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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Assessing the Impacts of Various Nitrogen Sources on Some Cool Season Turfgrasses*

Farklı Azot Kaynaklarının Bazı Serin İklim Çim Bitkileri Üzerine Etkilerinin Değerlendirilmesi

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Abstract

This study was conducted to determine the effects of different nitrogen resources on plant growth and turf quality of some cool season turfgrasses in 2017 and 2018 years at Bursa Osmangazi Municipality, Directorate of Parks and Gardens. The experiment was set out as two factors in randomized blocks with three replications. Nitrogen resources [slow release fertilizer (Biosmart 23-5-7), vermicompost (Sesol) and chemical fertilizer (21% ammonium sulphate)] were first factor and different cool season turfgrass (*Lolium perenne*, *Festuca arundinacea*, *Poa pratensis*) were second factor. The plot size is $1 \times 2 = 2\ m^{-2}$ and the sowing norm is $40\ g\ m^{-2}$. In the study, forever variety of perennial ryegrass, Debussy variety of tall fescue and Shannon variety of Kentucky bluegrass were used as plant materials. According to the results of the experiment; among the turfgrasses, *Festuca arundinacea* has given the best turf color and quality. This turfgrass was followed by *Lolium perenne*. The lowest performance was observed in *Poa pratensis*. The best results were obtained from ammonium sulphate in terms of nitrogen sources. However, in some observations and measurements, slow release fertilizer and ammonium sulphate also gave the best results, while the lowest turf color, quality and dry matter yield were obtained from vermicompost. Although slow release fertilizer is not superior to ammonium sulphate fertilizer, in most observations it gives values over 6, which is the lower limit of acceptable color and quality values. Based on these results, it can be said that slow-release fertilizer is not much superior to ammonium sulfate fertilizer, but it performs as well as it does. However, due to the phenomenon of nitrogen leaching that occurs in nitrogen fertilizers used in the fertilization of turfgrass plants, it is known that groundwater pollution and related environmental and health problems occur. Although the slow-release fertilizer used in the experiment did not yield the best turfgrass color and quality values at all observation dates, it did yield values above the lower limit of 6, which is considered acceptable, in most observations. Therefore, in areas where there are no high expectations regarding turf color, the application of slow-release fertilizer will both ensure the attainment of an acceptable turf color and contribute to environmental protection.

Key words: Nitrogen sources, Turf color, Turf quality, *Lolium perenne*, *Festuca arundinacea*, *Poa pratensis*

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Öz

Bu çalışma; 2017 ve 2018 yıllarında Bursa Osmangazi Belediyesi, Park ve Bahçeler Müdürlüğü, Fidanlık Tesislerinde, bazı serin iklim çim bitkilerinin bitki büyümesi ve çim kalitesi üzerine farklı azot kaynaklarının etkilerini belirlemek amacıyla yürütülmüştür. Deneme, üç tekrarlamalı, iki faktörlü olarak tesadüf blokları deneme desenine göre kurulmuştur. Azot kaynakları [yavaş salınımlı gübre (Biosmart 23-5-7), solucan gübresi (Sesol) ve kimyasal gübre (%21 amonyum sülfat)] birinci faktör, farklı serin iklim çim bitkileri [çok yıllık çim (*Lolium perenne,* kamışsı yumak (*Festuca arundinacea*) ve çayır salkım otu (*Poa pratensis*)] ise ikinci faktördür. Parsel büyüklüğü 1 × 2 = 2 m^2 ve ekim normu 40 g m^{-2}'dir. Çalışmada bitki materyali olarak çok yıllık çimin Forever, kamışsı yumağın Debussy ve çayır salkım otunun Shannon çeşitleri kullanılmıştır. Araştırma sonuçlarına göre; çim türleri arasında kamışsı yumak en iyi çim renk ve kalitesini vermiştir. Bu çim türünü çim renk ve kalitesi bakımından çok yıllık çim takip etmiştir. En düşük performans ise çayır salkım otunda gözlenmiştir. Azot kaynakları arasında en iyi sonuçlar amonyum sülfat gübresinden elde edilmiştir. Ancak bazı gözlem ve ölçümlerde yavaş salınımlı gübre ile amonyum sülfat en iyi sonuçları birlikte verirken, en düşük çim renk, kalite ve kuru ot verimi solucan gübresinden elde edilmiştir. Yavaş salınımlı gübre amonyum sülfat gübresinden üstün olmasa da çoğu gözlemde kabul edilebilir renk ve kalite değerlerinin alt sınırı olan 6 puanın üzerinde değerler vermektedir. Bu sonuçlara göre yavaş salınımlı gübrenin amonyum sülfat gübresinden çok üstün olmadığını, ancak onun kadar görev yaptığını söylemek mümkündür. Ancak çim bitkilerinin gübrelenmesinde kullanılan azotlu gübrelerde meydana gelen azot yıkanması olayı nedeniyle; yer altı sularının kirlenmesi ve buna bağlı olarak bazı çevre ve sağlık sorunlarının meydana geldiği bilinmektedir. Denemede yer alan yavaş salınımlı gübre tüm gözlem tarihlerinde en iyi çim renk ve kalite değerlerini vermemiş olsa da çoğu gözlemde kabul edilebilir renk ve kalite değerinin alt sınırı olan 6'nın üzerinde değerler vermiştir. Dolayısıyla çim rengi konusunda yüksek bir beklentinin olmadığı alanlarda yavaş salınımlı gübre uygulanması hem kabul edilebilir bir çim renginin elde edilmesini sağlayacak hem de çevrenin korunmasına yardımcı olacaktır.

Anahtar kelimeler: Azot kaynakları, Çim rengi, Çim kalitesi, *Lolium perenne, Festuca arundinacea, Poa pratensis*

1. Introduction

Perennial ryegrass (*Lolium perenne* L.), tall fescue (*Festuca arundinacea* Screb.), and Kentucky bluegrass (*Poa pratensis* L.) are favored cool season turf species for lawns set up in public and private parks, sports fields, golf course tees, fairways and rough. These cool-season turfgrass cultivars are the primary genotypes used for lawn installation in the Mediterranean countries (Russi et al., 2001; Russi et al., 2004; Martiniello, 2005; Bilgili and Acikgoz, 2007; Demiroglu et al., 2010; Salman et al., 2011).

Turfgrass is an important component of the urban and suburban landscape, contributing to water quality and nutrient cycling. Turfgrass managers have been under pressure to schedule N applications to maximize N use efficiency due to rising energy and subsequent N prices, as well as environmental concerns (Busey and Parker, 1992; Bauer et al., 2012). The mineral component that plants need in the greatest amounts is nitrogen (N), and it is frequently the one that limits turfgrass growth and development (Liu et al., 2008). N is required for the structural and functional properties of amino acids, amides, nucleotides, nucleic acids, pigments, and certain hormones (Hull and Liu, 2005).

The major objective of fertilizing turfgrass is to keep excellent turf density and color without encouraging excessive high growth. The fertilization program should be suited to the turfgrass's growth characteristics in order to accomplish this purpose. Fertilizer N that exceeds plant needs and soil capacity can depart lawns in a variety of ways, and the risk of excessive N losses due to over fertilizing increases with turfgrass age (Frank et al., 2006). N should be used with a frequency and rate that corresponds to the need for turfgrass. Plant uptake, gaseous atmospheric loss, soil storage, leaching, runoff, and clipping removal are some of the ways that the soil loses nitrogen (Petrovic, 1990). Fertilizers should be applied to turfgrass during the active growing season to reduce N leaching. Nitrate leaching has always been a problem of turf nitrogen loss. N leaching has the potential to degrade both surface and groundwater, causing eutrophication, acidification, and the potable water supply depletion (Chen et al., 2018). The yearly N leaching rates for turfgrass, according to Barton and Colmer (2006), 0 to 160 kg N ha^{-1} and contribute for up to 30% of N fertilizer applied.

Nitrogen sources can be divided into four categories: soluble, natural organic, reactive, and coated (Association of American Plant Food Control Officials, 2017). It is generally known that adequately applied N sources regularly raise turfgrass quality. Slow-release fertilizers give nutrients gradually over an extended period of time, increasing the effectiveness of using nitrogen fertilizer. Agriculture's usage of slow-release fertilizers is mostly restricted to turf (Zhang et al., 1998). Plant and animal by products or waste products are natural organic nitrogen sources. They are often lower in nutrient content, have limited burn or leaching potential, and require warm, moist soils to be available. Different organic sources emit nitrogen at varying rates.

In comparison to chemical fertilizers, organic fertilizers may have a decreased tendency to burn turfgrass, longer-lasting effects on turfgrass, vital nutrients in addition to nitrogen, and an increase in terms of total soil microbial populations (Liu et al., 1995) and decreasing thatch accumulation (Berndt et al., 1990). Additionally, some organic fertilizers can assist enhance the soil's physical properties (Duble, 1996; Mc Coy, 1998). Furthermore, because of the nutrient release rate is slower than with chemical fertilizers, nitrogen loss due to leaching or runoff, and thus negative environmental impact, may be decreased. As a result, although the price of organic fertilizers is higher than chemical fertilizers, some lawn managers prefer organic fertilizers (Cockerham and Minner, 1999).

This study's objective was to ascertain how various nitrogen sources affected plant development and turf quality in a few cool-season turfgrass species [perennial ryegrass (*Lolium perenne*), tall fescue (*Festuca arundinacea*) and Kentucky bluegrass (*Poa pratensis*)].

2. Materials and Methods

The research was carried out between 2017 and 2018 at turfgrass research plots of the Bursa-Osmangazi Municipality Parks and Gardens Directorate in Turkey. On the experimental site, the top 20 cm of soil were a sandy loam that was 7.4 pH, 180 kg K ha^{-1} rich in potassium, 71 kg P ha^{-1} medium in phosphorous, and 0.5% rich in organic matter. During the summer months, the land was tilled, levelled and rolled. 20 g P m^{-2} and 10 g K m^{-2} were added to the seedbed prior to sowing. On a yearly basis, average temperatures in 2017 and 2018 were 14.8, and 15.8 °C, respectively, with an average relative humidity of 69.3%. In 2017, and 2018, the yearly precipitation totaled 481.4 and 655.0 mm, respectively. The precipitation total in 2017 was 481.4 mm, which is significantly less than the long-term normal (695.1 mm).

Treatments in this trial were organized as two factors in randomized blocks with three replications. Plot size was 1 × 2 = 2 m^2 (Skogley and Sawyer, 1992; Bilgili et al., 2011), and the seeding rate was 40 g m^{-2}. Perennial ryegrass (*Lolium perenne*) cv. Forever, tall fescue (*Festuca arundinacea*) cv. Debussy 1, and Kentucky bluegrass (*Poa pratensis*) cv. Shannon were used as research materials.

According to the soil analysis results, the soils of the trial area; clay loam texture. It has a sufficient level of phosphorus and potassium, high in organic matter, slightly alkaline and pH 7.62. In terms of lime, it is in the low-lime class. On October 15, 2016, the experiment was started. After sowing the seeds were covered with a soil and peat mixture to keep the soil surface moist until full emergence. A rotating sprinkler system was used to apply irrigation on a regular basis in order to keep the soil near field capacity.

Fertilizer treatment were begun in the April 2017 and continued for 7 months (April-October) both years. As three nitrogen sources, nitrogen was applied monthly at dose of 5 g N m^2. Slow release fertilizer (Biosmart-23-5-7), vermicompost (Sesol-2.2-1.5-1.1), ammonium sulphate (21-0-0). Since the most appropriate turf color and turf quality was obtained from the application of a monthly dose of 5.0 g N m^{-2} in previous studies in the region (Bilgili and Acikgoz, 2005; Bilgili et al., 2011), we determined this dose as the standard nitrogen dose in our study.

Throughout the growth season, visual turfgrass color ratings were taken on each clipping date before mowing, using a scale of 1-9, where 1 = entirely yellow and 9 = dark green (Wehner and Martin, 1989; Goatley et al., 1994). Turfgrass uniformity, density, and color were visually assessed (1 = poorest; 5 = unacceptable; 6 = minimally acceptable; 7 = good; 9 = exceptional) at each clipping date on each plot during the growing seasons. Mowing was carried out between April and October seven times on different dates each year. First cutting was made on April 26, 2017, and when the plants reached a height of 6-8 cm, they were cut to 4 cm with a mower. Mowing was done in the 0.5 m x 1 m area in the middle of each plot, and then dried at 70 °C for 48 hours, and weighed (Karcher and Richardson, 2005; Bilgili et al., 2011; Kir, et al., 2019).

All data for the randomized complete block design were statistically analyzed using ANOVA findings. The least significant difference (LSD) at the P= 0.05 probability level was used to assess the differences between treatment means. An analysis of variance was performed on color and turf quality ratings, as well as cutting weights, for each sampling date.

3. Result and Discussion

Generally, turfgrass species (TS) and nitrogen sources (NS), and their two-way interactions had a significant effect on turf color, quality, and clipping yields, with the exception of the TS, NS factors and TS × NS interactions in some dates in both years (*Table 1*).

Data in *Table 2* shows that turf color was significantly affected by turfgrass species at all observation dates during the two years. Tall fescue had a greater color value than other species in all observations both years. In some observations, perennial ryegrass gave the highest color values with tall fescue. However, the Kentucky bluegrass had the lowest color values in all observations in 2017 and some observations in 2018. The ideal temperature for cool-season grass shoot growth is between 15 and 23 °C (Beard, 1973). However, during the summer months, temperatures in the transitional zone frequently reach 30 °C or greater. Cool-season turfgrasses grow best at 16-24 °C, with reduced growth occurring when temperatures approach 33 °C (Beard, 1973; Van Huylenbroeck et al., 1999). Drought, when combined with heat stress, can endure for extended periods of time. Drought or heat stress alone causes significant deterioration in cool season turfgrass quality (Wehner and Watschke, 1981; Huang et al., 1998a, b). Many species, including creeping bentgrass, Kentucky bluegrass, and perennial ryegrass, saw declines in photosynthetic rate, chlorophyll content, cell membrane stability, and carbohydrate buildup as a result of heat stress (White et al., 1988; Howard and Watschke, 1991; Huang et al., 1998b).

Table 1. Result of variance analysis of turf color, quality and clipping yields under turfgrass species (TS) and nitrogen sources (NS) in 2017 and 2018 experimental years.

Variation Sources	DF	Color						
		2017						
		26.4.17	26.5.17	16.6.17	06.7.17	02.8.17	17.9.17	21.10.17
TS	2	**	**	**	**	**	**	**
NS	2	**	**	**	ns	ns	**	ns
TS x NS	4	ns	*	*	ns	ns	*	ns
		2018						
		25.4.18	15.5.18	04.6.18	07.7.18	12.8.18	25.9.18	29.10.18
TS	2	**	**	**	**	**	**	**
NS	2	**	**	**	ns	ns	ns	ns
TS x NS	4	**	**	**	ns	ns	ns	ns
		Quality						
		2017						
		26.4.17	26.5.17	16.6.17	06.7.17	02.8.17	17.9.17	21.10.17
TS	2	**	**	*	ns	**	**	**
NS	2	**	**	**	*	*	ns	ns
TS x NS	4	*	ns	ns	*	**	ns	**
		2018						
		25.4.18	15.5.18	04.6.18	07.7.18	12.8.18	25.9.18	29.10.18
TS	2	**	**	**	**	**	**	**
NS	2	*	ns	**	ns	*	ns	ns
TS x NS	4	**	**	ns	*	ns	ns	**
		Clipping Yields						
		2017						
		26.4.17	26.5.17	16.6.17	06.7.17	02.8.17	17.9.17	21.10.17
TS	2	**	ns	**	**	**	**	**
NS	2	ns	**	**	**	**	**	ns
TS x NS	4	**	Ns	**	ns	ns	*	ns
		2018						
		25.4.18	15.5.18	04.6.18	07.7.18	12.8.18	25.9.18	29.10.18
TS	2	**	**	**	**	**	ns	**
NS	2	**	**	**	**	**	*	**
TS x NS	4	**	**	ns	**	**	ns	**

*: Significant at $p = 0.05$, **: Significant at $p = 0{,}01$, ns: Nonsignificant ($p > 0.05$)

Turfgrass species had significant effects on turf quality, as well as on turf color, in both years, except for the observation in July 2017. Tall fescue had a higher quality value than the other species in all two years of observations. In certain cases, perennial ryegrass outperformed tall fescue in terms of quality. In both years, Kentucky bluegrass had the lowest overall quality values (*Table 3*).

The highest turf color and quality at most observation dates was obtained from ammonium sulfate fertilizer. In addition, slow release fertilizer was included in the same statistical group with ammonium sulphate fertilizer on some observation dates and provided the best turf color and quality values. Among the nitrogen sources, the lowest turf color and quality values were obtained from vermicompost (*Table 2* and *3*). Generally, tall fescue and perennial ryegrass produced more uniform turf quality than Kentucky bluegrass. However, a decreasing trend in quality was observed from spring to late summer in both grass species and nitrogen sources in both years in the study (*Table 3*). Numerous studies have found that nitrogen has an impact on turfgrass color and quality.

Table 2. Turf color ratings (1-9) under turfgrass species and nitrogen sources in 2017 and 2018 experimental years.

TS	**2017**						
	26.4.17	**26.5.17**	**16.6.17**	**06.7.17**	**02.8.17**	**17.9.17**	**21.10.17**
L. perenne	8.0 a	7.8 b	8.5 b	8.7 a	8.4 a	8.2 b	8.5 b
F. arundinacea	7.7 a	8.8 a	9.0 a	9.0 a	8.3 a	9.0 a	9.0 a
P. pratensis	7.0 b	7.2 c	7.7 c	7.5 b	7.8 b	8.1 b	7.1 c
LSD (0.05)	0.49	0.43	0.26	0.33	0.40	0.40	0.40
NS**							
SRF	7.7 a	7.8 b	8.5 a	8.3	8.3	8.5 a	8.2
VC	7.1 b	7.5 b	8.1 b	8.3	8.0	8.0 b	8.0
AS	7.8 a	8.5 a	8.6 a	8.6	8.3	8.7 a	8.4
LSD (0.05)	0.49	0.43	0.26	ns	Ns	0.40	ns
TS	**2018**						
	25.4.18	**15.5.18**	**04.6.18**	**07.7.18**	**12.8.18**	**25.9.18**	**29.10.18**
L. perenne	8.7 a	9.0 a	8.8 a	7.0 b	7.2 b	8.0 b	6.6 b
F. arundinacea	9.0 a	9.0 a	9.0 a	8.7 a	8.2 a	9.0 a	8.7 a
P. pratensis	7.7 b	8.1 b	7.3 b	7.0 b	7.2 b	8.1 b	7.0 b
LSD (0.05)	0.30	0.27	0.19	0.50	0.45	0.46	0.66
NS							
SRF	8.2 b	8.5 b	8.3 b	7.5	7.6	8.5	7.6
VC	8.3 b	8.5 b	8.2 b	7.6	7.6	8.3	7.2
AS	9.0 a	9.0 a	8.6 a	7.5	7.3	8.2	7.5
LSD (0.05)	0.30	0.27	0.19	ns	ns	ns	ns

**: SRF: Slow release fertilizer, VC: Vermicompost, AS: Ammonium sulphate

Table 3. Turf quality ratings (1-9) under turfgrass species and nitrogen sources in 2017 and 2018 experimental years.

TS	**2017**						
	26.4.17	**26.5.17**	**16.6.17**	**06.7.17**	**02.8.17**	**17.9.17**	**21.10.17**
L. perenne	7.5 a	7.5 a	8.3 a	6.0	5.0 b	3.7 b	5.5 c
F. arundinacea	7.1 a	7.5 a	8.0 ab	6.4	6.0 a	6.8 a	7.6 a
P. pratensis	5.4 b	6.3 b	7.6 b	6.0	5.3 b	4.0 b	6.4 b
LSD (0.05)	0.54	0.58	0.48	ns	0.43	0.56	0.64
NS							
SRF	6.7 b	7.7 a	8.3 a	6.2 a	5.3 b	4.3	6.7
VC	6.0 c	6.1 b	7.3 b	5.7 b	5.7 a	4.7	6.3
AS	7.3 a	7.5 a	8.3 a	6.4 a	5.2 b	4.5	6.5
LSD (0.05)	0.54	0.58	0.48	0.41	0.43	ns	ns
TS	**2018**						
	25.4.18	**15.5.18**	**04.6.18**	**07.7.18**	**12.8.18**	**25.9.18**	**29.10.18**
L. perenne	7.8 b	6.5 a	6.2 b	4.1 c	5.2 b	5.7 b	5.8 b
F. arundinacea	8.7 a	6.8 a	6.8 a	7.1 a	6.5 a	7.5 a	7.7 a
P. pratensis	5.1 c	5.1 b	4.7 c	4.8 b	5.2 b	5.0 c	6.1 b
LSD (0.05)	0.61	0.60	0.60	0.54	0.45	0.43	0.60
NS				8.6 a			
SRF	7.5 a	5.8	6.2 a	5.6	6.0 a	6.0	6.5
VC	6.7 b	6.4	5.4 b	5.3	5.6 ab	6.1	6.4
AS	7.4 a	6.2	6.2 a	5.1	5.3 b	6.2	6.7
LSD (0.05)	0.61	ns	0.60	ns	0.45	ns	ns

During both years of the study, Carrow (1996) found that polymer-coated urea, sulfur coated urea, reacted urea, and natural organics produced mean yearly lawn color and quality that was less than or equivalent to urea. Reports of urea failing to produce appropriate lawn color and quality are rare, and are frequently dependant on N rate. Turfgrass quality is largely controlled by N. It has been shown that sufficient N must be applied to turf annually to maintain shoot growth, recuperative potential, color, and quality (Kerek et al., 2003). Hummel (1989) found that sulfurcoated urea and resincoated urea had the highest N recoveries when compared to normal soluble urea and concluded that resincoated ureas were an appropriate alternative for N supply. Zorer Çelebi et al. (2010) stated that wastewater treatment sludge increases the turfgrass performance of perennial ryegrass, can be used as an alternative to farm manure during the establishment phase, and the long-term nutrient needs of perennial ryegrass can be met from wastewater treatment sludge. Nizam (2009) determined that 12 kg da^{-1} N dose was suitable for seed production of perennial ryegrass in Tekirdağ conditions among 2001-2003, out of the N doses applied at 0, 12, 24 and 36 kg da^{-1}. Yılmaz (2021) investigated the effects of different row spaces (20 and 40 cm) and nitrogen doses (0, 10, 20 30 g N m^{-2}) on the seed yield and some agronomic characteristics of the perennial ryegrass variety "Esquire" in Sakarya/Pamukova, and stated that 30 g m^{-2} nitrogen dose gave the highest seed yield, but 20 g m^{-2} nitrogen dose would be a more environmentally friendly solution to avoid both fertilizer costs and pollution of soil and groundwater. In a study conducted under Tokat conditions, the effects of 5 different fertilizer doses (N-P-K; 0-0-0, 8-5-5, 16-10-10, 24-15-15 and 32-20-20 kg da^{-1}) applied to cool season turfgrass mixture (*Lolium perenne* cv. Ovation, *Poa pratensis* cv. Geronimo, *Festuca rubra rubra* cv. Franklin and *Festuca rubra commutata* Koket) on turf field performance were investigated between 1999 and 2002. According to the research results, the most suitable fertilizer dose was determined as 24-15-15 kg da^{-1} (Yılmaz, 2003). In another study, Yılmaz et al. (2011) investigated the effects of 8 different fertilizer doses (N-P-K; 0-0-0, 5-3-3, 10-6-6, 15-9-9, 20-12-12, 25-15-15, 30-18-18 and 35-21-21 kg da^{-1}) applied to a cool season grass mixture (40% *Lolium perenne* cv. Roadster, 25% *Festuca rubra commutata* cv. Intrique, 20% *Festuca rubra* cv. Fenway, 10% *Poa pratensis* cv. Wildhorse and 5% *Agrostis tenuis* cv. Highland) on turfgrass performance during the 2007-2010 period in Tokat ecological conditions, and the most suitable fertilizer doses were determined as 20-12-12 and 25-15-15 kg da^{-1}.

Table 4. Turfgrass clipping yields (g m^{-2}) under turfgrass species and nitrogen sources in 2017 and 2018 experimental years.

TS	2017						
	26.4.17	**26.5.17**	**16.6.17**	**06.7.17**	**02.8.17**	**17.9.17**	**21.10.17**
L. perenne	170.1 a	73.5	58.3 b	59.7 b	112.4 c	51.6 c	28.0 b
F. arundinacea	138.3 b	67.0	55.6 b	64.0 b	129.3 b	131.6 a	53.2 a
P. pratensis	106.1 c	69.7	80.8 a	121.1 a	177.8 a	73.0 b	36.5 b
LSD (0.05)	22.87	ns	7.86	10.18	16.65	7.45	8.61
NS							
SRF	128.3 b	72.6 b	64.6 b	80.2 b	125.7 b	77.0 b	40.0
VC	108.1 b	47.7 c	52.2 c	58.2 c	107.6 c	101.0 a	35.7
AS	178.1 a	89.8 a	78.0 a	106.4 a	186.2 a	77.7 b	42.0
LSD (0.05)	22.87	10.07	7.86	10.18	16.65	7.45	ns
TS	**2018**						
	25.4.18	**15.5.18**	**04.6.18**	**07.7.18**	**12.8.18**	**25.9.18**	**29.10.18**
L. perenne	130.5 b	76.2 c	57.2 c	123.3 b	196.6 a	166.6	116.5 a
F. arundinacea	196.3 a	108.5 a	66.1 b	151.1 a	160.7 c	168.2	77.5 b
P. pratensis	95.6 c	93.4 b	74.4 a	122.2 b	168.3 b	149.3	53.5 c
LSD (0.05)	14.30	10.24	6.09	11.54	7.18	ns	9.69
NS							
SRF	152.0 a	91.2 b	67.3 b	115.0 b	165.6 b	196.7 a	72.5 b
VC	111.4 b	83.7 b	55.4 c	91.0 c	153.5 c	129.5 b	87.5 a
AS	159.1 a	103.2 a	75.0 a	190.0 a	206.5 a	157.8 ab	87.5 a
LSD (0.05)	14.30	10.24	6.09	11.54	7.18	42.39	9.69

The effects of turfgrass species on turf clipping yield were significant in most observation. While the highest clipping yield was obtained from Kentucky bluegrass in some measurement in 2017, it was obtained from tall fescue in 2018. For clipping yields, nitrogen sources treatment differences were similar to those observed for turfgrass color and quality. The highest clipping yields were observed in ammonium sulphate fertilizer application among the nitrogen sources both years. It was followed by slow release fertilizer in the second statistical group. Vermicompost application gave the highest turfgrass clipping yield only on 17.09.2017 observation date; on the other observation dates, it gave the lowest turfgrass clipping yields (*Table 4*).

The interactions between the using nitrogen sources and turfgrass species were significant. All turfgrass species used in the research gave the highest turf color, quality and clipping yields from ammonium sulphate fertilizer application, followed by slow release fertilizer. In all turfgrass species, vermicompost produced the lowest clipping yields.

4. Conclusion

According to these results, slow release fertilizer has no advantage over ammonium sulfate fertilizer, but it is as effective on turfgrass color and quality. However, it is known that groundwater pollution and some environmental and health problems occur due to nitrogen leaching as a result of excessive nitrogen fertilization. Although the slow release fertilizer in the experiment did not give the best turf color and quality values at all observation dates, it gave values above 6, which is the minimum acceptable color and quality value, in most observations. Therefore, the application of slow-release fertilizer in places where turf color is not expected to be prominent will both ensure an acceptable turf color and help protect the environment.

Applying vermicompost as fertilizer can contribute to the recycling of nutrients while also reducing the use of chemical fertilizers. In this study, fertilization applications were made according to the nitrogen content of vermicompost used as a nitrogen source. This study revealed that vermicompost provided acceptable turf color and quality grades in some observation dates. Despite increased turf color and quality ratings, vermicompost provided a low clipping yield. This is a desirable situation when considering the clipping disposal problem.

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Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Bilgili, U., Köktaş, Z.; Design: Bilgili, U., Köktaş, Z.; Data Collection or Processing: Bilgili, U., Köktaş, Z.; Statistical Analyses: Bilgili, U., Köktaş, Z.; Literature Search: Bilgili, U., Köktaş, Z..; Writing, Review and Editing: Bilgili, U., Köktaş, Z.

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