality turfs in summer thanks to low water use and superior drought resistance.
The study was conducted at the Golf della Montecchia, located in Padua, (45°23′N, 11°46′E) in the eastern end of the Padan Plain.

In June 2010 Golf della Montecchia converted tees and fairways of the white course (9 holes) from cool-season to warm-season grasses. Original mix on fairways was *Poa pratensis*, *Lolium perenne* and *Festuca rubra*, with presence of common bermudagrass and *Poa annua*, while on tees *Agrostis stolonifera* cv. Penncross dominated. The bermudagrass (*Cynodon dactylon x transvaalensis* cv. Patriot) that substituted cool-season species reached 100% ground cover after 42 days from small plants establishment.
The superintendent Brian OgO'Flaerty monitored from 2007 to 2013 the cultural operations effectuated in the different playing areas, surveying the annual amount of engine working times. The data processing consisted in the comparison of data collected during 3 years before (from 2007 to 2009) and 3 years after transition (2011 to 2013). Data from 2010 was not considered because of the coexistence of both C3 and C4 species. Furthermore, data are altered by extra cultural operations needed for transition.

The engine working time were documented for machinery and equipment utilized for mowing, verti-cutting, fertilization, topdressing, coring, agrochemicals application and other cultural operations (green rolling, grooming, hydro jet use and dew removing, brush cutting, single rotary mowing, overseeding, brush and tree pruning, repairing divots, raking bunkers, and mowing of bunker edges, leaf blowing and irrigation system maintenance).

Results and discussion

Figure 1: Engine working time (hours) spent for cultural operation on tees and fairways before and after 2010.

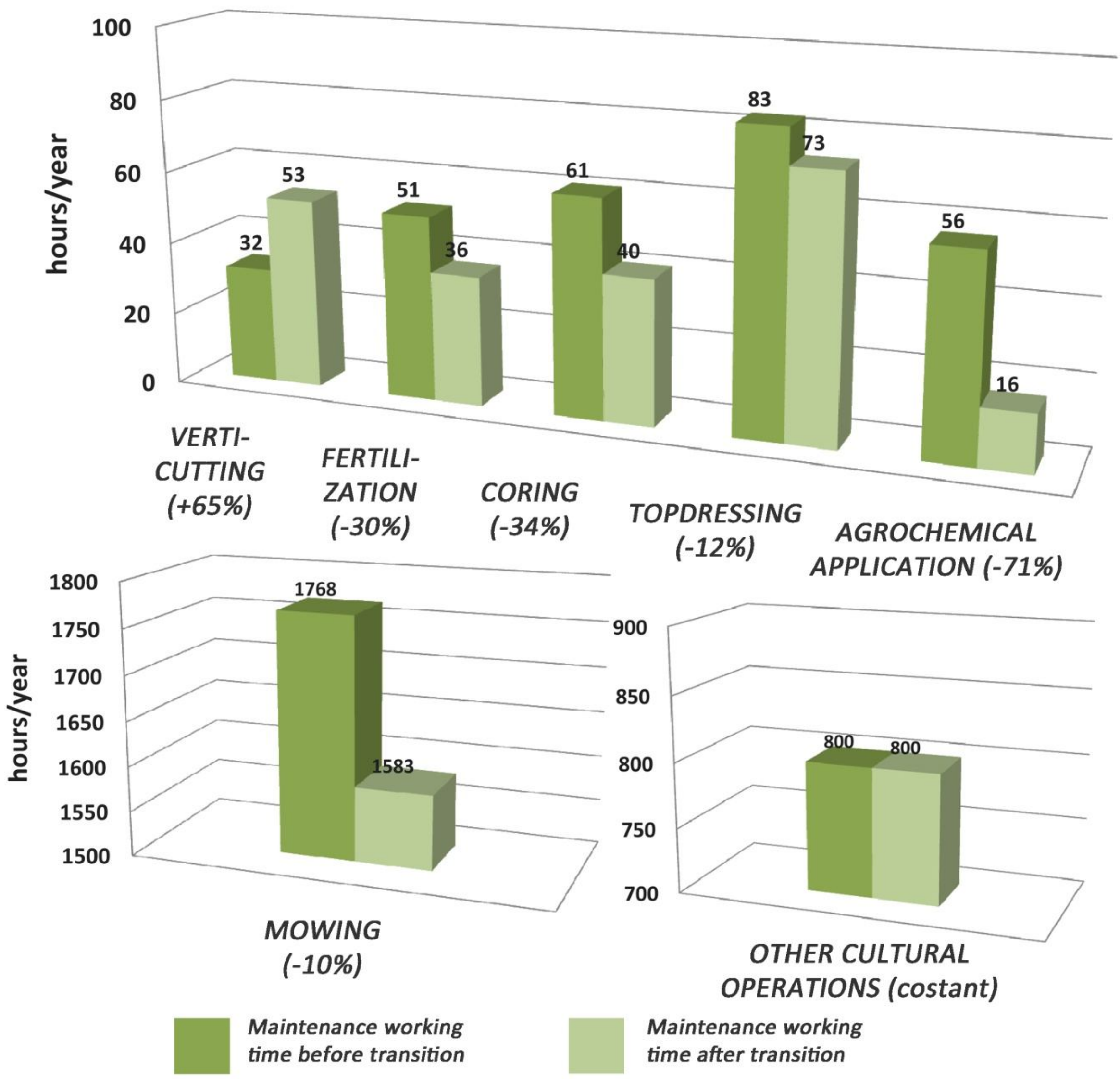
Cultural operation	*tees + fairways (before transition)*	*tees + fairways (after transition)*	*delta (%)*
mowing	688	503	-27%
verticutting	12	33	+172%
fertilization	29	13	-53%
coring	41	20	-50%
topdressing	49	39	-20%
pesticides application	40	0	-100%
total + 10%*	**945**	**670**	**-29%**

* indicates unexpected operations (+10%).

Figure 1 shows the annual amount of the machinery working time before and after the transition process, divided for each cultural operation. Values refer to the average of 3 years, both before and after transition.
The annual amount of hours spent in tee and fairways reduced almost 30% after 2010. Bermudagrass demonstrated an excellent adaptation and confirmed to require fewer inputs than most cool-season turf, according to the former studies effectuated at the same latitudes (DE LUCA, 2008).
Mowing activities after transition reduced 27%, accounting for 75% of total hours saved (data not showed). Despite bermudagrass requiring a great deal of mowing during the summer months, the total amount was lower because the active grow period of warm-season grass is shorter compared to cool-season grass. The reduction of N needs (more than 50%) and pesticides (100%) implied a lower use of machinery for the applications. Also the water

saving due to the drought tolerance of warm-season turf cut down energy consumption for irrigation pump and engines (data not present in the study).
Verti-cutting was the only cultural operation that increased the machinery working time after transition (+172%). Bermudagrass is characterized by an extensive deep root system and significant lateral growth (rhizomes and stolons), that may cause thatch accumulation if not managed. To maintain high quality turf the frequency of verti-cutting was more than doubled.

Figure 2: Annual amount (average of 3 years) of the maintenance working times in the whole surface of the 9 holes. In brackets the delta (%) for each cultural operations between the amount of hours before and after transition.



Despite tees and fairways represent only 16% of the surface of the 9 holes, their influence after transition on the amount of hours of maintenance was appreciable (-8%). Mowing represented the activity with higher reduction of hours, -185 hours/year, that accounted for more than 80% of total hours saved (data not showed). The activities under the item “other cultural practices” were not involved by the transition and they remained stable.

Conclusion

The transition from cool-season to warm-season grass permitted a more environment friendly maintenance. The study confirmed that warm-season grass requires fewer input (N, pesticides and water) and less hours of work, reducing CO_2 emissions from machinery fuel combustion. Mowing showed the greatest reduction of working time, thanks to the lower frequency intervention, accounting for 75% of total hours saved. On the contrary verti-cutting represented the only activity to increase the hours of work.

Despite the climate of the North of Italy, *Cynodon dactylon x transvaalensis* cv Patriot demonstrated an excellent resistance to thermal limits and a good wear tolerance. Thanks to the several environmental benefits above mentioned the transition contributed to the reduction of the golf course footprint.

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