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Determining the appropriate improvement methods for the pastures of eastern Anatolia region of Turkey

Erdal Cacan[1*] and Kagan Kokten[2]
[1]Department of Crop and Animal Production, University of Bingol, Turkey
[2]Department of Field Crops, University of Bingol, Turkey
*Corresponding author e-mail: ecacan@bingol.edu.tr
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Abstract
This study was conducted over a natural pasture located in Agricultural Research and Practice Center of Bingol University for two years (2016-2017) to determine appropriate pasture improvement method to be applied in Eastern Anatolian pastures of Turkey. For this purpose, total of 8 different pasture improvement methods (fertilization, stone picking, weed control and combination of these three methods) were tried in a trial. Effects of improvement methods on green fodder yield, dry matter yield, crude protein content, crude protein yield, fibre (NDF, ADF) contents, relative feed value (RFV) and weight-based botanical composition were investigated. According to the results, the fertilization + stone picking method was more effective on the yield attributes of pastures (green fodder, dry matter and crude protein yields), while fertilization + stone picking + weed control was effective on the quality attributes of pastures (low ADF, NDF and high RFV). Fertilization + stone picking also increased the proportion of grasses, while weed control increased numbers of legumes, but all improvement methods reduced the proportion of other family plants in botanical composition. It was concluded that fertilization + stone picking + weed control was the ideal improvement method for eastern Anatolian pastures of Turkey.

Keywords: Fertilization, Improvement, Pastures, Stone picking, Weed control

Introduction

Yield and quality of pasture lands are decreasing gradually and significantly. In addition, climate conditions, especially the precipitation, are the greatest limiting factors for well-developed pasture vegetation. Early and excessive grazing also reduced the yield potentials of the pastures. The majority of pasture vegetation have so weakened as not to hold on the soil they grow in (Acikgoz, 2001). Therefore, degraded past--ures should urgently be reclaimed. Pasture improvement is defined as facilities established over the pastures, arrangements, and practices performed to improve yield and quality of the pastures and to facilitate grazing of animals over the pastures (Altin *et al*., 2005). As it can be inferred from this definition, there are two targets in pasture improvement. The first one is to improve yield and quality and the second one is to provide the maximum benefit to grazing animals.

Fertilization, seeding, pests and disease control are the most common practices performed to improve fodder yields and botanical composition of the pastures. Fences, shelters, feeders, waterers, licking stones, pasture pathways and similar facilities are constructed to facilitate grazing of animals and to allow them to have maximum benefit from the pastures (Altin *et al*., 2005). Fertilization application increases herbage production (Naveen *et al.,* 2012), especially the nitrogen fertilization is one of the most practical and effective ways to improve yield and nutritional quality in plants (Kaur *et al*., 2016). Stone picking is used as cultural application in the pasture to preserve soil moisture levels (Ekiz *et al*., 2011). Weed control is also practiced before fertilization and positive results were reported (Genc Lermi and Altinok, 2009). Weed control even may improve fodder quality in pastures (Altin *et al.,* 2005).

One or more of these improvement methods may be practiced to improve forage yield and quality in pastures. If a pasture has already lost original botanical composition, then 'seeding' is the best method to be practiced to regain original composition. If the pasture was not lost the original botanical composition, then fertilization and controlled grazing may be sufficient to reclaim the pasture. Since the present research site did not lost its original botanical composition, the other pasture improvement methods, except for seeding, were considered. Therefore seeding, an expensive and risky

Table 1. Monthly average climate data of Bingöl for 2016-2017 and long years (2000-2015)

Months	Average temperature(°C)			Total precipitation(mm)			Relative humidity (%)		
	2016	2017	Long years	2016	2017	Long years	2016	2017	Long years
January	-2.8	-3.7	-2.5	235.1	63.9	154.0	75.3	71.1	73.3
February	2.4	-2.3	-0.9	86.3	32.9	137.7	73.7	61.6	72.2
March	7.0	5.9	4.9	125.5	114.5	124.1	60.4	64.7	64.2
April	13.9	10.8	10.9	45.5	166.4	103.8	48.4	58.8	61.2
May	16.3	16.4	16.2	62.2	92.4	66.8	57.4	56.2	55.8
June	22.2	22.6	22.6	34.6	9.6	18.4	43.6	39.0	42.5
July	26.9	28.0	27.0	3.5	0	7.3	33.4	28.1	36.7
August	28.0	27.6	26.8	0.0	2.5	5.4	28.0	26.0	36.8
September	19.9	23.5	21.3	29.1	0	16.4	40.3	26.4	42.2
October	15.2	13.4	14.2	4.4	52.8	70.3	43.0	48.6	58.9
November	6.4	7.3	6.5	53.7	99.5	91.8	47.9	68.5	64.7
December	-2.2	3.7	0.2	152.6	74.6	121.8	73.4	69.8	70.7
Total/Aver.	**12.8**	**12.8**	**12.3**	**832.5**	**709.1**	**917.8**	**52.1**	**51.6**	**56.6**

improvement method, was not taken into consideration in this study. But stone picking, weed control, fertilization and their combinations were considered as improvement methods and the effects of these improvement methods on forage yield, forage quality and botanical composition of the pastures were investigated.

Materials and Methods

Experimental area: This study was conducted at Agricultural Research and Practice Center of Bingol University. The study area had an altitude of 1093 m and located 15 km away from the Bingol city center. The study was continued for two years (2016-2017).

Climate and soil characteristics of the study area: Monthly climate data for the trial years (2016 and 2017) and long-term averages (2000-2015) were collected from Bingol Provincial Directorate of Meteorology. Trial years of 2016 and 2017 had higher temperatures and lower precipitations and relative humidity values than the long-term averages (Table 1). Soil samples were taken from 0-30 cm soil profile at different sections of the pasture and analyzed at laboratories of Soil Science and Plant Nutrition Department of Bingol University. Analyses revealed that pasture soils were clay-loam in texture, slightly acidic (pH=6.12), salt-free (0.011%), poor in organic matter (1.03%) and lime (0.40%), sufficient in potassium (20.12 kg da^{-1}) and phosphorus (7.56 kg da^{-1}).

Trial design and examined yield features: The trial was set up over 4275 m^2 land area on 10 March 2016. There were 8 trial parcels with 400 m^2 (20 m x 20 m) size and 5 m distance between the parcels. Different improvement methods and their combinations were applied to these parcels (Table 2). Stone picking was applied over 4 parcels, right after the trial setup (10-25 March 2016). Weed control was practiced in spring months of both years just before the flowering period of the plants with hand hoes and weeds were removed from the trial parcels. Fertilization was practiced in the trial area during first year through applying 8 kg da^{-1} nitrogen and 8 kg da^{-1} phosphorus. At the autumn of 2016 (October) and the spring of 2017 (April) phosphorus (8 kg da^{-1}) and nitrogenous (8 kg da^{-1}) fertilizers were applied, respectively. During the flowering period of dominant plants in the last week of May, 3 randomly selected sections were conducted with 33 x 33 cm frames in pasture parcels for harvesting herbage. Harvested herbage was weighed to get green fodder yields of the trial parcels. Herbage samples were then dried at 78°C for 48 hours to get dry matter yields. After dried samples were separated into three groups as of grasses, legumes and other family plants, botanical composition values were also obtained through proportioning of group weights to total plant weights.

Table 2. Pasture improvement methods

Improvement method	Abbreviations
Control	-
Fertilization	F
Stone picking	SP
Weed control	WC
Fertilization + stone picking	F + SP
Fertilization + weed control	F + WC
Stone picking + weed control	SP + WC
Fertilization + stone picking + weed control	F + SP + WC

Examined quality features: Dry herbage samples were ground and subjected to crude protein, ADF and NDF analyses with NIRS (Near Infrared Spectroscopy - Foss Model 6500) (Basaran *et al*., 2011; Mut *et al*., 2010; Cinar and Hatipoglu, 2015). Crude protein content were used to get crude protein yields per decare and ADF and NDF values were used to calculate relative feed value (RFV = (88.9-(0.779x%ADF)) x (120/%NDF) (Van Dyke and Anderson, 2000; Morrison, 2003). A sample was taken from each plant species. Samples were then identified following Serin *et al.* (2005) and Serin *et al.* (2008) and life durations and respond groups of samples were determined following standard method (Anonymous, 2018).

Data analyses: All statistical data were analyzed with JMP statistical software in randomized blocks trial design with 3 replications. In order to record main and interaction effect of application, two way ANOVA test was applied and then differences between the groups were compared with Tukey test (Steel and Torrie, 1980; Kalayci, 2005).

Results and Discussion

Green fodder and dry matter yields: Green fodder and dry matter yields of the pasture improvement parcels were recorded for both the years (Table 3). The effects of years, applications and years x applications on the green fodder and dry matter yields were found to be significant ($P<0.01$). The highest green fodder (927.7 kg da^{-1}) and dry matter (527.4 kg da^{-1}) yields were obtained from fertilization + stone picking parcel. The lowest green fodder (207.7 kg da^{-1}) and dry matter (69.4 kg da^{-1}) yields were obtained from the control parcel. Green fodder and dry matter yields were higher in the second year (2017) compared to first year (2016). However, the precipitations were higher in year 2016 than 2017. In fact, the precipitations during the months April and May in year 2017 were higher than both 2016 and long-term averages, which might have contributed to higher green and dry matter yields in year 2017.

Among the studied improvement methods, stone picking + fertilization had greater impacts on green fodder/dry matter yields and crude protein yields than the other methods (Table 3). As compared to the control parcel, fertilization + stone picking increased green fodder yields by 3 folds and increased dry matter yields by more than 6 folds. Since fertilization and stone picking can easily be adopted by the farmers, these methods should be considered as the better pasture improvement methods.

Table 3. Green fodder and dry matter yields of the pasture improvement parcels**

Improvement method	Green fodder yield (kg da^{-1})			Dry matter yield (kg da^{-1})#		
	2016	2017	Mean	2016	2017	Mean
Control	192.7 h	222.7 gh	207.7 d	60.8 h	77.9 h	69.4 f
F	360.7 fgh	677.7 cd	519.2 c	142.4 g	479.6 b	311.0 d
SP	453.3 ef	589.6 de	521.5 c	294.9 f	371.2 cd	333.0 c
WC	439.3 ef	541.2 def	490.3 c	150.3 g	341.0 de	245.7 e
F + SP	910.8 ab	944.7 a	927.7 a	394.7 c	660.0 a	527.4 a
F + WC	428.3 efg	730.5 bcd	579.4 c	158.5 g	475.2 b	316.9 cd
SP + WC	386.0 e-h	537.0 def	461.5 c	140.7 g	330.0 e	235.3 e
F + SP + WC	693.0 cd	816.7 abc	754.8 b	296.1 f	462.0 b	379.0 b
Mean	**483.0 B**	**632.5 A**	**557.8**	**204.8 B**	**399.6 A**	**302.2**

#1 hectare (ha) = 10 decares (da); **$P<0.01$, CV (green): 12.22%, CV (dry): 13.30%

Table 4. Grasses, legumes and other family plants in weight-based botanical composition**

Improvement method	Grasses (%)			Legumes (%)			Other family (%)		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Control	68.0 j	72.8 i	70.4 f	12.8 c	8.0 d	10.4 b	19.2 a	19.3 a	19.2 a
F	91.3 d	90.2 e	90.8 d	1.0 i	1.8 hi	1.4 f	7.7 c	8.0 bc	7.9 b
SP	88.2 f	92.5 c	90.4 d	6.5 e	4.4 f	5.4 c	5.4 e	3.1 g	4.3 e
WC	82.1 g	80.0 h	81.1 e	14.4 b	15.5 a	15.0 a	3.5 g	4.5 f	4.0 e
F + SP	95.4 b	97.5 a	96.5 a	1.2 i	1.0 i	1.1 f	3.4 g	1.5 i	2.5 g
F + WC	88.3 f	97.2 a	92.8 c	3.3 g	1.3 i	2.3 e	8.4 b	1.5 i	5.0 d
SP + WC	87.7 f	93.3 c	90.5 d	5.2 f	1.3 i	3.3 d	7.1 d	5.4 e	6.2 c
F + SP + WC	93.4 c	95.2 b	94.3 b	3.2 g	2.4 gh	2.8 de	3.4 g	2.4 h	2.9 f
Mean	**86.8 B**	**89.8 A**	**88.3**	**5.9 A**	**4.5 B**	**5.2**	**7.3 A**	**5.7 B**	**6.5**

**$P<0.01$, CV (grasses): 0.38%, CV (legumes): 6.01%, CV (other): 2.65%

Increasing dry matter yields with fertilizations were also reported earlier (Aydin and Uzun, 2000; Polat *et al*., 2000; Genc Lermi and Altinok, 2009; Naveen *et al.,* 2012; Yavuz and Karagul, 2013; Sahinoglu and Uzun, 2016).

Weight-based botanical composition: Weight-based botanical composition indicating the proportions of grasses, legumes and other families were also recorded (Table 4). The effect of years, applications and years x applications on the grasses, legumes and other family plant numbers were found significant (P<0.01). The highest proportion of grasses was found from fertilization + stone picking parcel, while the highest number of legumes was found from weed control parcel and the highest other family plants was from the control. With the application of improvement methods, proportion of grasses increased but legumes and the other family plants decreased in the second year. Average proportion of grasses, legumes and the other family plants over the entire pasture sections was 88.3, 5.2 and 6.5%, respectively.

With regard to weight-based botanical composition, it was observed that fertilization + stone picking application increased numbers of grasses, weed control application increased numbers of legumes. But all the improvement methods decreased the numbers of other family plants. Earlier it was also reported that fertilizer applications increased grasses (Aydin and Uzun, 2000; Polat *et al*., 2000; *Naveen et al.,* 2002; Genc Lermi and Altinok, 2009; Mut and Ayan, 2011; Yavuz and Karagul, 2014; Sahinoglu and Uzun, 2016) and decreased the number other family plants in pastures/ grasslands (Aydin and Uzun, 2000; Genc Lermi and Altinok, 2009; Mut and Ayan, 2011; Sahinoglu and Uzun, 2016).

Crude protein content and yield: Crude protein content of the dry matter was determined for each improvement parcels and crude protein yields were also calculated for these parcels (Table 5). The effect of years and years x applications on the crude protein content as well as yields were found to be significant (P<0.01). Crude protein content of the parcels varied between 12.8 to 14.7%, with an average value of 13.5%. The highest crude protein yield (76.9 kg da^{-1}) was obtained from fertilization + stone picking parcel and the lowest crude protein yield (9.1 kg da^{-1}) was obtained from the control parcel. Both the crude protein content and the yields were higher in year 2017 than in 2016.

Table 5. Crude protein content and yield of the pasture improvement parcels**

Improvement method	Crude protein (%)			Crude protein yield (kg da^{-1})#		
	2016	2017	Mean	2016	2017	Mean
Control	10.8 cd	14.8 ab	12.8 NS	6.6 h	11.6 h	9.1 e
F	12.6 a-d	14.2 abc	13.4	18.0 gh	68.4 bc	43.2 bc
SP	10.5 cd	15.9 a	13.2	30.8 fg	58.8 cd	44.8 b
WC	10.0 d	16.1 a	13.1	15.1 h	55.1 cd	35.1 cd
F + SP	15.2 ab	14.2 abc	14.7	59.9 cd	93.9 a	76.9 a
F + WC	11.9 bcd	16.2 a	14.1	18.7 gh	77.2 b	48.0 b
SP + WC	10.2 d	15.8 a	13.0	14.4 h	52.1 de	33.3 d
F + SP + WC	13.2 a-d	13.9 a-d	13.5	39.1 ef	64.0 bcd	51.6 b
Mean	11.8 B	15.1 A	13.5	25.3 B	60.1 A	42.7

#1 hectare (ha) = 10 decares (da); **P<0.01, NS: Non-significant, CV (ratio): 9.46%, CV (yield): 10.71%

Table 6. Fibre content and relative feed value of the pasture improvement parcels**

Improvement method	ADF (%)			NDF (%)			RFV		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
Control	40.1 abc	37.9 b-e	39.0 ab	65.8 ab	61.1 b-e	63.5 ab	81.5 cde	90.5 abc	86.0 bc
F	38.4 a-e	38.9 a-d	38.7 ab	65.7 abc	60.4 cde	63.1 ab	83.6 b-e	90.2 abc	86.9 abc
SP	41.1 ab	37.7 cde	39.4 a	65.3 abc	62.3 b-e	63.8 a	81.1 cde	88.8 abc	85.0 c
WC	41.5 a	38.6 a-d	40.0 a	68.7 a	58.6 e	63.7 a	76.6 e	93.4 ab	85.0 c
F + SP	35.3 e	37.5 cde	36.4 c	61.7 b-e	59.7 de	60.7 ab	92.5 ab	93.0 ab	92.8 a
F + WC	37.3 cde	36.9 de	37.1 bc	63.9 a-d	58.3 e	61.1 ab	87.5 a-d	96.0 a	91.7 ab
SP + WC	41.3 a	36.3 de	38.8 ab	68.2 a	57.8 e	63.0 ab	77.4 de	97.6 a	87.5 abc
F + SP + WC	36.2 de	37.0 cde	36.6 c	62.0 b-e	58.6 de	60.3 b	91.1 abc	95.4 a	93.3 a
Mean	38.9 A	37.6 B	38.2	65.2 A	59.6 B	62.4	83.9 B	93.1 A	88.5

**P<0.01, CV (ADF): 2.77%, CV (NDF): 2.80% , CV (RFV): 3.88%

Table 7. Name, family, lifetime and effect group of plant species, identified in the vegetation

Species name	Family	Life time	Effect group
Dactylis glomerata L.	*Poaceae*	Perennial	Decreasers
Elymus repens (L.) Gould	*Poaceae*	Perennial	Decreasers
Koeleria pyramidata (Lam.) P. Beauv.	*Poaceae*	Perennial	Decreasers
Poa bulbosa L.	*Poaceae*	Perennial	Increasers
Poa trivialis L.	*Poaceae*	Perennial	Increasers
Aegilops triuncialis L.	*Poaceae*	Annual	Invaders
Bromus danthoniae Trin.	*Poaceae*	Annual	Invaders
Bromus hordeaceus L.	*Poaceae*	Annual	Invaders
Bromus scoparius L.	*Poaceae*	Annual	Invaders
Bunium paucifolium DC	*Apiaceae*	Perennial	Invaders
Chardinia orientalis (L.) Kuntze	*Compositae*	Annual	Invaders
Crepis sp.	*Compositae*	Annual	Invaders
Crepis sancta (L.) Bornm.	*Compositae*	Annual	Invaders
Eremopoa persica (Trin.) Roshev.	*Poaceae*	Annual	Invaders
Eryngium campestre L.	*Apiaceae*	Perennial	Invaders
Euphorbia arvalis Boiss. & Heldr.	*Euphorbiaceae*	Annual	Invaders
Gundelia tournefortii L.	*Compositae*	Perennial	Invaders
Hordeum murinum L.	*Poaceae*	Annual	Invaders
Lathyrus sp.	*Fabaceae*	Annual	Invaders
Ornithogalum narbonense L.	*Asparagaceae*	Perennial	Invaders
Orobanche alba Stephan ex Willd.	*Orobanchaceae*	Annual	Invaders
Polygonum setosum Jacq.	*Polygalaceae*	Perennial	Invaders
Ranunculus arvensis L	*Ranunculaceae*	Annual	Invaders
Scabiosa argentea L.	*Caprifoliaceae*	Perennial	Invaders
Taeniatherum caput-medusae (L.) Nevski	*Poaceae*	Annual	Invaders
Trifolium campestre Schreb.	*Fabaceae*	Annual	Invaders
Trifolium pilulare Boiss.	*Fabaceae*	Annual	Invaders
Trifolium resupinatum L.	*Fabaceae*	Annual	Invaders
Tulipa julia K.Koch	*Liliaceae*	Perennial	Invaders
Turgenia latifolia (L.) Hoffm.	*Apiaceae*	Annual	Invaders
Vulpia ciliata Dumort.	*Poaceae*	Annual	Invaders
Zingeria biebersteiniana (Claus) P. A. Smirn.	*Poaceae*	Annual	Invaders

However, pasture improvement methods did not influence crude protein content of herbages. Since crude protein yield is directly related to dry matter yield, the highest crude protein yield was obtained from fertilization and stone picking parcels. Earlier workers also reported that improvement methods generally influenced and increased crude protein yields (Aydin and Uzun, 2000; Yavuz and Karagul, 2013, Karadavut *et al*., 2015; Sahinoglu and Uzun, 2016).

Fibre content and relative feed value: ADF, NDF contents and relative feed values of different improvement parcels were also recorded (Table 6). The effect of years, applications, years x applications on ADF, NDF contents and relative feed values were found to be significant ($P<0.01$). The lowest ADF content and the highest relative feed value were obtained from fertilization + stone picking and fertilization + stone picking + weed control parcels. The lowest NDF content was obtained from fertilization + stone picking + weed control parcel. The lowest ADF, NDF and the highest relative values were obtained in the year 2017 when compared to year 2016.

It was observed in this study that single stone picking and weed control methods did not influence ADF and NDF contents of pastures. ADF and NDF contents decreased especially with fertilizer application or with the combined applications including fertilization. Genc Lermi and Altinok (2009) reported that nitrogen fertilizer increased NDF content but phosphorus decreased NDF content. ADF values (27.56-43.13%) reported earlier by Omer *et al*. (2014) were corroborated to findings of the present study.

Plant species identified in the study site: A total of 32 plant species were identified in the study site and out of them 12 numbers were perennial and 20 numbers were annual plants (Table 7). With regard to the response of vegetation plants to excessive grazing, plants were divided into 3 groups as decreasers, increasers and invaders. Decreaser plants were the most valuable plants of the vegetation. They are quite delicious, thus their numbers in vegetation decreased under excessive grazing conditions. Increaser species usually took the place of decreasing plants with increasing grazing pressure, they are less delicious and resistant to grazing. Invader plants usually do not have any feed values or have feed value for short periods, they are generally in weed-class plants. Invader plants usually emerge when the increaser plants are decreased (Aydin and Uzun, 2002; Tukel and Hatipoglu, 2005; Gokku's *et al*., 2009). In the present study, the majority of plant species were classified as invader plants (27 species) without any feed values. Quite a few of them was classified as decreaser plants (3 species) with high feed values and increaser plants (2 species) with medium feed value. The number of legumes was also quite low (4 species) in the pasture. Although the number of grasses species was quite high (14 species), they were mostly invasive species.

Conclusion

Among the pasture improvement methods, fertilization + stone picking had the highest green fodder yield, dry matter and protein yields. As compared to control parcel, all pasture improvement methods increased green fodder, dry matter and protein yields and such increases were more than 6 folds in some applications. Besides yield parameters, fertilization + stone picking method also resulted the highest increase in grasses numbers in weight-based botanical composition. Weed control resulted the highest increase in legumes. However, all improvement methods reduced the numbers of the other family plants in the vegetation. Studied pasture improvement methods were not found to be effective on crude protein content. ADF and NDF contents were lowest under fertilization + stone picking + weed control method. The parcel with the lowest ADF and NDF contents had also the highest relative feed value. Fertilization + stone picking method was found more effective for pasture yield, while fertilization + stone picking + weed control was better for the quality of pasture. Therefore, it was concluded that fertilization + stone picking + weed control was the ideal method for improvement of Eastern Anatolian pastures.

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