Pak. J. Bot., 51(4): 1357-1364, 2019. DOI: http://dx.doi.org/10.30848/PJB2019-4(25)

THE EFFECTS OF DIFFERENT COMBINATIONS OF COMBINED FERTILIZER DOSES ON SOME TURFGRASS PERFORMANCES OF TURF MIXTURE

MUSTAFA YILMAZ

Pamukova Vocational School, Sakarya University of Applied Sciences, Sakarya, Turkey
Corresponding author's email: mustafayilmaz@sakarya.edu.tr

Abstract

This study was conducted to determine the effects of different combinations of combined fertilizer dose applications on the turfgrass characteristics of a turf mixture in the ecological conditions of Sakarya/Pamukova in Turkey, between the years of 2013-2015. The research was conducted in the randomized block design with four replications. A cool season turf mixture consisting of 40% *Lolium perenne* L., cv. Integra, 25% *Festuca rubra rubra* L., cv. Eugene, 20% *Festuca rubra commutata* Gaud., cv. Survivor and 15% *Poa pratensis* L., cv. Evora was used as the material of the study. Such is a widely used mixture in the region. Nine different combination of NPK fertilizer doses (0-0-0, 5-2.5-2.5, 10-5-5, 15-7.5-7.5, 20-10-10, 25-12.5-12.5, 30-15-15, 35-17.5-17.5 and 40-20-20 g m^{-2} respectively) were tested. In this research; turf cover, weed invasion, uniformity, turf texture, color and turf quality were determined. At the end of the study, the most promising data were taken from the 30-15-15 g m^{-2} fertilizer dose compared to control.

Key words: Cool season, Turf mixture, Fertilizer doses, Turfgrass color and quality.

Introduction

Turfgrasses enhance the aesthetic, economic and environmental value of surrounding landscapes. What's more, if established consciously, they create recreational vegetation, check the erosion and provide many ecological benefits.

Cool season turfgrasses are also widely used for home lawns and landscapes in temperate climatic conditions. The most suitable temperature for shoot growth of cool season turfgrasses is 15-23°C (Beard, 1973, Caskey, 1982; Lawson, 1996). However; in Turkey's coastal regions of typical Mediterranean climate, particularly the Aegean and Mediterranean shores, summer temperatures generally exceed 30°C. Drought or heat stress substantially decreases the turf quality of cool season turfgrasses (Huang *et al*., 1998). Practical techniques to completely eliminate high-temperature stress on turfgrass do not exist. A primary precaution is the usage of cultural practices which prevent loss of available soil moisture and internal plant water deficits (Beard, 1973). Infrequent irrigation increases the heat tolerance of the *Poa pratensis, Lolium perenne* and *Poa annua* cultivars. However, irrigation rate and frequency also affect nutrient loss in turfgrasses (Ledeboer & Skogley, 1973; Barton & Colmer, 2006). If irrigation of turfgrasses is optimally implemented, nitrogen leaching will decrease. Soil pH, soil temperature, microbial activity, moisture content and soil structure affect benefit from fertilizer (Jarrell & Boersma, 1979; Allen, 1984; Turner & Hummel, 1992; Zhang *et al*., 1998). Among these factors, heat is an important stress factor especially in the Mediterranean climate. Timing of fertilizer applications is necessary to grow good quality turfgrass and minimize the use of fertilizer. The ideal time for fertilizing turfgrass is between the last frost of spring and the first frost of autumn (Avcioglu, 2014).

From among macro nutrients, turfgrasses need a) nitrogen for shoot and root growth, enhancement of shoot frequency and color, and endurance against disease and pests, heat, cold and drought; b) phosphorus for transfer of secondary nutrients, improvement of root development and regrowth; and c) potassium for boosting growth and development, regulating water intake and continuity, and enhancing endurance against the heat and cold (Brohi & Aydeniz, 1991; Acikgoz, 1994; Avcioglu, 2014).

Best results for nitrogen, phosphorus and potassium (NPK) - the most essential macro nutrients used in turfgrasses - were reported in the dose 12/90-15-15 by Beard (1973), 30-7-20 by Hope (1983), 10-30 by Petrovic (1990), and Turner and Hummel (1992), 25-20-20 by Acikgoz (1994), 50-50-50 by Birant (1996), 25-15-15 by Avcioglu (1997), 25-20-20 by Oral (1998), 24-15-15 by Yilmaz (2003), 60-90 by Bilgili & Acikgoz (2007; 2011), 50-50-50 by Salman & Avcioglu (2010) and 25-15-15 g m^{-2} by Yilmaz *et al*., (2011). Certain researches who studied turfgrasses and turfgrass mixtures (Beard, 1973; Hope, 1983; Petrovic, 1990; Turner & Hummel, 1992; Birant, 1996; Zhang, *et al*., 1998; Oral, 1998; Yilmaz, 2003; Walker *et al*., 2007; Bilgili & Acikgoz, 2007; 2011; Salman & Avcioglu, 2010; Yilmaz *et al*., 2011; Demiroglu *et al*., 2011) have reported research results varying between scores of 3-9 according to the 1-9 scale on turf cover, uniformity, weed invasion, turf color and quality. This research was conducted to determine the performance of a quadruple mixture of newly introduced cultivars with different doses of combined fertilizer and to suggest the most suit dose.

Materials and Methods

The research was carried out in the field belonging to the Vocational School of the Pamukova district in the Sakarya province, which is situated in the eastern Marmara region (N 40° 30' 20.462, E 30° 10' 9.263 and 80 m above sea level).

Climatic data of the research period and long term average is presented in Table 1 and Fig. 1.

Total precipitation in the 1st year of the research was lower than long term average, but was higher in the 2nd year. Average temperature and relative humidity data for the 1st and 2nd year was similar to long term data.

Soil properties of the research area have been presented in Table 2. Soil samples taken from 0-20 and 20-40 cm depths of the research area were analyzed in the Vocational School laboratory and research area soils were found; clayey-loamy, slightly alkaline), saltless, medium limy, deficient in available phosphorus, potassium and organic substances (Brohi & Aydeniz, 1991).

Table 1. The climate dates of Geyve district for 2013-2015 years and Long Term Average (l.t.a.)(*).

Months	Total precipitation (mm)			Average temperature (°C)			Relative humidity (%)		
	1st year	2nd year	l.t.a.	1st year	2nd year	l.t.a.	1st year	2nd year	l.t.a.
November	29.2	83.2	49.0	10.1	10.1	10.2	83.8	86.6	83.8
December	55.2	101.8	96.5	1.6	8.0	4.3	82.7	91.5	86.6
January	20.8	141.0	94.7	6.7	3.5	4.4	80.7	86.9	84.2
February	11.2	146.6	78.3	7.7	6.6	6.8	76.1	82.2	80.0
March	52.8	48.1	64.4	9.9	8.9	9.1	75.4	78.9	63.8
April	33.0	94.2	57.1	14.3	11.0	13.8	71.6	72.5	70.3
May	66.8	23.4	53.3	18.4	18.7	18.3	73.8	70.4	72.5
June	93.0	48.8	42.8	21.5	20.9	22.2	74.6	76.8	69.6
July	35.0	2.0	10.0	24.7	24.2	24.8	71.0	69.3	65.6
August	9.0	5.2	6.9	25.2	25.7	25.2	70.4	68.0	65.4
September	114.2	66.0	64.5	20.5	23.2	21.3	76.9	73.0	68.4
October	76.4	85.2	68.4	15.6	15.8	15.4	83.2	85.0	78.4
Tot./Mean	**596.6**	**845.5**	**685.9**	**14.7**	**14.7**	**14.7**	**76.7**	**78.4**	**74.1**

(*): Meteorological Bulletin for Geyve/Sakarya

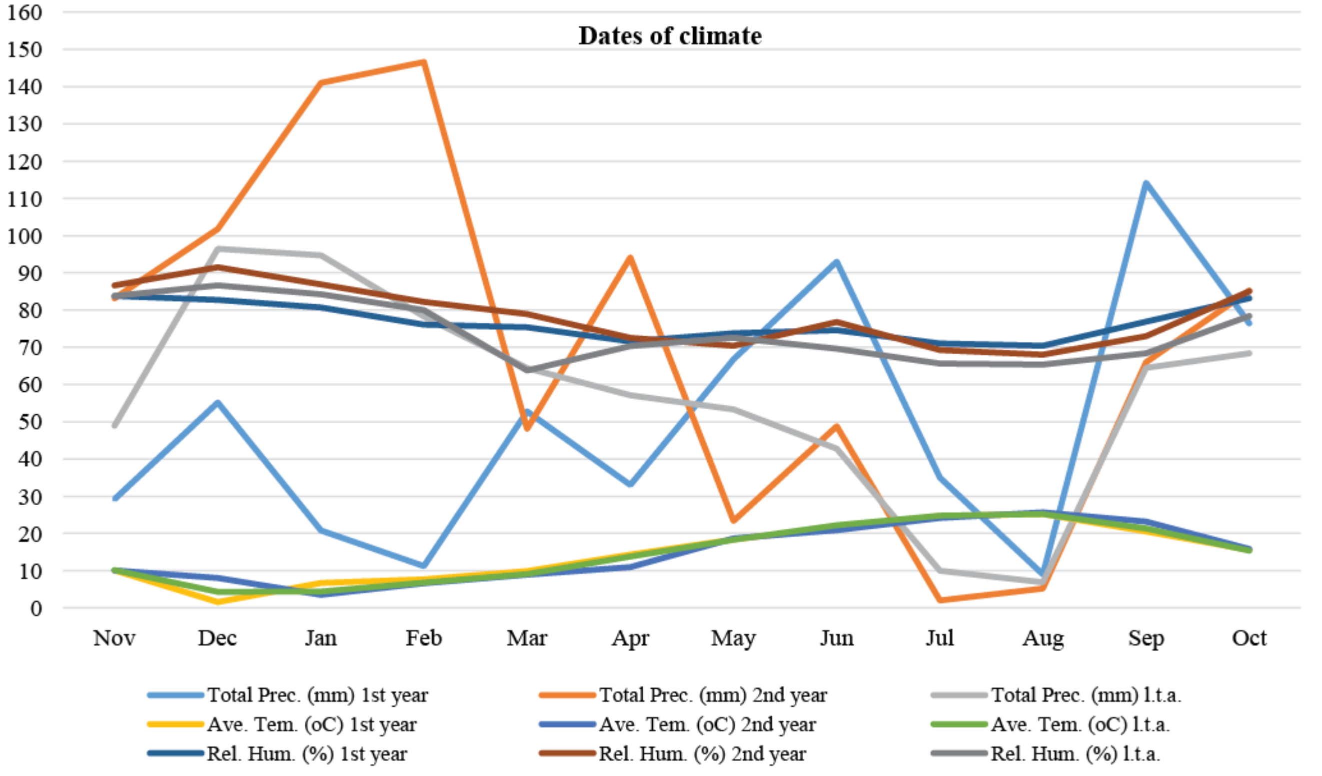

Fig. 1. The climate dates of Geyve district for 2013-2015 years and Long Term Average (l.t.a.)(*)

Table 2. Soil properties of the research area.

Properties	Sample depth (cm)	
	0-20	20-40
Structure	loamy	loamy
pH	7.4	7.61
Total salt (%)	0.024	0.023
$CaCO_3$ (%)	5.61	8.60
Organic matter (%)	1.61	0.94
Nitrogen (kg ha^{-1})	1.12	0.65
P_2O_5 (kg ha^{-1})	10.6	8.5
K_2O (kg ha^{-1})	190.0	255.0

The cool-season turf mixture used in the research consisted of 40% *Lolium perenne* L., cv. Integra and 20% *Festuca rubra commutata* Gaud., cv. Survivor, (American Pennington Seed), along with 25% *Festuca rubra rubra* L., cv. Eugene and 15% *Poa pratensis* L., cv. Evora, cultivars (Denmark DLF Trifolium Seed). The mixture was sown according to the widely proposed sowing norm for practical applications of 50 g m^{-2} (Acikgoz, 1994; Avcioglu, 2014).

The research was established on November 1, 2013, observation and measurements were carried out in spring, summer, autumn and winter between April 1, 2014-November 31, 2015. Plot sizes were 2×1 m, and 1-meter gaps were left between the plots.

Nine different NPK (Combined) fertilizer doses (0-0-0, 5-2.5-2.5, 10-5-5, 15-7.5-7.5, 20-10-10, 25-12.5-12.5, 30-15-15, 35-17.5-17.5 and 40-20-20 g m^{-2}) were applied in the research. As recommended for use in fertilization of turfgrasses by Acikgoz (1994) and Avcioglu (1997), the 15-15-15 combined and 26% Ammonium Nitrate fertilizers were used. Upon consideration of suggestions made by researchers who reported that application of fertilizers that turfgrass need only once or twice a year was insufficient in meeting expectations (Walker *et al*., 2007) and that application intervals needed to be more frequent, (Wehner & Martin, 1989; Mangiafico & Guillard 2006) annual fertilizer doses were applied between the last frost date of spring (April 21) and the first frost date of autumn (November 5) in 5 equal amounts with 40-day intervals (April 20, June 1, July 10, August 20, September 1).

Irrigation was realized via a rotary sprinkler system. Irrigation was done when the top of the soil was 30 mm dry and the plants reached fading point. Irrigation was implemented once a week in May, June and September, and three times a week in July and August. The irrigation water had a pH of 7.6, a sulfate content of 0.212 mg l^{-1} and an ionic chlorine content of 0.4 ppm.

Upon reaching heights of 6-10 cm, plants were mown to a height of 4 cm with a gas lawn mower 18 times per year (spring 6, summer 6, autumn 6 and winter 0).

In the study; turf cover data were determined in terms of percentage (%) according to the Quadrat method (Tosun, 1954; Van Dyne, 1965). Uniformity (1: very bad, 9: very good), weed invasion (1: a lot, 9: none), color (1: yellow, 9: dark green) and turf quality (1: very bad, 9: very good) data were scored on a scale of 1-9; where 9-8 was very good, 7.9-7 good, 6.9-6 medium, 5.9-5 acceptable, and 5 and below was unacceptable (Beard, 1973; Mehall *et al*., 1983; Sills & Carrow, 1983; Goatley *et al*., 1994; Acikgoz, 1994, Avcioglu, 2014). Texture data were measured in mm and were categorized using the scale determined by Beard (1973) and Caskey (1982) which reads as follows: smaller than 1 mm 'very fine', between 1-2 mm 'fine', between 2-3 mm 'medium', between 3-4 mm 'coarse' and bigger than 4 mm 'very coarse'.

The experiment was conducted with four replications in the design of randomized blocks, and statistical analyses of data were performed using the TOTEMSTAT Statistical Program (Acikgoz *et al*., 2004). LSD values (5%) were given below the Tables.

Results

Turf cover: Turf cover data obtained in the study is listed in Table 3 and Fig. 2. Analysis of data in terms of years showed that the vegetation reached a cover value of 92.73% in the first year and 94.69% in the second year. In terms of fertilizer doses, the 35-17.5-17.5 and 30-15-15 doses achieved highest value, whereas the lowest value was obtained from the control plot (74.43%). A cover rating of 93.20% was seen even in the plots that were administered the lowest fertilizer dose (5-2.5-2.5). In terms of year × fertilizer doses, the 35-17.5-17.5 and 30-15-15 fertilizer doses attained highest turf cover in both years, while the control plot showed lowest value.

Nitrogenous fertilization enables plants to grow and tiller faster, hence increasing turf cover (Brohi & Aydeniz, 1991; Acikgoz, 1994; Avcioglu, 2014). Review of the numbers indicated that the four highest fertilizer doses attained highest turf cover ratings. However, these began to decline as of dose 40-20-20, though difference was not significant,. It is important to catch the peak point in fertilizer experiments. Increased nitrogen doses primarily affect plants positively, but because after a certain point the carbohydrate required for protein synthesis is insufficient, the plant is negatively affected (Avcioglu, 2014;Turan ve Horuz, 2012). Salman & Avcioglu (2000) found similar results in the study conducted in Odemis/Izmir and saw that turf cover decreased after 15 g m^{-2} month of mixed fertilizer dose. Turf cover data were determined as the basal area of plants at ground level, not at turf surface. If the evaluation had been performed using turf surface, it would have been possible to say that all plots were 100% covered with turf. Each grass species constituting the mixture had different nitrogen requirements. Under these circumstances, some kind of dominance quickly covered the area (Avcioglu, 2014). According to turf cover values, fast and full coverage of the area was not only due to the favorable adaption of genera and cultivars in the mixture to the area but also because a cultivar with rhizomes such as *Poa* was used in the mixture and data collection started approximately six months after establishment of the turf area.

Weed invasion: Weed invasion data obtained in the study was presented in Table 3 and Fig. 3.

Table 3. Turf cover (%) and weed invasion scores (1-9 scale).

N - P – K (g m^{-2})	Turf cover			Weed invasion		
	1st year	2nd year	Mean	1st year	2nd year	Mean
0 - 0 - 0	71.50	77.35	74.43	5.50	6.10	5.80
5 - 2.5 - 2.5	92.15	94.25	93.20	7.50	8.70	8.10
10 - 5 - 5	93.50	94.75	94.13	7.60	8.80	8.20
15 - 7.5 - 7.5	94.40	95.75	95.08	7.90	8.80	8.35
20 - 10 - 10	95.15	96.75	95.95	8.25	8.90	8.58
25 - 12.5 - 12.5	95.75	97.50	96.63	8.50	9.00	8.75
30 - 15 - 15	97.35	98.75	98.05	8.75	9.00	8.88
35 - 17.5 - 17.5	97.50	98.70	98.10	8.75	9.00	8.88
40 - 20 - 20	97.25	98.45	97.85	8.60	8.90	8.75
Mean	**92.73**	**94.69**	----	**7.93**	**8.58**	----
LSD (5%)	F: 0.55	Y: 0.35	F×Y: 1.05 CV: 1.43	F: 0.03	Y: 0.02	F×Y: 0.04 CV:1.21

F: Combination of fertilizer, Y: Year, F×Y: Interaction

Assessment in terms of years revealed that highest weed invasion was observed in the first year, as it was the year of establishment, and scores were relatively low. Data showed that in terms of fertilizer doses, the 35-17.5-17.5 and 30-15-15 doses achieved notable success with a score of 8.8 in preventing weed invasion. The control plot showed greatest amount of weeds and received a score of 5.80. When values were examined in terms of year × fertilizer, the 25-12.5-12.5, 30-15-15 and 35-17.5-17.5 doses obtained the highest score (9.00) in the second year. For both years, highest weed invasion (5.50-6.10) was observed in the plot that was not applied any amount of fertilizer.

Scarcity of weeds was generally associated with the fast development of sown grass cultivars and broad turf cover. Weeds in the plots were manually removed in the spring of the first year, thus in the following seasons weed sprouting dropped considerably. Under normal conditions, high fertilization is expected to increase weed sprouting and development (Avcioglu, 2014). However; especially in the second year of the experiment, turf texture thickened and prevented practically any weeds from sprouting or developing. Salman & Avcioglu (2010) also supported our findings with their research on cool climate turfgrasses and their mixture with different doses of nitrogen.

Turf uniformity: Values obtained in the study were presented in Table 4 and Fig. 4. First and second year mean values were 7.64 and 7.81, respectively. Review of means for fertilizer doses showed that the 30-15-15 dose obtained the highest value (8.68), while the lowest (6.10) was obtained from the control plot.

In terms of year × fertilizer interaction, the 30-15-15 dose (8.85) achieved the highest values in the second year, and the control plot had the lowest values (6.05).

From the four cultivars in the mixture, *Poa* has the smallest seed. In order to uniformly sow the seeds in the mixture, fine seeds should either be perfectly mixed in with others during sowing or should be sown separately after large seeds have already been sown. Otherwise, fine seeds tend to be sown towards the edges of the area and disturb a uniform appearance, particularly in areas where seeds are sown without proper mixing (Beard, 1973; Acikgoz, 1994; Avcioglu, 2014). Uniformity values of the plots indicate that seeds in the mixture were sown according to technique. A good quality green area should show complete integrity and should not contain anomalies such as bare fields, weeds, etc. As would be expected, increasing doses of nitrogen caused a decline in values after a certain point in this character, but remained within acceptable limits.

Turf texture: Data obtained through the measurement of the widest section of leaf blades have been given in Table 4 and Fig. 5.

In terms of years, it can be observed that the data for the second year gave higher values than that of the first year. Highest texture data were obtained from the 30-15-15 dose with regard to fertilizer doses and year × fertilizer dose interactions.

Salisbury & Roos (1992) and Avcioglu (2014) report that the leaf blade may be affected by environmental conditions but also that it is mainly dependent on the genetic potential of plants. Furthermore, they say that applications such as fertilization, irrigation etc. can make no more than little changes. Among the cultivars used, *L. perenne* had “coarse” texture, whereas *F. r. rubra*, *F. r. commutada* and *P. pratensis* had "fine" texture (Beard, 1973; Caskey, 1982). Texture values were "between 2-3 mm - medium" according to the scale by Beard (1973) and Caskey (1982). Usage of fine textured cultivars in the mixture is considered to have contributed to "medium" level ratings in texture data.

Texture data can certainly reveal the true performance of plants that are not cut. However, it is said that leaves modify and narrow their texture in order to protect themselves from stress factors when constantly under cutting pressure (18 times annually) and in times when temperatures are relatively high for cool-season turfgrasses (Beard, 1973; Acikgoz, 1994; Avcioglu, 2014). The data obtained validate this assertion.

Turf color: Color values, one of the properties signifying turfgrass quality, were presented in Table 5 and Fig. 6.

Table 4. Turf Uniformity and Turf Texture Scores (1-9 scale).

N - P - K ($g\ m^{-2}$)	Turf uniformity			Turf texture		
	1st year	2nd year	Mean	1st year	2nd year	Mean
0 - 0 - 0	6.05	6.15	6.10	2.43	2.51	2.47
5 - 2.5 - 2.5	6.55	6.70	6.63	2.46	2.54	2.50
10 - 5 - 5	6.95	7.10	7.03	2.52	2.64	2.58
15 - 7.5 - 7.5	7.35	7.45	7.40	2.66	2.71	2.69
20 - 10 - 10	8.15	8.25	8.20	2.71	2.73	2.72
25 - 12.5 - 12.5	8.40	8.55	8.48	2.73	2.75	2.74
30 - 15 - 15	8.50	8.85	8.68	2.75	2.78	2.77
35 - 17.5 - 17.5	8.55	8.75	8.65	2.74	2.78	2.76
40 - 20 - 20	8.30	8.45	8.38	2.72	2.76	2.74
Mean	**7.64**	**7.81**	**----**	**2.64**	**2.69**	**----**

LSD (5%) F: 0.04 Y: 0.02 F×Y: 0.06 CV: 1.32 F: 0.03 Y: 0.02 F×Y: 0.04 CV:2.61

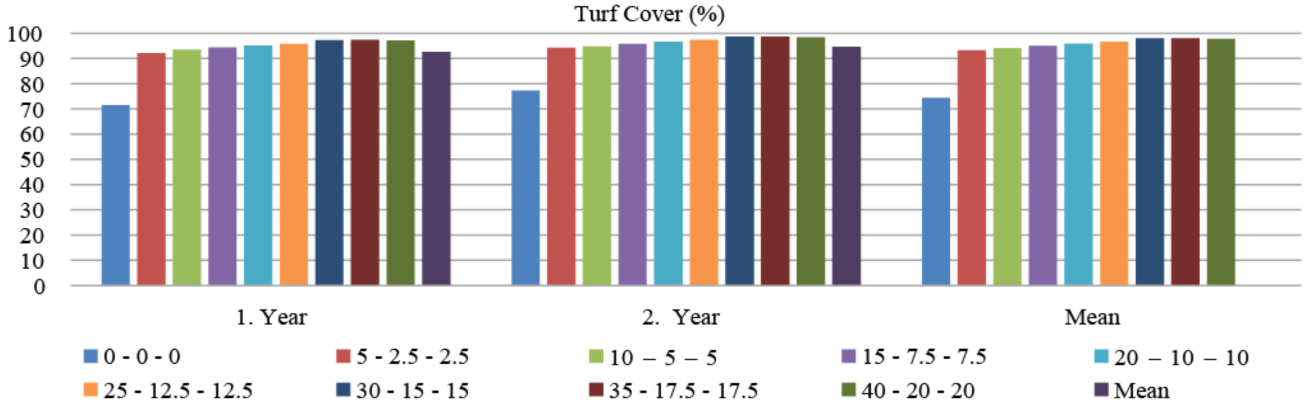

Fig. 2. Values of turf cover (%).

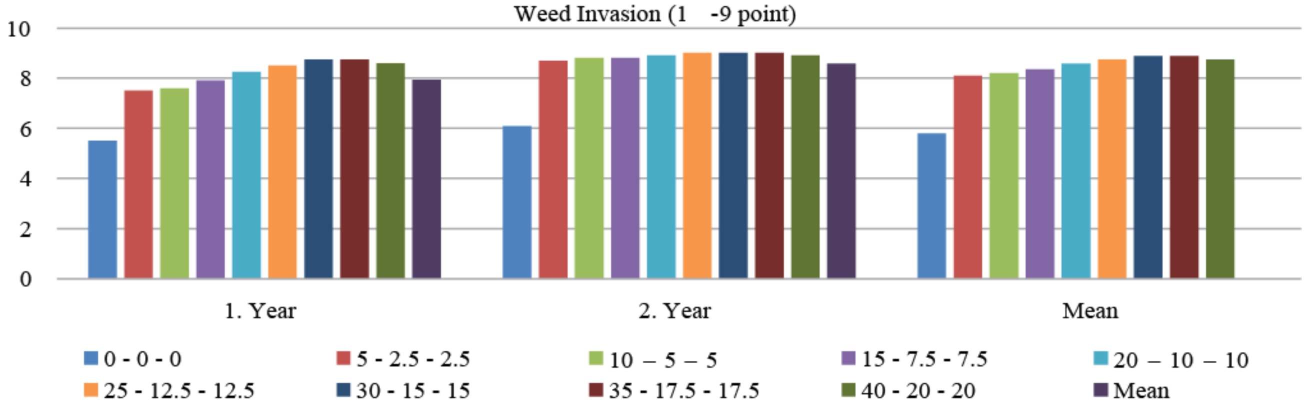

Fig. 3. Values of weed invasion (1-9 point).

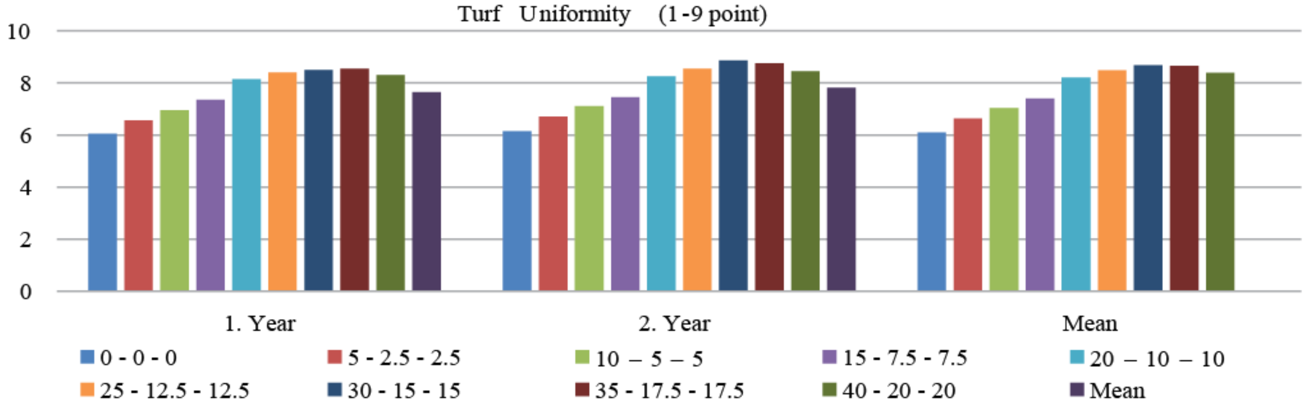

Fig. 4. Values of turf uniformity (1-9 point).

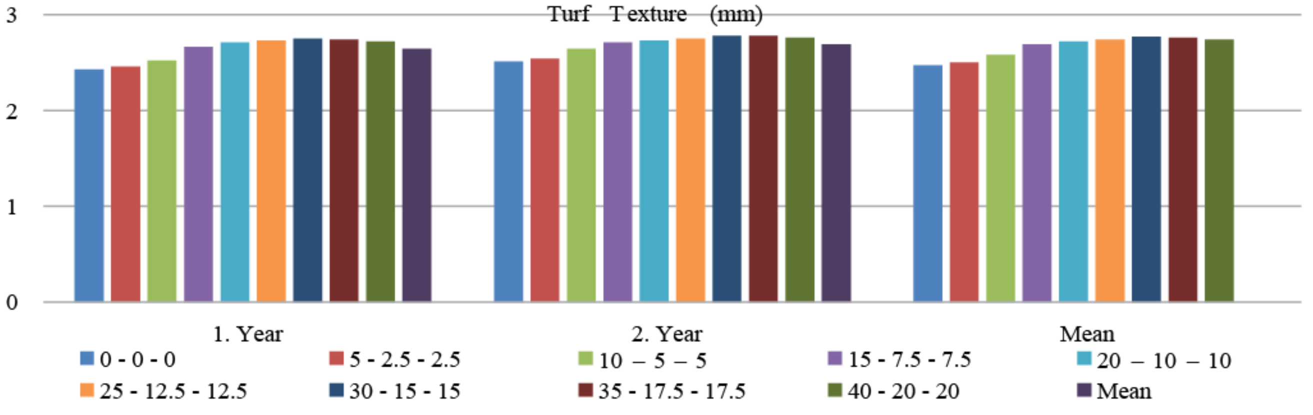

Fig. 5. Values of turf texture (mm).

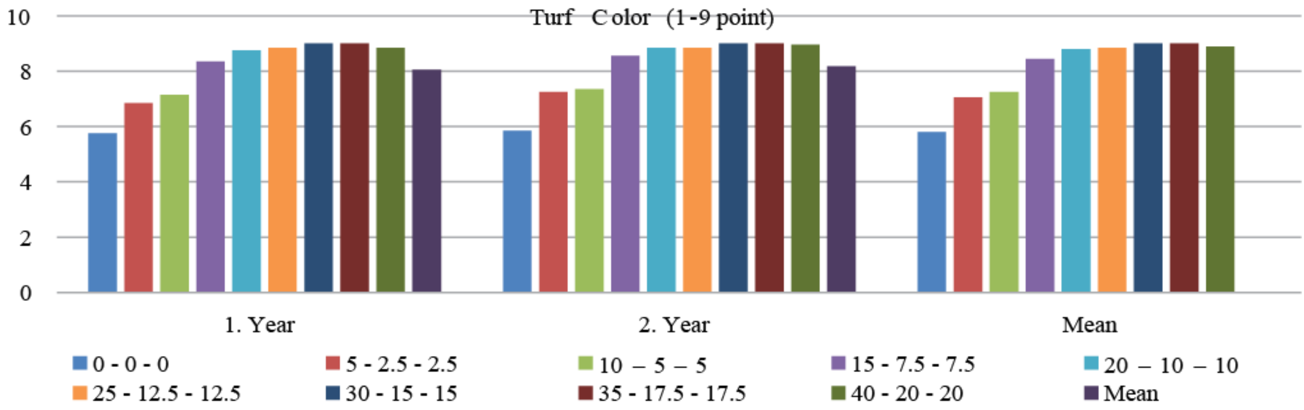

Fig. 6. Values of turf color (1-9 point).

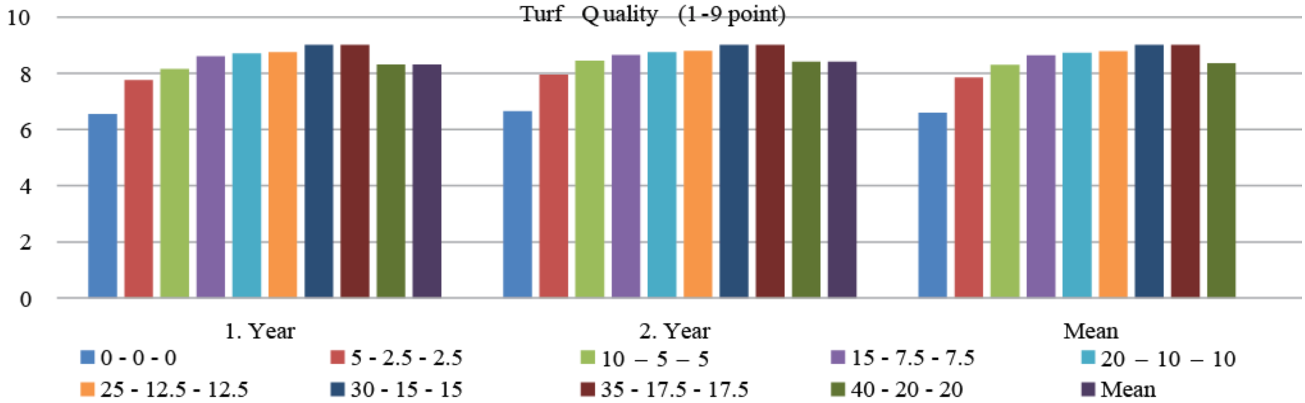

Fig. 7. Values of turf quality (1-9 points).

In terms of years, data revealed that the second year (8.18) had higher color values than the first year (8.06). Assessment of fertilizer doses and year x fertilizer doses showed that the 30-15-15 and 35-17.5-17.5 doses achieved a perfect score of 9.0 in both years, whereas the lowest color score for both years and in average was obtained from the control plot.

The green color created by chloroplast in the leaves and stems of plants is determined by the dose of nitrogen, iron and manganese in soils, the plant's water range and genetic structure, as well as various other factors. For this reason, almost all turf genera and varieties contain a unique green tone, which changes at certain limits (Beard, 1973; Brohi & Aydeniz, 1991; Acikgoz, 1994; Avcioglu, 2014). In accordance with the 1-9 scale suggested by Mehall *et al*., (1983) and Goatley *et al*., (1994), the color of basis for this study was dark bright green. According to assessment based on color, highest scores were respectively seen in; spring, autumn, summer and winter. Increasing N quantities, specifically in the months of spring, led to high color ratings. Similarly, many researchers have stated that an increasing amount of N significantly enhances the color grades of various turf mixtures (Beard, 1973; Acikgoz, 1994; Avcioglu, 2014; Bilgili & Acikgoz, 2005; 2011). The data obtained validate this assertion and show that the turf mixture adapted nicely to the area.

Turf quality: Turf quality values obtained in the study were listed in Table 5 and Fig. 7.

Assessment of the findings in terms of years revealed that the second year (8.41) attained higher figures than the first year (8.31). When scores were examined in terms of fertilizer doses and year × fertilizer doses interactions, the 30-15-15 and 35-17.5-17.5 doses had a perfect score of 9.0, while lowest scores were seen in the control plot. To enhance turf quality - an indicator of the general appearance of established turfgrasses – cultivars, which have similar shoot growth rates, colors and textures, should be uniformly sown to a well-prepared seed bed and following maintenance operations should be precise.

Turf quality was categorized according to the 1-9 scale (9-8 very good, 7.9-7 good, 6.9-6 medium, 5.9-5 acceptable, 5 and below unacceptable) recommended and used by many researchers (Beard, 1973; Mehall *et al*., 1983; Sills and Carrow, 1983; Goatley *et al*., 1994; Acikgoz, 1994, Avcioglu, 2014) On that account data obtained in this study were within acceptable limits even in unfertilized plots, however the need for fertilization to achieve strong and quality turfgrass was evident. An important aspect to take into account when creating a green area is that the desired appearance (uniformity, color, weed invasion, etc.) can be achieved during establishment. Even with such a visual image, fertilization constitutes an important point in maintenance processes. As Salman & Avcioglu (2010) have reported in some of our turfehosacteristics similarly increased the quality of turfgrass with increasing nitrogen doses and then decreased. Turk & Sozoren (2016) have found that rising concentrations of nitrogen increased grass quality when working with different nitrogen doses in Perennial Ryegrass (*Lolium perenne* L.), which was the main species of our mixture in Isparta conditions.

Table 5. Turf color and turf quality scores (1-9 scale).

N - P - K ($g\ m^{-2}$)	Turf color			Turf quality		
	1st year	2nd year	Mean	1st year	2nd year	Mean
0 - 0 - 0	5.75	5.85	5.80	6.55	6.65	6.60
5 - 2.5 - 2.5	6.85	7.25	7.05	7.75	7.95	7.85
10 - 5 - 5	7.15	7.35	7.25	8.15	8.45	8.30
15 - 7,5 - 7,5	8.35	8.55	8.45	8.60	8.65	8.63
20 - 10 - 10	8.75	8.85	8.80	8.70	8.75	8.73
25 - 12,5 - 12,5	8.85	8.85	8.85	8.75	8.80	8.78
30 - 15 - 15	9.00	9.00	9.00	9.00	9.00	9.00
35 - 17,5 - 17,5	9.00	9.00	9.00	9.00	9.00	9.00
40 - 20 - 20	8.85	8.95	8.90	8.31	8.41	8.36
Mean	**8.06**	**8.18**	----	**8.31**	**8.41**	----
LSD (5%)	F: 0.04 Y: 0.03	F×Y: 0.06	CV: 1.28	F: 0.02 Y: 0.01	F×Y: 0.03	CV:1.42

Discussion

Consideration of the research findings as a whole shows that most favorable results were obtained from the 30-15-15 and 35-17.5-17.5 g m^{-2} doses. These doses are in agreement with and support the findings of Beard (1973), Hope (1983), Petrovic (1990), Turner & Hummel (1992), Oral (1998), Yilmaz (2003) and Yilmaz *et al.*, (2011), who carried out studies in regions with similar ecological conditions to that of the research area.

However, the doses were significantly lower than the recommended dose of 60-90 g m^{-2} by Bilgili & Acikgoz (2007; 2011), who conducted research in similar climatic conditions. Bursa is a hotter region and thus required more frequent irrigation, which in turn resulted in greater leaching of plant nutrients and required the use of greater fertilizer amounts. This may explain why their fertilizer doses were higher. Furthermore, application methods and times, as well as the usage of a different fertilizer source may be cited among other reasons.

On the other hand, the doses identified as most suitable in this study were lower than the 50-50-50 g m^{-2} dose recommended by Birant (1996), and Salman & Avcioglu (2010), who conducted research in an ecologically hotter region and sandy-permeable soils. This is because irrigation is more frequent in regions with hot temperatures and irrigation water leaches nutrients away from plants due to the sandy nature of soil. The need for more water and more plant nutrients increased the amount of fertilizer used.

Values obtained regarding properties studied in the research were within the limits set by Beard (1973), Uzun (1992), Acikgoz (1994) and Avcioglu (1997)' for desirable turfgrass, because plant genera and cultivars included in the mixture were compatible with each other and suitable to the research ecology, and sowing-maintenance procedures were carried out in keeping with technique.

Moreover; research findings were in agreement with turf cover, uniformity, weed invasion, turf color and quality results reported by researchers studying turfgrass and turf mixtures (Beard, 1973; Hope, 1983; Petrovic, 1990; Turner & Hummel, 1992; Birant, 1996; Zhang, *et. al.*, 1998; Oral, 1998; Yilmaz, 2003; Walker *et. al.*, 2007; Bilgili & Acikgoz, 2007; 2011; Salman & Avcioglu, 2010; Yilmaz *et al.*, 2011) as being between 3-9 points, according to the 1-9 scale, but were higher than the results of certain researchers (Birant 1996; Salman & Avcioglu 2010) for reasons explained in the section about fertilization.

The ecology of the research area was highly suitable for cultivation of cool-season turfgrass. According to long term average data, annual precipitation was 685.9 mm and was distributed evenly to the seasons and months (winter: 269.5, autumn: 181.9, spring: 174.8 and summer: 59.7 mm). The most important point of consideration here is that the research area received rain in all the seasons and months of the year. Assessment of precipitation from a different perspective shows that the research area respectively received; 87.2-389.4 of rain in winter, 152.6-165.7 in spring, 137.0-56.0 in summer and 273.8-176.0 mm in autumn in the first and second year. Additionally, according to long term average data, the research area enjoys rain and cool temperatures for 128.6 days of the year, and has an average temperature of 14.7°C. It is possible to say that these conditions create a suitable ecological environment for cool-season turfgrass to demonstrate their true performance.

Taking into consideration all the figures obtained in the study, most favorable data were numerically achieved by the 30-15-15 and 35-17.5-17.5 g m^{-2} doses. According to the results obtained from our research, the 30-15-15 g m^{-2} NPK fertilizer is recommended for both environmental (to prevent soil and water pollution) and economic reasons.

Acknowledgements

The author wishes to thank Gokcehan Demir (Queens Public School 150, USA, and University of Bogazici, Faculty of Arts and Sciences, Department of Translation and Interpreting Studies) for language editing.

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(Received for publication 12 February 2018)