Acta Scientific AGRICULTURE (ISSN: 2581-365X)

Volume 6 Issue 11 November 2022

Research Article

Measurement of Green Field Performances in Turfgrass Cultivars with Smartphone Applications in Mediterranean Climate

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DOI: 10.31080/ASAG.2022.06.1196

Received: September 01, 2022

Published: October 06 2022

Abstract

Turf color and canopy cover are among the most basic features that determine the quality of turf areas. Recently, smartphone applications have been developed to measure both turf color and canopy cover. Fast and reliable measurements made in this way save time and expense, while also playing a role in the development of green areas and identifying problems of lawns. For this purpose, turfgrass visual quality (FieldScout GreenIndex+), canopy cover (Canopeo) of 35 different grass cultivars belonging to 7 different species (*Festuca arundinacea, Lolium perenne, Poa pratensis, Festuca rubra rubra, Festuca rubra trichopylla, Festuca rubra commutata, Festuca ovina*) in Aydın (Türkiye) ecology with Mediterranean climate were determined in a study conducted between 2019-2020. While the results revealed that different grass varieties stood out in each season, the values were higher especially in varieties belonging to the Festuca arundinacea species. In terms of coverage, it was determined that Lolium perenne had the least canopy coverage among the species. Depending on the maturation of the lawns, there may be differences in color and coverage in the following years. However, the preference of *Festuca arundinacea* varieties can provide more effective results in semi-arid and hot Mediterranean climate..

Keywords: Visual Rating; Canopy Cover; Turfgrass; Green Spaces; Turf Color

Introduction

Turfgrasses are easy to grow, adapt to many negative conditions, and also visually pleasing. These plants, which are known to have a lot of benefits, need to be suitable for maintenance to have an ideal appearance and to survive for many years. In the mowing process, which is one of the most important maintenance operations, the time and height of the mowing play an important role in determining the quality of the lawn [1].

The visual quality of turf is very important to facility managers. Green field managers, and researchers generally use turf quality attributes to monitor water and fertilizer needs, environment-plant interaction and plant health [2]. Grass color has been an important indicator of aesthetic quality in areas where water and nutrient management is done correctly [3]. Grass color is affected by many factors such as climatic conditions, nutrient and water content in the soil, apart from species and variety. Visual grading requires no equipment but is biased by experience [4]. Fast and reliable Field Scout Green Index+ app provides more accurate results than visual assessment [5].

In regions with Mediterranean climate, high temperatures and high evapotranspiration are observed during the active growth pe-

riod and precipitation is low [6]. In these temperatures and precipitations, while the coverage and grass color decreases, this affects the turf quality.

The coverage of turfgrasses helps to keep the water in the soil while providing the homogeneous distribution of the rainfall [7]. At the same time, dense turfgrass canopy cover increases the visual quality. For this purpose, the Canopeo application, which evaluates the green color algorithm, has been used in many studies and has been reported to have a positive correlation with other applications [8-9-10].

In this study, visual color quality and canopy cover analyzes were made for the use of smartphone applications in turfgrass areas. It is seen that these characteristics may also affect the choice of the appropriate species and cultivars for effective lawn management and savings in lawns.

Materials and Methods

The experiment was carried out in Aydın ecological conditions (37° 45' N, 27° 45' E), between 2019-2020 (Figure 1).

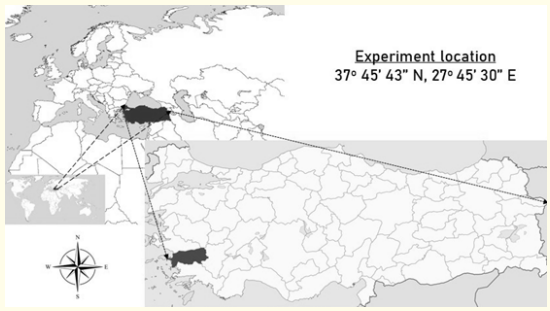

Figure 1: Experimental area.

The experimental area of soil was loamy and alkaline with low organic matter. Lime content of soil is 3.82%, total saline content of 0.02%, phosphorus (P) content of 35 ppm and available potassium of 320 ppm. When the climate data of the year in which the experiment was conducted are examined, it is seen that the temperature has a higher average than the long-term, while the total precipitation is lower than the long-term average (Table 1).

	Temperature (°C)		Precipitation (mm)	
	2019-2020	Long Term Ave.	2019-2020	Long Term Ave.
October	21.4	18.8	29.4	41.1
November	16.5	13.4	65.1	85.6
December	10.5	9.4	117.1	111.5
January	7.7	8.2	91.5	109.8
February	10.4	9.4	90.7	86.1
March	13.3	12.1	65.6	71.8
April	16.8	16.2	57.7	50.9
May	22	21	33.9	40.3
June	25.3	26	20.2	14.5
July	29.8	28.6	0	6.1
August	29.1	28.1	0.7	6.7
September	27	23.9	0	16.9
Average/Total	19.15	17.92	571.9	641.3

Table 1: Climatic data for the years 2019-2020 and the long-term averages in which the experiment was conducted.

Nitrogen, phosphorus and potassium fertilizers were applied at a rate of 75 kg ha^{-1} N, 50 kg ha^{-1} P_2O_5 and 50 kg ha^{-1} K_2O_3 respectively, before seeding and leveling the soil with a cultivator and harrow. In the experiment, 35 different cultivars of belonging to 7 different grass species were obtained. (Table 2).

Festuca arundinacea	***Lolium perenne***	***Poa pratensis***
Tomcat-1	Grandslam	Bluechip
Tahoe	Caddieshack	Evora
Tomahawk	Topgun	Miracle
Raptor 2	Greenway	Arrowhead
Essential	Monarch	
Filippa	Bizet	
Starlett	Kokomo	
Mona Lisa	Ecologic	
Forte	Double	
Avenger	Esquire	
Firaces		
Greenfront		
Patron		
Umbrella		
Festuca rubra rubra	*Festuca rubra trichopylla*	*Festuca ovina*
Corail	Rosita	Ridu
Cardinal	*Smyrna*	
Greenlight		
Maxima	*Festuca rubra commutata*	
Relevant	Maritza	

Table 2: Turfgrass species used in the experiment and their varieties.

The experiment was sown with 1x1 m^2 plots with 3 replications. In the experiment, 75 g m^{2-1} seeds were planted and covered with sifted soil in order to ensure rapid emergence after planting. Irrigation was carried out with full irrigation with sprinklers following the emergence.

The first mowing process took place when the plants reached a height of 15 cm. The mowing operations were carried out with AL-KO HIGHLINE 46.5 P-A gasoline lawnmower from a height of 7-8 cm in order not to affect any kind of development. No herbicide was applied for weed control in the trial, and Fiskars® Stand-up Weed Puller (4-claw) was used to remove weeds (Figure 2).

Figure 2: Weed control and mowing in the experiment.

Irrigation continued regularly throughout the spring and summer. Cultivars mowed regularly when the newshoots of the plants growth at the rate of 1/2. FieldScout GreenIndex+ Turf app and measurement board (Spectrum® Technologies, Inc.) was used to measure turf color quality (Figure 3). The primary output of GreenIndex+ Turf is an index (dark green colour index: DGCI) which quantifies the greenness of the turf and this index can be related to the visual rating of turf [11]. Grass color was observed in 4 seasons (11.2019, 02.2020, 05.2020, 07.2020) following the sowing period. Canopeo app (Oklahoma State University, USA) for measuring canopy coverage. Measurement was carried out 1 month after planting [12].

Statistical analyzes of the obtained data were carried out as ANOVA according to the randomized blocks experimental design (α = 0.05), and the relationship between the traits and cultivars was determined by the SAS package software [13].

Results and Discussion

When the DGCI values of the cultivars belonging to different species were examined, a strong statistical relationship was determined between the cultivars and the index from the measure in the seasons. *Festuca arundinacea* – Tomahawk variety was the highest DGCI value average of 0.685 in the first winter measurement following planting. In the following winter measurement, the values increased in general, while the highest value was found in the same variety with 0.707. Species-dependent changes were observed in the values in spring and summer. Especially, *Festuca arundina-*

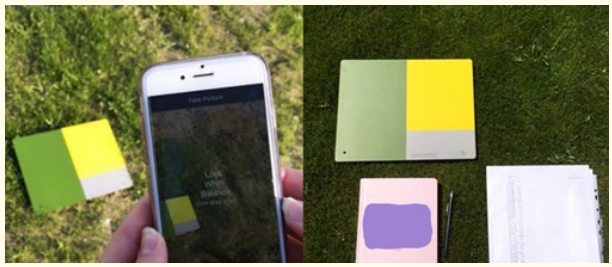

Figure 3: Color measurement with the FieldScout GreenIndex+ Turf app.

cea- Raptor 2 has a more stable index, while the drop in *Lolium perenne*- Caddieshack is among the highest statistically. The most stunning cultivars in summer measurement were *Lolium perenne*- Grandslam, *Festuca arundinacea*- Starlett and *Festuca arundinacea* - Avenger. Of these, Fa-Starlett preserved the value it obtained in the spring measurement, also in the summer months. On the other hand, Fa- Avenger showed the highest value in summer measurement with an increase (Table 3 and Figure 4).

The visual rating describes the quality of the grass color with a value between 1 and 9 depending on the DGCI. As in the DGCI, a strong statistical relationship was observed between the mea-

	Dark Green Color Index (DGCI)			
	11.2019**	**02.2020****	**05.2020****	**07.2020****
Lp-Caddıeshack	0.582	0.695	0.331	0.33
Lp-Topgun	0.562	0.643	0.189	0.343
Lp-Grandslam	0.554	0.54	0.58	0.633
Lp-Greenway	0.572	0.671	0.479	0.537
Lp-Monarch	0.531	0.511	0.512	0.45
Lp-Bizet	0.397	0.382	0.389	0.32
Lp-Kokomo	0.490	0.494	0.52	0.598
Lp-Ecologic	0.456	0.547	0.475	0.447
Lp-Double	0.453	0.527	0.502	0.507
Lp- Esquire	0.398	0.548	0.498	0.521
Fa-Essential	0.404	0.642	0.554	0.530
Fa-Starlett	0.445	0.477	0.629	0.63
Fa-Mona Lisa	0.514	0.525	0.443	0.489
Fa-Filippa	0.475	0.540	0.581	0.33
Fa-Avenger	0.491	0.488	0.57	0.625
Fa-Firaces	0.489	0.560	0.565	0.503
Fa-Greenfront	0.496	0.625	0.534	0.507
Fa-Forte	0.420	0.421	0.543	0.459
Fa-Patron	0.590	0.624	0.609	0.51
Fa-Umbrella	0.532	0.513	0.572	0.584
Fa-Tahoe	0.521	0.533	0.59	0.59
Fa- Tomahawk	0.685	0.707	0.538	0.539
Fa-Raptor 2	0.570	0.678	0.685	0.543
Pp-Evora	0.440	0.572	0.605	0.494
Pp-Miracle	0.466	0.522	0.542	0.48
Pp-Arrowhead	0.458	0.47	0.472	0.42
Frr-Maxima	0.490	0.503	0.658	0.52

Frr-Relevant	0.469	0.482	0.629	0.506
Frr-Cardinal	0.426	0.506	0.52	0.371
Frr-Corail	0.564	0.421	0.468	0.396
Frr -Greenlight	0.562	0.574	0.615	0.557
Frt-Smyrna	0.381	0.428	0.499	0.350
Frt- Rosita	0.470	0.498	0.498	0.393
Frc- Maritza	0.440	0.436	0.421	0.4
Fo- Ridu	0.537	0.616	0.574	0.547
Mean	0.495	0.540	0.525	0.484

Table 3: Turfgrass species used in the experiment and the average DGCI values of the varieties of these species in different seasons (**p < 0.01).

Lp: Lolium Perenne; Fa: Festuca Arundinacea; Pp: Poa Pratensis; Frr: Festuca Rubra Rubra; Frt: Festuca Rubra Trichophylla; Frc: Festuca Rubra Commutata; Fo: Festuca Ovina

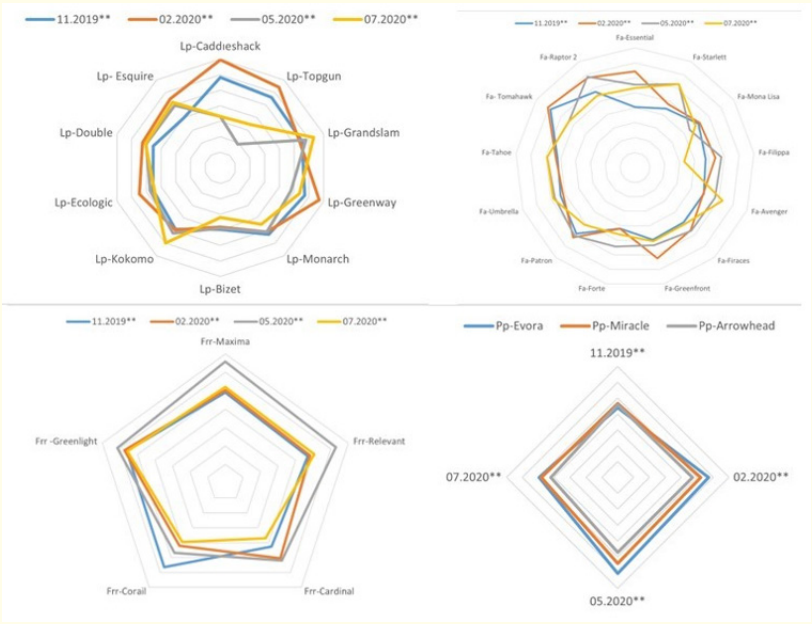

Figure 4: Varieties Dark Green Color Index (DGCI) averages in seasons.

surements of varieties and seasons in visual rating. *Festuca arundinacea*-Tomahawk cultivar had a high value in autumn and winter measurements. This species was followed by *Lolium perenne* cultivars. While the situation varied in summer measurement, *Lolium perenne*-Grandslam cultivar was found to have the highest value in terms of visual rating. According to the percentages of canopy coverage, one month after planting, the difference was determined between varieties and species, while the highest value was obtained from *Festuca arundincea* - Umbrella variety with 97.6%. Especially the species with rhizome are thought to have a higher percentage in terms of coverage (Table 4 and Figure 5).

Turf colour is of particular significance in intensive care turf evaluation and an indication of higher photosynthetic activity and

	Visual Rating (VR)				Canopeo
	11.2019**	02.2020**	05.2020**	07.2020**	(%)**
Lp-Caddıeshack	6.5	7.5	4.1	4.1	68.21
Lp-Topgun	6.1	7.1	2.8	4.2	66.57
Lp-Grandslam	6.2	6.2	6.5	7	82.67
Lp-Greenway	6.4	7.3	5.5	6.1	83.51
Lp-Monarch	6	5.8	5.7	5.1	65
Lp-Bizet	4.7	4.6	4.7	4.2	69.78
Lp-Kokomo	5.6	5.6	6.1	6.6	60.89
Lp-Ecologic	5.9	6.1	5.5	5.2	79
Lp-Double	5.3	6	5.7	5.8	92.45
Lp- Esquire	4.7	6.2	5.7	5.9	78.23
Fa-Essential	4.8	7	6.2	6	88.98
Fa-Starlett	5.2	5.5	6.9	6.9	89.67
Fa-Mona Lisa	5.8	5.9	5.2	5.5	67.85
Fa-Filippa	5,8	6.1	6.5	4.1	79.23
Fa-Avenger	5.6	5.6	6.3	6.9	90.23
Fa-Firaces	5.6	6.3	6.3	5.7	91.23
Fa-Greenfront	5.7	6.9	6	5.6	96
Fa-Forte	5	5	6.1	5.3	67.51
Fa-Patron	6.4	6.9	6.7	5.8	86.45
Fa-Umbrella	5.9	5.8	6.4	6.5	97.6
Fa-Tahoe	5.9	6	6.8	6.8	67.71
Fa- Tomahawk	7.1	7.8	6.1	6.1	72.97
Fa-Raptor 2	6.4	7.1	7.4	6.1	83.97
Pp-Evora	5.1	6.4	6.7	5.6	97.5
Pp-Miracle	5.4	5.9	6.1	5.5	89.23
Pp-Arrowhead	5.3	5.4	5.5	5.2	64.25
Frr-Maxima	5.6	5.8	6.8	6	67.6
Frr-Relevant	5.4	5.5	6.9	5.8	78.21
Frr-Cardinal	5.7	5.8	5.9	4.5	68.41
Frr-Corail	6.3	5	5.4	4.7	94.6
Frr -Greenlight	6.2	6.4	6.8	6.2	90.78
Frt-Smyrna	4.6	5	5.7	4.5	93.5
Frt- Rosita	5.6	5.7	5.7	4.7	65.1
Frc- Maritza	5.2	5.1	5	4.9	65
Fo- Ridu	6.1	6.8	6.4	6.1	90.54
Mean	5,68	6.08	5.94	5.57	79.72

Table 4: Visual rating averages in different season and canopy coverage values of turfgrass varieties (**p < 0.01).

Lp: Lolium Perenne; Fa: Festuca Arundinacea; Pp: Poa Pratensis, Frr: Festuca Rubra Rubra; Frt: Festuca rubra Trichophylla; Frc: Festuca Rubra ommutate; Fo: Festuca Ovin

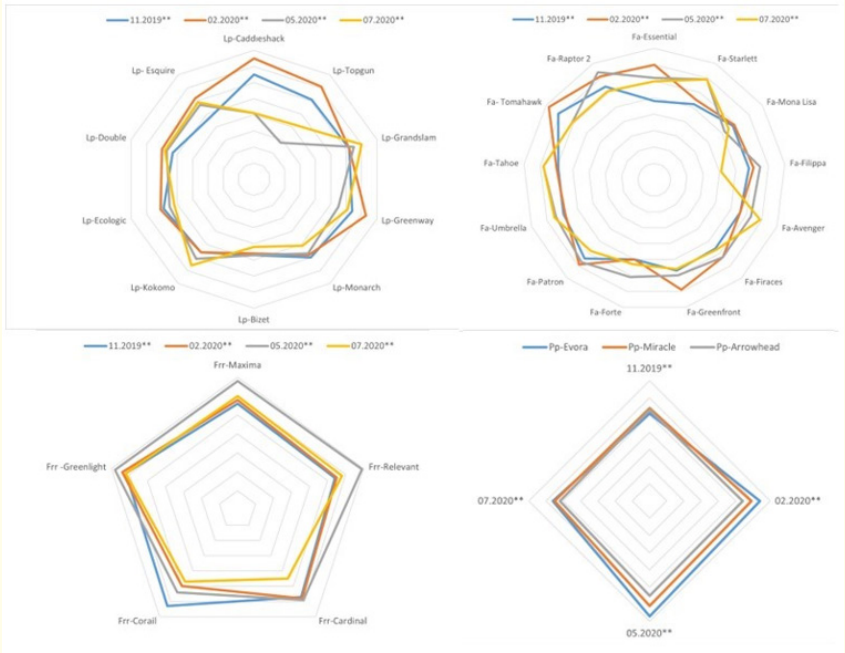

Figure 5: Varieties Visual Rate (VR) averages in seasons.

chlorophyll accumulation in turfgrass tissues, particularly in leaf cells. Since it is a characteristic determined mainly by genetically controlled mechanisms [14]. Turf color is especially studied in order to see healthy growth and high photosynthetic activity in turfgrasses [15]. Measurement of green color quality in cool climate types also gives an idea about other properties such as density, homogeneity, leaf texture. Green canopy coverage also depends on them [16]. Genetic variation in photosynthetic traits is available for selection and breeding purposes in cool climate grass plants [17]. In the experiment, especially *Festuca arundinacea* varieties performed well in winter conditions, while a decrease in values can be observed in semi-arid and warm Mediterranean climates. *Festuca arundinacea* cultivars were the only genotype maintaining relatively high scores of cover, color and quality in different seasons of the succeeding years and proved the wide range of adaptability to Mediterranean environment [14]. A study stated that pure *Festuca arundincea* cultivars are often preferred when adaptation to low-input or unfavorable conditions are targeted [18-19]. At the same time, researchers [20] stated that hot climate species like *Cynodon dactylon* will grow better in arid climates. Aamlid., *et al*. [21] obtained some similar results in terms of grass color quality in their study. Salman [22], in his study, cultivated some turfgrass species by overseeding the warm season turfgrass. Although similar and some different results were obtained in this study, this situation may have been different due to growing conditions. Degree of canopy cover of turf is an important reference to the growth condition of grasses in natural grasslands and the health of an ecosystem [23] also canopy coverage is very important for rainfall-related water management and visuality in grass areas in cities [7].

It is seen that the use of Canopeo and Field Scout GreenIndex+ on lawns has increased. For this purpose, in a study conducted for the accuracy of these applications, it was noted that there was no great difference compared to other methods, while the coverage used in the study showed similar results [24]. *Lolium perenne* showed the fastest growth in a study of cool-climate grass species for canopy cover [25]. Although this situation was also seen in our study at the beginning, *Festuca arundinacea* showed a higher coverage in the data discussed in the following period. Although *Festuca arundincea* cultivars did not produce rapid coverage, it may have shown higher coverage due to their rhizomes and rapid tillering in the first form. it is very important for maintaining order for sports facilities and large park areas. Canopy cover not only depends on genetic characteristics, but also changes depending on pressing density, tillering status, insufficient care, and climatic conditions.

However, since the conditions were the same for all varieties in the study, according to the results obtained, it can be said that genetic characteristics are generally effective in this.

Conclusion

Color and coverage characteristics in lawns are closely related to turfgrass quality. Different methods can be used to determine these properties. However, with some smartphone applications that have been developed in recent years, it can be easy and fast to determine the turfgrass quality. Studies on the reliability of these applications also state that they are usable. In this study, the color and canopy cover characteristics of some cultivars grown intensively in the Mediterranean climate were investigated. The results show that the cultivars belonging to *Festuca arundinacea* species have higher color values, while this situation may cause differences in some cultivars according to the seasons. It has been observed that *Festuca arundinacea* species, which has rhizome according to canopy cover, has fast covering feature. Today, when the effects of global climate change are beginning to be seen, water is the most important place in our lives. For this reason, the effective and saving of water is seen in all areas of life. The fact that there are grasses that consume a lot of water in the lawns and the Mediterranean climate has high temperatures and low precipitation in summers will cause the species that are least affected by extreme conditions to be preferred in these areas. Although the study was only one year old, it was concluded that the varieties belonging to *Festuca arundinacea* species could stand out visually in the short term.

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