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The Effects of Different Sowing Dates of Fiddleneck (*Phacelia tanacetifolia*) During the Autumn and Spring Sowing Periods on the Forage Yield and Quality

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Abstract

The objective of this study was to determine the best sowing period and sowing dates for fiddleneck in Western Black Sea Region and in similar ecologies. The study was conducted at the Akmanlar village of the city of Bartın during the autumn and spring vegetation periods of 2012-2013 and 2013-2014 with randomized block design with three replications. This research was conducted in the autumn and spring sowing periods. At the end of the study, the highest amount of dry matter (8.97 t ha^{-1} –September 30 and 8.96 t ha^{-1}- September 15) and crude protein yield (1.10 t ha^{-1} September 15 -1.09 September 30 t ha^{-1}) were obtained in September from the sowings conducted during the autumn period, whereas for the spring period the highest dry matter was obtained beginning of March sowing date (4.07 t ha^{-1}). The fiber ratios of fiddleneck were determined on average as ndf 44.14%, adf 37.79%, adl 23.91% during the autumn sowing period and as ndf 42.51%, adf 34.63%, adl 22.82% during the spring sowing period. As a result, it is suggested to prefer autumn sowing period for hay and to carry out the sowing in the months of September and October during this time frame.

Keywords: ADF, crude protein, NDF, spring and autumn, Western Black Sea Region

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Introduction

Fiddleneck is a plant that belongs to the *Phacelia* genus under the Hydrophillaceae family and has a wide range of usage areas. Fiddleneck (*Phacelia tanacetifolia* Benth.) is an important source of high quality nectar and pollen for honeybees (*Apis* ssp.) and bumblebees (*Bombus* spp.). Besides, it is used for forage, ornamental and cover crops (Ateş et al. 2010).

Fiddleneck is mostly cultivated in North America and Europe for bee forage use and it was determined as a result of various different ecological studies in Turkey that it can also be cultivated as a fodder plant (Ateş 2012; Ateş et al. 2010; Karadağ and Büyükburç 2003a; Geren and Kaymakkavak 2007; Başbağ et. al. 2001; Uçar and Tansı 1996; Sağlamtimur et.al. 1989). Karadağ and Büyükburç (2001) determined that the highest plant height, fresh hay, dried hay, seed and biological yield was obtained for 40 cm row spacing. Karadağ and Büyükburç (2003a) investigated the effects of 4 different sowing dates (March 5-March 20 –April 5 –April 20) on hay yield in fiddleneck as well as on various other agricultural properties thus putting forth that sowing dates have significant effects on fresh and dried hay yields while also stating that the highest values were obtained for March 5 sowing period.

Pastures are under intensive grazing pressure and fodder plant cultivation is conducted in very limited areas in the Western Black Sea region; thus, production and demand are not in balance for coarse fodder in the region. Since the fiddleneck plant that is mostly used for bee forage purposes is an alternative plant for the Western Black Sea region in terms of its ecology and agricultural activities as well as for apiculture and cattle, its potential as a plant should be emphasized by putting forth its fodder yield and quality. It was determined as a result of studies conducted on fodder yield and quality of fiddleneck that it can be used as a fodder plant and that it provides fodder for animals that is balanced and nutritious (Karadağ and Büyükburç 2003a; Ateş 2010) In western Turkey Ateş et al. (2010) determined the yield and feeding values of fiddleneck at different growth stages. In this research was obtained, NDF 45.43%, ADF 36.40%, ADL 22.43%, crude protein %10.21, dry matter yield 9.87 t/ha at ½ blom stage. Ateş 2012, was to determine the yield and forage quality of field pea (*Pisum arvense* L.), fiddleneck (*Phacelia tanacetifolia* Benth.) and their mixtures under dry land conditions. Highest NDF 44.0-44.7% and ADF 37.1-38.1% were determined respectively 25% field pea+75% fiddleneck mixture and pure fiddleneck. Pure fiddleneck yield was recorded 7.8 t ha^{-1}.

The use of fiddleneck for different agricultural activities is an important potential for the region. Putting forth the current potential of fiddleneck as well as the fact that there was no previous study for the region were the starting points of the study. To this end, the best sowing period and sowing date in terms of fidddleneck fodder yield and quality for the Western Black Sea region and regions with similar ecology were determined in this study.

Material and Method

This study was conducted at the Akmanlar village of the city of Bartın during the autumn and spring vegetation periods in 2012-2013 and 2013-2014. Soil samples obtained from the study area were subject to analyses. The soil was loamy and moderately calcareous (7.01 % $CaCO_3$), was rich in organic matter (3.20%) and had nitrogen content % 0.29 as well as slightly alkaline characteristic (pH 7.54). The rain data for the years during which the study was conducted as well as a long term annual rainfall average are given in Figure 1 for the study region. Long term annual rainfall average was 1033 mm, temperature average was 11.4 ^{0}C and the moisture value was 78.5 %.

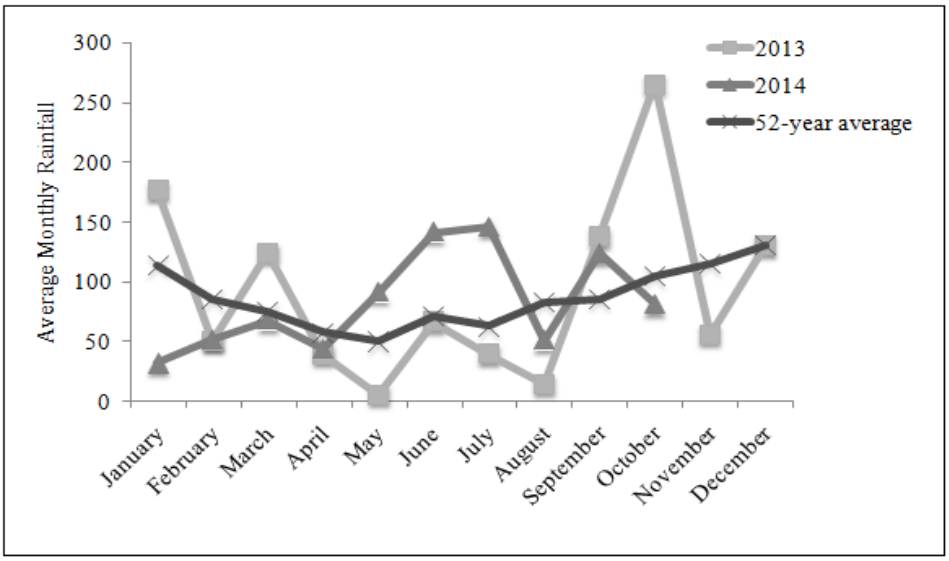

Figure 1. Monthly rainfall data for the study region for 2012, 2013, 2014 and long term data

The study was conducted with randomized block design with three replications. 12 different sowing dates were determined in two different periods as autumn and spring. The study area consists of 6 autumn sowing plots x 6 spring sowing plots x 3=36 plots in total. Each plot is 5x2=10 m^2. The total study area covers 476 m^2 including the distances between the plots and blocks. Sowings were conducted in autumn starting from September 15 (A1) in 15 day intervals as September 30 (A2), October 15 (A3), October 30 (A4), November 15 (A5) and November 30 (A6). The spring sowings were conducted starting from March in 15 day intervals as March 1 (İ1), March 15 (İ2), April 1 (İ3), April 15 (İ4), May 1 (İ5), May 15 (İ6). No emergence was obtained during the two years of the study for the sowing on May 15 (İ6) despite the fact that irrigation was continued. Italian origin Stala cultivar was used. The seeds were sown at a rate of 20 kg ha^{-1} (Karadağ and Buyukburç 2003b). Row spacing was 40 cm. Irrigation was continued in both sowing periods when there was no rainfall until emergence and water need was met via natural rains during the vegetation period. During the sowing, DAP fertilizer was given with the calculation of 100 kg ha^{-1}. The harvesting was conducted when the plants were at the % 50 flowering period by sawing the area within inside

the 1 m^2 quadrant after leaving 0.5 m edge effect (Geren and Kaymakkavak 2007). The hay samples taken during fresh hay harvest were dried in 70 ^oC oven until they reached a fixed weight after which they were weighed and the parcel dry matter weights were determined (Martin et al. 1990), these values were converted into hectare and dry matter yields (t ha^{-1}) were calculated. All dried samples were ground to small (<2 mm) pieces and were used for the analyses. The crude protein ratio was determined via the Kjeldahl metod. Dry matter yield was multiplied with crude protein ratio after which crude protein yield (t ha^{-1}) was calculated by dividing this value with 100 (Altınok and Karakaya 2002). The NDF, ADF and ADL ratios of ground samples were determined in accordance with the method developed by Van Soest et.al. (1991).

The results obtained from the trials were evaluated in accordance with the General Linear Model of the Statistical Analysis Software (SAS) with significance levels of % 5 and %1 (Anon. 1988). Duncan Test was applied in cases when interaction was observed between years and applications.

Results and Discussion

An active graph especially in terms of rain data (Figure 1) was determined during the years 2013 and 2014 when the study was conducted. This resulted in the acquisition of different results for both sowing periods. Even though the changes in rain regime between the years did not have significant effects on the autumn sowing, almost twice the values of the previous year were obtained in comparison with yield during the spring sowings S3-S4-S5 (Table 1).

The fact that rainfall was greater in the first year during the period from the sowing until harvesting resulted in higher yield from autumn sowing resulted in higher yield from autumn sowing. Whereas in the second year, rainfall was significantly greater than the average amount during the months of July and August following a dry winter and spring period. This resulted in the fact that the yields of sowings conducted during the spring period were higher than that of the first year.

Table 1. Dry matter yield, crude protein ratio and yield values for fiddleneck plant cultivated in different sowing periods

	Autumn								
	dmy t ha^{-1}			**cpy t ha^{-1}**			**cpr %**		
	2013	**2014**	**Ort.**	**2013**	**2014**	**Ort.**	**2013**	**2014**	**Ort.**
A1	9.43a**	8.50	8.96a*	1.18a**	1.06	1.10a**	12.49	12.45	12.47
A2	8.98ab	8.95	8.97a	1.09ab	1.09	1.09a	12.25	12.15	12.20
A3	7.73bc	8.70	8.21ab	0.95bc	1.05	0.99abc	12.22	12.04	12.13
A4	8.75ab	8.18	8.47ab	1.04ab	0.99	1.01ab	11.86	12.17	12.02
A5	6.30c	8.55	7.43bc	0.73c	1.07	0.89bc	11.52	12.46	11.99
A6	6.17c	7.66	6.97c	0.77c	0.97	0.87c	12.48	12.52	12.50
Ort.	7.89	8.44	8.17	0.96	1.04	0.99	12.14	12.30	12.22
SD	1.68	1.38		0.22	0.15		0.99	0.60	

	Spring								
	2013	**2014**	**Ort.**	**2013**	**2014**	**Ort.**	**2013**	**2014**	**Ort.**
S1	3.77a**	4.37a**	4.07a**	0.47a**	0.53a**	0.50a*	12.37	12.18	12.28
S2	3.05b	4.19a	3.62b	0.38b	0.52ab	0.45b	12.34	12.46	12.40
S3	1.95c	4.11a	3.03c	0.25c	0.48b	0.36c	12.62	11.62	12.12
S4	1.64d	2.60b	2.12d	0.19d	0.31c	0.25d	11.79	11.83	11.81
S5	1.28e	1.63c	1.46e	0.16e	0.20d	0.18e	12.09	12.15	12.12
Ort.	2.34B	3.38A**	2.86	0.29B	0.41A**	0.35	12.24	12.05	12.14
LSD	0.152	0.508		0.023	0.053		1.02	0.66	

A:Autum, A1:September 15, A2:September 30, A3:October 15, A4:October 30, A5:November 15, A6:November 30, S:Spring, S1: March 1, S2: March 15, S3:April 1, S4:April 15, S5:May 1, dmy: dry matter yield, cpy:crude protein yield, cpr:crude protein ratio. *P<0.05 **P<0.01

The highest dry matter and crude protein yield values were obtained for September sowings among the autumn sowing dates. Lowest yield values were obtained on November sowings for both years. Whereas a difference was observed in terms of dry matter yield and crude protein yield between the applications in the first year, there was no statistically significant difference in the second year. As a result, the difference between the years was determined to be statistically significant. No statistically significant difference was observed between the sowing date applications in the second year, however as was the case in the first year, highest yield was obtained from the sowing in September and the lowest yield was obtained from the sowing in November (Table 1). Sağlamtimur et.al. (1989) determined the dry hay yield of fiddleneck that is cultivated in Çukurova as a winter interval crop as 7.68 t ha^{-1}. Geren and Kaymakkavak (2007) state that under Mediterranean climate conditions at Bornova-İzmir, a dry matter yield of 4,57 tons per hectare is obtained for fiddleneck cultivation as a winter interval crop. The dry matter yield obtained in this study is much lower than that of our study. The differences in these results might be due to the facts that the different fiddleneck cultivars were used, different row spacings aplications effected and that the annual rainfall average (about 650 mm) is lower than our region. Karadağ and Büyükburç (1999) determined that the dry hay yield of fiddleneck cultivated under arid climate conditions at Tokat is 1.97 t ha^{-1}. Ateş 2010 conducted a study in the Marmara Region with has transition climate characteristics between the Black Sea and the Mediterranean climates determined that the crude protein ratio of fiddleneck is between 13.22-9.65% and that the dry matter yield is between 9.22-9.77 t ha^{-1}.

Crude protein ratios were not affected from sowing periods and sowing date applications. The crude protein values obtained in our study are in accordance with those obtained by Ateş 2010. Geren and Kaymakkavak (2007) determined that the crude protein ratio for different fiddleneck cultivars varies between 11.4-14.9 and that the crude protein yield is 7.44 t ha^{-1} which is the highest value in comparison with the two year average.

Lower dry matter yield and crude protein yield values were obtained in the spring sowing period than the autumn sowing period; whereas no statistically significant difference was observed between crude protein ratios. There were differences between the two years in terms of yield due to the rainfall amount differences between the first and

second year in the spring sowing periods. In the first year, the rainfall amount was above average due to early rains in the winter and early spring, which was followed by very low amount of rainfall in April and May. This had direct effects on the spring sowing period yields. Highest dry matter yield in the first year was obtained as 3.77 t/ha^{-1} in S1 sowing date. The reason for the increase in the second year yield values in comparison with the first year might be due to the rainfall amount in April, May and June to be close to or above the long term average value. Highest dry matter yields were obtained respectively for S1-S2-S3 sowing dates. Highest value of crude protein yield was obtained for the S1 sowing date. Karadağ and Büyükburç (2003a) researched 4 different sowing dates for the fiddleneck they cultivated in semi-arid climate conditions and determined that the highest values in terms of dry hay yield were obtained for the 5 March sowing date. The results that the researchers obtained are in accordance with the results of our study.

When the fiber values of fiddleneck are analyzed, a statistically significant difference was observed between the adf and adl values between autumn sowing dates, whereas there was no statistically significant difference between the ndf and ash values (Table 2). Ateş (2010) conducted a study that was different harvest times for fiddleneck in Tekirdağ. In this study fiber ratios were determined as the ndf values varied between 41.42-45.60 %, adf values varied between 36.20-37.33 %, adl values varied between 16.41-23.70 %. The same researcher conducted another study in 2012 during which the ndf value and adf value for fiddleneck respectively were obtained as 44.7%, and 38.1% (Ateş 2012). Geren and Kaymakkavak (2007) reported that the average crude ash ratio in fiddleneck species varies between 10.2-9.4%. The results obtained by the researchers are in accordance with our study.

Table 2. Fiber ratios and ash ratios of fiddlendeck plant cultivated in different sowing periods

	Autumn											
	ndf %			**adf %**			**adl %**			**ash %**		
	2013	**2014**	**Ort.**	**2013**	**2014**	**Ort.**	**2013**	**2014**	**Ort.**	**2013**	**2014**	**Ort.**
A1	44.55	44.44	44.49	38.36a**	38.35ba*	38.35	23.46c**	23.26c**	23.36b*	10.47	10.45	10.46
A2	43.48	44.33	43.90	37.50b	37.76bc	37.63	24.18ab	24.44a	24.31a	10.33	10.15	10.23
A3	44.19	44.37	44.28	37.49b	37.57c	37.53	24.56a	24.40ab	24.48a	9.93	9.97	9.95
A4	44.11	43.77	43.94	38.32a	38.60a	38.46	23.60bc	23.81bc	23.70b	9.73	10.00	9.86
A5	44.18	44.19	44.19	37.29b	37.34c	37.32	24.83a	23.52c	24.17a	10.22	10.10	9.86
A6	44.56	43.50	44.03	37.49b	37.42c	37.46	23.47c	23.40c	23.44b	9.38	10.45	10.16
Ort.	44.18	44.10	44.14	37.74	37.84	37.79	24.02	23.80	23.91	10.00	10.19	10.09
LSD	0.68	0.72		0.49	0.77		0.65	0.60		1.02	0.99	

	Spring											
	2013	**2014**	**Ort.**	**2013**	**2014**	**Ort.**	**2013**	**2014**	**Ort.**	**2013**	**2014**	**Ort.**
S1	42.83b**	42.15bc**	42.47b**	34.65	35.46a**	35.05a*	23.56	22.82b**	22.92	8.70b*	9.21a*	8.95b**
S2	42.40b	41.62d	42.01c	34.25	35.42a	34.84ab	22.48	23.19a	22.84	8.82ab	8.66b	8.74b
S3	42.59b	41.82dc	42.21bc	34.53	34.42b	34.47b	23.29	22.29b	22.79	8.29b	8.81ab	8.55b
S4	42.60b	42.47ab	42.54b	34.23	34.42b	34.32b	23.15	22.57b	22.86	8.50b	8.61b	8.56b
S5	43.83a	42.83a	43.33a	34.38	34.55b	34.46b	22.85	22.54b	22.69	9.43a	9.25a	9.34a
Ort.	42.84A**	42.18B	42.51	34.41B	34.85A*	34.63	23.06A**	22.57B	22.82	8.79	8.91	8.83
LSD	0.57	0.45		0.57	0.96		1.03	0.36			0.68	0.44

ndf: neutral detergent fiber, adf: acid detergent fiber, adl: acid detergent lignin, *P<0.05 **P<0.01

Fiber and ash values were lower in spring sowing applications when compared with the autumn sowing values. The vegetation duration in spring sowing period is shorter than that of the autumn sowing which might be the cause of a difference between the fiber ratios. A statistically significant difference was observed between years of Ndf, adf and adl values. The highest ndf ratio was determined as 42.83% for S5 sowing date, the highest adf ratio was determined as 35.05% for S1 sowing date, whereas the highest ash ratio was determined as 9.34% for S5 application (Table 2).

Conclusions

It was determined for the Western Black Sea region and regions with similar ecologies that at least twice the yield is obtained for autumn sowing periods in comparison with the spring sowing periods for fiddleneck cultivation. Higher yields were obtained from sowings conducted in the months of September and October in the autumn sowing period. It was observed that the sowing date did not cause significant changes in terms of fodder quality, but that there were significant differences between sowing periods. Lower yield values were obtained in the spring sowing period; however this can be turned into an advantage in April sowings by using them as sources of nectar and pollen for the bees since the number of flowers in the region decrease. As a result, autumn sowing period can be suggested for fiddleneck plant when it is cultivated for hay and spring sowing period when it is used as bee forage as well as for hay.

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