

# Agronomic behaviour of some *Cynodon dactylon* ecotypes for turfgrass use in the Mediterranean climate

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## Abstract

In Italy, the expansion of turfgrasses is limited by the lack of suitable species for cultivation in the Mediterranean climate. With this view, Mi.Te.A.Med. (*Turfgrass improvement in the Mediterranean climate*) research project was developed with the main purpose to find out and agronomically characterise native turfgrass species of Southern and Central Italy and to compare them with some commercial cultivars. During the first step of the research, 11 sites from 6 regions of Southern and Central Italy were identified. In these sites 24 ecotypes of *Cynodon dactylon* L. (Pers.) were collected and their habitus, phenology plus some biometric parameters have been determined. During the two years of research both botanic and agronomic characterisation of the collected *C. dactylon* ecotypes and their comparison

with 3 commercial cultivars (*Panama*, *Transcontinental* and *Yukon*) was carried out. In the first year the colour loss interval was assessed. In the second year, colour index was measured by an electronic colorimeter, weekly growth rate was measured by a turfmeter, turf quality and ground cover percentage were assessed by visual estimate. Some native accessions showed behaviour similar to commercial cultivars while an ecotype from the Abruzzo region showed better results compared to the commercial cultivars for several quality indices.

## Introduction

In the last few years, Italy witnessed an increase of green areas for recreational, technical and sport purposes, which raised the attention of the turfgrass industry on quantitative and qualitative aspects of turfgrasses.

On one hand, this increased interest stimulated an extensive research activity mostly aimed at assessing the adaptation and the aesthetic and functional features of a wide range of cool season grasses (Veronesi *et al.*, 1991b, 1992, 1997; Volterrani *et al.*, 1996, 1997; Davolio *et al.*, 2000; de Bruijn, 2010).

In Italy, the most used species for turfgrass are cool season grasses, which are not always suitable for the climatic condition of Central and Southern Italy, characterised by hot and dry summer. This has led to poor turfgrass performance, low stand persistence, frequent need for stand re-establishment, unsustainable use of irrigation water, all producing unjustified financial and environmental costs (van Wijk, 1993; McCoy and McCoy, 2005; McCoy *et al.*, 2007).

The outstanding tolerance to high temperatures and soil salinity (Malcolm and Smith, 1971; Beard, 1973; Peacock *et al.*, 2004), the resistance to water stress (Volterrani *et al.*, 1996; Cereti, 2004; Marchione, 2004; Huang, 2008; Marchione, 2012) and the excellent recovery rate from biotic and abiotic stress (Croce *et al.*, 2001; Turgeon, 2004) make warm season turfgrasses more adapted to Mediterranean climatic conditions and suitable to increase turf areas in central and Southern Italy (Severmutlu *et al.*, 2011).

The majority of the commercially available turfgrasses used in Italy, are of foreign origin (USA and Australia) (Veronesi and Falcinelli, 1988; Veronesi *et al.*, 1991a). Therefore, a great threat can be the use of this alien plant material into natural ecosystems (Potenza *et al.*, 2012).

The use of native warm-season grasses would be preferred due to their reduced threat to native ecosystems and their greater resistance to high temperature and water deficit stress (Kenna *et al.*, 2008; Erdogan *et al.*, 2011). Native ecotypes represent an important source of genetic variability that can be used to support specific plant breeding programmes. Germplasm of turf ecotypes selected from the areas of potential utilisation or similar environments is much more likely to

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be successful for obtaining new turf cultivars (Romani *et al.*, 2004).

Among warm season grasses, Bermudagrass [*Cynodon dactylon* L. (Pers.) var. *dactylon*] is the most used worldwide for turf purposes.

Until now, the research on Bermudagrass breeding programs in Italy has been scarce (Veronesi and Falcinelli, 1988; Veronesi *et al.*, 1991b; Volterrani *et al.*, 1996; Romani *et al.*, 2002; Marchione, 2004; Romani *et al.*, 2004; De Luca *et al.*, 2008; Potenza *et al.*, 2014) and all the cultivars available on the market are of foreign origin.

There are 9 species and 10 varieties of *Cynodon* in the world that are widely distributed, genetically diverse, and generally considered leading reclamation pioneer species. Bermudagrass plants thrive in overgrazed pastures and other disturbed and degraded sites (Chapman, 1996).

*C. dactylon* var. *dactylon* (common Bermudagrass) is the most important *Cynodon* species and is geographically widely distributed between latitudes of 45° N and 45° S (Anderson *et al.*, 1993), penetrating to approximately 53° N in Europe (Harlan and de Wet, 1969).

*Cynodon* spp. L.C. Rich. is frequently used in the transition zone where it can provide an excellent surface for golf course fairways and athletic fields. However, these species have a tendency to be injured or killed by low temperatures in the transition zone (Munshaw *et al.*, 2006; Anderson *et al.*, 2007; Esmaili and Salehi, 2012).

Moreover, native ecotypes can be affected by bermudagrass white leaf (BGWL) disease that is associated with a phytoplasma infection (Chen *et al.*, 1972). The disease is characterised by extensive chlorosis, proliferation of axillary shoots, bushy growing habit, small leaves, shortened stolons and rhizomes, stunting and death of the plants (Marcone *et al.*, 1997). Therefore it is important

to select resistant genotypes to the above-mentioned phytoplasma.

The purpose of this study, conducted in a coastal area of the Basilicata region (Southern Italy), was to evaluate the agronomic behaviour of the 24 collected native populations of *C. dactylon* from Central and Southern Italy in order to identify biotypes with good qualities for turf use in the Mediterranean region.

## Materials and methods

### Collection sites

Samples of 24 of *C. dactylon* ecotypes were collected in different coastal and sub littoral sites of southern Italy characterised by Mediterranean climate with mild winters and hot summers. The mean annual temperatures of the collection sites ranged from 14 to 18°C with annual rainfall of less than 600 mm received predominantly in autumn and winter (Biondi *et al.*, 1995). Altitude of the collection sites ranged from 0 to 400 m above sea level (asl). Plants from two habitat types, sandy dunes and hilly lawns, were selected for the trials. Every recorded specimen of interest was sampled from each location following the approach suggested by Romani *et al.* (2002), by walking on a transect. Whole plants (including roots embedded in soil) at the vegetative stage were collected every 2-5 m along the transect.

### Research site and experimental design

Plant samples were vegetatively propagated by transplanting stolon

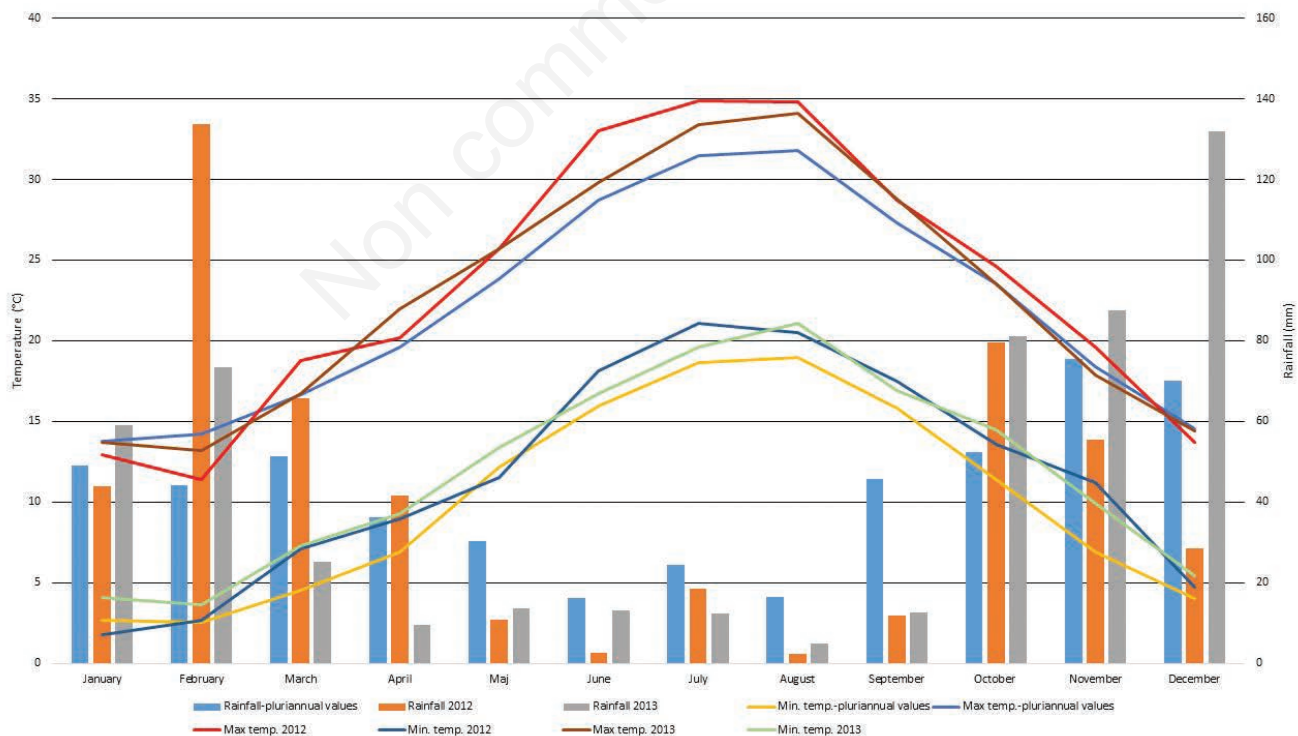


Figure 1. Trend of monthly minimum and maximum temperatures and rainfall recorded during the two-year of research in comparison to pluriannual values.

fragments into plastic pots in an unheated greenhouse. When vegetative material was enough, plots were established in open field at Lucana Prati sod farm (+40° 22'N, +16° 47' E; 6 m asl) of Metaponto (Basilicata region, South of Italy).

The soil of the experimental area was clay-textured (64% clay, 17% silt and 19% sand), with good total nitrogen (1.1‰), available phosphorus (25 ppm) and rich in exchangeable potassium (350 ppm). Twenty-four autochthonous bermudagrasses and three bermudagrass commercial cultivars (*Panama*, *Transcontinental* and *Yukon*) used as standard reference, were compared in a randomised complete block design with 3 replications. Plot surface area was 2.25 m<sup>2</sup> (1.5×1.5 m).

### Agronomic traits

Between the first and the second year (December 2012-March 2013), the colour loss interval was determined by calculating the duration (d) of vegetative stasis on the basis of colour and ground cover of each turf plot: more precisely winter loss colour and spring green up were evalu-

ated by visual judgment when the green cover of the plot was ≤20% and ≥80% respectively.

During the second year, from May to September 2013, the following data were recorded: i) growth rate, measured by a turf meter as the turf weekly vertical growth of turfs maintained at 45 mm cutting height by a rotary mower; ii) colour index: it represents the intensity of the green colour and it is influenced by genetic characteristics of the species, conditions of environmental stress (water and/or thermal stress), from nutritional deficiencies and parasitic attacks. This parameter has been measured monthly using a Turf 500 NDVI-Turf Color Meter (Spectrum Technology, Aurora, CO, USA) that measures the reflected light in the spectral bands of red (600 nm) and infrared (850 nm), which correlate with the concentration of chlorophyll pigments in the leaves. From the measurement of NDVI, a colour index on a scale from 1 (=brown) to 9 (=dark green) can be calculated; iii) turf quality is a synthetic index evaluated by visual observations, and it highlights the quality of turf; it is influenced by the uniformity, density, turf colour, leaf texture, per-

**Table 1. Origin of *C. dactylon* ecotypes collected in Central and Southern Italy, monthly and cumulative growth of ecotypes compared to commercial cultivars during the trial period (2013).**

ID	Ecotypes				Months assessed growth (mm)					Cumulative height May-Sept (mm)
	Location	Altitude (m asl)	Latitude (UTM)	Longitude (UTM)	May	Jun	July	August	September	
1	Massafra (TA)	30	677949	4492375	44 <sup>d</sup>	62 <sup>hi</sup>	49 <sup>d</sup>	42 <sup>bc</sup>	33 <sup>ef</sup>	230 <sup>c</sup>
2	Vasto (CH)	5	478443	4661223	28 <sup>hi</sup>	34 <sup>o</sup>	24 <sup>mn</sup>	21 <sup>h</sup>	27 <sup>h</sup>	135 <sup>p</sup>
3	Vasto (CH)	5	478443	4661223	26 <sup>ij</sup>	44 <sup>l</sup>	25 <sup>lm</sup>	18 <sup>i</sup>	29 <sup>gh</sup>	142 <sup>n</sup>
4	Vasto (CH)	5	478443	4661223	18 <sup>mn</sup>	39 <sup>n</sup>	19 <sup>op</sup>	25 <sup>g</sup>	12 <sup>kl</sup>	114 <sup>r</sup>
5	Vasto (CH)	5	478443	4661223	32 <sup>fg</sup>	58 <sup>j</sup>	29 <sup>k</sup>	32 <sup>e</sup>	33 <sup>ef</sup>	184 <sup>i</sup>
6	Vasto (CH)	5	478443	4661223	22 <sup>kl</sup>	35 <sup>o</sup>	25 <sup>lm</sup>	28 <sup>f</sup>	35 <sup>ce</sup>	146 <sup>m</sup>
7	Pisticci (MT)	43	634308	4476229	22 <sup>kl</sup>	39 <sup>n</sup>	46 <sup>e</sup>	40 <sup>c</sup>	27 <sup>h</sup>	174 <sup>j</sup>
8	Pisticci (MT)	167	631894	4470852	31 <sup>fg</sup>	43 <sup>lm</sup>	29 <sup>k</sup>	41 <sup>bc</sup>	24 <sup>i</sup>	168 <sup>k</sup>
9	Pisticci (MT)	6	651327	4462126	22 <sup>kl</sup>	30 <sup>p</sup>	16 <sup>q</sup>	15 <sup>jk</sup>	10 <sup>lm</sup>	94 <sup>t</sup>
10	Ginosa (TA)	5	666275	4484012	12 <sup>o</sup>	36 <sup>o</sup>	21 <sup>no</sup>	12 <sup>l</sup>	20 <sup>j</sup>	101 <sup>s</sup>
11	Ginosa (TA)	5	666275	4484012	24 <sup>jk</sup>	53 <sup>k</sup>	44 <sup>ef</sup>	40 <sup>c</sup>	26 <sup>h</sup>	188 <sup>h</sup>
12	Ginosa (TA)	5	666275	4484012	5 <sup>p</sup>	12 <sup>q</sup>	17 <sup>pq</sup>	18 <sup>i</sup>	10 <sup>lm</sup>	63 <sup>v</sup>
13	Montescaglioso (MT)	302	650379	4491214	25 <sup>j</sup>	63 <sup>gh</sup>	35 <sup>i</sup>	35 <sup>d</sup>	29 <sup>gh</sup>	188 <sup>h</sup>
14	Feronia (RM)	408	301916	4668620	38 <sup>e</sup>	72 <sup>bc</sup>	41 <sup>gh</sup>	48 <sup>a</sup>	27 <sup>h</sup>	226 <sup>d</sup>
15	Diamante (CS)	0	578877	4376962	30 <sup>gh</sup>	60 <sup>ij</sup>	28 <sup>kl</sup>	36 <sup>d</sup>	37 <sup>c</sup>	192 <sup>g</sup>
16	Conversano (BA)	100	678146	4537292	17 <sup>n</sup>	35 <sup>o</sup>	30 <sup>jk</sup>	24 <sup>gh</sup>	10 <sup>lm</sup>	116 <sup>q</sup>
17	Conversano (BA)	105	678146	4537292	24 <sup>jk</sup>	41 <sup>mn</sup>	29 <sup>k</sup>	29 <sup>f</sup>	13 <sup>k</sup>	137 <sup>o</sup>
18	Matera (MT)	268	640701	4501305	19 <sup>mn</sup>	35 <sup>o</sup>	15 <sup>q</sup>	14 <sup>kl</sup>	9 <sup>m</sup>	92 <sup>u</sup>
19	Metaponto (MT)	72	654410	440640	20 <sup>lm</sup>	74 <sup>b</sup>	42 <sup>fg</sup>	42 <sup>bc</sup>	34 <sup>de</sup>	213 <sup>f</sup>
20	Ascea (SA)	5	515761	4438447	33 <sup>f</sup>	68 <sup>de</sup>	40 <sup>gh</sup>	41 <sup>bc</sup>	30 <sup>g</sup>	212 <sup>f</sup>
21	Ascea (SA)	5	515761	4438447	55 <sup>b</sup>	65 <sup>fg</sup>	33 <sup>ij</sup>	41 <sup>bc</sup>	36 <sup>cd</sup>	230 <sup>c</sup>
22	Ascea (SA)	5	515761	4438447	43 <sup>d</sup>	58 <sup>j</sup>	20 <sup>op</sup>	13 <sup>kl</sup>	24 <sup>i</sup>	158 <sup>l</sup>
23	Ascea (SA)	5	515761	4438447	63 <sup>a</sup>	137 <sup>a</sup>	59 <sup>a</sup>	49 <sup>a</sup>	50 <sup>a</sup>	359 <sup>a</sup>
24	Ascea (SA)	5	515761	4438447	36 <sup>e</sup>	69 <sup>d</sup>	52 <sup>c</sup>	29 <sup>f</sup>	27 <sup>h</sup>	213 <sup>f</sup>
<i>Panama</i>	Commercial	-	-	-	55 <sup>b</sup>	61 <sup>hj</sup>	39 <sup>h</sup>	36 <sup>d</sup>	41 <sup>b</sup>	231 <sup>c</sup>
<i>Transcontinental</i>	Commercial	-	-	-	45 <sup>d</sup>	66 <sup>ef</sup>	46 <sup>e</sup>	43 <sup>b</sup>	36 <sup>cd</sup>	236 <sup>b</sup>
<i>Yukon</i>	Commercial	-	-	-	43 <sup>d</sup>	70 <sup>cd</sup>	56 <sup>b</sup>	24 <sup>gh</sup>	31 <sup>fg</sup>	224 <sup>e</sup>
Mean					31	54	34	31	27	177

Values not having any letter in common are significantly different at P≤0.05 (Duncan's test).

centage of coverage and freedom from weeds, insects and disease damage. It varies from 1 (poorest quality) to 9 (highest quality - ideal turf); iv) ground cover percentage, is an assessment of the ground cover of the plot; this index was evaluated monthly by visual estimation.

All data were analysed with ANOVA procedure and means were compared with Duncan's test.

### Cultural practices

Two fertilisations (May and July) with Nitrophoska gold (15-9-15), both with a rate of 60 kg ha<sup>-1</sup> N, 36 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> and 60 kg ha<sup>-1</sup> K<sub>2</sub>O were carried out; weekly irrigation to restore 60% of ETo and a weekly cutting frequency by a rotary mower with a mowing height of 45 mm were performed.

### Climate parameters

As shown in Figure 1, the climatic trend was typically Mediterranean with an average temperature that was consistently higher than 15°C from April to October of 2012 and 2013.

During summer of 2012, maximum temperatures detected have constantly been around 35°C. Monthly average minimum temperatures were lower than the average in January (1.8°C) and higher than the average during October and November (13.6 and 11.2°C). During the first decade of December, a rough decrement of temperatures occurred determining the beginning of dormancy of accessions.

The average rainfall in 2012 was in line with pluriannual average values. Rains were concentrated in February (134 mm), March (66 mm) and October (80 mm). During the summer period, the only relevant rainy event occurred in July (19 mm). The hottest months in 2013 were July and August with monthly average maximum temperatures of 33.4 and 34.1°C. In the same period the absolute maximum temperature in many cases were close to 40°C. The coldest months were January and February, respectively, with monthly average minimum temperatures of 4.1°C and 3.6°C. In the summer period of 2013, rainfall totals were scarce (43 mm); during the months of June, July and September, the rainfall amounted to a value slightly greater than 10 mm, while in August, was only 5 mm.

**Table 2. Colour index and days of winter colour loss interval of ecotypes and commercial cultivars during the trial period (2012-2013).**

Ecotypes and cultivars	May	Jun	July	August	September	Mean May-Sept (2013)	Winter colour loss interval (d)
1	6.8 <sup>bd</sup>	6.7 <sup>ab</sup>	6.8 <sup>a</sup>	6.0 <sup>ce</sup>	6.0 <sup>de</sup>	6.5 <sup>ab</sup>	133 <sup>j</sup>
2	6.5 <sup>d</sup>	6.2 <sup>ef</sup>	6.3 <sup>be</sup>	6.1 <sup>bd</sup>	6.0 <sup>de</sup>	6.2 <sup>ce</sup>	146 <sup>f</sup>
3	7.0 <sup>ab</sup>	6.6 <sup>ac</sup>	6.4 <sup>bd</sup>	6.2 <sup>ac</sup>	6.1 <sup>cd</sup>	6.5 <sup>ab</sup>	125 <sup>k</sup>
4	7.0 <sup>ab</sup>	6.7 <sup>ab</sup>	6.3 <sup>be</sup>	5.5 <sup>hj</sup>	5.4 <sup>i</sup>	6.2 <sup>ce</sup>	146 <sup>f</sup>
5	6.7 <sup>cd</sup>	6.3 <sup>cf</sup>	5.9 <sup>fg</sup>	6.0 <sup>ce</sup>	5.8 <sup>fg</sup>	6.1 <sup>df</sup>	151 <sup>e</sup>
6	6.7 <sup>cd</sup>	6.3 <sup>cf</sup>	6.1 <sup>ef</sup>	6.3 <sup>ab</sup>	6.3 <sup>ab</sup>	6.3 <sup>bd</sup>	146 <sup>f</sup>
7	6.8 <sup>bd</sup>	6.2 <sup>ef</sup>	6.3 <sup>be</sup>	6.1 <sup>bd</sup>	6.1 <sup>cd</sup>	6.3 <sup>bd</sup>	143 <sup>g</sup>
8	6.8 <sup>bd</sup>	6.6 <sup>ad</sup>	6.2 <sup>de</sup>	5.6 <sup>gi</sup>	5.7 <sup>gh</sup>	6.2 <sup>ce</sup>	151 <sup>e</sup>
9	6.8 <sup>bd</sup>	6.1 <sup>fg</sup>	6.1 <sup>ef</sup>	5.8 <sup>eg</sup>	6.3 <sup>ab</sup>	6.2 <sup>ce</sup>	152 <sup>de</sup>
10	6.7 <sup>cd</sup>	6.3 <sup>cf</sup>	6.5 <sup>b</sup>	6.0 <sup>ce</sup>	6.3 <sup>ab</sup>	6.4 <sup>ac</sup>	146 <sup>f</sup>
11	6.8 <sup>bd</sup>	6.6 <sup>ad</sup>	6.4 <sup>bd</sup>	6.1 <sup>bd</sup>	6.2 <sup>bc</sup>	6.4 <sup>ac</sup>	138 <sup>i</sup>
12	6.2 <sup>e</sup>	5.9 <sup>g</sup>	5.6 <sup>h</sup>	5.7 <sup>fh</sup>	6.0 <sup>de</sup>	5.9 <sup>f</sup>	145 <sup>fg</sup>
13	6.7 <sup>cd</sup>	6.3 <sup>df</sup>	6.2 <sup>ce</sup>	6.1 <sup>bd</sup>	6.1 <sup>cd</sup>	6.3 <sup>bd</sup>	146 <sup>f</sup>
14	6.8 <sup>bd</sup>	6.7 <sup>ab</sup>	6.5 <sup>b</sup>	6.0 <sup>ce</sup>	6.2 <sup>bc</sup>	6.4 <sup>ac</sup>	157 <sup>c</sup>
15	6.9 <sup>ac</sup>	6.5 <sup>ad</sup>	6.3 <sup>be</sup>	6.4 <sup>a</sup>	6.2 <sup>bc</sup>	6.5 <sup>ab</sup>	138 <sup>i</sup>
16	6.7 <sup>cd</sup>	6.2 <sup>ef</sup>	6.2 <sup>ce</sup>	5.3 <sup>j</sup>	5.5 <sup>hi</sup>	6.0 <sup>ef</sup>	153 <sup>d</sup>
17	7.0 <sup>ab</sup>	6.2 <sup>ef</sup>	6.2 <sup>ce</sup>	5.6 <sup>gi</sup>	5.3 <sup>j</sup>	6.0 <sup>ef</sup>	166 <sup>b</sup>
18	6.8 <sup>bd</sup>	6.4 <sup>be</sup>	6.3 <sup>be</sup>	5.6 <sup>gi</sup>	5.8 <sup>eg</sup>	6.2 <sup>ce</sup>	173 <sup>a</sup>
19	6.7 <sup>cd</sup>	6.4 <sup>be</sup>	6.2 <sup>ce</sup>	5.8 <sup>eg</sup>	5.5 <sup>hi</sup>	6.1 <sup>df</sup>	141 <sup>h</sup>
20	6.9 <sup>ac</sup>	6.5 <sup>ad</sup>	6.5 <sup>b</sup>	5.9 <sup>df</sup>	6.2 <sup>bc</sup>	6.4 <sup>ac</sup>	133 <sup>j</sup>
21	6.8 <sup>bd</sup>	6.3 <sup>df</sup>	6.3 <sup>be</sup>	5.9 <sup>df</sup>	5.9 <sup>ef</sup>	6.2 <sup>ce</sup>	138 <sup>i</sup>
22	6.8 <sup>bd</sup>	6.3 <sup>df</sup>	5.8 <sup>gh</sup>	5.6 <sup>gi</sup>	5.9 <sup>ef</sup>	6.1 <sup>df</sup>	146 <sup>f</sup>
23	7.1 <sup>a</sup>	6.5 <sup>ad</sup>	5.7 <sup>gh</sup>	5.7 <sup>fh</sup>	5.8 <sup>eg</sup>	6.2 <sup>ce</sup>	138 <sup>i</sup>
24	6.8 <sup>bd</sup>	6.3 <sup>cf</sup>	6.1 <sup>ef</sup>	5.4 <sup>ij</sup>	5.7 <sup>fg</sup>	6.1 <sup>df</sup>	143 <sup>g</sup>
<i>Panama</i>	7.0 <sup>ab</sup>	6.3 <sup>cf</sup>	6.5 <sup>bc</sup>	6.2 <sup>ac</sup>	5.7 <sup>fg</sup>	6.4 <sup>ac</sup>	133 <sup>j</sup>
<i>Transcontinental</i>	7.0 <sup>ab</sup>	6.8 <sup>a</sup>	6.5 <sup>bc</sup>	6.1 <sup>bd</sup>	5.9 <sup>ef</sup>	6.5 <sup>ab</sup>	125 <sup>k</sup>
<i>Yukon</i>	7.0 <sup>ab</sup>	6.8 <sup>a</sup>	6.5 <sup>bc</sup>	6.3 <sup>ab</sup>	6.5 <sup>a</sup>	6.6 <sup>a</sup>	133 <sup>j</sup>
Average	6.8	6.4	6.3	5.9	5.9	6.3	144

Values not having any letter in common are significantly different at P≤0.05 (Duncan's test).

## Results and discussion

The results of the evaluations carried out in 2012 and 2013, of the 24 native ecotypes of *C. dactylon* compared with 3 commercial bermudagrasses cultivars are shown in Tables 1-4.

The *ecotype* caused significant difference in each of the tested parameters when subjected to analysis of variance. For simplicity, the results for each parameter have been analysed separately.

### Monthly growth

The mean total growth during the period May-September was 177 mm (Table 1), with extreme variations observed between the ecotype 12 (63 mm) and ecotype 23 (359 mm). A similar behaviour was also found by Marchione (2008) on 12 commercial varieties of bermudagrass.

The extreme variability observed among the accessions compared is due in part to the genotypic characteristics of each accession and in part to an attack of phytoplasma BGWL, which resulted in an arrest of

the vegetation and the discolouration of the leaf blades especially for accessions no. 12, 18, 9, 10 and 16.

A prostrate growth habit reducing values of the cumulative growth was observed for the accessions no. 2, 3, 4 and 17; on the contrary accessions that showed the greatest growth were the no. 23 (359 mm) and no. 21, 1 and 14, all with values ranging around 230 mm.

### Colour index

Data in Table 2 show for this character, mean values above sufficiency, between 6.3 and 6.8 in the first 3 months of observation (May-July 2013), on the contrary, the colour index was below the sufficiency (5.9) during August and September 2013. These results are in accord to other researchers who studied 40 accessions of native *C. dactylon* collected in Sicily (Southern Italy) in order to identify biotypes with good qualities for broad scale turf in the Mediterranean region (Leto *et al.*, 2008). The lower colour index values observed during August and September was due mainly to high temperatures and low rainfall, which caused a drought stress in plants.

Table 3. Turf quality of ecotypes and commercial cultivars during the trial period (2013).

Ecotypes and cultivars	May	Jun	July	August	September	Mean May-Sept (2013)
1	6.1 <sup>cd</sup>	6.2 <sup>de</sup>	6.0 <sup>de</sup>	5.4 <sup>cd</sup>	5.4 <sup>c</sup>	5.8 <sup>d</sup>
2	4.9 <sup>k</sup>	4.8 <sup>lm</sup>	4.9 <sup>k</sup>	4.8 <sup>hi</sup>	4.7 <sup>gi</sup>	4.8 <sup>i</sup>
3	7.2 <sup>a</sup>	7.3 <sup>a</sup>	6.7 <sup>a</sup>	6.2 <sup>a</sup>	6.0 <sup>a</sup>	6.7 <sup>a</sup>
4	5.3 <sup>hi</sup>	5.4 <sup>hi</sup>	5.3 <sup>j</sup>	5.1 <sup>fg</sup>	5.0 <sup>de</sup>	5.2 <sup>gh</sup>
5	5.1 <sup>ik</sup>	4.6 <sup>mn</sup>	4.3 <sup>m</sup>	4.6 <sup>ik</sup>	4.7 <sup>fi</sup>	4.7 <sup>j</sup>
6	5.4 <sup>h</sup>	5.3 <sup>hj</sup>	5.0 <sup>k</sup>	5.2 <sup>ef</sup>	4.9 <sup>df</sup>	5.2 <sup>gh</sup>
7	4.9 <sup>k</sup>	5.2 <sup>ij</sup>	5.0 <sup>k</sup>	5.7 <sup>b</sup>	4.7 <sup>fi</sup>	5.1 <sup>hi</sup>
8	5.3 <sup>hj</sup>	5.1 <sup>jk</sup>	5.0 <sup>k</sup>	5.1 <sup>fg</sup>	5.0 <sup>de</sup>	5.1 <sup>hi</sup>
9	5.8 <sup>f</sup>	4.9 <sup>kl</sup>	4.2 <sup>m</sup>	4.4 <sup>kl</sup>	4.5 <sup>ij</sup>	4.8 <sup>i</sup>
10	6.1 <sup>cd</sup>	5.8 <sup>g</sup>	5.6 <sup>h</sup>	5.0 <sup>gh</sup>	5.0 <sup>de</sup>	5.5 <sup>ef</sup>
11	6.0 <sup>ce</sup>	5.9 <sup>fg</sup>	5.0 <sup>k</sup>	5.6 <sup>bc</sup>	5.1 <sup>d</sup>	5.5 <sup>ef</sup>
12	3.8 <sup>m</sup>	3.5 <sup>o</sup>	2.9 <sup>n</sup>	3.0 <sup>m</sup>	3.3 <sup>l</sup>	3.3 <sup>l</sup>
13	6.4 <sup>b</sup>	6.2 <sup>cd</sup>	6.1 <sup>cd</sup>	6.0 <sup>a</sup>	5.6 <sup>bc</sup>	6.1 <sup>c</sup>
14	6.1 <sup>cd</sup>	6.3 <sup>bd</sup>	6.2 <sup>c</sup>	5.6 <sup>bc</sup>	5.5 <sup>bc</sup>	5.9 <sup>d</sup>
15	5.8 <sup>ef</sup>	6.0 <sup>ef</sup>	5.7 <sup>g</sup>	5.6 <sup>bc</sup>	5.7 <sup>b</sup>	5.8 <sup>d</sup>
16	4.6 <sup>l</sup>	4.5 <sup>n</sup>	4.2 <sup>m</sup>	4.3 <sup>l</sup>	4.4 <sup>j</sup>	4.4 <sup>k</sup>
17	4.9 <sup>k</sup>	4.9 <sup>kl</sup>	4.6 <sup>l</sup>	4.7 <sup>ij</sup>	4.9 <sup>dg</sup>	4.8 <sup>i</sup>
18	5.0 <sup>jk</sup>	5.2 <sup>ij</sup>	4.9 <sup>k</sup>	4.8 <sup>hi</sup>	3.9 <sup>k</sup>	4.9 <sup>ij</sup>
19	5.5 <sup>gh</sup>	5.3 <sup>hj</sup>	5.3 <sup>ij</sup>	4.9 <sup>hi</sup>	4.8 <sup>eh</sup>	5.1 <sup>hi</sup>
20	6.1 <sup>cd</sup>	6.1 <sup>df</sup>	5.9 <sup>ef</sup>	5.5 <sup>cd</sup>	5.4 <sup>c</sup>	5.8 <sup>d</sup>
21	5.7 <sup>fg</sup>	5.8 <sup>g</sup>	5.8 <sup>fg</sup>	4.9 <sup>hi</sup>	5.0 <sup>de</sup>	5.4 <sup>fg</sup>
22	5.3 <sup>hj</sup>	4.9 <sup>kl</sup>	4.8 <sup>k</sup>	4.4 <sup>l</sup>	4.4 <sup>j</sup>	4.8 <sup>i</sup>
23	5.3 <sup>hj</sup>	5.4 <sup>hi</sup>	5.3 <sup>ij</sup>	4.9 <sup>hi</sup>	4.9 <sup>df</sup>	5.2 <sup>gh</sup>
24	5.8 <sup>df</sup>	5.5 <sup>h</sup>	5.5 <sup>hi</sup>	5.3 <sup>de</sup>	4.6 <sup>hi</sup>	5.4 <sup>fg</sup>
<i>Panama</i>	6.1 <sup>cd</sup>	5.9 <sup>fg</sup>	5.4 <sup>ij</sup>	5.6 <sup>bc</sup>	5.5 <sup>bc</sup>	5.7 <sup>de</sup>
<i>Transcontinental</i>	6.3 <sup>bc</sup>	6.1 <sup>df</sup>	5.8 <sup>fg</sup>	5.5 <sup>cd</sup>	5.4 <sup>c</sup>	5.8 <sup>d</sup>
<i>Yukon</i>	6.5 <sup>b</sup>	6.4 <sup>bc</sup>	6.4 <sup>b</sup>	6.2 <sup>a</sup>	6.0 <sup>a</sup>	6.3 <sup>b</sup>
Mean	5.6	5.5	5.2	5.1	5.0	5.3

Values not having any letter in common are significantly different at  $P \leq 0.05$  (Duncan's test).

From May to September 2013, the ecotypes 1, 3 and 15 showed the highest mean value equal to 6.5, whilst commercial cultivars gave mean values equal to 6.5. In contrast accessions that showed the lowest value, equal to 6, were accessions 12, 16 and 17.

### Colour loss interval

The average duration of the dormancy period of compared accessions was 144 days. For most of the evaluated ecotypes (Table 2) it occurred between the first and second week of December, while the vegetative growth with the relative recovery of the colour was observed between the second week of April and the first week of May. Ecotypes that shown the lowest dormancy period were 3, 1 and 20, with values ranging between 125 and 133 days. On the contrary, accessions 18 and 17 showed the longest dormancy period among the ecotypes evaluated, with 173 and 166 days respectively. The three commercial varieties included in the research showed a period of dormancy ranging within 125 and 133 days, similar to the values achieved by best ecotypes.

### Turf quality

Analysing data in Table 3 it is possible to verify that turf quality ranged between 5.6 (May) and 5 (September) (Table 3). This data are

remarked in other native *C. dactylon* ecotypes of the Mediterranean region (Leto *et al.*, 2008).

During the entire period of experimentation, ecotypes that showed the highest mean values were 3, 13 and 14, respectively, with 6.7 to 6.1 and 5.9; they also showed a good preservation of quality from May 2013 to September 2013. Among the commercial cultivars used in the experiment, the most satisfactory result was detected for *Yukon*, with a value equal to 6.3, and a good stability during the entire period.

At the lowest level were ranked, accessions 12 and 16, with values respectively equal to 3.3 and 4.4. These values extremely low were due partly to the genotypic characteristics of accession and to a considerable extent of phytoplasma BGWL attacks, which have widely affected the aesthetic quality of ecotypes. The lower values of these ecotypes have strongly influenced the mean of turf quality during whole period and also for single months.

### Ground cover percentage

The coverage percentage (Table 4) showed a mean value generally equal to 70%, in accordance with the findings of Volterrani *et al.* (1997) and Croce *et al.* (2001) in other Italian sites. Mean values higher than 75% were observed during the May-June period; during the August-September period, however, a decrease of the index has been noted,

**Table 4. Ground cover percentage of ecotypes and commercial cultivars during the trial period (2013).**

Ecotypes and cultivars	May	Jun	July	August	September	Mean May-Sept (2013)
1	6.1 <sup>cd</sup>	6.2 <sup>de</sup>	6.0 <sup>de</sup>	5.4 <sup>cd</sup>	5.4 <sup>c</sup>	5.8 <sup>d</sup>
2	4.9 <sup>k</sup>	4.8 <sup>lm</sup>	4.9 <sup>k</sup>	4.8 <sup>hi</sup>	4.7 <sup>gi</sup>	4.8 <sup>j</sup>
3	7.2 <sup>a</sup>	7.3 <sup>a</sup>	6.7 <sup>a</sup>	6.2 <sup>a</sup>	6.0 <sup>a</sup>	6.7 <sup>a</sup>
4	5.3 <sup>hi</sup>	5.4 <sup>hi</sup>	5.3 <sup>j</sup>	5.1 <sup>fg</sup>	5.0 <sup>de</sup>	5.2 <sup>gh</sup>
5	5.1 <sup>ik</sup>	4.6 <sup>mn</sup>	4.3 <sup>m</sup>	4.6 <sup>jk</sup>	4.7 <sup>fi</sup>	4.7 <sup>j</sup>
6	5.4 <sup>h</sup>	5.3 <sup>hj</sup>	5.0 <sup>k</sup>	5.2 <sup>ef</sup>	4.9 <sup>df</sup>	5.2 <sup>gh</sup>
7	4.9 <sup>k</sup>	5.2 <sup>ij</sup>	5.0 <sup>k</sup>	5.7 <sup>b</sup>	4.7 <sup>fi</sup>	5.1 <sup>hi</sup>
8	5.3 <sup>bj</sup>	5.1 <sup>jk</sup>	5.0 <sup>k</sup>	5.1 <sup>fg</sup>	5.0 <sup>de</sup>	5.1 <sup>hi</sup>
9	5.8 <sup>f</sup>	4.9 <sup>kl</sup>	4.2 <sup>m</sup>	4.4 <sup>kl</sup>	4.5 <sup>ij</sup>	4.8 <sup>j</sup>
10	6.1 <sup>cd</sup>	5.8 <sup>g</sup>	5.6 <sup>h</sup>	5.0 <sup>gh</sup>	5.0 <sup>de</sup>	5.5 <sup>ef</sup>
11	6.0 <sup>ce</sup>	5.9 <sup>fg</sup>	5.0 <sup>k</sup>	5.6 <sup>bc</sup>	5.1 <sup>d</sup>	5.5 <sup>ef</sup>
12	3.8 <sup>m</sup>	3.5 <sup>o</sup>	2.9 <sup>n</sup>	3.0 <sup>m</sup>	3.3 <sup>l</sup>	3.3 <sup>l</sup>
13	6.4 <sup>b</sup>	6.2 <sup>cd</sup>	6.1 <sup>cd</sup>	6.0 <sup>a</sup>	5.6 <sup>bc</sup>	6.1 <sup>c</sup>
14	6.1 <sup>cd</sup>	6.3 <sup>bd</sup>	6.2 <sup>c</sup>	5.6 <sup>bc</sup>	5.5 <sup>bc</sup>	5.9 <sup>d</sup>
15	5.8 <sup>ef</sup>	6.0 <sup>ef</sup>	5.7 <sup>g</sup>	5.6 <sup>bc</sup>	5.7 <sup>b</sup>	5.8 <sup>d</sup>
16	4.6 <sup>l</sup>	4.5 <sup>n</sup>	4.2 <sup>m</sup>	4.3 <sup>l</sup>	4.4 <sup>j</sup>	4.4 <sup>k</sup>
17	4.9 <sup>k</sup>	4.9 <sup>kl</sup>	4.6 <sup>l</sup>	4.7 <sup>ij</sup>	4.9 <sup>dg</sup>	4.8 <sup>j</sup>
18	5.0 <sup>jk</sup>	5.2 <sup>ij</sup>	4.9 <sup>k</sup>	4.8 <sup>hi</sup>	3.9 <sup>k</sup>	4.9 <sup>ij</sup>
19	5.5 <sup>gh</sup>	5.3 <sup>hj</sup>	5.3 <sup>ij</sup>	4.9 <sup>hi</sup>	4.8 <sup>eh</sup>	5.1 <sup>hi</sup>
20	6.1 <sup>cd</sup>	6.1 <sup>df</sup>	5.9 <sup>ef</sup>	5.5 <sup>cd</sup>	5.4 <sup>c</sup>	5.8 <sup>d</sup>
21	5.7 <sup>fg</sup>	5.8 <sup>g</sup>	5.8 <sup>fg</sup>	4.9 <sup>hi</sup>	5.0 <sup>de</sup>	5.4 <sup>fg</sup>
22	5.3 <sup>bj</sup>	4.9 <sup>kl</sup>	4.8 <sup>k</sup>	4.4 <sup>l</sup>	4.4 <sup>j</sup>	4.8 <sup>j</sup>
23	5.3 <sup>bj</sup>	5.4 <sup>hi</sup>	5.3 <sup>ij</sup>	4.9 <sup>hi</sup>	4.9 <sup>df</sup>	5.2 <sup>gh</sup>
24	5.8 <sup>df</sup>	5.5 <sup>h</sup>	5.5 <sup>hi</sup>	5.3 <sup>de</sup>	4.6 <sup>hi</sup>	5.4 <sup>fg</sup>
<i>Panama</i>	6.1 <sup>cd</sup>	5.9 <sup>fg</sup>	5.4 <sup>ij</sup>	5.6 <sup>bc</sup>	5.5 <sup>bc</sup>	5.7 <sup>de</sup>
<i>Transcontinental</i>	6.3 <sup>bc</sup>	6.1 <sup>df</sup>	5.8 <sup>fg</sup>	5.5 <sup>cd</sup>	5.4 <sup>c</sup>	5.8 <sup>d</sup>
<i>Yukon</i>	6.5 <sup>b</sup>	6.4 <sup>bc</sup>	6.4 <sup>b</sup>	6.2 <sup>a</sup>	6.0 <sup>a</sup>	6.3 <sup>b</sup>
Mean	5.6	5.5	5.2	5.1	5.0	5.3

Values not having any letter in common are significantly different at  $P \leq 0.05$  (Duncan's test).

with mean values varying from 57% to 63%. Among the ecotypes compared, the one that showed the highest mean value was the ecotype 3 (87%); satisfactory values were also reported for accessions 13 and 1, with mean values equal to 84 and 77% respectively. Commercial cultivar that achieved the best value was *Yukon* with 85%.

The lowest value was reached by genotype 12 (22%). This anomalous value is partly imputable to the massive attack of BGWL, which continued during the entire period of the research.

## Conclusions

The research project was of particular interest in increasing knowledge on bermudagrass germplasm in Central and Southern Italy.

The bio-agronomic evaluation of 24 ecotypes of *Cynodon* spp. showed high variability in the collected germplasm, as far as the biometric and qualitative parameters were concerned.

Many of the ecotypes compared resulted susceptible to BGWL, which influenced all the considered parameters with the exception of ecotypes 1, 3, 13, 14, 21, 23 and 24. Susceptibility to phytoplasma is a factor to be considered for the selection of ecotypes for turf.

The native accession 3 from Vasto (Abruzzo region) achieved the best results among-native bermudagrasses and showed the same or higher values than *Yukon*, *Panama* and *Transcontinental* cultivars, used as reference of commercial varieties. For some parameters, several ecotypes (1, 13, 14 e 20) from Massafra (Puglia region, Southern Italy), Montescaglioso (Basilicata region, Southern Italy), Feronia (Lazio region, Central Italy) and Ascea (Campania region, Southern Italy) showed similar biometric and qualitative performances than *Yukon*, *Panama* e *Transcontinental* and could result of great interest for selecting future bermudagrass cultivars for turfgrasses use.

Further studies are needed to better characterise the above native accessions of *C. dactylon*, in order to promote them in the turfgrass market and to assess the potential benefits compared to alien species in the Mediterranean environments.

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