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Some Morphological Characteristics of Perennial Ryegrass Genotypes and Correlations among Their Characteristics

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***Abstract*—**The present study involved analysis of certain characteristics of the perennial ryegrass (*Lolium perenne* L.) genotypes collected from the natural flora of Ankara, and explores a correlation among them. In order to evaluate the plants for breeding purpose as per Turkey's environmental conditions, the perennial ryegrass plants were collected from natural pasture of Ankara in 2004 and were utilized for the study. Seeds of the collected plants were sown in pots and seedlings were prepared in a greenhouse. In 2005, the seedlings were transplanted at 50 × 50 cm^2 intervals in Randomized Complete Blocks Design in an experimental field. In 2007 and 2008, data were recorded from the observations and measurements of 568 perennial ryegrasses. The plant characteristics, which were investigated, included re-growth time in spring, color, density, growth habit, tendency to form inflorescence, time of inflorescence, plant height, length of upper internode, spike length, leaf length, leaf width, leaf area, leaf shape, number of spikelets per spike, seed yield per spike and 1000 grain weight and the correlation analyses were made using this data. Correlation coefficients were estimated between all paired combinations of the studied traits. The yield components exhibited varying trends of association among themselves. Seed yield per spike showed significant and positive association with the number of spikelets per spike, 1000 grain weight, plant height, length of upper internode, spike length, leaf length, leaf width, leaf area and color, but significant and negative association with the growth habit and re-growth time in spring.

***Keywords*—**Correlation, morphological traits, *Lolium perenne*.

I. Introduction

PERENNIAL ryegrass (*Lolium perenne* L.) is among the most common species for construction of green areas. It is also grown to be utilized for forage [1]. It is a native plant in the temperate regions of Eurasia and North Africa [2], [3] and exists in the natural flora of Turkey [4]. Due to foreign pollination, it has acquired high genetic variability [1]. The natural flora of Turkey has a significant amount of perennial ryegrass genotypes, which offers a great opportunity for the plant breeders. The development of novel cultivars, collection of plants from natural flora and determination of relationship between the plant characteristics and genotypes is required. The target of plant breeding is to effectively and efficiently select the best phenotypes leading to the development of improved cultivars [5]. Thus, the objectives of this study were to determine certain characteristics of the perennial ryegrass genotypes, which were collected from the natural flora of Ankara, and also to analyze the correlation between those characteristics, in order to establish the selection criteria for genotypes that can be used in perennial ryegrass breeding.

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II. Material and Method

The study was conducted during the years, 2007 and 2008. The experiment was performed in a region in the southern part of the Central Anatolia. The experimental location is situated 1016 meters above the sea level and experiences a semi-arid continental climate. During 2007, the average monthly temperature was 0.4°C in February, the highest temperature was recorded as 26.3°C in July, and the average yearly temperature was 13.1°C as in August. During 2008, the average monthly temperature was −3.5°C in January, the highest average temperature was 26°C and the average yearly temperature was observed to be 12.3°C as in August. The monthly lowest average relative humidity was 53.8% in 2007 and 59.4% in 2008. Total annual precipitation was 261.7 mm in 2007 and 293.9 mm in 2008. The soil samples were collected from 0-30 cm depth in a trial field and analyzed for the characteristics. The analyses revealed that the trial field was composed of alkaline (pH = 7.7) clay soil. The other properties of the field soil were as follows: organic matter rate was 1.19%, EC (μS cm^{-1}) = 193, P_2O_5 = 10.86 ppm, K_2O = 221.16 ppm, Zn = 2.12 ppm, Fe = 1.30 ppm, Cu = 0.82 ppm, Mn = 4.95 ppm, Ca = 5800.00 ppm and Na = 65.49 ppm.

The perennial ryegrass genotypes (*Lolium perenne* L.) collected from natural flora of Ankara were used as the study material and their seeds were planted in pots at a greenhouse. As soon as the seeds showed considerable growth, they were transferred into tubes. On formation of sufficient tiller plants, the perennial ryegrasses were then re-transferred into four tubes, one for each genotype. The field was plowed two times, in autumn and in spring. Fertilizers, 150 kg ha^{-1} of nitrogen, 150 kg ha^{-1} of phosphorus and 150 kg ha^{-1} of potassium, were applied to the field before beginning the plantation. The seedlings were planted with four replications on May 20, 2005 in Randomized Complete Block Design and were spaced 50 × 50 cm^2 apart.

The plants were cultivated following the common farming practices such as irrigation, weed control, fertilization, harvesting, and cutting. The plants were watered with drip irrigation and the fertilization was done in the spring season of each year after cutting, and 150 kg per hectare composite

forms (12% N, 12% P, 12% K + 20% organic matter, 0.5% Fe, 0.1% Zn, 0.1% Mn) were applied to the field. The plants were cut, with lawn mower after winter, with the aim to clean, and were cut manually when the seeds ripen in summer. Weeds were controlled by hand hoeing.

In the study, observations and measurements were made of 568 perennial ryegrass genotypes in the years, 2007 and 2008. Data were evaluated using the "Guidelines for The Conduct of Tests for Distinctness, Homogeneity and Stability" UPOV directory for Ryegrass (*Lolium* spp.) [6], Republic of Turkey Ministry of Food Agriculture and Livestock, Variety Registration and Seed Certification Centre's "Guidelines for the Conduct of Tests for Distinctness, Homogeneity and Stability" Document for Grass (ryegrass) (*Lolium* spp.) [7], "National plant Germplasm System" of the plant expression of USDA [8] and the National Turfgrass Evaluation Program (NTEP) of USA [9], and also according to the methods previously used by other research groups. Data were collected by observation for the characteristics: re-growth time in spring, color, density, growth habit, tendency to form inflorescence, time of inflorescence, whereas for the plant height, length of upper internode, spike length, leaf length, leaf width, leaf area, leaf shape, number of spikelets per spike, seed yield per spike and 1000 grain weight, measurements were used for evaluation.

The characteristics and their respective units are detailed in Table I. Data were analyzed using the MSTAT-C statistical software package.

TABLE I
MORPHOLOGICAL CHARACTERISTICS AND DESCRIPTIONS IN PERENNIAL RYEGRASS PLANTS

Characteristics	Definition of characters
In the spring re-growth time	Scale: 1 = too early - 9 = too late
Color	Scale: 1 = Very light green - 9 = Very dark green
Density	Scale: 1 = very rare - 9 = very often
Growth shape (Plant habitus)	Scale: 1= erect - 9 = prostrate
Tendency to form inflorescence	Scale: 1 = absent or very weak - 9 = very strong
Time of inflorescences	Scale: 1 = too early - 9 = too late
Plant height	The distance between soil surface and portion of the spike (cm)
Length of upper internode	The length of the node of top (cm)
Spike length	The distance between spike at the bottom and spike at the top (cm)
Leaf length	Mature leaf length (cm)
Leaf width	Mature leaf width (mm)
Leaf area	Leaf width cm x leaf length (cm^2)
Leaf shape	As a ratio, leaf length / leaf width
Number of spikelets per spike	Number of spikelets per spike (number $spike^{-1}$)
Seed yield per spike	Seed yield per spike (g $spike^{-1}$)
1000 grain weight	1000 grain weight

III. RESULTS AND DISCUSSION

The minimum, maximum, mean and standard deviation values for the examined characteristics are presented in Table II.

TABLE II
MINIMUM, MAXIMUM, MEAN AND STANDARD DEVIATION FOR THE EXAMINED CHARACTERISTICS OF 568 PERENNIAL RYEGRASS GENOTYPES

Characteristics	Min.	Max.	Mean	Standard Deviation
In the spring re-growth time (1 to 9 visual scale)	2.25	6.50	4.37	0.78
Color (1 to 9 visual scale)	2.75	7.75	4.66	0.82
Density (1 to 9 visual scale)	1.25	6.88	4.22	0.828
Growth habit (1 to 9 visual scale)	1.00	8.00	4.03	1.066
Tendency to form inflorescence (1 to 9 visual scale)	1.00	9.00	4.72	1.244
Time of inflorescence (1 to 9 visual scale)	1.00	7.50	3.63	1.072
Plant height (cm)	19.35	48.05	33.34	4.20
Length of upper internode (cm)	8.31	25.54	16.45	2.632
Spike length (cm)	6.76	16.28	11.02	2.632
Leaf length (cm)	6.44	14.57	9.32	1.027
Leaf width (mm)	2.41	4.01	3.12	0.235
Leaf area (leaf length x leaf width cm^2)	1.68	4.87	2.94	0.445
Leaf shape (leaf length / leaf width)	21.23	45.52	30.41	3.508
Number of spikelets per spike (spikelet $spike^{-1}$)	11.63	23.75	17.65	1.635
Seed yield per spike (g)	0.031	0.151	0.079	0.019
1000 grain weight (g)	1.23	2.38	1.84	0.193

The observations of the two year average values ranged from 2.25 to 6.50 for the re-growth time in spring, 2.75 to 7.75 for color, 1.25 to 6.88 for density, 1.0 to 8.0 for growth habit, 1.0 to 9.0 for tendency to form inflorescence, 1.0 to 7.5 for time of inflorescence emergence (Table II). The measurements varied between 19.35−48.05 cm for plant height, 8.31−25.54 cm for length of upper internode, 6.76−16.28 cm for spike length, 6.44−14.57 cm for leaf length, 2.41− 4.01 mm for leaf width, 1.68−4.87 cm^2 for leaf area, 21.23−45.52 for leaf shape, 11.63−23.75 for spikelet number per spike, 0.031−0.151 g spike for seed yield per spike and 1.23−2.38 g for thousand grain weight (Table II). The findings of our study showed that there were significant variations among the genotypes, with respect to the traits that were investigated. The high level of genotypic variability increased the possibility of selection of suitable genotypes. Our research results indicated that the superior genotypes of perennial ryegrass could be utilized for future breeding programs.

The correlation coefficients among the morphological characteristics are given in Table III.

It was observed that the re-growth time in spring was significantly and positively correlated with the leaf shape, while it was significantly and negatively correlated with the density and the seed yield per spike. Moreover, in the spring, the re-growth time was found to be positively and insignificantly correlated with the traits, color, leaf length, leaf area and number of spikelets per spike. Lastly, re-growth time in spring was negatively and insignificantly correlated with growth habit, tendency to form inflorescence, time of inflorescence, plant height, length of upper internode, spike length, leaf width and 1000 grain weight characteristics of the plants.

The color was observed to be significantly and positively correlated with density, tendency to form inflorescence, time

of inflorescence, number of spikelets per spike and seed yield per spike.

TABLE III
CORRELATIONS COEFFICIENTS AMONG THE EXAMINED CHARACTERISTICS IN PERENNIAL RYEGRASS GENOTYPES

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	0,0814	-0,1991**	-0,0046	-0,0692	-0,0731	-0,0594	-0,0751	-0,0518	0,0403	-0,0611	0,0036	0,0829*	0,0318	-0,0959*	-0,0606
2		0,2340**	0,0095	0,1144**	0,1545**	0,0737	0,0568	0,0518	0,0046	-0,009	0,0024	-0,0043	0,1165**	0,0860*	-0,0299
3			-0,0478	0,5389**	-0,1088**	0,2528**	0,2581**	0,1081**	0,2818**	-0,0432	0,1965**	0,2695**	0,03	-0,0466	0,0372
4				-0,1026*	0,0168	-0,1926**	-0,1644**	-0,1647**	-0,0893**	-0,0097	-0,0682	-0,0831*	-0,0422	-0,2786**	-0,1343**
5					-0,3199**	0,3348**	0,3359**	0,1818**	0,1888**	0,0189	0,1564**	0,1510**	0,1389**	0,0185	0,0695**
6						-0,1145**	-0,1440**	0,0087	-0,082	0,0185*	-0,0577	-0,0840*	-0,1324**	0,0596	-0,1602
7							0,9280**	0,8033**	0,3332**	0,0896*	0,2850**	0,2527**	0,2852**	0,3117**	0,1330**
8								0,5868**	0,2842**	0,087	0,2489**	0,2057**	0,1996**	0,2370**	0,1191**
9									0,2755**	0,1393**	0,2682**	0,1669**	0,3821**	0,4292**	0,1059*
10										0,2839**	0,8708**	0,7486**	0,0639	0,1957**	0,0733
11											0,6973**	-0,3930**	0,1611**	0,2011**	0,0014
12												0,3354**	0,1177**	0,2286**	0,0494
13													-0,0422	0,0574	0,0724
14														0,3902**	-0,0454
15															0,1630**

1: In the spring re-growth time, 2: Color, 3: Density, 4: Growth shape (Plant habitus), 5: Tendency to form inflorescence, 6: Time of inflorescence, 7: Plant height, 8: Length of upper internode, 9: Spike length, 10: Leaf length, 11: Leaf width, 12: Leaf area, 13: Leaf shape, 14: Number of spikelets per spike, 15: Seed yield per spike, 16 1000 grain weight

*p<0.05, **p<0.01

However, color was found to be positively but insignificantly correlated with growth habit, time of inflorescence, length of upper internode, spike length, leaf length and leaf area. Insignificant and negative correlations between color and the traits, leaf width, leaf shape and 1000 grain weight were observed.

Density showed a significant and positive association with each of the following characteristics: tendency of inflorescence, plant height, length of upper internode, spike length, leaf length, leaf area and leaf shape, however, a positive but insignificant association with the traits: number of spikelets per spike and 1000 grain weight. The correlation of density was significant and negative with time of inflorescence, but insignificant and negative with growth habit and leaf width and seed yield per spike.

Growth habit displayed a significant and negative relationship with the traits: tendency to form inflorescence, plant height, length of upper internode, spike length, leaf length, leaf shape, seed yield per spike and 1000 grain weight, but an insignificant and negative relationship with each of the following characteristics: leaf width, leaf area and number of spikelets per spike. Growth habit also had an insignificant and positive relationship with time of inflorescence.

The tendency to form inflorescence was significantly and positively correlated with plant height, length of upper internode, spike length, leaf length, leaf width, leaf area, leaf shape, number of spikelets per spike and 1000 grain weight. Whereas, it was positively but insignificantly correlated with leaf width and seed yield per spike. The same trait showed a significant and negative correlation with time of inflorescence.

Time of inflorescence was observed to be significantly but negatively associated with plant height, length of upper internode, leaf shape and number of spikelets per spike; however, insignificant and negative association of the trait was also observed with leaf area, leaf area and 1000 grain weight. Besides, time of inflorescence was significantly and positively associated with leaf width, and positively but insignificantly associated with spike length and seed yield per spike.

The feature, plant length, showed significant and positive correlation with the following traits: length of upper internode, spike length, leaf length, leaf width, leaf area, leaf shape, number of spikelets per spike, seed yield, and 1000 grain weight.

Upper internode length was found to be significantly and positively correlated with spike length, leaf length, leaf area, leaf shape, number of spikelets per spike, seed yield per spike and 1000 grain weight, but, positively and insignificantly correlated with the leaf width trait.

Spike length showed a significant and positive association with the following traits: leaf length, leaf width, leaf area, leaf shape, number of spikelets per spike, seed yield and 1000 grain weight.

Leaf length exhibited significant and positive correlation with leaf width, leaf area, leaf shape and seed yield per spike. Whereas it was positively but insignificantly correlated with the number of spikelets per spike and 1000 grain weight.

Leaf width showed significant and positive relationship with leaf area, number of spikelets per spike and seed yield per spike, but an insignificant relationship with 1000 grain weight. Leaf width also had significant and negative relationship with leaf shape.

Leaf area was observed to be significantly and positively

correlated with leaf shape, number of spikelets per spike and seed yield per spike, while it was found to be positively but insignificantly correlated with 1000 grain weight.

Leaf shape showed an insignificant and negative correlation with number of spikelets per spike and insignificant and positive correlation with seed yield per spike and 1000 grain weight.

Number of spikelets per spike had a significant and positive relationship with seed yield per spike, while insignificant and negative correlation with 1000 grain weight.

A significant and positive correlation was observed between seed yield per spike and 1000 grain weight.

Perennial ryegrass has been utilized for a variety of purposes (parks, golf courses, soccer fields, landscape, forage crops, etc.). Therefore, the variations observed for the different traits assessed in this study are relevant in context to the purpose in *Lolium perenne* breeding programs.

Previously, breeding efforts concentrated on the vegetative qualities of the perennial ryegrass, for forage or turf, however, now-a-days the plant breeding has also focused on improving the seed yield. Recently, improved seed yielding capacity has become a more important selection criterion in the grass breeding, since it is relevant in terms of cost of seed multiplication and ultimately it determines the commercial success of a cultivar regardless of its forage or turf qualities [10]. Plant breeders require selection criteria to ensure high and stable seed production of new cultivars [11]. Correlation and path-coefficient analyses have been successful tools for the development of the selection criteria [12]. Since our perennial ryegrass (*Lolium perenne* L.) breeding program is mainly focused on an increased seed yield and better turf quality, in the present research, we performed correlation analyses on seed yield and certain major agronomic characteristics in *Lolium perenne*. It was observed that the seed yield per spike showed significant and positive association with number of spikelets per spike, 1000 grain weight, plant height, length of upper internode, spike length, leaf length, leaf width, leaf area and color, but significant and negative association with growth habit and the spring re-growth time.

Our results are in concordance with the previous findings from studies on *Lolium perenne* by other research groups. One such study [13] reported positive correlation of seed yield with spikelet numbers per spike, spike length and seed number per spike, but negative correlation with plant height. Leaf length is a good selection criterion to be used for improvement of the *Lolium* cultivars with higher dry matter yield [14]. Spike length is one of the important characteristics for seed yield [15]. A research group [16] determined that the number of spikelets per spike has positive and significant effect on seed yield and consequently, regarded high number of spikelets to be a good selection criterion for seed yield [16].

Thus, to conclude, seed yield was found to be affected by several yield components. Further, detailed investigations on the direct and indirect associations between the vegetative and generative yield components may be useful to conduct path analysis.

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