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Warm Season Turfgrass Adaptation in Europe North of the 45º Parallel

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ABSTRACT
Italy's climate fits almost entirely within the transition zone, in which warm season turfgrass species suffer from winter dormancy and loss of green color. Research carried out in Italy around the N 43º parallel have shown the good adaptability of *Cynodon* spp., *Paspalum vaginatum* and certain species of *Zoysia*. The goal of this research was to study some warm season turfgrass species and cultivars grown in Northern Italy, in order to evaluate their potential for use in golf courses of that region. The trial was carried out in 2004-2007 at the Montecchia Golf Club in Padua (45°42'N, 11°86'E). The following species and cultivars were evaluated: *Cynodon dactylon* (L.) cv Princess 77, *Cynodon dactylon x transvaalensis* cv Tifway 419, *Eremochloa ophiuroides* cv Tifblair, *Paspalum vaginatum* cv Salam, *Pennisetum clandestinum* cv AZ1, *Zoysia japonica* cv El Toro, *Zoysia japonica* cv Zenith, *Zoysia matrella* cv Zeon. Princess, Tifblair, AZ1 and Zenith cultivars were seeded, while the rest of the cultivars were established by vegetative propagation methods. Species were established on June 28 2004, following a randomized block layout with 4 replications of 6 m^2 plots. During the trial the following evaluations were carried out: percent ground cover during establishment, spring green-up, fall color retention, turfgrass quality, leaf blade width, shoot density, total rhizome-stolon length per unit area. The fastest-establishing species were the bermudagrasses and in particular Tifway 419. Best quality, highest shoot density and highest rhizome-stolon length per unit area were shown by *Zoysia matrella* cv Zeon. In conclusion, the species that showed best adaptation to trial environment were the Zoysias and the bermudagrasses, with vegetatively propagated cultivars having an edge over seeded cultivars in terms of overall results. *Eremochloa ophiuroides* showed good turfgrass quality.

Keywords: spring green-up, fall color retention, quality, *Zoysia*, *Cynodon*.

INTRODUCTION

In the Italian climate, with its hot and dry summers, turfgrass establishment is increasingly carried out with warm season species as opposed to the more widespread cool season species. Warm season turfgrass species can give numerous advantages over cool season species, such as lower water needs, the possibility of irrigating with salty waters and wastewater (Harivandi, 1991; Carrow and Duncan, 1988) and lower susceptibility to fungal diseases (Gullino et al., 2000). So far the widespread use of warm season turfgrass species in Italy has been limited by the scarce information available on their adaptability to the various climate conditions, and to lower winter temperatures in particular. The Italian latitudes are characterized by a transition climate in which warm season turfgrass species suffer from winter dormancy with loss of green color. A previous research carried out at the N 43º parallel (Volterrani et al., 1997) showed good adaptation by *Cynodon* spp., *Paspalum vaginatum* and by some Zoysias. In Italy most golf courses are located in the northern part of the country, with only few courses being present in the central and southern parts of the country, where some soccer fields and golf course fairways have already been constructed with the use of warm season turfgrass species.

The goal of this trial was to evaluate the adaptability of some warm season turfgrass species and cultivars to the latitudes of northern Italy.

METHODS

The trial was carried out during 2004-2007 at the Montecchia Golf Club in Padua (45°42'N, 11°86'E). The native soil was composed of 25% sand, 47% silt and 28% clay. The water infiltration rate was 45 mm h^{-1} and the organic matter content was 0.89% .
The following turfgrass species and cultivars were evaluated:

Species	Cultivar		Establishment
Cynodon dactylon (L.) Pers.	Princess 77	(*Cd*)	seed
Cynodon dactylon x transvaalensis Burtt. Davy	Tifway 419	(*Cdxt)*	sprig
Eremochloa ophiuroides (Munro) Hack	Tifblair	(*Eo*)	seed
Paspalum vaginatum Swartz	Salam	(*Pv*)	sprig
Pennisetum clandestinum Hochst ex Chiov.	AZ1	(*Pc*)	seed
Zoysia japonica Steud.	El Toro	(*ZjE*)	sprig
Zoysia japonica Steud.	Zenith	(*ZjZ*)	seed
Zoysia matrella (L.) Merr.	Zeon	(*Zm*)	sprig

Seeding rates were: 5 g m^{-2} for *Eo* and *Pc*, 10 g m^{-2} for *Cd* and *ZjZ*. For vegetatively propagated species, sprigging rate was approximately 2 l m^{-2} of stolons. Species were sowed or sprigged on June 28 2004, following a randomized block trial design with 4 replications in 6 m^2 (2 x 3 m) plots. A 50 cm bare soil corridor was maintained between plots by regular weed control, so as to avoid any contamination between species.

Irrigation: Three daily water distributions were made during establishment for two weeks, after which irrigation frequency was gradually reduced to two distributions per week during June-August.

Mowing: first mowing was carried out on August 7 2004 with a rotary mower at 6 cm cutting height. During following mowing the cutting height was gradually reduced to 4 cm. From the first year after establishment mowing was carried out with a rotary mower at 25 mm cutting height.

Fertilization: during 2004 a total of 130 kg ha^{-1} of N and 65 kg ha^{-1} of both P_2O_5 and K_2O were distributed in three dates: at establishment time, in August and in September. During 2005-2007 monthly fertilizations were carried out in the May-September period for a yearly total of 180 kg ha^{-1} of N, 28 kg ha^{-1} of P_2O_5 and 140 kg ha^{-1} of K_2O.

No turf cultivation, or verticutting was practiced on the experimental area, in order to avoid contamination between plots.

In order to better evaluate competition with weeds, no chemical weed control was applied during trial period.

The following evaluations were carried out during the trial:

- Ground cover during establishment: weekly visual evaluations on percent turfgrass cover until full establishment.
- Spring green-up: weekly visual evaluations on percent green cover during spring green-up.
- Fall color retention: weekly visual evaluations on percent green cover during fall turfgrass transition to dormancy.
- Turfgrass quality: visual evaluations at 15 to 30 day intervals on turfgrass quality during the growing season (1 = poorest quality, 9 = highest quality).

In 2005 fall (October 16), the following parameters were measured on three 52 cm^2 core samples per plot:

- Leaf blade width: the leaf blade width was measured on 20 sample fully expanded leaf blades taken from each core sample.
- Shoot density: the number of live shoots was counted on each core sample.
- Total rhizome-stolon length per unit area: the total length of rhizomes and stolons found in each core sample was measured and is expressed per area unit.

All data were subject to ANOVA and LSD for $P \leq 0.05$ was used to detect differences between means.

RESULTS

Establishment and adaptation

During establishment year (2004), the lowest minimum temperature was recorded in December (-3.6°C). During this month, soil temperatures never dropped below 2°C. The air and soil minimum temperatures for the coldest months of 2005-2007 are shown in Table 1.

The fastest-establishing species were the bermudagrasses, and in particular Tifway 419 that reached 100% ground cover after 50 days from sprigging. On September 20 *Pc*, *Pv* and both bermudagrass cultivars plots showed total ground cover. On the same date *Eo* cover was also quite high (88%), while the Zoysias appeared slower with covers ranging between 28% (cv El Toro) and 65% (cv Zeon). These three cultivars only achieved complete ground cover during the following year. However, Zoysias showed a considerably superior color retention during Fall 2004 (95%, data not shown) compared to other species exhibiting much lower values (20%). Despite reaching full ground cover at the end of the 2004 vegetative season, *Paspalum vaginatum* and *Pennisetum clandestinum* emerged significantly damaged at following Spring 2005 green-up, with the few surviving plants giving only partial green cover. Winter 2005-2006 saw the death of both species.

Throughout the entire trial period no fungal diseases occurred on any of the trial species and cultivars.

Table 1. Air and soil (10 cm depth) minimum temperatures (°C) for the coldest months of 2005-2007 .

Months	Air temperatures			Soil temperatures		
	2005	2006	2007	2005	2006	2007
January	- 5.2	- 8.0	- 2.7	0.8	- 0.1	3.6
February	- 5.0	- 3.8	- 2.6	0.8	0.6	4.1
March	- 7.5	- 1.4	0.8	0.8	3.9	8.1
April	0.9	1.9	7.4	9.0	9.2	11.9
October	6.3	5.1	4.4	11.2	12.2	11.1
November	- 1.8	- 0.5	0.8	3.5	7.4	4.4
December	- 1.0	- 3.1	-	3.2	2.0	-

Cynodon spp.

As far as spring green-up is concerned (Table 2), *Cdxt* showed a far higher green cover percentage compared to seeded cultivars, while little difference was detected between cultivars in fall color retention. Both trial cultivars showed a finer leaf texture (0.9 mm) and an average shoot density (Table 3). More differences between cultivars showed in the total rhizome-stolon length per unit area and turfgrass quality, for which Princess falls regularly below sufficient levels.

Table 2. Comparative spring green-up, fall color retention among species and cultivar during the trial period.

Species	Cultivar	Percent Green Color					
		Spring Green-Up*			Fall Color Retention**		
		2005	2006	2007	2005	2006	2007
Cd	Princess 77	5	14	30	55	22	50
Cdxt	Tifway 419	66	56	46	57	32	50
Eo	Tifblair	33	64	78	60	45	65
Zjt	El Toro	63	53	73	91	55	93
Zjz	Zenith	65	66	74	37	60	95
Zm	Zeon	73	45	65	90	62	99
LSD 5%		*8*	*10*	*13*	*5*	*11*	*8*

* Last decade of April

** First decade of November

***Zoysia* spp.**

At Spring 2006 green-up (Table 2), vegetatively propagated Zoysias showed a lower green cover percentage, which can be ascribed to a more severe winter injury. In the last trial year all cultivars showed high fall color retention values. Concerning biometric characters and turfgrass quality of *Z. japonica* and *Z. matrella* (table 3), manilagrass showed a finer leaf texture (1 mm compared with 2.3 mm), a more than double shoot density (7.5 shoots cm^{-2}) and a higher rhizome-stolon length per unit area (5.6 cm cm^{-2}). *Zm* turfgrass quality was consistently above 8. Among the japanese zoysiagrasses, cv El Toro showed a higher rhizome-stolon length per unit area (3.7 cm cm^{-2}) compared to cv Zenith (1.8 cm cm^{-2}).

Table 3. Comparative turfgrass characteristics among species and cultivar during the trial period.

Species	Cultivar	Leaf Blade Width	Shoot Density	Rhizome-stolon Length per unit area	Mean Visual Turfgrass Quality		
		(mm)	(n° cm^{-2})	(cm cm^{-2})	2005	2006	2007
Cd	Princess 77	0.9	4.6	0.5	5.0	4.4	5.1
Cdxt	Tifway 419	0.9	4.7	1.3	6.4	7.3	6.4
Eo	Tifblair	2.8	1.6	1.4	6.3	7.0	7.1
Zjt	El Toro	2.3	3.2	3.7	7.1	7.3	7.1
Zjz	Zenith	2.3	3.0	1.8	6.6	7.4	7.0
Zm	Zeon	1.0	7.5	5.6	8.9	8.5	8.8
LSD 5%		*0.2*	*1.3*	*1.2*	*0.8*	*0.6*	*0.8*

Eremochloa ophiuroides
Except for the year following establishment, centipedegrass showed a prompt spring green-up and acceptable fall color retention. Leaf texture was above average (2.8 mm), shoot density was the lowest of the trial cultivars (1.6 shoots cm^{-2}) and rhizome length per unit area was similar to *Cdxt* and *ZjZ*. Turfgrass quality was always acceptable.

DISCUSSION

The fastest-establishing cultivars were the bermudagrasses, and in particular *Cdxt*. During establishment year the species that were slower in entering dormancy were the Zoysias that only became brown approximately one month after first frost. The 2005 spring green-up saw the Zoysias gaining a one week advance over other cultivars, with seeded bermudagrass cv Princess being the slowest in greening up. This trend was confirmed in the following trial years. Highest turfgrass visual quality, shoot density and rhizome length per unit area were all recorded by *Zoysia matrella* cv Zeon.

The species that showed best adaptation to the trial environment were the Zoysias and the bermudagrasses, with the vegetatively propagated cultivars faring generally better than seeded ones, in accordance with the findings of Croce et. al. (2001) in other Italian sites. Winter injury suffered by vegetatively propagated Zoysias during the winter of 2006 is in accordance with the findings of Patton and Reicher (2007), although this trend was not confirmed in the following trial years. This inconsistent behavior can be explained by the peculiarity of the 2004-2007 winters, with air temperatures falling to - 8°C, but with soil temperatures not falling below 0°C and therefore not enough to highlight the differences between cultivars. Centipedegrass was particularly interesting, given its good turfgrass quality. *Paspalum vaginatum* and *Pennisetum clandestinum* demonstrated their non adaptability to the winter temperatures associated with the trial latitudes.

APPLICATION

This research has supplied vital information on the adaptability of warm season turfgrass species and cultivars to the latitudes of northern Italy, a region where most Italian golf courses are located.

Current climate changes can spur the use of some warm season turfgrass species at latitudes that have so far been considered suitable only to cool season species, with considerable environmental and economical advantages.

Trial results have shown the compatibility of *Cynodon dactylon x transvaalensis* cv Tifway 419, *Eremochloa ophiuroides* cv Tifblair, *Zoysia japonica* (cv El Toro e cv Zenith) and

Zoysia matrella cv Zeon with the trial environment, which could lead to their future potential use in the fairways of golf clubs located around 45°N.
The Authors believe that the findings of this trial will be a useful tool for Golf Developers, Owners, Managers, Superintendents and Greenkeepers of golf clubs located around this latitude.

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