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Locations of Perennial Ryegrass (*Lolium perenne* L.) Landraces in Central Anadolu Region of Türkiye and Some Soil Characteristics of the Locations

Abdullah Özköse[1]*, Mehmet Ali Avcı [1], Ahmet Tamkoç[1]

[1]Selçuk University, Faculty of Agriculture, Department of Field Crops, Konya, Türkiye

*Corresponding author: aozkose@selcuk.edu.tr https://orcid.org/0000-0002-5393-6748

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Abstract

This study was aimed to determine the characteristics of the soils of perennial ryegrass genotypes found in the natural flora in the Central Anadolu Region in Türkiye. Within the scope of the study, perennial ryegrass populations were collected from the provinces of Ankara, Eskişehir, Afyon, Konya, Aksaray, Karaman and Mersin and Antalya provinces in 2006 and 2007. Plants were collected and soil samples were taken and analysed from 87 sites in Ankara (20), Eskişehir (9), Afyon (5), Konya (39), Aksaray (1), Karaman (5), Mersin (2) and Antalya (6). According to the analysis results, the pH varied between 6.35-8.50, EC 52-1395 µS/cm, organic matter 0.04-9.1 %, lime 1.2-64.2%, P_2O_5 4.28-128.7 mg/kg, K_2O 24.7-1360. 8 mg/kg, Ca 820-4030 mg/kg, Mg 32.7-3569 mg/kg, Na 0.6-2016 mg/kg, Fe 2.78-67.50 mg/kg, Zn 0.10-8.97 mg/kg, Cu 0.21-9.43 and Mn 2.33-42.34 mg/kg. As a result of soil analyses, large differences were observed between the locations where plants were collected in terms of the characteristics examined. This change shows the potential of developing grass varieties that can grow in different soil properties with a good breeding study of perennial ryegrass populations.

Keywords: Grassland soils, habitat, perennial ryegrass, plant collection, soil properties.

Introduction

Perennial ryegrass (*Lolium perenne* L.) is a native plant of Asia Europe and North Africa (Hoover et al., 1948; Watson and Dallwitz, 1992). Nowadays, it is widely distributed worldwide, including in North and South America, Europe, New Zealand and Australia (Hannaway et al., 1999). It is also found naturally in the flora of Türkiye (Davis, 1985; Özköse et al., 2012; Özköse and Tamkoç, 2014a; Özköse et al., 2015). Although the natural flora of Türkiye contains a significant amount of perennial ryegrass (*L. perenne* L.) genotypes and has great breeding potential, studies on this plant are still very few. Perennial ryegrasses are intensively used both in green areas and as forage crops (Bolaric et al. 2005; Avcı et al., 2012; Özköse and Tamkoç, 2014b). It is highly utilized in turf mixtures especially in cool climate zones. Perennial ryegrass is also widely used in meadows for grazing in livestock farms. High palatability and digestibility make this species highly valuable for the green fodder requirements of dairy cattle and sheep (Hannaway et al., 1999).

The collection of perennial ryegrasses found in the natural flora of Türkiye, their use in breeding and the development of new varieties suitable for the conditions of the country will increase the chances of success in turf areas. With global warming, extreme temperatures, long summer and winter months without precipitation, and decreases in total annual precipitation are becoming more common day by day. People must allocate less water to turf areas with scarce water resources. Again, in areas where there is urbanization, the soils in the areas where green areas will be established may not be very suitable for the healthy growth of turfgrass plants It may be necessary to move a significant amount of soil for a good turf establishment. However, breeding plants that are resistant or tolerant to soil-based stresses without high soil selectivity will reduce turf establishment costs and contribute to the longevity of the turf establishment. This study aims to determine the soil properties of perennial ryegrass genotypes found in the natural flora of Türkiye. Plants were collected from the areas where perennial ryegrass genotypes were found in the natural flora, soil samples were taken, and the soil samples were analysed. As a result of the analyses, information about the soil requirements of perennial ryegrass genotypes will be obtained. In addition, if genotypes that grow in extreme soil conditions in the natural flora are identified, that feature will be utilized in breeding.

Materials and Methods

In the study, perennial ryegrass plant collection trips were carried out in the Central Anadolu in Türkiye for two years (2006 and 2007). The routes of the plant collection trips were determined according to the regions where perennial ryegrass plants can grow, such as pastures, grasslands, riverbeds, etc. by the project team, which knows as a result of many meadow pasture improvement projects, expertise and plant collection trips in the region.

As a result of two years of field work, perennial ryegrass plants were collected and soil samples were taken from 87 locations in Ankara (20), Eskişehir (9), Afyon (5), Konya (39), Aksaray (1), Karaman (5), Mersin (2) and Antalya (6). The locations where soil samples were taken are shown in Fig. 1.

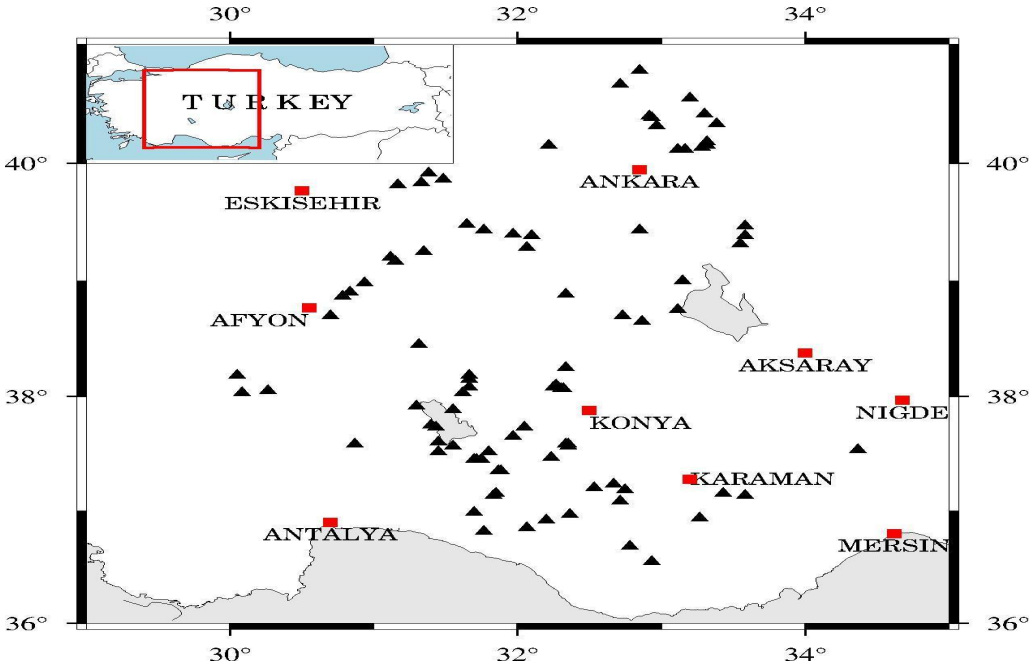

Figure 1. Distribution of *Lolium perenne* collection in the Central Anadolu Region of Türkiye.

Field work program in 2006;

25-26-27-28-29-30/07/2006: Konya – Afyon – Eskişehir – Ankara – Konya provinces

01-02-03-04-04-05-06/07/2006: Konya – Aksaray – Karaman – Konya provinces

08-09-10-11-12-13/07/2006: Konya – Mersin – Antalya – Konya provinces

Field work program in 2007;

21-22-23-24/6/2007: Konya – Aksaray – Karaman – Konya provinces

28-29-30/06 and 01-02-03-04/07/2007: Konya – Afyon – Eskişehir – Ankara – Konya provinces

07-08-09-10-11-12/07/2007: Konya – Mersin – Antalya – Konya provinces

Plants were collected from each location as seeds or rooted plants and soil samples were taken. The soil samples were numbered and information about the collection site was recorded regularly. Soil samples were taken from 0-20 cm depth after removing the plants on the soil surface. The soil samples were dried in the laboratory in accordance with the technique and crushed in a porcelain mortar (Karapınar, 2023), then sieved through a 2 mm sieve and prepared for analysis.

Soil samples were analysed for soil reaction (pH) (pH meter), EC (EC meter), organic matter (Smith-Weldon method - Sağlam, 1979), lime (calcimeter), phosphorus (Olsen method - Bayraklı, 1987), potassium (1 N NH_4OAc; flame photometer - Bayraklı, 1987), Fe, Zn, Mn, Cu (by extraction with 0.005 M DTPA + 0.01 M $CaCl_2$ + 0.1 M TEA (pH = 7.3)), available Ca and Mg (1 N NH_4-Acetate (pH = 7) - Sağlam, 1979), Na+ (flame photometer - Rhoades, 1982).

According to the results of the analyses, the highest, lowest, mean, quartile deviation, median value, range of variation and standard deviation values for each trait were determined by JMP Statistical Software.

Results and Discussion

Plant and soil samples were taken from 87 locations during a two-year field study. The local names and coordinates, altitudes and soil analysis results of the locations where soil samples were taken are given in Tables. The Central Anadolu Region (Fig. 1), where the plants were collected, is a region with a continental climate, cold winters, hot summers and annual rainfall ranging between 280 and 600 mm. Perennial ryegrass, which is the subject of the study, is a plant that likes cool climates and rainfall. For this reason, perennial ryegrass is not homogeneously distributed in the target region but can be found in riverbeds such as streams, around water sources or in grassland areas. Moist pasture areas are the general distribution areas of perennial ryegrass. Therefore, these soil analysis results also give us the soil characteristics of the pasture areas of the Central Anadolu Region. For a better understanding of the soil analysis results, the basic parameters such as minimum,

maximum, quartile deviation, median value, arithmetic mean, width of variation, standard deviation are given in Table 3 and histograms of frequency distribution are given.

In the Central Anadolu Region of Türkiye, perennial ryegrass genotypes are naturally distributed between 538 m - 2067 m altitudes (Table 1 and Table 2). When we look at the frequency distribution (Fig. 2A), it is mostly distributed at altitudes between 1000 and 1500 meters. The fact that the altitude change width is 1529 m shows that the adaptation ability of the perennial ryegrass is high (Table 1).

Table 1. Soil characteristics of the natural distribution areas of perennial ryegrass.

	N	Min.	Quartile	Median	Quartile	Max.	Variation Width	Mean	Std Dev.
Altitude (m)	87	538	979	1125	1372	2067	1529	1173	280
pH	87	6.35	7.20	7.40	7.60	8.50	2.15	7.38	0.36
EC (µS/cm)	87	52	124	166	275	1395	1343	261	256
Org. M. (%)	87	0.04	0.70	1.56	3.20	9.10	9.06	2.21	1.98
Lime (%)	87	1.20	3.3	10.6	27.0	64.2	63	17.1	16.1
P_2O_5 (mg/kg)	87	4.28	9.20	14.46	22.73	128.7	124.42	18.88	17.10
K_2O (mg/kg)	87	24.7	113.9	252.2	421.7	1360.8	1336.1	316.3	271.7
Ca (mg/kg)	87	820	4030	4870	5826	8198	7378	4841	1543
Mg (mg/kg)	87	32.7	206.5	416.6	729.2	3569	3536.3	620	651
Na (mg/kg)	87	0.6	8.0	23.0	97.7	3016.0	3015.4	143.1	437.7
Fe (mg/kg)	87	2.78	5.10	8.12	17.67	67.50	64.72	14.57	14.98
Zn (mg/kg)	87	0.10	0.33	0.55	1.07	8.97	8.87	0.88	1.12
Cu (mg/kg)	87	0.21	1.00	1.43	2.80	9.43	9.22	2.05	1.62
Mn (mg/kg)	87	2.33	7.72	10.47	15.46	42.34	40.01	12.71	8.03

Table 2. Some location information and analysis results of soil samples results of the locations where perennial ryegrass landraces were collected.

No	Province	Location	Lat. (N) (°.')	Lon. E (°.')	Alt. (m)	pH	EC (µS/cm)	OM (%)	Lime (%)
1	Konya	Akören	37.28	32.14	1181	7.43	100	0.2	1.6
2	Mersin	Ermenek - Mut	36.33	32.56	538	7.65	135	0.32	52.7
3	Konya	Hatunsaray	37.35	32.2	1097	6.98	695	2.06	3.4
4	Konya	between Fevziye - Kulu	39	33.09	950	8.1	870	1.44	26.7
5	Konya	Cihanbeyli	38.45	33.07	910	7.9	1395	0.28	22.5
6	Konya	Seydişehir	37.21	31.53	1091	7.87	112	0.6	3.4
7	Konya	Akören	37.34	32.21	1098	7.53	102	0.58	1.8
8	Konya	Cihanbeyli	38.39	32.52	971	8.3	917	4.65	25.9
10	Konya	Cihanbeyli	38.42	32.44	989	7.65	312	1.88	34.5
11	Konya	between Cihanbeyli-Yunak	38.53	32.2	1016	7.45	430	4.83	24.3
12	Eskişehir	Mihalıççık	39.52	31.29	1372	7.3	145	2.32	2.4
13	Ankara	Akyurt	40.07	33.07	1090	7.5	338	7.2	13.4
14	Eskişehir	Çifteler	39.12	31.07	914	7.38	355	2.55	26.2
15	Eskişehir	between Alpu-Mihalıççık	39.49	31.1	861	7.27	363	6.93	26.1

16	Eskişehir	between Mihalıççık-Nallıhan	39.55	31.23	1569	7.43	166	0.77	10.4
17	Ankara	between Ankara-Kulu	39.26	32.51	1091	7.65	174	3.63	23.2
18	Konya	between Seydişehir-Konya	37.39	31.58	1360	6.51	77	0.24	1.2
19	Konya	Huyuk	37.53	31.33	1141	7.38	136	1.25	12.9
20	Mersin	between Karaman-Mut	36.56	33.16	1500	7.48	130	0.63	49.8
21	Ankara	çubuk	40.24	32.55	1488	7.01	214	3.17	1.8
22	Ankara	between çubuk-Karagöl	40.19	32.58	1307	6.46	112	2.23	1.3
23	Eskişehir	between Alpu-Mihalıççık	39.5	31.2	979	7.2	176	0.21	4.6
24	Konya	between Kurucuova-Beyşehir	37.44	31.26	1126	7.08	240	8.42	3.6
25	Konya	between Deşdigin-Doğanhisar	38.05	31.4	1475	6.69	81	0.56	3.0
26	Konya	between İnlice-Konya	37.44	32.03	1549	6.35	236	3.49	1.2
27	Konya	between Şarkikaraağaç -Beyşehir	37.55	31.18	1125	7.11	256	2.52	16.6
28	Konya	Deşdiğin	38.02	31.37	1495	7.06	131	0.51	1.3
29	Konya	Seydişehir	37.31	31.48	1124	7.13	219	0.26	19.9
30	Konya	Sarayönu	38.15	32.2	1039	7.38	151	0.81	39.4
31	Ankara	between Çubuk-Karagöl	40.23	32.56	1308	7.39	126	0.06	3.3
32	Karaman	Karaman	37.31	31.27	1127	7.09	357	2.77	19.7
33	Konya	between Tarasçı-Seydişehir	37.27	31.42	1680	7.26	90	1.04	1.5
34	Konya	Kurucuova	37.36	31.27	1128	7.23	174	2.74	4.0
35	Konya	between Yeşildağ-Beyşehir	37.34	31.33.	1170	7.13	136	0.91	2.7
36	Konya	between Argıthan-Doğanhisar	38.09	31.4	1176	7.26	161	3	33.5
37	Konya	between Tarasçı-Seydişehir	37.27	31.43	1542	7.73	134	0.04	23.1
38	Karaman	Taşkale	37.08	33.35	1278	7.48	147	1.03	56.6
39	Konya	between Seydişehir –Taraşcı	37.27	31.45	1219	7.28	87	0.04	18.8
40	Konya	Yükselen	38.06	32.16	1736	7.35	160	1.05	8.4
41	Konya	between Argıthan-Doğanhisar	38.11	31.4	1158	7.27	115	0.44	6.4
42	Konya	between Şarkikaraağaç-Beyşehir	37.45	31.24	1139	7.15	227	7.04	33.8
43	Konya	Yükselen	38.04	32.19	1524	7.21	175	1.65	28.0
44	Konya	Güneyyurt	36.41	32.47	950	7	830	5.08	49.0
45	Konya	between Doğanhisar - Beyşehir	38.05	31.4	1400	7.23	155	5.05	3.4

Table 2. (continued).

No	Province	Location	Lat. (N) (°.')	Lon. E (°.')	Alt. (m)	pH	EC (µS /cm)	OM (%)	Lime (%)
46	Aksaray	between Aksaray-Ereğli	37.32	34.22	1627	7.19	270	1.37	40.7
47	Karaman	Taşkale	37.09	33.26	1108	7.12	227	1.59	37.0
48	Konya	Bozkır	37.12	32.32	1372	7.18	222	1.56	20.5
53	Konya	Yükselen	38.04	32.18	1647	7.11	150	0.65	29.0
54	Konya	Yükselen	38.05	32.15	1675	7.45	180	3.05	11.4
56	Ankara	between Akyurt-Kalecik	40.07	33.1	1165	7.52	301	3.2	11.6
63	Konya	Yükselen	38.04	32.19	1524	7.2	185	1.6	27.0
64	Konya	between Cihanbeyli-Sülüklü	38.39	32.52	963	7.65	312	1.88	34.5
65	Konya	Akören – Konya	37.35	32.21	1099	7.4	96	0.63	1.5
66	Konya	Seydişehir	37.21	31.52	1101	7.8	102	0.7	3.6
101	Antalya	Yarpuz	37.08	31.5	1257	7.2	71	1.53	2.3
102	Antalya	Yarpuz	37.09	31.51	1240	7.5	106	3.32	2.4
103	Antalya	Geriş	36.59	31.42	643	7	202	4.35	3.0
104	Antalya	Akbelenli	37.35	30.52	966	7.5	130	3.1	3.9
105	Konya	Korualan	36.58	32.22	1747	7.5	130	2.34	9.8
106	Antalya	Egrigol	36.55	32.12	2067	7.4	98	1.35	6.0
107	Antalya	Eksere	36.51	32.04	1486	7.6	107	0.88	42.9
108	Afyon	Karakuyu	38.03	30.16	1005	7.8	615	9.1	36.7
109	Afyon	Gençali	38.02	30.05	932	7.7	154	1.17	64.2
110	Afyon	Bozhüyük	38.11	30.03	821	7.6	285	4.48	30.4
111	Afyon	İncehisar	38.52	30.47	1135	7.4	111	1.02	1.7
112	Afyon	Bayat	38.59	30.56	1059	7.7	155	0.7	8.8
113	Eskişehir	Buzluca	39.15	31.21	857	7.5	1200	4.26	24.3
114	Eskişehir	Nasrettin Hoca	39.29	31.39	986	7.7	162	1.43	53.7
115	Eskişehir	Hamamkarahisar	39.26	31.46	838	8.5	795	4.13	10.6
116	Eskişehir	Kavuncu Yaylası	39.24	31.58	701	7.7	227	0.06	27.6
117	Ankara	Aydınlı	39.23	32.06	841	7.5	265	3.36	45.3
118	Ankara	Polatlı	39.17	32.04	728	8	985	5.61	31.7
119	Kırşehir	between Kırşehir - Ankara	39.19	33.33	1020	7.5	145	1.21	15.0
120	Kırıkkale	Kırıkkale - Ankara	39.23	33.35	1030	7.5	618	3.43	10.6
121	Kırıkkale	between Kırıkkale-Ankara	39.28	33.35	956	7.4	171	2.09	5.3
122	Ankara	between Eskiköy - Ankara	40.08	33.17	966	7.4	87	0.95	1.5
123	Ankara	between Ciftlik köyü - Ankara	40.09	33.19	1097	7.6	185	1.96	5.7
124	Ankara	between Karahüyük - Ankara	40.11	33.19	1048	7.6	318	4.97	9.4
125	Ankara	between Hasayaz - Ankara	40.2	33.23	748	7.3	403	1.19	10.6
126	Çankırı	between Çankırı - Ankara	40.25	33.18	893	7.2	275	3.71	1.8

127	Çankırı	between Çankırı - Ankara	40.33	33.12	1386	6.5	67	1.66	2.0
128	Çankırı	between Çankırı - Ankara	40.47	32.51	1142	7.8	149	1.76	26.4
129	Ankara	between Yukarıçanlı - Ankara	40.4	32.43	1483	6.9	52	0.63	1.5
130	Ankara	Beypazarı	40.09	32.13	1087	7.3	111	1.11	1.8
131	Konya	Karasınır	37.14	32.4	1089	7.4	124	1.14	5.3
132	Karaman	Agaçoba	37.11	32.45	1312	7.4	106	1.22	3.8
133	Karaman	Habiller Köyü	37.05	32.43	1300	7.6	166	0.44	17.4

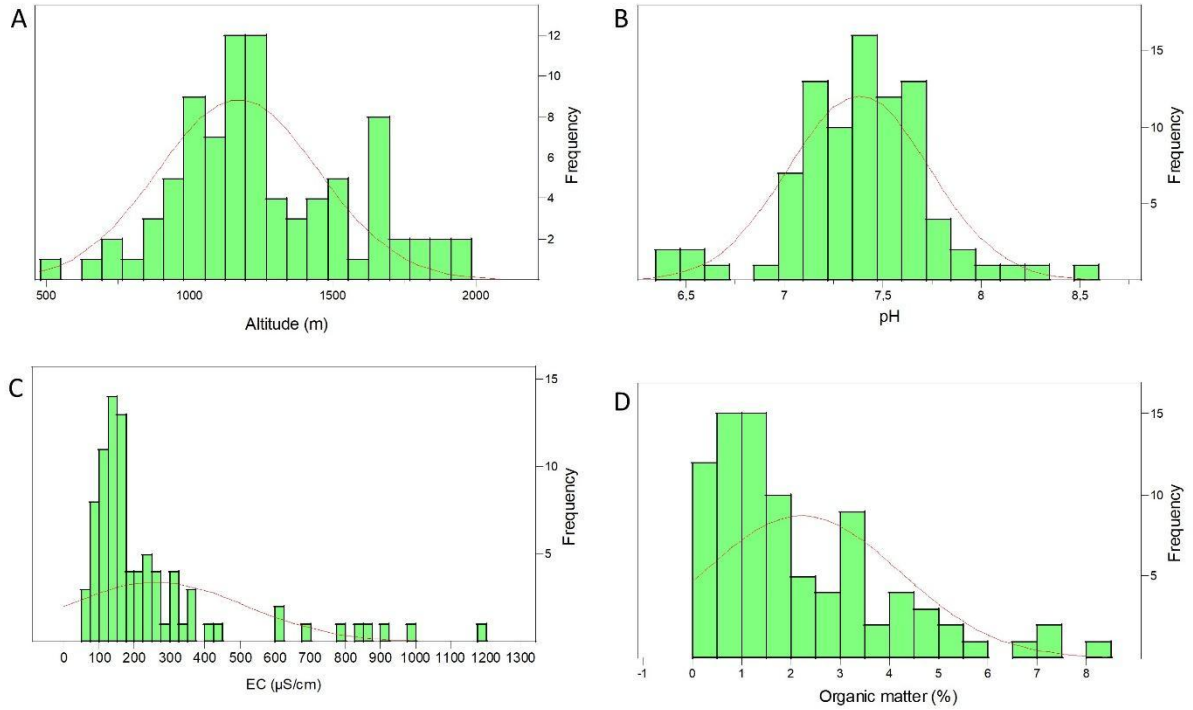

Figure 2. Histograms of the frequency distribution of soil-related features in *Lolium perenne* habitats collected from the Central Anatolia Region of Türkiye. (A) Altitude. (B) pH. (C) EC. (D) Organic matter.

The pH values of the soil samples were the lowest pH 6.35 and the highest pH 8.50 (Table 1). The pH of soil samples mostly varies between 7.0 and 7.8 (Fig. 2B). The median value and the arithmetic mean were very close to each other, and the pH values showed a normal distribution. It can be said that perennial ryegrass is more common in neutral to slightly alkaline soils, or it is adapted to these soils because most of the soils in the region are neutral to slightly alkaline.

The EC value of the areas where perennial ryegrass plants were collected varied between 538 - 2067 µS/cm, the mean was 261 µS/cm, the width of variation was 1343 µS/cm and in general the soil was classified as non-saline (non-saline: <2 mS/cm, Anonymous, 2023). EC values are mostly concentrated between 75-275 µS/cm (Fig. 2C).

Organic matter content varied between 0.04 - 9.10% (Table 2). The mean was 2.21%, the median was 1.56% and the width of variation was 9.06% (Table 1). Extreme values have an increasing effect on the average organic matter content. In general, the organic matter content of the soils in which perennial ryegrasses are found naturally is determined to be between 0 - 2.0% (Fig. 2D), very little or little (very little: 0-1%; little: 1-2%, Ülgen and Yurtsever, 1974).

The lime content of the soil samples varied between 1.2 - 64.2% with an average of 17.1% (Table 1). Perennial ryegrasses were naturally distributed in soils ranging from low to very calcareous (low calcareous: 0-1%; very high calcareous: >25%, Ülgen and Yurtsever, 1974) (Fig. 3A).

The phosphorus (P_2O_5) content of soils from which perennial ryegrass plants were collected ranged from 4.28 to 128.7 mg/kg, with an average of 18.88 mg/kg (Table 1). However, a few extremely high values increased both the mean and the standard deviation. Disregarding these extreme values, perennial ryegrasses were found to be naturalized mostly in soils containing 0 - 30 mg/kg phosphorus (Table 3, Fig. 3B). The soils in which perennial

ryegrass plants naturally spread were classified as very low, low, medium and high in phosphorus content (according to Ülgen and Ateşalp (1972), (alkaline soils) very low: <2.5; low: 2.5-6.0; medium: 6.0-12; high: >12 mg/kg) were determined.

Table 3. Analysis results of soil samples results of the locations where perennial ryegrass landraces were collected.

No	P_2O_5 (mg/kg)	K_2O (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)
1	19.03	132	1351	236	28.4	20.44	0.31	0.47	8.81
2	18.06	444	7059	730	8.1	7.66	0.33	0.79	8.46
3	46.04	75	4749	446	62.9	4.41	1.70	0.89	20.75
4	18.7	1361	4808	978	724.5	9.91	0.41	1.95	10.13
5	11.7	731	4626	396	1220.0	2.78	0.70	0.44	3.64
6	7.68	80	5173	135	8.0	11.17	0.18	1.27	11.71
7	9.37	525	4313	457	138.9	3.68	0.17	1.37	9.46
8	23.36	505	5844	2606	3016.0	3.71	0.85	3.39	20.49
10	13.4	230	5829	1078	192.0	3.40	0.48	1.25	15.45
11	59.82	1039	7561	2018	2468.0	16.61	1.47	5.17	25.68
12	15.52	115	5414	698	37.4	15.72	0.22	3.16	11.20
13	15.31	58	8113	673	145.1	50.98	1.51	5.63	12.04
14	14.46	1085	6010	299	114.9	6.52	0.74	2.03	7.45
15	20.4	1028	5139	964	1.5	4.73	0.91	2.54	28.68
16	17	35	3401	108	33.6	9.64	0.47	1.00	11.62
17	19.87	283	4613	320	99.1	8.12	8.97	2.38	6.73
18	27.39	264	2117	487	11.1	19.81	0.50	1.34	42.34
19	16.58	517	8198	2246	19.7	5.28	0.33	1.50	7.72
20	11.28	122	4270	76	32.0	7.73	0.21	0.39	5.76
21	12.55	139	5196	2426	79.8	40.93	0.73	3.80	24.81
22	11.7	195	3000	308	96.5	59.16	0.55	1.00	15.85
23	19.55	310	2840	729	10.2	7.73	0.83	2.81	10.47
24	26.12	116	5882	285	18.3	58.37	1.83	3.07	4.24
25	14.67	25	1016	105	1.2	6.06	0.34	0.35	10.42
26	50.92	246	2217	318	97.7	67.50	1.53	1.08	11.77
27	52.4	1060	5495	479	23.2	7.08	1.36	1.65	27.34
28	7.89	28	2193	424	11.4	19.68	0.28	0.58	14.55
29	8.74	59	4463	100	9.1	6.15	0.33	0.93	6.58
30	22.73	416	5417	159	0.8	4.74	0.37	0.76	9.24
31	14.67	268	7124	1945	88.0	26.62	0.46	2.56	5.68
32	28.87	185	4935	156	6.8	40.23	1.24	2.80	13.52
33	10.43	83	3576	334	8.1	4.81	0.27	0.57	8.95
34	21.03	278	4665	376	17.9	24.46	1.50	3.53	20.83
35	26.75	236	3517	234	6.1	11.81	0.39	1.43	29.81

36	29.09	201	2151	121	0.6	19.97	0.76	1.80	16.89
37	5.13	29	4583	376	16.9	4.55	0.26	0.32	3.73
38	14.88	98	4030	78	1.3	16.71	1.07	0.69	5.53
39	9.8	56	4709	33	2.1	3.45	0.27	0.21	2.62
40	9.8	63	3645	144	20.7	4.29	0.10	1.50	8.68
41	8.1	174	5097	95	2.5	5.98	0.23	0.95	10.11
42	31.42	169	6431	212	28.5	38.42	1.14	2.96	3.93
43	16.79	110	4870	118	5.1	7.66	0.64	0.98	7.31
44	128.71	351	6811	551	1.4	8.69	4.04	9.43	11.51
45	69.79	262	3473	108	0.9	10.51	3.79	1.45	23.78
46	14.03	259	6731	813	11.0	17.67	0.29	3.15	11.06
47	26.97	323	4111	178	9.1	5.69	0.70	0.94	20.93

Table 3. (continued).

No	P_2O_5 (mg/kg)	K_2O (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Mn (mg/kg)
48	7.46	300	7361	657	63.9	7.84	0.16	4.26	9.38
53	15.69	100	4500	128	1.1	3.66	0.63	0.91	8.31
54	20.8	93	4655	165	30.6	5.10	0.16	1.61	10.63
56	9.2	48	820	652	140.3	40.10	1.55	5.20	11.14
63	16.29	111	4802	120	5.2	7.56	0.65	0.97	7.41
64	13.4	230	5829	1078	192.0	3.40	0.48	1.25	15.45
65	8.37	530	4450	477	128.9	3.50	0.18	1.41	8.96
66	7.52	79	5020	124	8.2	10.10	0.16	1.22	12.73
101	4.28	219	6840	207	12.6	7.55	0.43	1.38	23.60
102	7.89	102	4678	424	3.4	8.12	1.80	1.20	11.77
103	14.03	218	6386	342	41.2	25.72	0.98	2.55	14.86
104	8.1	82	3496	357	11.5	16.75	0.57	3.21	3.90
105	5.98	114	4347	531	10.4	30.74	0.39	2.60	8.07
106	13.4	109	6262	111	4.9	12.45	1.04	3.81	9.77
107	7.04	154	7198	417	5.4	8.51	0.24	1.65	4.06
108	31.84	406	2508	1806	283.4	11.83	1.87	6.43	12.25
109	7.04	296	5312	457	8.5	6.94	0.33	1.02	9.37
110	21.67	444	6828	1056	128.2	61.79	1.59	3.22	7.98
111	6.19	312	2533	585	91.4	4.64	0.23	1.28	9.24
112	11.7	566	3657	223	20.4	4.30	0.97	0.56	9.92
113	32.48	959	6261	588	54.5	3.46	0.97	1.32	16.91
114	9.58	481	5431	322	16.9	4.06	0.48	1.52	15.46
115	18.49	649	3187	2096	588.6	50.20	1.51	0.86	8.39
116	10.01	681	5296	1320	106.2	5.75	0.21	2.14	2.33
117	8.95	422	5334	405	8.0	9.91	1.06	1.12	7.15

118	28.66	287	2765	226	25.9	6.38	1.53	1.59	15.83
119	10.01	290	6531	398	23.0	3.80	0.34	1.31	10.23
120	37.56	214	5751	1010	103.5	18.01	1.42	6.05	36.16
121	22.94	326	5775	500	59.9	6.25	0.94	1.21	11.16
122	8.31	202	5311	436	6.9	7.17	0.33	1.35	7.77
123	27.18	540	5371	588	233.6	10.35	1.54	2.85	11.53
124	11.92	539	5826	3569	280.1	32.61	1.32	6.02	19.02
125	10.22	348	5495	1244	365.7	6.73	0.60	2.05	6.63
126	23.15	500	4695	1243	276.6	7.32	0.81	2.49	38.88
127	16.15	356	4600	1158	25.4	13.55	0.52	1.97	24.09
128	4.92	208	5428	620	63.8	18.03	0.38	1.33	3.96
129	4.28	318	4665	534	27.9	3.77	0.20	1.09	6.40
130	14.46	581	5745	952	11.0	4.37	0.49	0.72	14.28
131	7.04	330	4554	240	1.5	9.67	0.46	1.61	17.35
132	13.82	145	3625	170	3.6	13.23	0.80	4.12	4.60
133	5.77	252	5305	257	35.2	11.47	0.28	1.26	10.59

The potassium (K_2O) content of the soils of the lands where perennial ryegrass plants were collected varied between 24.7 - 1360.8 mg/kg, with a mean of 316.3 mg/kg and a range of 1336.1 mg/kg (Table 1). According to these results, the majority of perennial ryegrasses were distributed in all soils with potassium content of very low, low and medium (according to FAO (1990), very low: <50; low: 50-110; medium: 110-290; high: 290-1000; very high: >1000 mg/kg) (Table 3, Fig. 3C).

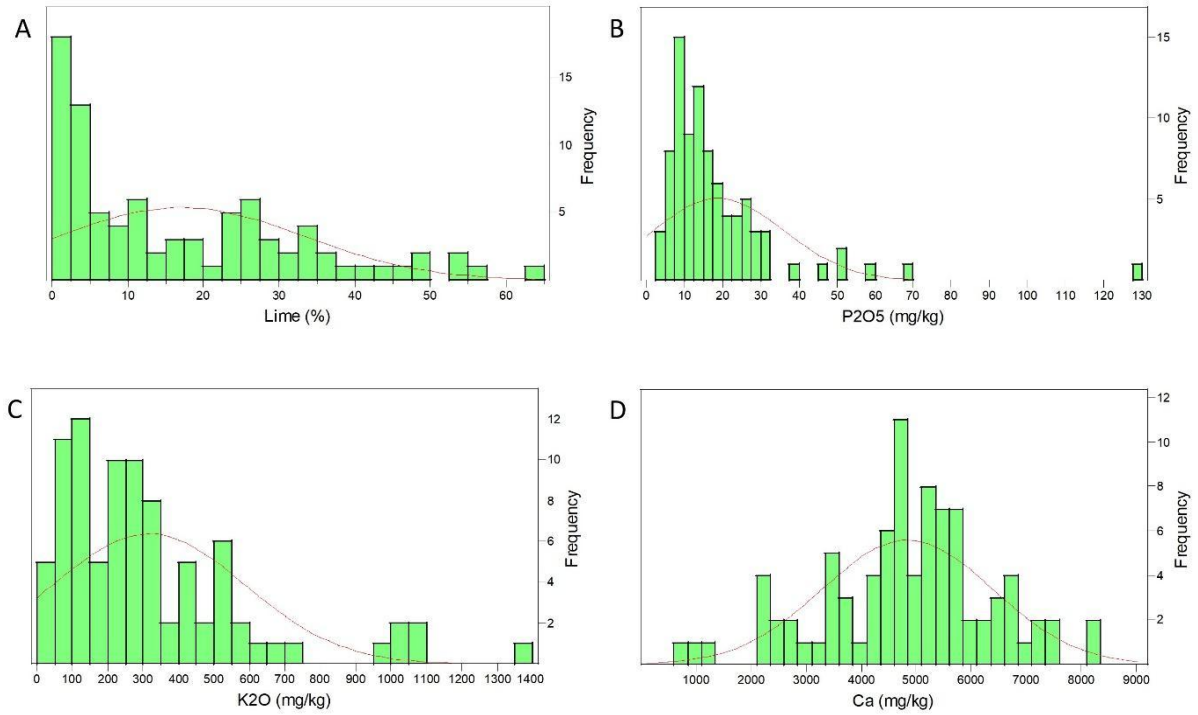

Figure 3. Histograms of the frequency distribution of soil-related features in *Lolium perenne* habitats collected from the Central Anatolia Region of Türkiye. (A) Lime. (B) P_2O_5. (C) K_2O. (D) Ca.

The calcium (Ca) content of the soils of the locations where perennial ryegrass plants were collected ranged from 820 to 8198 mg/kg with a mean of 4841 mg/kg and a variation width of 7378 mg/kg (Table 1). The soils in which perennial ryegrass was distributed were mostly soils with low, medium and high (according to FAO (1990), low: 238; medium: 1150-3500; high: 3500-10000 mg/kg) calcium contents (Table 3, Fig. 3D).

The magnesium (Mg) content of the soils of the locations where perennial ryegrass plants were collected ranged from 32.7 to 3569 mg/kg, with a mean of 620 mg/kg and a variation width of 3536.3 mg/kg (Table 1). The soils in which perennial ryegrass genotypes are naturally distributed are mostly soils with low, medium and high (according to FAO (1990), low: 50-160; medium: 160-480; high: 480-1500 mg/kg) magnesium content. The difference between the median value and the mean and the high standard deviation is because the extreme values increase the mean and standard deviation. It can also be stated that perennial ryegrass can grow naturally in soils with low magnesium content (Table 3, Fig. 4A).

The sodium (Na) content of the soils of the locations where perennial ryegrass plants were collected varied between 0.6 - 3016 mg/kg, with a mean of 143.1 mg/kg and a variation width of 3015.4 mg/kg (Table 1). Most of the soils (67 locations) in which perennial ryegrasses are naturally distributed have low sodium content (according to Korkmaz et al. (2012), low: <100 kg/mg) (Table 3, Fig. 4B).

The iron (Fe) content of the soils of the locations where perennial ryegrass plants were collected ranged from 2.78 to 67.50 mg/kg, with a mean of 14.57 mg/kg and a variation width of 64.72 mg/kg (Table 1). The iron content was medium at 16 locations where perennial ryegrass genotypes naturally spread, and high at 71 locations (according to Lindsay and Norvell (1978), medium: 2.5 – 4.5; high: >4.5 mg/kg) (Table 3, Fig. 4C).

The zinc (Zn) content of the soils of the locations where perennial ryegrass plants were collected ranged from 0.10 to 8.97 mg/kg, with a mean of 0.88 mg/kg and a variation width of 8.87 mg/kg (Table 1). Zinc content was very high in one location, high in two locations, very low in seven locations and low or medium in 77 locations where perennial ryegrass genotypes were naturally distributed (according to FAO (1990), very low: <0.2; low: 0.2-0.7; medium: 0.7-2.4; high: 2.4-8.0; very high: >8.0 mg/kg) was found (Table 3, Fig. 4D).

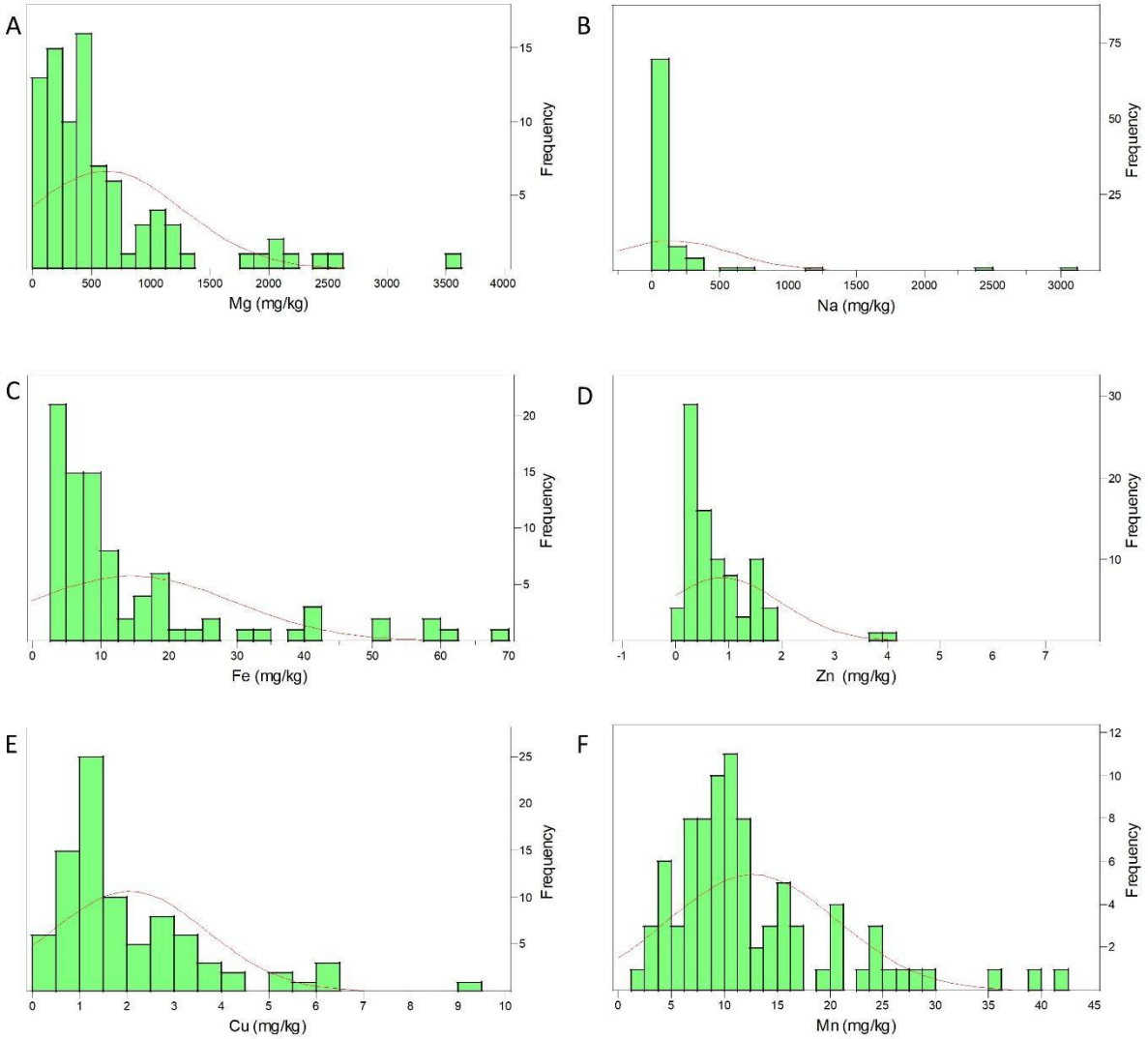

Figure 4. Histograms of the frequency distribution of soil-related features in *Lolium perenne* habitats collected from the Central Anatolia Region of Türkiye. (A) Mg. (B) Na. (C) Fe. (D) Zn. (E) Cu. (F) Mn.

The copper (Cu) content of the soils of the locations where perennial ryegrass plants were collected ranged from 0.21 to 9.43 mg/kg, with a mean of 2.05 mg/kg and a variation width of 9.22 mg/kg (Table 1). In all 87 locations where perennial ryegrass genotypes were naturally distributed, zinc was sufficient (according to Follet (1969), insufficient: <0.2; sufficient: >02 mg/kg) (Table 3, Fig. 4E).

Manganese (Mn) content of the soils of the locations where perennial ryegrass plants were collected ranged from 2.33 to 42.34 mg/kg, with a mean of 12.71 mg/kg and a variation width of 40.01 mg/kg (Table 1). Manganese content was very low in 7 locations, low in 53 locations and medium in 27 locations where perennial ryegrass genotypes were naturally distributed (according to FAO (1990), very low: 4<; low: 4-14; medium: 14-50 mg/kg) (Table 3, Fig. 4F).

Soil, It occurs with the breaking down of the main rock into small pieces by external factors, mixing of many organic materials with the soil and chemical dissolution (Bağdatlı and Can, 2020). Soil is an important resource for the natural and agro-ecosystems on earth to survive (Özgül, 2020). In general, a significant amount of land area in the Central Anadolu Region of Türkiye has saline-sodic soil properties (Yıldız et al., 2017). However, soil can vary almost step by step. The analysed properties of an entity with a heterogeneous structure like soil also show a great variation (Sarı et al. 2019). Topography, climate, vegetation and grazing constantly affect each other in the rangeland ecosystem. Grazing has led to a significant annual and seasonal changes in which we measure some of the soil parameters (Yalçın et al., 2016). For this reason, there are great differences in the soil properties of the pasture areas where perennial grass is collected. Similarly, Korkmaz et al. (2012) analysed soil samples taken from the natural habitats of some taxa belonging to the genus Gypsophila L. growing in Türkiye and found significant differences in soil physical and chemical properties. Akın and Taşova (2019) conducted a study to determine the nutrient contents in the agricultural soils of the Central Anadolu Region and found that 89.2% of the soils in the region were slightly alkaline, 99.4% were non-saline, 85.5% were low and very low in organic matter content, 56.1% were high and very high in lime, 75.4% were medium, low and very low in phosphorus, 94. 4% had high useful potassium content, 99.2% had adequate, high and very high exchangeable calcium content, 93.4% had adequate, high and very high exchangeable magnesium content, 44.8% had low and very low iron content, 75.3% had low and very low zinc content, 92.3% had low and very low manganese content and 98.8% had adequate copper content. Zengin et al. (2019), who conducted a study in Beyşehir District, which is within the scope of our study area, found that agricultural soils generally have slightly alkaline pH, non-saline, medium calcareous and low organic matter characteristics, and have sufficient levels of phosphorus, potassium and microelement amounts. The results are generally similar to our research results. The differences may be that the agricultural soils are continuously cultivated and fertilized, while the areas where we collected the plants are not cultivated and fertilized, and the pasture areas are constantly covered with plants and the soil is moist most of the year.

Conclusions

There have not been many studies on the collection and identification of perennial ryegrass in the natural flora of Türkiye and not much information about their distribution in Central Anadolu has been recorded in the literature. In this study, perennial ryegrass genotypes were identified, plant samples were taken, coordinate information was recorded and soil samples were taken in the areas around the water flowing from small springs in the fields, in the meadow areas, river banks, wetlands, seeps (seeps; sloping lands, areas where moisture is found in the soil even in the hot summer period, oases of the steppe) in the Central Anadolu Region. The soil samples were analysed and the results were summarized. According to these results, perennial ryegrass plants are adapted to many different soil types and tolerate deficiency of some elements and excess of some elements. These results give information about the general soil requirements of perennial ryegrass plants. In most of the areas where turf will be established, suitable soil for the development of grass plants cannot be found. For this reason, a significant amount of soil is transported to the the area where turf will be installed. This increases the cost of establishing turf. The development of varieties that are resistant or tolerant to excess and deficiency of nutrients in turfgrass plants will reduce the costs in the establishment of turf areas and extend the life span of turfgrass areas. It is thought that perennial ryegrass genotypes collected from extreme soil conditions within the scope of this study will provide a genetic advantage in breeding for unfavourable soil conditions.

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Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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