[redacted], 2020 Journal of Animal & Plant Sciences (J.Anim.Plant Sci. ISSN 2071-7024)
Vol.46 (2): 8175-8186 https://doi.org/10.35759/JAnmPlSci.v46-2.2

Forage Yield and Nutritive Values of Phacelia (*Phacelia tanacetifolia* Benth.) as affected by different nitrogen doses under warm temperate type climate in Turkey

[redacted]

1 ABSTRACT

The aim of the study was to examine the changes in the yield, forage quality and nutritive value of the phacelia due to different nitrogen doses for potential use in Köpen Geiger Csa type hot and temperate The investigation evaluated nutritive values of the three phacelia genotypes (Saglamtimur, Stala and Enton) after application of five nitrogen doses (0 kg ha^{-1}, 25 kg ha^{-1}, 50 kg ha^{-1}, 75 kg ha^{-1}, 100 kg ha^{-1}). The fresh matter yield and dry matter yield increased in with increasing nitrogen doses (0 to 100 kg ha^{-1}). The maximum fresh matter and dry matter yield was determined in Stala genotype with 20.01 t ha^{-1} and 18.48 t ha^{-1}, while minimum fresh matter and dry matter yield was determined in Saglamtimur with 17.64 t ha^{-1} 15.79 t ha^{-1}, respectively. The results confirmed that crude protein percentage increased using 100 kg ha^{-1} nitrogenous fertilizer with the highest crude protein percentage of 19.68%. A significant decrease in acid detergent fiber and neutral detergent fiber values was also noted. Total Digestible Nutrient values increased with increased nitrogen doses. Digestible dry matter (65.87 %), dry matter intake (2.95 %), relative feed value (150.68 %) values gave the highest values using 75 kg ha^{-1} N. Whereas, 50, 75 and 100 kg ha^{-1} application of nitrogen gave the maximum net energy lactation value (1.526), and availability of potassium (4.063 %), calcium (1.972 %), magnesium (0.696 %) and phosphorus (0.296 %) contents from the dried matter of the plant. Comparing analyzed parameters for genotypes and nitrogen doses, the genotype Enton using 75 kg ha^{-1} nitrogen dose appeared as the optimum genotype. In light of these results, it is concluded that phacelia is suitable for Csa climate type conditions. Due to crude protein percentage (19.68%) and high digestion percentage, it should be used more in terms of animal feeding rotation.

2 INTRODUCTION

Phacelia (*Phacelia tanacetifolia* Benth.) with about 200 species is an annual forage crop in the *Hydrophillaceae* family with North American origin. Therefore, phacelia has been cultivated quite extensively as a bee plant in tropical areas like Kenya, Masai District, Mau Narok (Verdcout, 1970). The plant develops upright and grows up to 40-120 cm in length. It is grown as a winter catch crop in temperate climates on marginal, uncultivated areas under harsh winter, spring, or summer conditions (Kizilsimsek and Ates, 2004) with multiple uses. Since it has a typical long blooming period and high flower density per unit area, it is also evaluated in honey bees (*Apis* ssp.) and bumblebees (*Bombus* ssp.), farming (Williams and Christian, 1991; Westphal *et al.*, 2003) and is evaluated among top 20 plants considered the most suitable for use in honey bee farming (Kumova and Korkmaz, 2002; Gilbert, 2003). The plant finds wide use as green manure in the reclamation of poor soils and as a cover plant for erosion control (Jensen, 1991). Due to the high rate of vegetative growth and low cellulose production, the plant is also evaluated as a forage crop in many parts of the World (Becker and Hedtke, 1995). The crop itself is great for non-plough cultivation, which because of economics gives a great advantage over other post-crop plants (Leszczyńska, 2012). Therefore, phacelia is very intensively used in organic agriculture recently. Many factors may affect the yield, quality, and nutritional value of forage. Growth and development of phacelia are affected by abiotic (climate and temperature), biotic factors (disease and pests) and agronomic factors like maturity, harvest time, leaf stem rate, fertilization, soil conditions, harvest time, that have a significant influence on the yield and the quality of produce. The nutrients sought for animal production should be fiber forages with a high protein and energy content that do not exceed a certain limit. The nutritional value of the forage like protein, carbohydrates, vitamins, and minerals along with digestibility of nutrients, net energy obtained an entire nutritional efficiency are also affected by the environment (Coleman and Moore, 2003). Therefore, care should be taken to meet the microbial needs in ruminants, as ruminal fiber digestion remains under pressure, undigested residues accumulate in the rumen, and the amount of intake decreases until the minimum N requirement is met in the rumen. Feeding ruminants with high protein and ruminants will facilitate the digestion of fiber in the rumen. The increase in forage quality is influenced by the protein percentage that shows a positive increase due to nitrogen accumulation in the tissues. Application of nitrogenous fertilizers also reduce fiber ratio while increasing the quality, flavor, and digestibility of forage (Mcdonald *et al.*, 1991). Therefore, reduction in the synthesis of organic nitrogen compounds and accumulation of sugars is not desired during photosynthesis (Karic *et al.*, 2005). This leads to an increase in cell wall components, that in turn, lead to indirect increases in the ratio of fibrous compounds (ADF, acid detergent fiber; NDF, neutral detergent fiber etc.). There is an inverse proportion between fiber compounds and forage flavor + digestibility. Each increase in fibrous compounds results in a decrease of flavor and digestibility. Ankara has Köpen Geiger Csa type hot and temperate climate (Yilmaz and Cicek, 2018) and is hotter compared to Southwest California (centre of origin of the phacelia) with Köpen Geiger Csb, warm temperate type of climate (Anonymous, 2019a). Therefore, information about the adaptability of phacelia in hotter the Mediterranean type climate is desirable and can provide very useful information about the expansion of the usage area of this plant. The aim of the study was to examine the changes in the yield, forage quality and nutritive value of the phacelia due to different nitrogen doses for potential use in Köpen Geiger Csa type hot and temperate Turkish production system as a new introduction that may contribute and act as an alternate forage crop.

3 MATERIAL AND METHODS

3.1 Climatic Parameters : The research was conducted in the experimental fields of Ankara University, Faculty of Agriculture, Department of Field Crops (860 m above sea level and is located in between 39° 57' Northern latitude and 32° 52' Eastern longitude) during 2015-2016 using split plots in randomized blocks experimental design with 3 replications. The soil of the research site has argillaceous-loamy structure, is slightly alkaline (7.37), calcareous (5.66%), with a harmless total salt level (0.042%), moderate in phosphorus (55.2 kg ha^{-1}), rich in potassium (1920 kg ha^{-1}), and insufficient organic matter (1.05%). The total rainfall was 231.0 mm, the average temperature was 17.12°C and the relative humidity was 55.6% during 2015 and the total rainfall was 92.0 mm, the average temperature was 19.1 °C and the relative humidity was 49.97% in 2016. The study was carried out during 4 months of April-July in 2015 and 2016 (Anonymous, 2019b).

3.2 Experimental design and field applications: The phacelia genotypes [Saglamtimur (C_1), Stala (C_2) and Enton (C_3)] were placed in the main plots and 21% ammonium sulfate fertilizer [0 (control) 25 (N_1), 5 (N_2), 75 (N_3) and 100 kg ha^{-1} (N_4)] in the sub-plots. Half of these nitrogen doses applied the soil with the sowing stage, rest of them were applied when the plants reach the height of 30 cm. The area of the cultivated plots was 2m × 2m = 4 m^2 with 5 rows separated by 30 cm. The spacing between the blocks was determined as 1 m to prevent the influence of each fertilizer dose affecting neighbouring plots. The seeds (15 kg ha^{-1} each) of each genotype were sown on 12 April 2015 and 14 April 2016 at a depth of 1-1.5 cm. In addition, 25 kg ha^{-1} P_2O_5 and 25 kg ha^{-1} K_2O fertilizer was also applied to all plots at the time of sowing. All operations were performed under rainfed conditions. Manual weed control was carried out when and where necessary during the growth period.

3.3 Measurements and chemical analyses: The forage quality and dry matter of phacelia's was determined after collecting 500 g of plant mass by harvesting plants surface of the soil at 50% blooming period. These samples were collected in inflammable paper bags and dried for 48 hours at 70ºC in the oven and calculated dry matter. ANKOM ® fiber machine (NY, USA) was used to analyze and determine the Acid Detergent Fibre (ADF) and the Neutral Detergent Fibre (NDF) percentage of the dried and the ground forage samples. The ADF and NDF percentage of the forage materials were calculated following Van Soest *et al.* (1991). The crude protein was calculated by measuring the nitrogen amount by transforming the nitrogen in the forage initially into ammonium sulfate. It is ensued by ammonia with the addition of alkali (sodium hydroxide) by means of burning forage material with concentrated H_2SO_4 and lastly titration with 0.1 N HCl (AOAC, 2019). The data obtained at the end of the analysis was placed into the formula and the nitrogen percentage in the sample was calculated. Whereas, crude protein percentage was calculated by multiplying the total amount of N obtained from forage samples by 6.25. The values are an indication of total digestible nutrients (TDN), dry matter intake (DMI), digestible dry matter (DDM), and relative feed value (RFV).These values were obtained using formulas following by Harrocks and Valentine (1999);

TDN = (-1.291 × ADF %) + 101.35 (1)

DMI = 120 / NDF % (2)

DDM = 88.9 - (0.779 × ADF %) (3)

RFV = DDM% × DMI% × 0.775 (4)

NEl = [1.044- (0.01)19 × %ADF)] × 2.205 (5)

Where, DDM was digestible dry matter as percentage (%) of dry matter and DMI was dry matter intake as a (%) of body weight.

3.4 Statistical Analysis: The data obtained in the study were subjected to analysis of variance in accordance with the split plots technique in randomized blocks experimental design using Mstat-C computer software (Russell, 1986) to compare significant differences among treatments. Duncan's multiple range test was applied to compare the means. Tables 1-3 show F-values, and LSD values for genotypes. In addition, standard deviation values were presented in Table 1-3.

4 RESULTS AND DISCUSSION

Although, significant differences were noted in genotypes and different nitrogen doses in terms of agronomic characteristics, a non-significant interaction was found in genotypes and different nitrogen doses in terms of two years' effect. Therefore, instead of carrying out an analysis of variance for two years separately, combined statistical analysis was performed for the results of two years and are described below.

Table 1. Yield parameters according to different N doses and genotypes

Nitrogen Doses (kg ha^{-1})	Fresh matter yield (tonnes ha^{-1})	Dry Matter Yield (tonnes ha^{-1})
0	15.80 ± 0.14 e	14.15 ± 0.13 e
25	17.16 ± 0.19 d	15.36 ± 0.17 d
50	19.04 ± 0.16 c	17.03 ± 0.14 c
75	21.38 ± 0.12 b	19.12 ± 0.10 b
100	22.43 ± 0.11 a	20.01 ± 0.09 a
ORT	19.16	17.13
F-values	2.35**	2.25**
Genotypes		
Saglamtimur	17.64 ± 0.32 c	15.79 ± 0.28 c
Stala	20.67 ± 0.25 a	18.48 ± 0.22 a
Enton	19.18 ± 0.22 b	17.13 ± 0.20 b
ORT	19.16	17.13
LSD	49.92	44.80
F-values	3.89**	3.81**

Capital letters were used for comparisons of nitrogen doses and genotypes in subgroups ($P<0.01$).
(* $P<0.05$, ** $P<0.01$).

4.1 Fresh matter yield and Dry Matter Yield: The effect of different nitrogen doses and genotypes on fresh matter yield were significantly different ($p<0.01$). It was been determined that there was an increase of approximately 42% in fresh matter yield from the control dose to the nitrogen dose of 100 kg ha^{-1}. The fresh matter yield, which was 15.81 t ha^{-1} at the control dose, increased to 22.43 t ha^{-1} at 100 kg ha^{-1} nitrogen dose (Table 1). The highest fresh matter yield was obtained in Stala genotype with 20.01 t ha^{-1}. The lowest fresh matter yield was determined as 17.64 t ha^{-1} in Saglamtimur genotype. Wilczewski *et al.* (2008), Ates *et al.* (2014), Yilmaz and Albayrak (2018), Ozkan and Sevimay (2020) reported the positive effects of increasing nitrogen doses on fresh matter yield. The effect of different nitrogen doses and genotypes on dry matter yield were significantly different ($p<0.01$). It was determined that there was an increase of 41.38% in dry matter yield from the control dose to the nitrogen dose of 100 kg ha^{-1}. Dry matter yield, which was 14.15 t ha^{-1} at the control dose, increased to 20.01 tonnes ha^{-1} at 100 kg ha^{-1} nitrogen dose (Table 1). The highest dry matter yield was obtained from Stala genotype with 18.48 t ha^{-1}. The lowest dry matter yield was determined as 15.79 t ha^{-1} in Saglamtimur genotype. Ates *et al.* (2014), Yilmaz and Albayrak (2018), Ozkan and Sevimay (2020) stated that the positive effects of increased nitrogen doses on dry matter yield. Increasing doses of nitrogen reduce the fibrous compounds (ADF, NDF) in the dry matter. This positive property results in an increased rate of digestion of the dry matter. Therefore, animals can benefit from dry matter better.

4.2 Acid Detergent Fiber (ADF): The effect of different nitrogen doses on ADF were significantly different ($p<0.01$), while the genotypes and years had a non-significant effect on ADF. The ADF values are important because they are related to the abilities of animals to digest forage. Digestibility of forage usually decreases with an increase of ADF. ADF and digestibility have inverse correlation and low ADF is desirable. ADF could increase due to maturity, weathering, rain damage, high temperatures, weeds, excessive fertilizing, etc. The mean ADF values ranged from 29.56-36.08% in this study (Table 2). Application of 75 kg ha^{-1} nitrogen (N_3) generated the highest quality forage (minimum ADF) with the highest digestibility ADF percentage in the forage. The highest ADF value (lowest digestibility) of forage was obtained in the control treatment (N_0) without any application of N (Figure 1). ADF percentage ranged from 31.98 % to 32.37 % and showed not statistically significant differences among genotypes (Table 2). However, based on ADF percentages of the genotypes they could be numerically ranked as Stala (C_2)> Saglamtimur (C_1)> Enton (C_3) in descending order. The results of this study are in agreement with Adeli *et al.* (2005), Sanz *et al.* (2005), Almodares *et al.* (2009), Albayrak and Yuksel (2010), and Carpici *et al.* (2010). All researchers agree that increasing doses of nitrogen adversely affects forage quality. Kiraz (2011), Ates (2012), Kalber *et al.* (2012), and Ates *et al.* (2014) has also reported the ADF of phacelia as 29.95-37.7%. Yilmaz and Albayrak (2017) estimated the average ADF percentage in phacelia as 34.52% in Enton (C_3) and as 35.14% in Stala (C_2). The fact that the ADF percentages in this study are lower, in general, indicates that the obtained forage has a higher quality and digestibility.

Table 2. Effects of different N doses and genotypes on means of forage quality parameters

Nitrogen Doses (kg ha^{-1})	**ADF (%)**	**NDF (%)**	**CP (%)**	**TDN (%)**	**DDM (%)**	**DMI (%)**	**RFV (%)**
0	36.08 ±2.04 a	46.96 ±2.31 a	13.69 ±0.79 e	54.78 ±2.64 d	60.80 ±1.59 d	2.56 ±0.12 c	120.79 ± 8.72 c
25	33.47 ±2.54 b	44.07 ±2.76 b	15.57 ±1.05 d	58.14 ±3.28 c	62.82 ±1.97 c	2.73 ±0.18 b	133.31 ±12.97 b
50	31.48 ±2.68 c	42.44 ±3.30 bc	16.54 ±1.11 c	60.72 ±3.46 b	64.38 ±2.09 b	2.84 ±0.22 ab	142.16 ±15.71 ab
75	29.56 ±1.11 d	40.73 ±1.59 c	17.94 ±0.63 b	63.19 ±1.43 a	65.87 ±0.86 a	2.95 ±0.11 a	150.68 ± 7.56 a
100	30.03 ±1.18 cd	41.49 ±1.27 c	19.68 ±0.95 a	62.59 ±1.52 ab	65.51 ±0.92 ab	2.89 ±0.08 a	147.02 ± 6.00 a
ORT	32.12	43.14	16.68	59.88	63.88	2.79	138.79
F-values	18.758**	12.260**	129.518**	18.734**	18.732**	10.973**	13.372**
Genotypes							
Saglamtimur	32.01 ±3.62	43.53 ±3.73	17.17 ±2.35 a	60.30 ±4.67	63.97 ±2.82	2.76 ±0.23	138.03 ±17.18
Stala	32.37 ±3.11	42.90 ±2.88	16.69 ±2.32 b	59.56 ±4.02	63.68 ±2.42	2.81 ±0.10	138.93 ±13.84
Enton	31.98 ±2.70	42.98 ±3.03	16.20 ±2.19 c	60.06 ±3.49	63.98 ±2.10	2.81 ±0.20	139.42 ±14.67
ORT	32.12	41.14	16.69	59.97	63.88	2.79	138.79
LSD	2.13	2.66	0.32	2.75	1.66	0.18	12.60
F-values	0.161	0.262	36.277**	0.162	0.162	0.165	0.048

Capital letters were used for comparisons of nitrogen doses and genotypes in subgroups (P<0.01).
(* P<0.05, ** P<0.01).

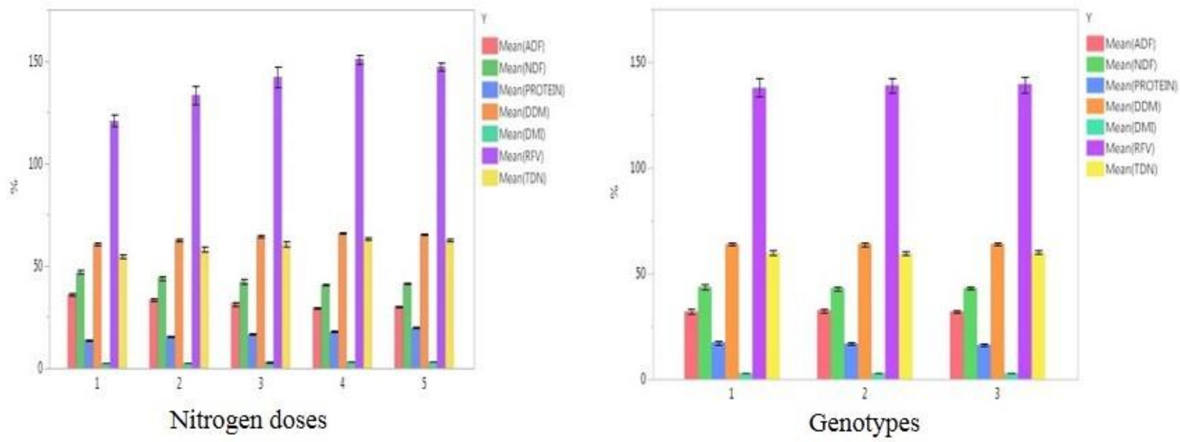

Figure 1. Effects of diffrent nitrogen doses and genotypes on nutritive values (for nitrogen doses; 1= 0 kg ha^{-1}, 2= 25 kg ha^{-1}, 3= 50 kg ha^{-1}, 4= 75 kg ha^{-1}, 5= 100 kg ha^{-1}, for genotypes; 1= Saglamtimur, 2= Stala, 3= Enton)

4.3 Neutral Detergent Fibre (NDF): The effect of different nitrogen doses on NDF was significantly different (p<0.01), while the genotypes and years had a non-significant effect on NDF. The mean NDF values ranged 40.73-46.96 % (Table 2). The highest NDF percentage (46.96 %) was found in the control treatment (N_o) and the lowest NDF percentage (40.73 %) was found as in treatments with an application of 75 kg ha^{-1} nitrogen (N_3) (Figure 1). The NDF has structurally composed of cell wall components such as lignin + cellulose + hemicellulose. The increase in these components leads to a significant decrease in the nutritive value and rumen digestibility. Similar to ADF, decreases in NDF levels were observed with increasing nitrogen doses. Adeli *et al.* (2005), Sanz *et al.* (2005), Almodares *et al.* (2009), Albayrak and Yuksel (2010), Carpici *et al.* (2010) have reported that increased doses of nitrogen lowered the NDF percentage in confirmation to the results of this study. Kiraz (2011) reported the NDF percentage in phacelia as 38.48-41.06 %, Ates (2012) as 44.7 %, Kalber *et al.* (2012) as 43.2 %, which are parallel to the results of this study. Considering that the highest percentage of NDF was estimated as 46.96 % in this study, a forage with high digestibility has been produced. Non statistically significant differences were detected among different genotypes (Table 2). NDF percentages ranged 42.90-43.53 % with the lowest NDF percentage for Stala (C_2) genotype. This is followed by Enton (C_3) and Saglamtimur (C_1) in NDF percentage in descending order (Table 2) (Figure 1). Yilmaz and Albayrak (2017) estimated the NDF ratio as 45.37 % in Enton (C_3) and as 45.38% in Stala (C_2). The results obtained from this study are in parallel with the results obtained by Yilmaz and Albayrak (2017).

4.4 Crude Protein (CP): Different nitrogen doses had significantly different (p<0.01) effects on crude protein (CP) as distributed among different genotypes. Means of different nitrogen doses for crude protein percentage had values between 13.69-19.68 % (Table 2). The highest crude protein percentage was obtained as 19.68 % from the treatments, where 100 kg ha^{-1} nitrogen was applied while the lowest crude protein percentage was obtained as 13.69 % from the control treatments without any nitrogen application (N_0) (Figure 1). Different genotypes had a statistically similar effect on the crude protein percentage. The mean values of crude protein percentage varied between 16.20-17.17 % and the genotypes are ranked as Stala (C_2)>Saglamtimur (C_1)> Enton (C_3) in descending order (Table 2) (Figure 1). This study showed that increased nitrogen doses have positive effects on crude protein percentage. The results of this study are confirmed by the works of Albayrak and Yuksel (2010), Carpici *et al.* (2010), Jacobs and Ward (2011), Islam *et al.*

(2012), Yilmaz and Albayrak (2017). They also reported an increase in the crude protein percentage in line with increasing nitrogen doses. Yilmaz and Albayrak (2017) focused on the Enton and Stala genotypes and noted statistically similar crude protein percentage of 14.68 % and 14.00 %, respectively. Feeding animals with high protein forages facilitate in a more balanced and productive diet during animal husbandry enabling higher digestion of fiber and meeting microbial needs of rumen. It can be suggested that if the crude protein percentage is <12 %, the forage quality is low. The forage quality is medium at 13-15 % protein percentage and high if protein percentage is >18 %. Based on these results, it can be understood that phacelia had the highest protein percentage using nitrogen dose of 100 kg ha^{-1} (N_4) and the quality of the produced hay was "high" in terms of forage quality.

4.5 Total Digestible Nutrients (TDN): The effect of different nitrogen doses on TDN was observed significantly different (p<0.01), while the genotypes had non-significantly different effect on TDN. TDN values of different nitrogen doses ranged from 54.78-63.19 % (Table 2). TDN percentage depends on the ADF percentage of the forages. Also, each increase in ADF results in a corresponding decrease of TDN. The highest TDN percentage was estimated as 63.19 % in the nitrogen application at the rate of 75 kg ha^{-1} (N_3) and the lowest TDN percentage of 54.78 % was noted in control treatment without any fertilizer application (N_o) (Figure 1). Increasing doses of nitrogen application also lead to an increase in the total digestible nutrients. TDN percentage of genotypes ranged from 59.56 to 60.30 %, displaying almost similar values (Table 2). The Saglamtimur genotype had the highest TDN percentage with 60.30 %, while Stala genotype had the lowest TDN percentage of 59.56 %. A range of 55-65 % TDN has been recommended for beef cows (NRC, 2016). The total digestible nutrient percentage has an inverse correlation with ADF. The decrease in the percentage of ADF with the increase in administered fertilizer doses results in an increase in the percentage of total digestible nutrients (Kering *et al*., 2011). Yilmaz and Albayrak (2017) estimated the TDN percentage of 56.7 % in Enton (C_3) and 55.99% in Stala (C_2).

4.6 Digestible Dry Matter (DDM): The effect of different nitrogen doses on DDM was observed significantly different (p<0.01) among fertilizer doses; while the genotypes and years had a non-significant effect on DDM. Similar to TDN, each increase in ADF resulted in corresponding decrease in DDM. Different nitrogen doses influenced DDM percentage that ranged from 60.80-65.87 % (Table 2). The highest DDM value was noted using 75 kg ha^{-1} N (N_3) and the lowest DDM percentage (60.80 %) was measured in the control treatments without any fertilization (N_o) (Figure 1). Among the genotypes, DDM values were almost similar to each other and ranged from 63.68-63.98 % (Table 2). The highest DDM value was estimated at 63.98 % in Enton (C_3) compared to the lowest DDM value of 63.68 % in Stala (C_2). The results of this study showed that the dry matter digestion ability of phacelia is generally similar to that of cereals.

4.7 Dry Matter Intake (DMI): The effect of different nitrogen doses on DMI was observed significantly (p<0.01) different; while the genotypes and years had a non-significant effect on DMI. The NDF is used to predict DMI. It has an inverse relationship with DMI, which means that when NDF is high the quality and the DMI are low (Horrocks and Vallentine, 1999). The effects of different nitrogen doses in the DMI percentage ranged 2.56-2.95 % (Table 2). The highest DMI value was estimated as 2.95 % in the third treatment having a nitrogen dose of 75 kg ha^{-1} (N_3) and the lowest DMI value was calculated as 2.56 % in the control treatment (N_o) (Figure 1). DMI percentages varied between 2.76-2.81 % in terms of genotypes. Highest DMI percentage was estimated as 2.81 % in Stala (C_2) and Enton (C_3) and the lowest DMI percentage was calculated as 2.76 % in Saglamtimur (C_1).

4.8 Relative Feed Value (RFV): The effect of different nitrogen doses on RFV was observed significantly different (p<0.01), while the genotypes and years had non-significant effect on RFV. RFV is an index that combines digestibility and intake potential into one number. The RFV system was developed for comparing forages based on energy (Stokes *et al.*, 1998). RFV percentages of different nitrogen doses ranged from 120.79-150.68 % (Table 2). The highest RFV percentage was noted using 75 kg ha^{-1} N (N_3) and the lowest RFV percentage was calculated as 120.79 % in the control treatment without any fertilizer application (N_o) (Figure 1). Among the genotypes, RFV ranged 138.03-139.42 % (Table 2). While Enton (C_3) yielded the highest RFV percentage with 139.42%, Saglamtimur (C_1) yielded the lowest RFV percentage with 138.03%. Moore and Undersander (2002) noted that forage quality and RFV were directly correlated. Decreased forage quality ends up with decreased RFV rate or vice versa. It is well established that the best forage quality has the RFV over 150. RFV value of 103-124 is 2^{nd} quality, 87-102 is 3^{rd} quality, 75-86 is 4^{th} quality and under 75 is 5^{th} quality (Rohweder *et al.*, 1978). Yilmaz and Albayrak (2017) observed that average RFV of 128.00% in Enton (C_3) and 127.00% in Stala (C_2) genotype. The results of this study yielded much higher RFV values compared to Yilmaz and Albayrak (2017).

Table 3: Effects of different nitrogen doses and genotypes on macro mineral matter ratios and net energy metabolic

Nitrogen Doses (kg ha^{-1})	**K (%)**	**MG (%)**	**P (%)**	**CA (%)**	**NE1**
0	3.800 ±0.13 b	0.613 ±0.05 c	0.270 ±0.01 a	1.668 ±0.12 c	1.355 ±0.05 d
25	3.963 ±0.16 a	0.670 ±0.07 ab	0.273 ±0.01 a	1.854 ±0.14 b	1.424 ±0.06 c
50	4.063 ±0.22 a	0.647 ±0.05 bc	0.287 ±0.01 a	1.810 ±0.14 b	1.476 ±0.07 b
75	4.061 ±0.14 a	0.684 ±0.08 ab	0.288 ±0.01 a	1.972 ±0.17 a	1.526 ±0.02 a
100	4.058 ±0.21 a	0.696 ±0.05 a	0.296 ±0.01 a	1.966 ±0.08 a	1.514 ±0.03 ab
ORT	3.990	0.662	0.282	1.854	1.46
F-values	4.242**	4.073*	13.376**	11.281**	18.799**
Genotypes					
Saglamtimur	3.993 ±0.24	0.643 ±0.07	0.284 ±0.01 a	1.830 ±0.18	1.462 ±0.09
Stala	3.930 ±0.20	0.705 ±0.09	0.276 ±0.01 a	1.927 ±0.17	1.453 ±0.08
Enton	4.045 ±0.14	0.639 ±0.05	0.288 ±0.01 a	1.805 ±0.14	1.463 ±0.07
ORT	3.989	0.662	0.283	1.854	1.459
LSD	0.29	0.09	0.03	0.02	0.05
F-values	0.617	2.515	12.000*	1.956	0.162

Capital letters were used for comparisons of nitrogen doses and genotypes in subgroups (P<0.01).
(* P<0.05, ** P<0.01).

4.9 Macro minerals (K, Mg, P, Ca) and Net energy lactation (NEl): Significantly different (p<0.01) effects were observed due to different nitrogen doses on the ratio of potassium (K), phosphorus (P) and calcium (Ca) uptake. Similarly, uptake of magnesium (Mg) ratio was also significantly different (p<0.05) under different N treatments. Different genotypes only affected (p<0.01), the ratio of phosphorus (P) uptake and had non-similar effect on potassium (K), calcium (Ca) and magnesium (Mg) uptake. Forage crops are very important sources of the minerals essential for animal health. The percentage of individual minerals in forages' genotypes extensively depend on species, soil, growth stages, biotic and abiotic stress conditions and management factors. Eighteen mineral elements are known required by at least some animal species. They can be divided into two groups (macro and microelements) based on the quantity required in the forage. Macro elements (Ca, K, P, Mg etc.)

are required in variable amounts. The mineral elements are contained in approximately 1.5-5.5 % of the animal body; out of which 1.4 % is Ca, 0.8 % is P, 0.19 % is K and 0.046 % is Mg (Ates *et al.*, 2010). Different nitrogen doses increased potassium (K) magnesium (Mg) and phosphorus (P), calcium (Ca) in range of 3.800-4.063 %, 0.613-0.696 %, 0.270-0.296 %, and 1.668-1.972 % (Table 3) (Figure 2). The highest percentage (4.063 %) of K was noted after application of 50 kg ha^{-1} N (N_2), Mg and P as 0.696 % and 0.296 % respectively; whereas, the highest percentage (1.972%) of Ca was obtained after the application of nitrogen at the rate of 100 kg ha^{-1} (N_4). The lowest macro element ratios were yielded by the control treatment (N_0). Ates (2012) noted Ca, K, Mg, and P ratio 0.87 %, 2.23 %, 0.33 %, and 0.57 % in phacelia in the same order. Ates *et al.* (2014) noted that nitrogen doses of 0-150 kg ha^{-1} results in an increase of Ca from 0.79-0.84 %, K from 2.27-2.41 %, Mg from 0.35-0.37 % and P from 0.49-0.56 % in phacelia. The results from this study yielded greater values in terms of K, Ca, Mg, and lower values in terms of P. Macro element ratios in different genotypes are generally almost similar (Table 3) (Figure 2). Stala (C_2) achieved the highest values in terms of magnesium (Mg) and calcium (Ca) ratios. Also, Enton (C_3) reached the highest values in terms of potassium and phosphorus. Net energy lactation ranged from 1.355-1.526 for different nitrogen doses in this study (Table 3). While the highest net energy lactation value was obtained as 1.526 at a nitrogen dose of 75 kg ha^{-1} (N_3), the lowest net energy lactation value was yielded as 1.355 by the control treatment without any nitrogenous fertilizer (N_0). Net energy lactation values for different genotypes were almost similar to each other. The highest net energy lactation value of 1.463 was achieved with Enton (C_3) genotype, Stala (C_2), on the other hand, had the lowest net energy-lactation value of 1.45. Bingol *et al.* (2007) estimated the net energy lactation value of 2.45 in hairy vetch as, 2.50 in common vetch, 2.29 in Hungarian vetch, and 2.22 in woolly pod vetch as. Canbolat (2012) estimated the NEI value of 6.90 in corn, 6.60 in sorghum, 6.90 in wheat, 5.60 in barley, 6.60 in oat, 5.40 in the rye, and 6.1 in triticale. Net energy lactation ranges among the above described plants yielded much higher values compared to this study.

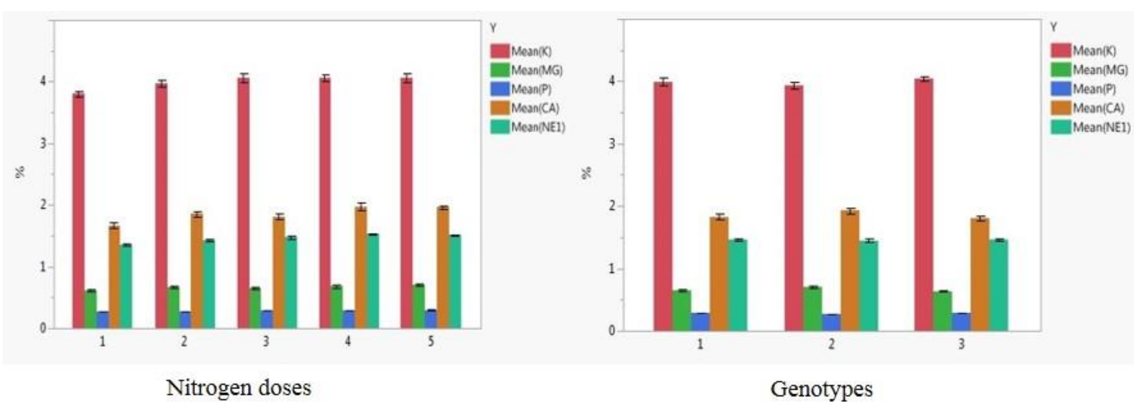

Figure2. Effects of different nitrogen doses and genotypes on macro mineral percentage and net energy lactation (for nitrogen doses; 1= 0 kg ha^{-1}, 2= 25 kg ha^{-1}, 3= 50 kg ha^{-1}, 4= 75 kg ha^{-1}, 5= 100 kg ha^{-1}, for genotypes; 1= Saglamtimur, 2= Stala, 3= Enton).

5 CONCLUSION

The results of the study showed that the three genotypes are highly stable and could be cultivated under warm temperate conditions for a better fresh matter yield and dry matter yield. Moreover, this study further indicate that increasing nitrogenous fertilizer application also increases the forage quality and nutritive value within a certain application range (from 0 kg ha^{-1} to 75 kg ha^{-1}). The long blooming period of this plant also allows bee farming that has no negative effects on obtaining high-quality forage of phacelia even after the blooming period. Therefore, phacelia can be added as a multipurpose crop in the Turkish farming system.

6 DECLARATION OF CONFLICTING INTERESTS

We have no conflict of interest to declare.

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