African Journal of Biotechnology Vol. 8 (18), pp. 4469-4474, 15 September, 2009
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2009 Academic Journals

Full Length Research Paper

Performances of some warm-season turfgrasses under Mediterranean conditions

Hakan Geren*, Riza Avcioglu and Melis Curaoglu

Ege University, Faculty of Agriculture, Department of Field Crops, 35100 Izmir-Turkey.

Accepted 27 July, 2009

This study was conducted in order to determine the performances of some world wide used C_4 warm-season turfgrasses (*Buchloe dactyloides*, *Cynodon dactylon*, *C. dactylon* x *C. transvaalensis*, *Stenotaphrum secundatum*, *S. variegatum*, *Paspalum notatum*, *P. vaginatum*, *Pennisetum clandestinum*, *Zoysia japonica*) under mediterranean ecological conditions of Izmir/Turkey in 2006 - 2007. The experimental design was a randomised complete blocks with four replications. Results indicated that, all tested warm-season turfgrasses except *Z. japonica* cultivars and *Stenotaphrum variegatum*, performed very well on the experimental area in terms of leaf blade width, ground cover, weed competition, total clipping yield, spring green-up, fall colour retention and visiual turf quality.

Key words: C_4 warm-season turfgrasses, adaptation, turf quality.

INTRODUCTION

The turf is an integral and significant part of the landscape and enhances its beauty when established properly, while a poor turf will detract from the overall appearance (Brede, 2000). It is a general idea that turfs increase the aesthetic, economic and environmental value of the landscape and provides recreational canvas, erosion control and other ecological benefits (Beard, 1973; Busey, 2003).

Main characteristics of mediterranean climate are represented by mild, rainy winters and hot, dry summers. Because of those climatic conditions, Mediterranean regions are considered as transition zones. Due to the dry summer and high temperatures as well as low temperatures in winter are of tremendous significance in terms of turfgrass and proper medium growing selection (Croce et al., 2001). Traditionally and depending on very old information on turf sector, C_3, cool-season turfgrasses such as *Lolium perenne*, *Festuca rubra* and *Poa pratensis* have been commonly used in mediterranean part of Turkey and similar regions of neighbouring countries (Volterrani et al., 1997). On the contrary, very limited summer rainfalls of the mediterranean regions, along with the limited water supplies are dictating the need to use the warm-season turfgrasses with low water use rate and drought tolerant properties. Although, winter dormancy is the most important drawback of warm season turfgrasses and in order to obtain evergreen turf, overseeding with cool-season turfgrasses required (Harivandi, 1996). However, this species could be used more extensively with regard to water conservation strategy (Dernoeden and Carroll, 1992; Dotray and McKenney, 1996; Croce et al., 2003).

The higher quality, C_4, warm-season turfgrasses used on sport fields, golf courses and reclamation areas have been vegetatively propagated (Beard, 1973). The characteristics of the seeded materials have typically been of a low density, open growth habit, particularly when compared to the vegetatively propagated C_4 turfgrasses (Croce et al., 1999). The lack of readily available vegetative production sources were the contributing factors for the preferences to use seeded grasses instead of benefiting from the improved vegetatively propagated, hybrid cultivars in the mediterranean regions of Europe (Patton et al., 2004). Another objection to the warm-season turfgrass which occurs generally in the mediterranean region is the lack of green colour during the winter dormancy period.

Considering the superiority of warm-season species in drought resistance and low water use rate preferences for seeded types of C_3, cool-season turfgrasses has been unfortunate (Beard, 1989). Successful turfgrass management begins with the selection of a turfgrass species and

*Corresponding author. E-mail: hakan.geren@ege.edu.tr.

Table 1. Monthly average temperatures and total precipitations recorded at experimental area.

Months	Temperature (ºC)			Precipitation (mm)		
	2006	2007	1980 2000	2006	2007	1980 2000
January	6.9	10.6	8.1	77.5	33.1	109.7
February	9.6	10.6	8.6	93.4	22.6	89.8
March	12.1	13.4	10.8	180.9	29.7	72.3
April	17.4	16.2	15.0	29.4	19.3	48.9
May	21.1	22.4	20.2	0.2	44.1	32.2
June	25.7	27.5	25.0	10.0	0.3	8.2
July	28.1	30.1	27.6	-	-	3.6
August	29.2	29.2	27.0	-	-	2.1
September	23.8	24.4	22.2	167.2	0.0	17.0
October	19.2	19.7	18.0	114.5	107.7	46.8
November	12.4	13.9	13.2	63.1	111.6	80.3
December	9.7	9.0	9.9	9.1	118.8	122.3
$\mathbf{x}$ - Σ	17.9	18.9	17.1	745.3	487.2	633.2

cultivars adapted to the wide fluctuation of mediterranean climate (Busey, 2003).

As a group the *Cynodon*, *Buchloe*, *Paspalum* species have superior drought resistance, heat stress resistance, deep rooting and wear stress tolerance, but have poor shade adaptation (Beard and Sifers, 1997; Goss et al., 2006). Moreover, the *Stenotaphrum* and *Zoysia* species have superior shade tolerance in addition to heat resistance but poor drought resistance and high soil pH avoidance (Brede, 2000; Patton et al., 2004; Lee et al., 2005). Accordingly, the objective of the present study was to asses the turfgrass performances and adaptations of 6 genus and a total of 11 C_4 warm-season turfgrass species under mediterranean conditions of Turkey.

MATERIALS AND METHODS

Experiments were conducted in 2006-2007 at Bornova experimental area (38°27.236N, 27°13.576E) in Ege University, Izmir-Turkey, at about 28 m a.s.l. with typical mediterranean climate characteristics (Table 1). The native root zone was composed of 80.2% sand with 95% above 0.25 mm in diameter, 18.1% silt and 1.84% clay. The infiltration rate was 89 mm h^{-1} and the organic matter content was 3.8% and a pH of 7.2.

The following turfgrass species and cultivars entries were tested (Table 2). A randomized complete block design arranged with 4 replications was used. Plot size was 2 m long by 1 m wide. A 0.5 m bare soil corridor was maintained between plots. Sprigs of an average length of 15 cm with an average of 5 nodes, were planted by hand in 5 rows, 20 cm apart in each plot on 20 July 2005. Sprigged areas were rolled and irrigated to encourage sprig–soil contact and to avoid desiccation. Pre-herbicide, oxadiazon, was applied at 2.4 kg ai ha^{-1} a week before sprigging.

N was applied to soil at 50 kg ha^{-1}, beginning 2 weeks after planting and continuing monthly through September in both years. P and K were applied twice annually as needed based on chemical soil tests. Supplemental irrigations were applied as needed to prevent visual wilt of the turf by sprinkling during summer season. No turf cultivation or vertical cutting was practiced on the experimental area in order to avoid interplots contamination. Invading weeds were hand removed during the establishment period, but after the turfs were fully established the weed is allowed to invade due to better evaluation of competition with turfgrass cultivars. The first mowings were carried out 5 weeks after spriging with a rotary mower at 50 mm cutting height. During following mowing the cutting height was gradually reduced to 25 mm from the first year. After establishment, mowing was carried out with a rotary mover at 20 - 25 mm cutting height. The following evaluations were carried out during the trial.

Leaf blade width was measured on the midpoint of the second-youngest, fully expanded leaf blades of 20 samples. Ground cover was determined by quadrate (dm^2, 4 replications) on each plot as percent ground cover after second mowing for each turfgrass. Weed competation was based on vying ratings (1 = very weak, 9 = highly competitive). Clippings were collected after every mowing (1.5 m x 0.50 m) and were dried in a forced-air oven at 70ºC for 48 h and continued until the end of the experiment in both years. Number of cuttings displayed in Table 2. Fall colour retention was based on weekly visual evaluations on percent green cover during fall turfgrass transition to dormancy (De Luca et al., 2008). Spring green-up were determined by weekly visual evaluations on percent green cover during spring. Visual turfgrass quality estimates were made at 15- to 30-day intervals throughout the growing season. These ratings were based primarily on a composite of 2 components; turf colour and uniformity of appearance. The rating scale used was 1 = poorest quality and 9 = highest quality. A rating of 6.5 or higher represented an acceptable quality (De Luca et al., 2008).

The data were processed and statistically analyzed using analysis of variance (ANOVA) with the Statistical Analysis System (SAS 1990). Probabilities equal to or less than 0.05 were considered significant. If ANOVA indicated differences between treatment means a LSD test was performed to separate them.

RESULTS

The results are summarized in Table 3.

Table 2. Tested C_4 warm-season turfgrass species, cultivars and number of cuttings.

No.	Turfgrass species	Cultivar	Establishment	Number of cuttings	
				2006	2007
1	*B. dactyloides* (Nutt.) Engelm	Bowie	Sprig	7	6
2	*B. dactyloides* (Nutt.) Engelm	Cokey	Sprig	7	6
3	*C. dactylon* (L.) Pers.	SR-9554	Sprig	10	8
4	*C. dactylon* x *C. transvaalensis* Burtt. Davy	Tifway-419	Sprig	9	8
5	*S. secundatum* (Walter) Kuntze	Floratam	Sprig	16	14
6	*S. variegatum* (Walter) O. Kuntze	*	Sprig	9	7
7	*Paspalum notatum* Flueggé	Pensacola	Sprig	10	8
8	*P. vaginatum* Swartz	Seaspray	Sprig	16	14
9	*Pennisetum clandestinum* Hochst ex Chiov.	Whittet	Sprig	12	10
10	*Z. japonica* Steud.	Meyer	Sprig	12	10
11	*Z. japonica* Steud.	Zenith	Sprig	15	14

*Ornamental, no registration.

Leaf blade width

Significant differences were obvious among the leaf blade width of tested warm-season turfgrass species and cultivars in both years. Tifway-419 of *Cynodon* hybrid had the narrowest average leaf blade (1.2 mm), whereas leaf blade width was largest in *Stenotaphrum* species (6.6 - 7.1 mm). Second year records displayed similar results with the first year and Tifway-419 had the narrowest average leaf blade (1.4 mm) which was slightly larger than the first year.

Ground cover

There were also significant differences among the tested turfgrasses in terms of coverage. Maximum cover detected in *Cynodon* species (SR-9554 and Tifway-419) being 85-95% and lowest average ground cover was obtained from *S. variegatum* with 58% in 2006 and from *Z. japonica* (Zenith) 47% in 2007 (Table 3). Some turfgrasses such as *B. dactyloides* species (Bowie and Cokey) and *P. vaginatum* (Seaspray) increased their rate of ground cover; on the contrary, *Cynodon* and *Z. japonica* species (Meyer and Zenith) decreased the rates of same property in the second year. Average results of the individual years also displayed a general decrease.

Weed competition

Warm season turfgrass stands tested in the study, except *Z. japonica* and *B. dactyloides* species (6.2 - 6.6) and S. *variegatum* (6.8) were quite vying turfs to weed in the first year. Better weed competition ratings were shown by *C. dactylon* (8.7), *P. vaginatum* (8.9) and *P. clandestinum* (Whittet) (8.9) in the second year.

Total clipping yield

Turfgrass species exhibited significantly different performances in terms of clipping yields which were the indication of biomass production and vigor. *P. clandestinum* and *C. dactylon* ranked at the top of the list in 2006 and 2007, former having an average clipping yield of 3887 kg and 4047 kg ha^{-1}, respectively. *S. variegatum* and *Z. japonica* species ranked far below the successful turfgrasses in the list of both years (Table 3).

Spring green-up

Higher rates of spring green-up scores of *P. vaginatum* were evident in both years, as 78 and 82%, respectively. *S. secundatum* (Floratam) exhibited similar accomplishment, having the rates of 73 and 81%, respectively. *Z. japonica* displayed also satisfactory rates of spring green-up. In contrast, *B. dactyloides* cultivars were very limited in spring green-up performances, having only 6 and 9% in the first year and 9 and 14% in the second year, respectively.

Fall colour retention

There were significant differences among the turfgrasses in term of fall colour retention in both years, consequently Tifway-419 of *Cynodon* hybrid and *P. vaginatum* had higher rates compared to the other warm-season turfgrass material, former having 88 and 91% and latter having 88 and 94% in different years, respectively. *B. dactyloides* cultivars had lower fall colour retentions compared to the other grass material, indicating the long term winter dormancy periods of this turf grass which is not a desirable property in turfs. All turfgrasses tested in

Table 3. Comparative turf characteristics among 11 vegetatively propagated C_4 warm-season turfgrass cultivars at Bornova in 2006 - 2007.

Turfgrass species	Leaf blade width (mm)	Ground cover (%)	Weed competition	Total clipping yield (kgha^{-1})	Spring green-up[1] (%)	Fall colour retention[2] (%)	Mean visual turfgrass quality
2006							
B. dactyloides {Bowie}	2.2	82	6.5	2478	9	47	6.6
B. dactyloides {Cokey}	2.2	78	6.2	2366	6	38	6.4
C. dactylon	2.8	95	8.7	3672	52	67	8.2
C. d.xC. transvaalensis	1.2	85	7.2	3250	57	88	7.6
S. secundatum	6.6	75	8.1	3368	73	73	7.3
S. variegatum	7.1	58	6.8	1915	48	51	4.6
P. notatum	3.1	78	7.4	3120	51	63	6.8
P. vaginatum	2.7	87	8.3	3317	78	88	8.1
P. clandestinum	5.2	72	8.1	3887	52	68	7.3
Z. japonica {Meyer}	4.3	61	6.6	2261	63	59	5.4
Z. japonica {Zenith}	3.9	63	6.2	2058	69	78	4.8
Mean	3.8	75.8	7.3	2881	50.7	65.5	6.6
LSD (.05)	0.9	4.7	0.8	353	6.1	10.7	0.9
F-test	**	*	**	*	*	*	**
2007							
B. dactyloides {Bowie}	1.9	85	7.1	2596	14	54	6.8
B. dactyloides {Cokey}	2.1	69	5.8	2189	9	46	6.6
C. dactylon	2.5	90	8.7	3821	58	79	8.2
C. d.xC. transvaalensis	1.4	83	6.9	2966	63	91	7.0
S. secundatum	6.3	81	8.0	3517	81	79	7.4
S. variegatum	6.7	55	6.2	1623	54	60	4.2
P. notatum	3.2	69	6.6	2514	51	72	6.5
P. vaginatum	2.5	91	8.9	3766	82	94	8.1
P. clandestinum	5.4	84	8.9	4047	56	71	7.5
Z. japonica {Meyer}	3.8	56	5.8	1863	65	68	4.9
Z. japonica {Zenith}	4.0	47	4.6	1539	76	85	4.1
Mean	3.6	73.6	7.0	2767	55.4	72.6	6.5
LSD (.05)	0.8	3.9	1.2	261	7.3	5.7	0.8
F-test	**	**	**	*	*	*	**

[1]Last decade of March; [2]first decade of November.
*Significant at P ≤ 0.05; **Significant at P ≤ 0.01.

the study were completely brown (dormant) during winter period.

Visiual turf quality

Mean visiual turf quality characteristic ratings depending on turf colour and uniformity of appearance indicated the superiority of *C. dactylon* (8.2) and *P. vaginatum* (8.1) over the other turfgrasses tested in both years. On the contrary, *Z. japonica* species and *S. variegatum* had lower ratings with regard to mean visiual turf quality. *B. dactyloides* cultivars and *P. notatum* could also sustain a minimum acceptable turf quality (6.5 -6.8).

DISCUSSION

Overall results of the experiment conducted for 2 years indicated that a group of C_4 turfgrasses such as *Cynodon* species (SR-9554 and Tifway-419) and *P. vaginatum* (Seaspray) performed better than the other grasses tested. These results were based on a cutting height of 20-25 mm which is typical mowing practices on recreational and minimal use areas. All cultivars did not exhibit visually significant disease or insect pest problems during the experimental period under the mediterranean climatic conditions of Bornova, Izmir, Turkey.

The narrow leaf blade widths of *C. dactylon* x *C. transvaalensis* and *B. dactyloides* cultivars which were classified as fine textures by Beard (1973) and De Luca et al. (2008) clearly displayed their advantages with regard to turf texture. *P. vaginatum* had also favourable leaf width in both years reminded that this feature was the natural result of the genetic structure of this grass (Trenholm et al., 1999), confirming Lee et al. (2005)'s findings which describe the morphological and physiological features of seashore paspalum. *Stenotaphrum* species and *P. clandestinum* cultivar displayed highly coarser textures which were confirmed by many turf researchers (Cudney et al., 1993; Salman, 2008).

The ground cover rate of *C. dactylon* was much higher compared to the other turf grasses due to the higher regrowth rate of *C. dactylon* (Beard, 1989; Croce et al., 2003). Harivandi (1996) and Avcioglu (1997) described *C. dactylon* as an agressive warm season turf grass that spread rapidly by above-ground (stolons) and below-ground (rhizomes) stems. *P. vaginatum* had also an extensive network of stolons or rhizomes resulting in a densed ground cover which was in accordiance with the Salman (2008)'s findings describing *P. vaginatum* (Seashore) as a fast growing turf grass with very high rates of ground cover. *P. clandestinum* had also an extensive network of stolons and rhizomes (Cudney et al., 1982), however, stolons were relatively thick and fleshy compared to the other turf grasses tested. Although *Zoysia* species also spread by stolons and rhizomes, the rate of regrowth was quite slow so that the lowest coverage were detected in *Zoysia* plots. It was concluded that, ground cover rates of *Zoysia* were the lowest because of the alkaline reaction of the soil in the experimental area. Patton et al. (2004) claimed that, soil reaction has a significant impact on growth and development of *Zoysia* grass and soil pH of 6 to 6.5 is the most proper levels for regrowth.

High ground cover rates in *C. dactylon*, *P. vaginatum*, *P. clandestinum* resulted in a good weed control. Many researchers emphasized that the ground cover and stolon density are key components in turf quality and also are strong factors impacting the relative competitive ability of the turfgrass under weed invasion (Cudney et al., 1994; Dotray and McKenney, 1996; Goss et al., 2006). Rate of regrowth was very slow in *Zoysia japonica* species so that the limited coverages were detected in *Zoysia* plots, most probably creating favourable conditions for weed seed germination due to the rich radiant energy penetration in to the soil.

Clipping yield characteristic provides useful assessment criteria for turfgrass growth and vigour, although it is an operationally cumbersome and labour-intensive procedure. Harivandi (1996) and Avcioglu (1997) put forward that a high clipping yield is also a significant dimension contributing to enhanced intraspecies wear stress tolerance. *C. dactylon*, *P. vaginatum* and *P. clandestinum* had higher clipping yields in both years, whereas second year yield values were variable probably because of the differentiating climatic parameters (De Luca et al., 2008).

Spring green-up characteristic of C_4 warm-season turf grasses is a dependable indication of early regrowth and greening in stands (De Luca et al., 2008). As far as spring green-up is concerned, *P. vaginatum* and *S. secundatum* showed far higher green cover percentages compared to the other turfgrasses, except *Z. japonica*. Those were the evidence of superiority of above mentioned turfgrasses over the others, confirming many other research workers who suggested this feature as the proof of the longer green period of turf stands (Beard, 1989; Salman, 2008).

Results displaying fall colour retention which is an indicative diamension of green period of turfgrasses throughout the years confirmed that, *Cynodon* hybrid (Tifway-419) and *P. vaginatum* were the most succesful warm-season turfgrasses under the experimental conditions. Many researchers (Croce et al., 1999; Gibeault et al., 2002; Bunnell et al., 2003) also confirmed our results, including some *Z. japonica* cultivars. *B. dactyloides* had lowest fall colour retention which indicated the long term dormany characteristic of this turfgrass which is not a desirable property in turfs. Our findings were also confirmed by Dotray and McKenney (1996) and Avcioglu (1997).

As conclusion, considering the visiual turf quality results which are the overall expression of compatibility of turfgrasses to the local habitat (Salisbury and Ross, 1992) and depending on the general results of the tests, it was suggested that *Cynodon* species and *Paspalum vaginatum* were the most successful turf grasses in terms of many aspects in the experimental area and those were selected as targeted C_4 warm-season turfgrasses for the local recreational areas under Mediterranean conditions. It is also concluded that *Z. japonica* and *S. variegatum* are not promising turfgrass choices at all under the experimental conditions.

ACKNOWLEDGEMENTS

The authors wish to thank Stanley Baker, Meadowland Seed Company, USA, for their kind help providing research materials and financial support. Special thanks are also for Neville Coleman, UK, for critical reading of manuscript. This research work was supported by Ege University Scientific Research Project Commission.

REFERENCES

Avcioglu R (1997). Turf Technique (Turf Establisment & Manage-ment), Ege Universty Press, p. 223.

Beard, JB (1973). Turfgrass: Science and Culture, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA. p. 658.

Beard JB (1989). Turfgrass water stress: drought resistance components, physiological mechanisms, and species-genotype diversity. Proceedings of the International Turfgrass Research Conference, 6: 23-28.

Beard JB, SI Sifers (1997). Genetic diversity in dehydration avoidance and drought resistance within the Cynodon and Zoysia species. Int. Turfgrass Soc. Res. J. 8: 603-610.

Bunnell BT, Baker RD, Mccarty LB, Hall DW, Colvin DL (2003). Differential response of five Bahiagrass (*Paspalum notatum*) cultivars to metsulfuron, Weed Tech. 17: 550-553.

Brede D (2000). Turfgrass Maintenance Reduction Handbook: Sports, Lawns and Golf, Sleeping Bear Press, Chelsea, MI.

Busey P (2003). Cultural management of weeds in turfgrass: a review, Crop Sci. 43: 1899-1911.

Croce P, De Luca A, Mocioni M, Volterrani M, Beard JB (1999). Seeded and vegetatively propagated cultivar comparisons within both *Cynodon* and *Zoysia* species, 4th International Herbage seed Conference, Perugia-Italy.

Croce P, De Luca A, Mocioni M, Volterrani M, Beard JB (2001). Warm-season turfgrass species and cultivar characterizations for a Mediterranean climate, Int. Turfgrass Soc. Res. J. 9: 855-859.

Croce P, De Luca A, Mocioni M, Volterrani M, Beard JB (2003). Adaptability of warm season turfgrass species and cultivars in a Mediterranean climate, 1st International Conference on Turfgrass Management & Science for Sport Fields, Athens.

Cudney DW, Gibeault VA, Baldwin RL, Brece JR (1982). Chemical and cultural control of kikuyugrass in turf, California Agric. 36(1): 4-5.

Cudney DW, Downer JA, Gibeault VA, Henry JM, Reints JS (1993). Kikuyugrass (*Pennisetum clandestinum*) management in turf. Weed Tech. 7(1): 180-184.

Cudney DW, Henry JM, Downer JA, Elmore CL, Gibeault VA, Reints JS (1994). Herbicide program can control kikuyugrass in cool-season turf. California Agric. 48(2): 24-28.

De Luca A, Volterrani M, Gaetani M, Grossi N, Croce P, Mocioni M, Lulli F (2008). Warm season turfgrass adaptation in Europe North of the 45° parallel, (www.federgolf.it)

Dernoeden PH, Carroll MJ (1992). Meyer zoysiagrass regrowth from sod debris as influenced by herbicides, Hort. Sci. 27: 881-882.

Dotray PA, McKenney CB (1996). Established and seeded buffalograss tolerance to herbicides applied preemergence, Hort. Sci. 31: 393-395.

Gibeault VA, Autio RE, Cockerham ST (2002). Seeded Bermuda-grass fall color retention, California Turfgrass Cult. 52: pp. 1-2.

Goss RM, McCalla JH, Gaussoin RE, Richard MD (2006). Herbicide tolerance of Buffalograss, Online. Appl. Turfgrass Sci. doi:10.1094/ ATS-2006-0621-01-RS.

Harivandi MA (1996). Hybrid bermudagrass winter overseeding, University of California, Cooperative Extension, California Turfgrass Cult. 36(1-2-3-4).

Lee G, Carrow RN, Duncan RR (2005). Criteria for assessing salinity tolerance of the halophytic turfgrass seashore paspalum, Crop Sci. 45: 251-258.

Patton AJ, Hardebeck GA, Williams DW, Reicher ZJ (2004). Establisment of Bermudagrass and Zoysiagrass by seed, Crop Sci. 44: 2160-2167.

Salman A (2008). Effect of different fertilizer levels on some cool and warm season turfgrass on turf performances, Ege University Graduate School of Natural and Applied Sciences, Unpublished PhD Thesis, p. 170

Salisbury FB, Ross CW (1992). Plant Physiology, Wadsworth Pub. Com., Inc., Belmont, California-USA.

SAS Institute (1990). SAS Users Guide:Statistics, Version 6. SAS Inst., Cary, NC.

Trenholm LE, Duncan RR, Carrow RN (1999). Wear tolerance, shoot performance, and spectral reflectance of seashore paspalum and bermudagrass. Crop Sci. 39(4): 1147-1152.

Volterrani M, Grossi N, Pardini G, Miele S, Gaetani M, Magni S (1997). Warm season turfgrass adaptation in Italy. Int. Turfgrass Soc. Res. J. 8(2): 1344-1354.