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COMPARISON OF AGRONOMIC CHARACTERS OF *FESTULOLIUM*, *FESTUCA PRATENSIS* HUDS. AND *LOLIUM MULTIFLORUM* LAM. GENOTYPES UNDER HIGH ELEVATION CONDITIONS IN TURKEY

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Abstract

Prior {*Lolium perenne* × *Festuca pratensis*) and Elmet (*Lolium multiflorum* × *Festuca pratensis)* cultivars were compared with *Festuca pratensis* Huds. and *Lolium multiflorum* Lam. genotypes for some agronomical characteristics (green and dry matter yields, crude protein, seed yield, crude ash content) under Erzurum ecological conditions. Analysis of variance and mean separation were performed using the SPSS 11.0 computer program. There was a significant difference among genotypes in every character tested except for green and dry matter yield and crude ash content. Hybrid genotypes had higher plant height, dry and green matter yield, seed yield per plant and crude protein yield except 1000-seed weight. Elmet performed better than Prior except for seed yield per plant.

Introduction

The development of new cultivars with improved forage quality is an important objective of many forage improvement programs. *Festuca* and *Lolium* genera are among the very extensively studied noncereal grasses. It has long been a goal for forage breeders to combine the stress tolerant characteristics of *Festuca* species with the earliness and high nutritive value of *Lolium* species. Some breeding programs have been designed to transfer *Festuca* genes into *Lolium,* and as a result some *Festulolium* cultivars have been developed in Europe and in the USA (Humphreys *et al.,* 2003). Intergeneric crosses between *Lolium* and *Festuca* species produced enhanced palatability and forage quality of *Lolium* species with higher resistance to disease and abiotic stresses, such as cold and drought that are typical of *Festuca* species (Şengül 1983, Thomas and Humphreys 1991, Thomas *et al.* 2003). The traits considered for improvement of future grass varieties are higher dry matter and seed yield, herbage feeding value, crude protein, water-soluble carbohydrates, fibers, concentration of alkaloid toxins and traits associated with good persistency, including tolerance to a range of abiotic and biotic stresses (Wilkins and Humphreys 2003). A major problem for amphidiploid breeding is the high level of homologous pairing between the different genomes leading to genetic instability and loss of hybridity in advanced generations. To overcome these problems and to reduce transfer of deleterious *Festuca* traits, selective introgression of genes for desirable traits from *Festuca* into *Lolium* has been proved to be fruitful method. The process involves the transfer of small segments of alien *Festuca* chromatin into the recipient *Lolium* genome and has been successfully employed to produce *Festulolium* lines. These hybrids can provide good quantities of animal fodder from early Spring through to late Autumn (Humphreys and Thomas 1993, Humphreys *et al.* 2005).

In the present study, Prior and Elmet cultivars, the first amphidiploids *Festulolium* cultivars, were compared for some agronomic traits of *F. pratensis* and *L. multiflorum,* and their adaptability to Erzurum's ecological conditions in Turkey was investigated.

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Materials and Methods

The experiment was conducted during 2000 - 2002 on the Atatürk University Agricultural Research Farm, Erzurum, Eastern Anatolia, Turkey (39º55'N, 41º16'E, and 1850 m above sea level). Climatic data of research area include yearly averages for temperature, relative humidity and rainfall for 200l and 2002 and long term averages (LTA) for above parameters are given in Table 1. Prior (*Lolium perenne* × *Festuca pratensis)* and Elmet (*Lolium multiflorum* × *Festuca pratensis)* hybrids with *Lolium perenne* L, (2n = 2x = 14) *Festuca pratensis* Huds (2n = 2x = 14) and *Lolium multiflorum* L. (2n = 2x = 14*)* genotypes were used in the trial. Prior and Elmet, the first amphidiploid *Festulolium* cultivars, were bred at the Welsh Plant Breeding Station, UK (now Institute of Grassland and Environmental Research). A population was raised from the hybrid seeds of the selected plants and the hybrid population was studied by Karaca (2001) and reported the individuals as allotetraploid (2n = 28).

Table 1. Climatic data of the research location with long term average (LTA): 1929-2002.

	Temperature (ºC)			Relative humidity (%)			Rainfall (mm)		
Months	2001	2002	LTA	2001	2002	LTA	2001	2002	LTA
January	–12.2	–16.1	–8.6	80.6	72.4	76	4.9	14.0	25.5
February	–5.7	–3.4	–7.0	71.9	72.6	75	11.9	8.9	29.3
March	4.4	–1.0	–2.7	65.0	71.3	74	51.1	37.4	37.3
April	7.2	4.2	5.2	65.4	67.1	64	104.9	81.2	53.5
May	6.3	9.8	10.8	61.3	55.8	60	68.7	73.1	73.5
June	15.4	14.3	14.0	48.1	57.0	56	7.3	74.0	54.3
July	20.6	18.3	10.2	46.2	53.0	50	36.6	39.1	29.1
August	19.9	16.6	10.6	44.1	53.6	46	9.2	54.6	18.6
September	14.3	13.6	15.0	42.0	52.9	49	3.8	52.9	28.4
October	6.2	8.9	8.5	60.1	61.9	80	51.2	61.9	46.4
November	2.6	1.3	1.8	71.4	69.4	71	39.6	69.4	35.8
December	–5.1	–12.0	–5.2	80.4	73.5	76	35.1	73.5	23.0

Seeds were sown in trial boxes (0.70 × 0.50 m) at 2000 Fall and seedlings were transplanted to the field on May 5, 2001. The experiment was set up as randomized complete block design with three replications. Each plot contained 5 rows of 5 m long and 0.50 m apart. An empty space of 0.50 m between adjacent plots was used to separate plants from each other. Plots were 12.5 m^2 and each plot had 50 seedlings (ten plants in each row).

Fertilizers were applied as 200 kg N/ha (Ammonium sulphate 21% N) and 50 kg P_2O_5/ha (Triple super phosphate 42-44% P_2O_5) (Serin *et al.* 1996). Same amount of N at the Spring and P_2O_5 at the Fall were applied in the next year. Weeds were controlled with hoeing and plans were watered as and when necessary. Two rows from each plot were discarded to compensate border effects and total of 24 plants (3 row × 8 plants) were observed. Half of these plants [(36 plants from each genotype (12 plant × 3 replicates)] were used to determine seed yield and 1000-seed weight. All panicles/spikes from each plant were harvested at maturity, placed in paper bags, and dried. Seeds from each plant were threshed, cleaned, and weighed. The second part (36 plants) were used to determine plant height, green matter yield, dry matter yield, crude protein yield and rate, and crude ash rate (Kacar 1972, Açıkgöz 1982, Serin *et al.* 1996). The plants were clipped at the flowering time. While plants were harvested once in first year, they were harvested twice in second year. In the second year *L. perenne* plants died due to winter injury. Analysis of variance and mean separation were performed using the SPSS 11.0 computer program.

Results and Discussion

There was statistically highly significant difference for plant heights on both years (Table 2). Mean of plant height ranged from 73.68 to 87.75 cm. The maximum height of plant was found in Elmet, followed by *F. pratensis*. The minimum plant height attained by Prior but no statistical difference was found between *L. multiflorum* and Prior. Mean plant height was higher in first year than second year and the difference was highly significant. In the second year, except of Elmet, in all plants height increased. A highly significant interaction between year and genotype was recorded. The highest average green matter yield for two years was obtained from Elmet (292.83 g/plant) and *L. multiflorum* showed the lowest green matter yield (183.40 g/plant). Green matter yield of all genotypes increased in second year except Elmet (Table 2).

Table 2. Plant height and green matter yield of *Festulolium* cultivars (Elmet, Prior), *Festuca pratensis* and *Lolium multiflorum*.

Genotypes	Plant height (cm)			Green matter yield (g/plant)		
	1st year	2nd year	Mean	1st year	2nd year	Mean
Elmet	88.67 a*	86.83 a*	87.75 A*	303.40	282.27	292.83
Prior	70.67 b	76.70 b	73.68 C	182.93	293.73	238.33
F. pratensis	75.57 ab	88.57 a	82.07 AB	175.00	226.60	200.80
L. multiflorum	64.70 b	88.00 a	76.35 BC	147.47	219.33	183.40
Mean	74.90	85.03	79.96	185.53	247.15	216.34
LSD	13.80	7.06	7.22			

*Values with same letter in a vertical column are not significantly different according to LSD test at p<0. 01.

No appreciable difference in dry matter yield between genotypes was observed in either years (Table 3). The average dry matter yield ranged between 71.25 and 53.12 g/plant. Elmet showed higher yields than that of others genotypes. Similarly no marked difference in mean seed yield also was observed in the first year. Comparing mean seed yield of all genotypes, highly significant difference were found between genotypes in the second year. Average seed yield of genotypes ranged from 4.81 to 2.68 g/plant. Prior cultivar yielded the highest seed/plant and *L. multiflorum* showed the lowest yield of seed/plant. However, the difference between genotypes (Elmet, *F. pratensis* and *L. multiform)* in seed yield was statistically significant (Table 3) in the second year. Similar reflection was also observed in mean yield of seed.

Table 3. Dry matter yield and seed yield of *Festulolium* cultivars (Elmet, Prior), *Festuca pratensis and Lolium multiflorum.*

Genotypes	Dry matter yield (g/plant)			Seed yield (g/plant)		
	1st year	2nd year	Mean	1st year	2nd year	Mean
Elmet	74.07	68.43	71.25	2.66	4.33 b*	3.50 b*
Prior	66.80	72.00	69.40	3.83	5.79 a	4.81 a
F. pratensis	59.07	65.57	62.32	2.39	3.86 b	3.12 b
L. multiflorum	49.00	57.23	53.12	1.69	3.66 b	2.68 b
Mean	62.23	65.81	64.02	2.64	4.41	3.53
LSD					1.39	1.18

*Values with same letter in a vertical column are not significantly different according to LSD test at p<0. 01.

One thousand-seed weight revealed a highly significant difference between genotypes, and the weight ranged from 2.39 and 3.48 g (Table 4). *F. pratensis* and *L. multiform* recorded higher weight of 1000-seed in comparison to other genotypes. However, no significant difference in 1000-seed weight of Elmet and Prior was observed.

Genotype ash contents were found between 10.98 and 10.45% (Table 4) and no marked differences were observed in crude ash content among the genotypes examined.

Table 4. One thousand-seed weight and crude ash rate of *Festulolium* cultivars (Elmet, Prior) *Festuca pratensis* and *Lolium multiflorum.*

Genotypes	1000-seed weight (g)			Crude ash content (%)		
	1st year	2nd year	Mean	1st year	2nd year	Mean
Elmet	2.54 b*	2.35 b*	2.44 B*	11.25	10.06	10.66
Prior	2.61 b	2.17 b	2.39 B	10.89	10.01	10.45
F. pratensis	3.38 a	3.59 a	3.48A	10.87	10.73	10.80
L. multiflorum	3.21 a	3.47 a	3.33 A	11.01	10.96	10.98
Mean	2.93	2.81	2.91	11.00	10.44	10.72
LSD	0.11	0.33	0.27			

*Values with same letter in a vertical column are not significantly different according to LSD test at p<0. 01.

Genotypes revealed highly significant difference in mean crude protein content and its yield among them (Table 5). The highest mean crude protein content was found in Elmet (12.45%) and that of the lowest values was estimated in *L. multiflorum* (9.78%). Mean crude protein yield of genotypes ranged from 8.86 to 5.22 g per plant and the highest yield of the same was obtained from Elmet. Interaction between years × genotypes was found to be non-significant for both crude protein content and its yield.

Table 5. Crude protein rate and its yield of *Festulolium* cultivars (Elmet, Prior), *Festuca pratensis* and *Lolium multiflorum.*

Genotypes	Crude protein rate (%)			Crude protein yield (g/plant)		
	1st year	2nd year	Mean	1st year	2nd year	Mean
Elmet	12.01	12.88 a*	12.45 a*	9.00	8.77	8.86 a*
Prior	10.41	10.69 b	10.55 bc	6.84	7.53	7.19 ab
F. pratensis	11.97	11.01 b	11.49 ab	7.06	7.15	7.10 ab
L. multiflorum	9.58	9.99 b	9.78 c	4.73	5.71	5.22 b
Mean	10.99	11.14	11.07	6.91	7.29	7.10
LSD		1.70	1.70			2.63

*Values with same letter in a vertical column are not significantly different according to LSD test at p<0. 01.

Elmet generally showed higher values for agronomic components than other genotypes while low values were obtained for prior except for seed yield. As explained earlier, *L. perenne* did not show good Winter survival and since *L. perenne* is one of the Prior's parents, genes from *L. perenne* have contributed to low performance of Prior in this study. Prior performed better in dry matter yield and plant height at the glasshouse conditions (Karaca 2001). Dry matter yield, one of the important criteria of forage crops production, was found to be higher at hybrid genotypes. Elmet had 60% higher dry weight per plant than *L. multiflorum*, but it was not statistically different.

In a previous study with these hybrids it was indicated that genetic stability was not achieved and aneuploidy rate was 73.33% for Elmet, 41.67% for Prior (Karaca 2001). An investigation on populations of autotetraploid meadow fescue reported that green matter yield or seed yield was highly affected by aneuploidy (Klinga 1986a). Similar results were reported by Tosun and Sağsöz (2003). The tolerance of aberrant gametes and zygotes varies among the species. In some crops, such as *L. perenne* and *L. multiflorum*, the viability was generally high (Simonsen 1973, Klinga 1986b). Aneploidy rate shows difference within species, and also within the population of same species (Klinga 1986a). Setting of seed was also affected by meiotic abnormalities (Sağsöz *et al.* 2002). Genotype × environment interaction may be considered as an effective mechanism in aneuploid producing plants (Romel 1963).

The highest seed yield was obtained from Prior plants. Low aneuploid found in Prior affecting seed yield could explain high seed yield obtained from the genotype. Karaca (2001) pointed out that cell rate (14 : 14) of stable anaphase I was more in Prior. The same study also indicated that spikelet and flower number are responsible for producing good seed yield were higher in Prior. One thousand-seed weight of hybrid genotypes was lower than *F. pratensis* and *L. perenne*. It is possible due to their high number of seeds occurring per plant in hybrid genotypes and aneuploid gametes forming in hybrids affect the size and weight of seeds. In the trial aneuploidy rate of the harvested seed was not investigated.

Crude protein yield and crude protein content, quality criteria of the forage crops were highest in Elmet and lowest in *L. perenne*. However, there was no statistical difference in genotypes for the crude ash rate.

Allotetraploid hybrids showed difference from their parents to drought and winter survival and adaptation capacity was better than parents because of the higher tolerance to environmental stresses (Lewis *et al.* 1973). It has been reported that the hybrid plants of *Lolium* and *Festuca* species gave higher yield of seed and dry matter (Berg *et al.* 1979, Humphreys 1993, Deniz1997).

In conclusion, hybrid plants were found to be more productive than *F. pretensis* and *L. multiflorum* plants in Erzurum's ecological conditions. Although *L. perenne* failed to grow because of the winter injury. Prior produced more green and dry matter yield than *F. pratensis* and *L. multiflorum*. However, Prior performed less compared to Elmet hybrid, except seed yield per plant.

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