

## EFFECTS OF DIFFERENT NITROGEN SOURCES ON TURF QUALITY AND PLANTS GROWTH OF SOME WARM-SEASON TURFGRASSES

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Received: 10.02.2022

### ABSTRACT

This research was conducted to determine the effects of different nitrogen sources and rates on some warm-season turfgrasses under Mediterranean-type climate conditions in 2017-2018. The experiment was arranged in a randomized complete block design with split-split plot arrangement and having three replications. In the arrangement, turfgrass species as the main plot, nitrogen sources as the subplots, and nitrogen doses as the sub subplots. The main plots consist of four nitrogen sources: two slow-release fertilizers, one organomineral fertilizer, and one sewage sludge. Subplots consist of three warm-season turfgrass species; zoysiagrass (*Zoysia japonica* Steud.), hybrid Bermudagrass (*Cynodon transvaalensis* x *Cynodon dactylon*), seashore paspalum (*Paspalum vaginatum* Sw.), and one cool-season turfgrass species, tall fescue (*Festuca arundinacea* Schreb.). The nitrogen doses were as follows; 0.0, 2.0, 3.0 and 4.0 g m<sup>-2</sup>. Turf color and quality were evaluated visually monthly. Also, clipping weight is determined. According to the result, slow-release and organomineral fertilizers can be considerable as N sources that will meet the nutritional needs of the turfgrasses. Zoysiagrass and seashore paspalum showed almost equivalent scores and gave sufficiently dark turf color and quality. Turfgrass should be fertilized at least with 3.0 g m<sup>-2</sup> N to provide acceptable turf color and quality.

**Keywords:** Nitrogen sources, nitrogen rate, turf color, turf quality, warm-season turfgrasses

### INTRODUCTION

Warm-season turfgrasses belong to the Poaceae family and have a C<sub>4</sub> photosynthetic system. Due to the C<sub>4</sub> mechanism, warm-season turfgrasses have better resistance to drought stress and exhibits improved nitrogen and water use efficiency nearly two times higher than that of C<sub>3</sub> grasses (Braun et al., 2020). Due to global warming and the associated climatic change, the adoption of warm-season plants for decorative and sports turfs has recently been pushed in Mediterranean nations (Minelli et al., 2014; Giola et al., 2019; Kir et al., 2019).

Excessive nitrogen fertilizer application is a typical technique to guarantee that plants do not become N-deficient, especially in urban environments. Excess nitrogen that is not used by the plant adds to a waste of natural resources as well as money (Trenkel, 2010; Hopkins, 2020). Nitrogen fertilizer may result in nitrogen loss to the environment via ammonia volatilization, nitrate leaching, and denitrification/nitrification byproducts. Nitrogen loss, in its different mobile forms, adds to problems in the atmosphere and hydrosphere, which eventually impair human and animal health (Mulvaney et al., 2009; Olson et al., 2009; Hopkins, 2020). On a wide range of species, research has been conducted to improve nitrogen usage efficiency by following optimally management techniques such as applying the proper source

at the right rate, positioning, and time (Stevens et al., 2007; LeMonte et al., 2018; Hopkins, 2020). Using slow-release fertilizers combined with improved irrigation techniques may reduce N<sub>2</sub>O emissions so reducing N<sub>2</sub>O emissions from turf may help mitigate climate change and atmospheric ozone destruction (Braun and Bremer, 2018). Besides slow-release; organomineral and sewage sludge fertilizers can offer many potential benefits for the fertilization of turfgrasses such as decreasing the leaching losses of nutrients (Granlund et al., 2000).

Slow-release fertilizers have lower nitrogen loss by leaching or volatilization, fewer chances of fertilizer burn, fewer applications at higher rates. Also, slow-release fertilizers provide economic savings and consistent release of nitrogen over a long period. Besides, slow-release nitrogen sources provide for more uniform growth compared to synthetic sources (Hummel and Waddington, 1981; Simonne and Hutchinson, 2005). Organomineral fertilizer is defined as organic fertilizers or soil improvers that are produced from organic ruins such as poultry litter, turf, or sewage sludge, with at least one inorganic source (Antille et al., 2013). These fertilizers contain vary in macro-nutrients, micro-nutrients, and organic matter content, but they provide nutrients via gradual solubilization (Eghball and Power, 1994; Carvalho et al., 2014). The use of organomineral and slow-release

fertilizers is one of the backbones of sustainable agricultural practices to eliminate the negative effects of the unbalanced use of chemical fertilizers on humans and the environment. Andiru et al. (2015) stated that slow-release fertilizer applications are as effective on plant growth as standard fertilizers. Sewage sludge is the product of sewage treatment in wastewater treatment plants and includes high levels (10% to > 20%) of organic matter, nitrogen, phosphorus, potassium, and some micronutrient elements such as copper, zinc, iron (Brady and Weil, 1999). The use of sewage sludge compost and other processed sludge products for turfgrass establishment and maintenance is an environmentally sound and cost-effective way to use sewage sludge-derived products. In addition to inorganic fertilizers, compost can be applied to the surface of turfgrass. Thus adding macro and micronutrients to the soil (Angle, 1994).

It is a necessity to investigate the use of alternative nitrogen sources to reduce environmental pollution. This research was conducted to the determination of the effects

of nitrogen sources and nitrogen doses on turf color, quality, and clipping yield for some warm-season turfgrasses.

## MATERIALS AND METHODS

This study was carried out in the turfgrass experimental plots of Research and Training Centre of Faculty of Agriculture, Bursa Uludag University, in Bursa, Turkey in 2017 and 2018. The research area has a Mediterranean-type climate. Table 1 shows the temperature, precipitation, relative humidity in 2017 and 2018 growing season, and long-term average records. The long-term average temperature was 19.5 °C, the average relative humidity was 61.7%, and seasonal precipitation was 281.3 mm in the region. Relative humidity of the 2017-2018 growing seasons were higher (8% and 11%, respectively) than the long-term average records. Likewise, average temperatures of the 2017-2018 growing seasons were higher (0.2 and 0.9°C, respectively) than the long-term average. The 2017-2018 growing season drier than the long-term average.

**Table 1.** Climate data of the research area.

Months	Temperature (°C)			Precipitation (mm)			Relative Humidity (%)		
	2017	2018	LT*	2017	2018	LT	2017	2018	LT
April	12.2	15.8	12.8	38.1	14.2	63.4	68.8	70.8	66.1
May	17.2	19.9	17.6	33.3	89.8	44.3	71.5	76.5	62.0
June	22.1	23.5	22.1	56.4	59.2	34.3	70.0	70.1	57.8
July	24.6	26.1	24.6	18.9	9.6	15.3	63.0	63.5	56.2
August	24.5	26.4	24.3	6.3	1.8	15.7	66.4	59.6	57.3
September	22.9	21.8	20.1	0.1	29.6	39.5	56.4	67.8	63.8
October	14.4	16.9	15.2	57.6	60.6	68.8	73.2	76.7	68.7
<i>Tot./Ave.</i>	<i>19.7</i>	<i>21.4</i>	<i>19.5</i>	<i>210.7</i>	<i>264.8</i>	<i>281.3</i>	<i>67.0</i>	<i>69.3</i>	<i>61.7</i>

\* LT: Long term (1950-2015)

The experiment was carried out on previously established turfgrass plots. The treatments were set up in a randomized complete block design with a split-split plot arrangement, having three replications. The trial was conducted on plots established in 2013. Turfgrass species were designated as the main plot, nitrogen sources as the subplots, and nitrogen doses as the sub subplots. The main plot size 6 m × 4 m = 24 m<sup>2</sup>, sub subplot size was 1 m × 2 m = 2 m<sup>2</sup>, total area 24 m<sup>2</sup> × 16 = 384 m<sup>2</sup>. The main plots consist of four nitrogen sources; Floranid® (16-7-15 + 2 MgO + minor elements), Biosmart® (23-5-7 + minor elements), Sewage sludge (4,7-1,9-0,6), and Hexaferm® (12-15-5 + 10SO<sub>3</sub> + minor elements). Types of fertilizers used in the research; Floranid and Biosmart were slow-release fertilizers, sewage sludge was obtained by collecting and processing solid wastes of vegetable from the wastewater treatment system of Penguen Food Company. The sludge was dried to evaporate the water and reduce the moisture content. The dried muds have been ground and turned into granules for ease of application. Sewage sludge was analyzed at Department of Soil Science and Plant Nutrition, Faculty of Agriculture, Bursa Uludag University before the beginning the experiment. Analysis results are presented in Tables 2 and 3. Hexaferm was organomineral fertilizer. The organomineral fertilizer

contains at least 20% organic matter, 7% humic-fulvic acid, 5% elemental sulfur-derived SO<sub>3</sub>, and zinc, as well as N, P, K.

Subplots consist of three warm-season turfgrass species, zoysiagrass (*Zoysia japonica* Steud. cv. Zenith), seashore paspalum (*Paspalum vaginatum* Sw. cv. Seaspray), hybrid Bermudagrass (*Cynodon transvaalensis* x *Cynodon dactylon* cv. Tifdwarf), and one cool-season turfgrass species, tall fescue (*Festuca arundinacea* Schreb. cv. Jaguar 4G). The nitrogen doses were grouped into sub-subplots. Nitrogen was applied monthly at rates of NS1: 0.0 (control) g N m<sup>-2</sup>; NS2: 2.0 g N m<sup>-2</sup>; NS3: 3.0 g N m<sup>-2</sup> and NS4 4.0 g N m<sup>-2</sup>. Irrigation was provided at 3-day intervals via a rotary sprinkler system. Nitrogen fertilizer treatments began in mid-April 2017 and lasted for seven months. Turfgrass color and quality were rated monthly. During the growing seasons, turfgrass color ratings were assessed visually on a scale of 1-9 (1 = completely yellow; 5 = unacceptable; 6 = acceptable; 9 = dark green). Turf quality was evaluated visually using a scale of 1-9 (1 = poorest; 5 = unacceptable; 6 = minimally acceptable; 7 = good; 9 = excellent) on each plot based on turfgrass uniformity, density, and color (Krans and Morris, 2007). When the plants reached a height of 6 to 8 cm, the subplots were mowed to a height of 4 cm. A 0.5 m 1.0 m strip across the

center of each plot was cut at each clipping date, dried at 70 °C for 48 hours, and then weighed (Candogan et al., 2014).

Color, quality, and clipping yields data were based on two years average results. Except for visual turf color and

quality, only clipping yield data were statistically analyzed. The differences between treatment means were evaluated by the least significant difference (LSD) at P= 0.05 probability level. (Steel and Torrie, 1980; Acikgoz et al., 2004; Kir et al., 2019).

**Table 2.** Analysis results of sewage sludge and soil.

Parameters (on a dry matter basis)	Soil	Sewage Sludge (Penguin)
pH (1:2.5, soil:water and 1:10, sludge:water)	8.48	6.73
Electrical conductivity (mmhos/cm)	468	6780
% N	0.106	4.66
Ammonium-N (mg.kg <sup>-1</sup> )		4.66
Total-P %		1.87
Available-P (mg.kg <sup>-1</sup> )	30.95	785.9
Organic C (%)	2.091	42.15
C/N (%)		5.24
Total Na (mg.kg <sup>-1</sup> )	675	1262.5
Total K (mg.kg <sup>-1</sup> )	5180	6050
Total Ca (%)	17415	2.51
Total Mg (mg.kg <sup>-1</sup> )	15090	7768.8
Total Mn (mg.kg <sup>-1</sup> )	788.3	625.6
Total Fe (mg.kg <sup>-1</sup> )	36210	9211.3

**Table 3.** Analysis result of some heavy metal standards and contents of sewage sludge and soil (mg kg<sup>-1</sup>).

Parameters	Standards*			
	Soil	Sewage Sludge	Research Area Soil	Sewage Sludge (Penguin)
Total Cd	1-3	10	0.148	1.4
Total Zn	50-300	2500	54.95	578.9
Total Cr	100	1000	134.0	176.4
Total Ni	30-75	300	97.08	93.1
Total Cu	50-140	1000	33.48	115.3
Total Pb	150-300	750	10.42	30.3

## RESULTS AND DISCUSSION

Results of visual turf color and quality average values present in Table 4, and clipping yield average values present in Table 5. Since warm-season turfgrasses were yellowish-brown throughout the winter months, only data from the spring-summer-autumn seasons were statistically analyzed for clipping yield (Kir et al., 2019).

During the experiment, nitrogen sources (NS), turfgrass species (TS), nitrogen doses (ND) substantially impacted visual turfgrass color, quality, and clipping yield. NS x TS interaction had a significant effect on turf color, quality, and clipping yields, except for the NS x TS interaction of the quality in spring season. NS x ND interaction color, quality, and clipping yields values were found significant for all season observations. TS x ND interactions turfgrass color, quality, and clipping were significant for all observations (Table 4). In the present study, generally the sewage sludge fertilizer produced minimum color and quality values among nitrogen sources, while the highest values were obtained from the application slow-release fertilizer. Biosmart, Hexaferm and Floranid gave high turf color and quality (Table 5). The highest clipping yield was obtained from Hexaferm slow-release fertilizer, and the

lowest clipping yield was obtained from sewage sludge fertilizer during the trial (Table 6).

Differences were observed between the effects of nitrogen sources used in our experiment. Higher color and quality values were obtained in one of the slow-release fertilizers compared to the other. This situation may have developed due to many different reasons, from minor element differences in the content of fertilizers to coating material. Some researchers state that slow-release fertilizers show different properties according to the coating material (Azeem et al., 2014; Mehmood et al., 2019). Slow-release fertilizers nitrogen releasing rate is affected by coating thickness, soil temperature, soil moisture, and soil N concentration gradient, which also affects plant growth (Braun and Bremer, 2018). Ucgun et al. (2020) reported that in the studies conducted with slow-release fertilizers, there were differences between fertilizers belonging to different companies, as well as differences between fertilizers belonging to the same company and using the same coating material, so emphasizes that the effect of factors such as the thickness of the coating material on the release time of the fertilizers. The nutrient release of slow-release fertilizers over time cannot be predicted exactly and the amount of release

depends on soil and climatic conditions (Azeem et al., 2014).

Biosmart x zoysiagrass, Biosmart x seashore paspalum, and Hexaferm x zoysiagrass interactions gave the highest

turfgrass color and quality values. Sewage sludge x hybrid Bermudagrass, sewage sludge x tall fescue interactions gave the lowest color and quality ratings.

**Table 4.** Result of variance analysis of color, quality, and clipping yield under nitrogen sources (NS), turfgrass species (TS), and nitrogen doses (ND).

Factor Sources of variation	Color			Quality			Clipping yield		
	Spr.***	Sum.	Aut.	Spr.	Sum.	Aut.	Spr.	Sum.	Aut.
NS	*	**	*	*	*	**	*	**	*
TS	**	**	**	**	**	**	**	**	**
ND	**	**	**	**	**	**	**	**	**
NS x TS	*	**	*	ns	*	*	*	**	**
NS x ND	**	**	**	**	*	*	**	*	*
TS x ND	**	**	**	**	**	**	**	*	**
NS x TS x ND	ns	*	*	*	*	*	**	**	*

\*, \*\*: F-test significant at  $p \leq 0.05$  and  $p \leq 0.01$ , respectively. ns: not significant.

\*\*\*: Spr: Spring, Sum.: Summer, Aut.: Autumn

**Table 5.** Turf color and quality of some turfgrass species (TS) under different nitrogen sources (NS), and nitrogen doses (ND).

NS	Color					Quality				
	Spr.	Sum.	Aut.	Win.	Mean	Spr.	Sum.	Aut.	Win.	Mean
NS <sub>1</sub>	5.6	6.2	5.9	-	5.9	5.5	5.9	5.7	-	5.7
NS <sub>2</sub>	5.9	6.4	6.0	-	6.1	5.8	6.2	5.8	-	5.9
NS <sub>3</sub>	5.3	5.8	5.4	-	5.5	5.3	5.7	5.2	-	5.4
NS <sub>4</sub>	5.7	6.2	5.9	-	5.9	5.7	6.1	5.9	-	5.9
Mean	5.6	6.1	5.8	-	5.8	5.6	6.0	5.7	-	5.7
TS										
1	5.2	6.0	5.4	-	5.5	5.1	5.8	5.2	-	5.4
2	5.9	6.5	6.0	-	6.1	5.7	6.2	5.9	-	5.9
3	6.0	6.7	5.9	-	6.2	5.9	6.4	5.7	-	6.0
4	5.5	5.6	6.0	-	5.7	5.5	5.5	5.9	-	5.6
Mean	5.6	6.2	5.8	-	5.8	5.6	6.0	5.7	-	5.7
ND										
0.0	3.1	3.7	3.4	-	3.4	3.0	3.4	3.3	-	3.2
2.0	5.5	6.1	5.7	-	5.7	5.4	5.9	5.7	-	5.7
3.0	6.6	7.1	6.7	-	6.8	6.5	6.9	6.5	-	6.6
4.0	7.4	7.9	7.4	-	7.5	7.3	7.7	7.2	-	7.4
Mean	5.6	6.2	5.8	-	5.8	5.6	6.0	5.7	-	5.7

\*: NS1: Floranid® (16-7-15 + 2 MgO + minor elements), NS2: Biosmart® (23-5-7 + minor elements), NS3: Sewage sludge (4,7-1,9-0,6), and NS4: Hexaferm® (12-15-5 + 10SO<sub>3</sub> + minor elements)

\*\*: 1: Tifdwarf (*Cynodon transvaalensis* x *Cynodon dactylon*), 2: Seaspray (*Paspalum vaginatum* Sw), 3: Zenith (*Zoysia japonica* Steud.), 4: Jaguar 4G (*Festuca arundinacea* Schreb.)

\*\*\*: g N m<sup>-2</sup>

The sewage sludge fertilizer exhibited values above 6 with respect to color and quality, which is acceptable for some observations. However, compared to other nitrogen sources, it exhibited lowest turf color, quality, and clipping yield values (Table 5). In our previous study, which we carried out using three different sewage sludge, it was determined that the application of sewage sludge at rates as low as 4.0 g N m<sup>-2</sup> was beneficial as at least 6.0 g N m<sup>-2</sup> nitrogen dose. Although sewage sludge was less effective than chemical fertilizers, it at least resulted in acceptable turfgrass color and quality, so it was stated that sewage sludge may be an alternative to chemical fertilizers (Zere and Bilgili, 2016). In a study conducted by applying sewage sludge to Bermudagrass, researchers reported positive results for turf growth. The use of sewage sludge is an

alternative to waste disposal as it meets environmental and economic requirements (Nobile et al., 2014). However, heavy, or toxic metals in sewage sludge cause heavy metal accumulation and threaten long-term soil quality (Dai et al., 2007; Lin et al., 2017). The sewage sludge used in the study was collected from the activated sludge system of a food processing and canning factory, not from industrial production, so the heavy metal concentration of the sewage sludge was low. Therefore, they did not pose environmental damage or a potential health risk. Heavy metal contents of the sewage sludge were all lower than the recommended limit values in sewage sludge as stated by USEPA 40 CFR Part 503 regulations (USEPA, 1994).

**Table 6.** Clipping yield of some turfgrass species (TS) under different nitrogen sources (NS), and nitrogen doses (ND).

NS	Spring	Summer	Autumn	Winter	Mean
NS <sub>1</sub>	116.9 b	119.5 c	99.5 c	-	111.9
NS <sub>2</sub>	134.3 a	154.1 a	134.4 a	-	140.9
NS <sub>3</sub>	110.5 b	118.7 c	97.2 c	-	108.8
NS <sub>4</sub>	126.2 a	134.9 b	120.2 b	-	127.1
Mean	121.9	131.8	112.8		122.2
LSD <sub>0.05</sub>	8.08	4.55	10.90	-	
TS					
1	69.0 d	86.2 c	77.7 d	-	77.6
2	149.3 b	164.1 b	127.7 b	-	147.0
3	182.4 a	200.3 a	154.1 a	-	178.9
4	87.2 c	76.5 d	92.2 c	-	85.3
Mean	121.9	131.7	112.9		122.2
LSD <sub>0.05</sub>	8.50	7.04	8.19	-	
ND					
0.0	37.8 d	47.4 d	40.9 d	-	42.0
2.0	102.3 c	111.4 c	95.3 c	-	103
3.0	140.1 b	156.4 b	130.7 b	-	142.4
4.0	207.8 a	211.8 a	184.6 a	-	201.4
Mean	122	131.7	112.8		122.2
LSD <sub>0.05</sub>	6.82	8.63	8.23	-	

\*: F-test significant at  $P < 0.05$ , \*\*: F-test significant at  $P \leq 0.01$ , ns: not significant.

NS: Nitrogen Sources, TS: Turfgrass species, ND: Nitrogen Doses.

The highest color and quality values were obtained from Biosmart x 4.0 g N m<sup>-2</sup> interaction for the spring season, and from the Biosmart x 4.0 g N m<sup>-2</sup> and hexaferm x 4.0 g N m<sup>-2</sup> interaction for the summer and autumn seasons. Also, Biosmart x 4.0 g N m<sup>-2</sup> interaction gave the highest clipping yield, and Floranid x 0.0 g N m<sup>-2</sup>, sewage sludge x 0.0 g N m<sup>-2</sup> interactions gave the lowest clipping yield values.

In our study, zoysiagrass and seashore paspalum showed high color and quality values for summer season. Likewise, the highest clipping yields were obtained from zoysiagrass and seashore paspalum (Table 5, 6). Due to improved morphological uniformity seashore paspalum and zoysiagrass are high turf quality (Hanna and Anderson, 2008). Hybrid Bermudagrass color, quality, and clipping yield values found lower than other warm-season turfgrasses (Table 5, 6). Rezende et al. (2020) determined that Bermudagrass has slow growth, and consequently a low need for maintenance. During our study, tall fescue, which is a cool-season turfgrass, has low color and quality scores in the summer season when compared to warm-season turfgrasses. The highest color and quality values of tall fescue were obtained in the spring and autumn season when the temperature is lower than summer months. As a result, higher turfgrass color and quality values were obtained from the warm-season turfgrasses at low nitrogen doses in the summer season than the cool-season turfgrasses. Temperature is the major factor limiting the growth of cool-season turfgrasses during the summer months (Jiang and Huang, 2001). Researchers indicated that warm-season turfgrass optimum growth rate occurs at lower nitrogen concentrations than cool-season grasses also, nitrogen requirements are less than cool-season grasses. Warm-season grasses grow faster than cool-season

turfgrass across a wide range of nitrogen concentrations (Wilson and Brown, 1983; Brown, 1985).

As a rule, warm season turfgrasses perform well in the summer on average, whereas cool-season turfgrasses do well during the coldest months (Richardson et al., 2008; Charif, 2021). Some researchers have observed that warm-season grass species use less water to generate the same dry matter weight due to their distinct physiology, therefore they are more suitable to Mediterranean climates and have greater recovery when compared to cool-season turf species (Croce et al., 2004; Turgeon, 2012; Volterrani and De Bertoldi, 2012; Lulli et al., 2012; Fontanelli et al., 2017). When warm-season turfgrasses begin active development during an optimal spring transition, cool-season turfgrasses lose vigor and density (Horgan and Yelverton, 2001).

The amount of nitrogen applied was the most important factor in determining turfgrass quality (Trenholm and Unruh, 2005). Increasing the dose of N application enhanced the color and quality for both years in our research. The 4.0 g N m<sup>-2</sup> dose provided the highest turf color and quality. The second highest turf color and quality obtained was 3.0 g N m<sup>-2</sup>. Except for the summer season of color, 2.0 g N m<sup>-2</sup> nitrogen dose exhibited unacceptable turf color and quality. In all seasons, the control N rate (0.0 g N m<sup>-2</sup>) ranked unsatisfactory quality (rating < 6). Clipping yield values increased with increasing nitrogen doses (Table 6). Turf quality is a multifaceted feature that plays a critical role in turfgrass assessment (Russi et al., 2004). The visual ratings of turfgrass quality, which is based on a mix of color, density, uniformity, disease or environmental stress, and other factors, is generally done monthly or seasonally on a scale of 1 to 9 (Morris and Sherman, 2000). In the present study, an acceptable turfgrass color and quality were attained under the 3.0 g N m<sup>-2</sup> dose treatment

throughout all months of the trial season. (Table 5). Our previous study applied the doses of chemical fertilizers (0, 2, 4, 6 g N m<sup>-2</sup>) on three different warm-season turfgrass species of the hybrid Bermudagrass (Tifdwarf: *Cynodon dactylon* x *Cynodon transvaalensis*; Gobi, Sydney: *Cynodon dactylon* L. Pers.) was determined a nitrogen dose of 4.0 g N m<sup>-2</sup> for acceptable turfgrass color and quality in the Mediterranean-type climate (Bilgili et al., 2017). It can be said that the application of microbial fertilizer in lower doses compared to chemical fertilizer improves color and quality.

Zoysiagrass x 4.0 g N m<sup>-2</sup> and seashore paspalum x 4.0 g N m<sup>-2</sup> interactions gave the highest turf color and quality values. While zoysiagrass x 4.0 g N m<sup>-2</sup> interactions gave the highest clipping yields, hybrid Bermudagrass x 0.0 g N m<sup>-2</sup> gave the lowest clipping yields.

Warm-season turfgrasses develop best in the temperature range of 25-35°C. These species thrive well in the summer when the temperature is high. In autumn and winter, when the temperature drops below 10°C, their growth ceases and their color turns yellow-brown (Christians, 2004; Bilgili et al., 2016). "Dormancy", which appears in the form of yellowing in warm-season turfgrass

plants in winter, occurs as a result growth arrest and fragmentation of chlorophyll molecules, only the living growth points remaining in the knuckles of stolons and rhizomes survive the winter (Avcioglu, 1997). According to the recorded data of both years, which revealed similar results; the earliest zoysiagrass entered the dormant period in autumn, followed by seashore paspalum, and hybrid Bermudagrass varieties, respectively. The period of dormancy for both years showed substantial similarity to the previous year for zoysiagrass (80 and 83 days), seashore paspalum (133 and 123 days), and hybrid Bermudagrass (108 and 110 days) (Table 7). Some researchers declare that zoysiagrass enters the dormant period at the earliest in autumn, and they report results consistent with our findings. Also, researchers working on zoysiagrass report that this turfgrass plant has a shorter dormant period than other warm-season turfgrasses (Croce et al., 2004; Aaron et al., 2007; Salman, 2008). Certain components of turfgrass care, such as fertilizer, mowing, and irrigation type, can also impact quality, color, and dormancy and should be considered when evaluating turfgrasses for dormancy length.

**Table 7.** Dates of the beginning and the exit from dormancy during the years of trial.

Species	Beginning of dormancy	Cessation of dormancy	Vegetation (days)	Dormancy (days)
Tifdwarf		31.03.2017		108
Seaspray		22.03.2017		133
Zenith		08.03.2017		80
Tifdwarf	04.12.2017	24.03.2018	248	110
Seaspray	10.12.2017	12.04.2018	263	123
Zenith	10.12.2017	03.03.2018	277	83
Tifdwarf	03.12.2018		254	
Seaspray	08.12.2018		271	
Zenith	08.12.2018		280	

## CONCLUSION

In this research, two slow-release fertilizers, one organomineral fertilizer, and one sewage sludge were used. Results of this study showed that effects of the slow-release fertilizers used in the study were different. Among the slow-release fertilizers, slow-release fertilizer (NS2) gave better turf color and quality than slow-release fertilizer (NS1) showed a lower performance. The slow-release fertilizer (NS2), organomineral fertilizer gave high turf color and quality. The lowest performance was obtained sewage sludge fertilizer. Zoysiagrass and seashore paspalum showed almost equivalent scores in terms of color and quality parameters. We can say that zoysiagrass and paspalum turfgrass species are more successful than other turfgrass species. Our results suggest that to provide acceptable turf color and quality at least throughout the growing season should be fertilized with 3.0 g m<sup>-2</sup> N monthly. To eliminate the negative environmental effects caused by chemical fertilizers, a sustainable understanding, and program that envisages the effective application of microbial fertilizers in agriculture should be put into effect.

In this context, slow-release and organomineral fertilizers can be assessable as sources that will meet the nutritional needs of the turfgrasses.

## ACKNOWLEDGMENTS

This research was supported by The Scientific and Technical Research Council of Turkey (Tubitak-1120745 Project Leader: Prof. Dr. Ugur Bilgili). The authors thank The Scientific and Technical Research Council of Turkey for financial support during this study.

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