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Determination of Agricultural Characteristics of Smooth Bromegrass (*Bromus inermis* Leyss) Lines under Konya Regional Conditions

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***Abstract*—**The present study was conducted to determine the yield and yield components of smooth bromegrass lines under the environmental conditions of the Konya region during the growing seasons between 2011 and 2013. The experiment was performed in the randomized complete block design (RCBD) with four replications. It was found that the selected lines had a statistically significant effect on all the investigated traits, except for the main stem length and the number of nodes in the main stem. According to the two-year average calculated for various parameters checked in the smooth bromegrass lines, the main stem length ranged from 71.6 cm to 79.1 cm, the main stem diameter from 2.12 mm from 2.70 mm, the number of nodes in the main stem from 3.2 to 3.7, the internode length from 11.6 cm to 18.9 cm, flag leaf length from 9.7 cm to 12.7 cm, flag leaf width from 3.58 cm to 6.04 mm, herbage yield from 221.3 kg da^{-1} to 354.7 kg da^{-1} and hay yield from 100.4 kg da^{-1} to 190.1 kg da^{-1}. The study concluded that the smooth bromegrass lines differ in terms of yield and yield components. Therefore, it is very crucial to select suitable varieties of smooth bromegrass to obtain optimum yield.

***Keywords*—**Semiarid region, smooth bromegrass, yield, yield components.

I. Introduction

SMOOTH bromegrass (*Bromus inermis* Leyss) is a native of Europe and Asia and is adapted to most temperate climates [1], [2]. It is a leafy, sod-forming perennial grass, which spreads vegetatively by underground rhizomes. The species is grown alone, as well as in the combination with other grasses and legumes, and used for pasture, hay, and to control erosion [1].

A significant portion of quality roughage required for livestock is produced from meadow and pasture areas and through forage cultivation [3]. The fodder obtained from natural grasslands is insufficient to feed the animals [4], and therefore, the livestock enterprises should increase both the sowing area and the yield of forage to meet the demands of quality forage. Additionally, the meadow and pasture areas should be restored appropriately [3].

Smooth bromegrass is important for the establishment of the artificial pastures in the fields and the restoration of degraded meadow land [5]. An early spring growth with good persistence under grazing is the other desirable aspect of this species. Smooth bromegrass is not commonly cultivated in the Central Anatolia Region, Turkey [6]; therefore, it is necessary to determine the appropriate genotype of this grass, suitable to the environmental conditions of the Konya region. The aim of this study was to determine the yield and yield components of selected smooth bromegrass (*Bromus inermis* Leyss) lines under the environmental conditions of the Konya region.

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II. Materials and Methods

The study was conducted in the growing season from 2011 to 2013 in Konya, Central Anatolia Region, Turkey. The experimental area was 1,016 meters above sea level. Konya, the city where the experiment was performed, is located in the southern part of the Central Anatolia and has a semi-arid continental climate. Winters are harsh, cold, and snowy, whereas summers are hot with little rainfall.

The rainfall, temperature, and humidity of the climate during the trial (from April 2011 to June 2013) are compiled in Table I [7]. While the lowest temperature observed was –16.6 °C in January 2012, the highest temperature recorded was 39.2 °C in July 2012. The average monthly temperatures, including the highest and lowest temperatures, ranged from –0.9 °C (in January 2012) to 26.2 °C (in July 2011 and 2012). The average monthly, lowest and the highest relative humidity and precipitation were measured to be 27.4% (in July 2011) to 78.4% (in January 2012), and 0.4 mm (in September 2011) to 86.6 mm (in January 2012), respectively.

The soil sample was obtained from 0–30 cm depth at the trial field and analyzed. The results revealed the soil to have a clay texture, alkaline (pH = 7.8), with an organic matter rate of 1.67% and electrical conductivity (EC) of 167 µS cm^{-1}. The levels of various elements and compounds were as follows: phosphorus pentoxide (P_2O_5) = 10.49 ppm, potassium oxide (K_2O) = 233.16 ppm, zinc (Zn) = 2.19 ppm, iron (Fe) = 1.18 ppm, copper (Cu) = 0.91 ppm, manganese (Mn) = 4.83 ppm, calcium (Ca) = 5867.00 ppm, and sodium (Na) = 63.86 ppm.

The trial was arranged in randomized complete block experimental designs with four replications. Five smooth bromegrass lines namely L1, L2, L3, L4, and L5 were utilized. The field was plowed two times in autumn and spring followed by application of 150 kg ha^{-1} each of nitrogen, phosphorus, and potassium fertilizers. Seeds were sown on 27 April 2011, by hand, at the rate of 20 kg seeds ha^{-1} with a separation of 40 cm between rows. The plot size was 3.2 m × 5.0 m = 16.0 m^2, consisting of eight rows. The net harvested area in each plot was 9.6 m^2 after the subtraction of 6.4 m^2

area to rule out border effects.

TABLE I
MONTHLY TEMPERATURE, HUMIDITY AND RAINFALL OF KONYA REGION [7]

Years	Months	Temperatures			Humidity	Rainfall
		Min °C	Max °C	Mean °C	%	mm
2011	4	-0.6	20.4	10.6	58.9	63.2
	5	4.4	26.2	15.0	55.9	44.6
	6	11.9	33.6	20.2	45.1	39.6
	7	15.6	37.9	26.2	27.4	3.8
	8	15.3	37.4	24.2	28.1	2.0
	9	11.3	31.2	20.6	28.2	0.4
	10	1.0	26.5	11.9	51.7	43.6
	11	-6.4	15.1	3.3	63.0	8.6
	12	-5.3	15.2	3.0	64.1	25.4
2012	1	-16.6	11.0	-0.3	78.4	86.6
	2	-14.7	11.6	-0.9	69.2	37.8
	3	-6.0	17.5	4.8	55.4	11.8
	4	3.2	27.1	14.4	43.7	9.2
	5	6.8	25.9	16.3	55.2	51.0
	6	10.8	34.6	23.0	39.3	11.2
	7	14.3	39.2	26.2	33.1	2.4
	8	13.1	35.0	23.2	38.3	18.0
	9	10.9	32.1	21.1	37.4	8.2
	10	7.1	28.3	15.7	58.9	29.0
	11	-1.4	24.3	8.6	77.0	34.4
	12	-4.6	18.2	4.6	69.0	57.0
2013	1	-8.9	16.4	2.7	74.1	33.6
	2	-3.8	18.4	5.9	66.8	24.4
	3	-4.5	23.6	8.6	51.7	20.0
	4	4.3	27.5	13.0	54.6	31.2
	5	8.2	31.5	19.5	45.2	50.6
	6	11.5	35.3	22.3	42.0	15.0

Measurements were done according to "Guidelines for the conduct of tests for distinctness, homogeneity and stability document for *Bromus* L. species" [8], recommended by 'The Republic of Turkey Ministry of Food, Agriculture and Livestock' and 'Variety Registration and Seed Certification Centre, Turkey.' In this research, the main stem length (cm), the main stem diameter (mm), the internode length (cm), number of nodes in the main stem (number), flag leaf length (cm), flag leaf width (mm), herbage and hay yield (kg da^{-1}) were determined. The data obtained were analyzed using analysis of variance (ANOVA) for RCBD. The significance levels ranged from p = 0.05−0.01. The differences between means were assessed by the Least Significant Difference (LSD) test at p = 0.01 or 0.05 levels of significance. Statistical analyses were performed using the MSTAT-C statistical software package.

III. RESULTS AND DISCUSSION

Analysis of variance (ANOVA) was utilized to observe the statistical difference in yield and yield components among selected smooth bromegrass lines. The variance analysis showed a statistically significant effect of year on the main stem length, main stem diameter, number of nodes, internode length, flag leaf width, herbage and hay yield (Table II). The various lines were found to have a significant effect on the main stem diameter, internode length, flag leaf length and width, herbage and hay yield. Lastly, the location × line interaction significantly affected the main stem diameter, internode length, flag leaf length, and herbage yield of smooth bromegrass.

TABLE II
ANALYSIS OF THE VARIANCE IN SMOOTH BROMEGRASS

Source	Main stem length	Main stem diameter	Node numbers	Internode length
Year (Y)	**	**	**	*
Line (L)	ns	**	ns	**
Y x L	ns	*	ns	*
Source	**Flag leaf length**	**Flag leaf width**	**Herbage yield**	**Hay yield**
Year (Y)	ns	**	**	**
Line (L)	*	**	**	**
Y x L	*	ns	*	ns

F-test significance: *: P ≤ 0.05 ; **: P ≤ 0.01 ; ns: not significant

The main stem length was greater (79.9 cm) in 2012 than (68.2 cm) in 2013. L2 recorded the highest main stem length followed by L3, L5, L4, and L1. In the year × line interaction, the highest (82.0 cm) and the lowest (62.9 cm) main stem length was observed in L2 and L1, respectively, in 2013 (Table III). However, the main stem length difference between lines and the year × line interaction was statistically insignificant. The smooth bromegrass lines used in this study were genotypically close to each other in terms of main stem length. Moreover, the environment is considered as an important factor influencing the length of the main stem. Different researchers reported the main stem length in smooth bromegrass to vary from 92.6 cm to 100.0 cm [9], 61.0 cm to 119.4 cm [10] and 45.55 cm to 87.86 cm [6]. The main stem length is an important character because of its positive effect on seed yield [11], hay yield [6], and dry matter yield [12].

TABLE III
MAIN STEM LENGTH (CM) AND MAIN STEM DIAMETER (MM) OF SMOOTH BROMEGRASS LINES AND LSD TESTS

Line No:	Main stem length (cm)			Main stem diameter (mm)		
	2012	2013	Mean	2012	2013	Mean
L1	80.4	62.9	71.6	2.91a	2.36b	2.63A
L2	82.0	76.2	79.1	2.15b	2.09b	2.12B
L3	81.4	68.8	75.1	3.04a	2.35b	2.70A
L4	76.6	67.2	71.9	2.78a	2.16b	2.47AB
L5	79.0	66.3	72.6	2.95a	2.05b	2.50A
Mean	79.9A	68.2B	74.1	2.76A	2.20B	2.48
LSD	Year: 6.614** Line: ns Year x Line: ns			Year: 0.2285** Line: 0.3613** Year x Line: 0.3783*		

*: P ≤ 0.05; **: P ≤ 0.01; ns: not significant

The main stem diameter was found to be 2.76 mm in 2012 and 2.20 mm in 2013 (Table III). Among smooth bromegrass lines, L3 recorded the highest main stem diameter followed by L1, L5, L4, and L2. In the year × line interaction, the highest main stem diameter (3.04 mm) was obtained from L3 in 2012 whereas the lowest main stem diameter (2.05 cm) was obtained from L5 in 2013 (Table III). A study reported the main stem diameter to range from 3.38 mm to 5.13 mm [6].

Another study reported the main stem diameter of smooth bromegrass to range from 2.02 mm to 3.38 mm [13]. The effects of methods of sowing, nitrogen doses, and various artificial range mixtures on the main stem diameter were found to be statistically insignificant.

The number of nodes in the main stem was determined to be 4.4 in 2012 and 2.6 in 2013 (Table IV). Among the lines, the highest value for the node numbers in the main stem was recorded (3.7) for L5, whereas L2 had the lowest value (3.2). The highest node number (4.7) was observed in L3 in 2012, and the lowest (2.4) was recorded in L2 in 2013 in the year × line interaction. However, the main stem diameter difference in the lines, and in the year × line interaction was statistically insignificant. A study conducted measured the number of nodes in the main stem in the range of 3.93 to 4.50 [6].

TABLE IV
NODE NUMBERS (NUMBER) AND INTERNODE LENGTH (CM) OF SMOOTH BROMEGRASS LINES AND LSD TESTS

Line No:	Node numbers (number)			Internode length (cm)		
	2012	2013	Mean	2012	2013	Mean
L1	4.5	2.5	3.5	13.1cd	13.6	13.4BC
L2	4.0	2.4	3.2	19.7a	18.1	18.9A
L3	4.7	2.5	3.6	11.2de	16.0	13.6BC
L4	4.0	2.7	3.4	14.1cd	14.1	14.1B
L5	4.6	2.7	3.7	9.2e	14.0	11.6C
Mean	4.4A	2.6B	3.5	13.4B	15.1A	14.3
LSD	Year:0.2984** Line: ns Year x Line: ns			Year:1.509* Line: 2.038** Year x Line: 3.374*		

*: P ≤ 0.05; **: P ≤ 0.01; ns: not significant

The internode length among the smooth bromegrass lines remained significant. The highest internode length (18.9 cm) was recorded in L2 whereas the lowest (11.6 cm) was recorded in L5 (Table IV). Internode length was greater (15.1 cm) in 2013 than (13.4 cm) in 2012. It exhibited an insignificant variation (Table II) in the year × line interaction. The maximum internode length (19.7 cm) was observed in L2 in 2012, whereas the minimum internode length (9.2 cm) was observed in L5 in 2012. The results are in agreement with an earlier study [6], which reported a range of 7.8 to 9.99 cm for the internode length of smooth bromegrass lines.

The line L4 reported the highest flag leaf length, followed by L2, L1, L5, and L3, respectively (Table V). Flag leaf length was found to be 11.4 cm in 2012 and 10.4 cm in 2013. The L4 in 2013 exhibited the maximum flag leaf length (13.4 cm), whereas L5 in 2013 recorded the minimum flag leaf length (8.6 cm) in the year × line interaction.

The flag leaf width of smooth bromegrass lines ranged from 3.25 mm to 7.10 mm in the year × line interaction (Table V). L2 in 2013 had the narrowest flag leaf width of 3.25 mm, whereas L4 in 2012 had the broadest flag leaf width of 7.10 mm. Among the lines, maximum flag leaf width (6.04 mm) was observed in L4, which was closely followed by L1, L5, and L3. The minimum flag leaf width was observed in L2 with 3.58 mm. Flag leaf width was determined to be 5.91 mm in 2012 and 4.52 mm in 2013.

The herbage yield obtained was 409.3 kg da^{-1} in 2012 and 211.1 kg da^{-1} in 2013 (Table VI). In smooth bromegrass lines, L1 indicated the highest herbage yield followed by L2, L3, L5, and L4. In the year × line interaction, the highest herbage yield (490.2 kg da^{-1}) was obtained from L1 in 2012, while the lowest herbage yield (190.5 kg da^{-1}) was recorded from L4 in 2013 (Table VI). A study reported that herbage yield of smooth bromegrass had a high significant difference between the two location and yields ranged from 202.5 kg da^{-1} to 942.1 kg da^{-1} [6].

TABLE V
FLAG LEAF LENGTH (CM) AND FLAG LEAF WIDTH (MM) OF SMOOTH BROMEGRASS LINES AND LSD TESTS

Line No:	Flag leaf length (cm)			Flag leaf width (mm)		
	2012	2013	Mean	2012	2013	Mean
L1	10.5bc	11.0abc	10.7B	6.35	5.38	5.86A
L2	11.5ab	11.0abc	11.3AB	3.90	3.25	3.58B
L3	11.5ab	7.9d	9.7B	5.80	4.63	5.21A
L4	11.9ab	13.4a	12.7A	7.10	4.98	6.04A
L5	11.5ab	8.6cd	10.0B	6.40	4.35	5.38A
Mean	11.4	10.4	10.9	5.91A	4.52B	5.21
LSD	Year: ns Line: 1.737* Year x Line: 2.456*			Year: 0.9239** Line: 1.461** Year x Line: ns		

*: P ≤ 0.05 ; **: P ≤ 0.01 ; ns: not significant

TABLE VI
HERBAGE YIELD (KG/DA) AND HAY YIELD (KG/DA) OF SMOOTH BROMEGRASS LINES AND LSD TESTS

Line No:	Herbage yield (kg/da)			Hay yield (kg/da)		
	2012	2013	Mean	2012	2013	Mean
L1	490.2a	219.2b	354.7A	258.6	82.6	170.6A
L2	454.2a	224.6b	339.4A	281.7	98.5	190.1A
L3	452.1a	225.8b	338.9A	230.5	79.4	155.0AB
L4	252.1b	190.5b	221.3B	129.7	71.1	100.4B
L5	397.9a	195.3b	296.6AB	207.6	73.7	140.7AB
Mean	409.3A	211.1B	310.2	221.6A	81.1B	151.3
LSD	Year: 62.29** Line: 98.49** Year x Line: 103.1*			Year: 38.83** Line: 61.69** Year x Line: ns		

*: P ≤ 0.05 ; **: P ≤ 0.01 ; ns: not significant

The hay yield was greater (221.6 kg da^{-1}) in 2012 than (81.1 kg da^{-1}) in 2013 (Table VI). In the smooth bromegrass lines, the highest value for hay yield was recorded by L2 with 190.1 kg da^{-1} whereas L4 had the lowest value of hay yield (100.4 kg da^{-1}). The hay yield depicted an insignificant variation (Table II) in the year × line interaction and ranged from 71.1 kg da^{-1} to 281.7 kg da^{-1} (Table VI). The maximum hay yield was observed in L2 in 2012. Minimum hay yield was observed in L4 in 2013. A study reported the hay yield of smooth bromegrass in the range of 290.9 kg da^{-1} to 999.9 kg da^{-1}, which increased after the application of nitrogen fertilizers in the spring and autumn [5].

IV. Conclusion

In this study, eight characteristics of five different lines of smooth bromegrass were determined during a period of two years, and average values for each characteristic were obtained. Variations were observed in most of the investigated

agronomic traits among the selected smooth bromegrass lines. Choosing an appropriate cultivar/line according to the region and cultivation conditions would play a significant role in determining the yield of smooth bromegrass. Similar studies should be conducted to develop more resistant and productive varieties of smooth bromegrass for the Konya region.

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