

Variability of Quantitative Traits in Cocksfoot (*Dactylis glomerata* L.) Genotypes

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Abstract: This study examines major quantitative traits in three experimental genotypes of cocksfoot (*Dactylis glomerata* L.) as compared to the cultivar BL-Krajina (standard). The research was conducted at the trial field of the Faculty of Agriculture of Republic of Srpska, Banjaluka, in 2005-2007. The three-year investigations revealed significant differences between the cocksfoot genotypes in both yield and quality of biomass and seed yield. The highest average dry matter (DM) yield over the three-year period was produced by the R17-45/6 genotype (12.9 t ha⁻¹ DM), the yield being 2.14 t ha⁻¹ DM higher than that of cv. BL-Krajina (10.78 t ha⁻¹ DM). As regards seed yield, cocksfoot genotypes gave high average yields, the differences as compared to standard BL-Krajina being highly significant. The genotype R17-45//6 produced the highest average seed yield over the three-year period (535.7 kg ha⁻¹).

Key words: cocksfoot, genotype, dry matter, quality, seed yield

Introduction

Cocksfoot (*Dactylis glomerata* L.) is one the most important perennial grasses commonly grown in sown meadows. In the upland areas, which are

unfavourable for legume cultivation due to its biological properties, the cocksfoot is often grown in sown meadows either as pure stand or in mixtures with other grasses. In some countries such as France, England, Switzerland and Czech Republic the cocksfoot is the most frequent component of the sown meadows.

Cocksfoot has highly significant biological and agronomical properties and it can grow on different types of soil. It shows a very high production potential in terms of biomass yield and gives good quality of dry matter. Also, it is characterized by marked resistance to drought, ability to regenerate rapidly after cutting or grazing, good summer growth etc. Given the economic importance of cocksfoot and the importance of cultural practices used in its cultivation, the objective of this study was to evaluate the quantitative properties of the experimental genotypes against the BL-Krajina variety (the standard). The obtained results would facilitate further expansion of cocksfoot production and improvement of biomass and seed production under different agricultural and environmental conditions in the Republic of Srpska, Republic of Serbia, etc.

Material and Methods

The research has been conducted at the trial field of the Agricultural Institute of Republic of Srpska in Banja Luka during 2005-2007. Three genotypes of cocksfoot, developed from introduced genotypes and local populations, were used in this research, along with BL-Krajina (standard).

A two-factor trial (factor A – genotype, factor B – year) was set up on well prepared cambisol in a randomized block design in four repetitions. The elementary plot had a surface area of 5 m² (5 m x 1 m), and a 20 cm inter-row spacing was employed. Sowing was performed manually in autumn 2004 at a rate of 24 kg ha⁻¹ of seed.

During the three-year period of study, the most important quantitative properties of cocksfoot were monitored, being as follows: dry matter yield (t ha⁻¹) and seed yield (kg ha⁻¹).

The quality of dry matter was evaluated using standard methods of chemical analysis for the contents of crude proteins (CP) and crude fibre (CF) according to Kjeldahl and Honneberg-Stohman, respectively.

The results on dry matter and seed yield were subjected to an analysis of variance (ANOVA), and significant differences between means were calculated by *t*-test. In addition, the genotype x mean interaction was calculated for DM and seed yield in cocksfoot genotypes.

Soil and weather conditions – Testing of the quantitative properties of cocksfoot was conducted on well prepared cambisol which was favourable for growing perennial grasses. The results provided by the Agricultural Institute Laboratory for Soil Testing show that the soil is mildly acid (pH 5.6-6.5), with a medium humus content (2.70%), a low phosphorus content (9.8 mg/100 g soil), and a medium potassium supply (16.9 mg/100 g soil) in the top 30 cm.

The average precipitation during the growing season (IV-X) for the period 1961-2004 was 650.0 l/m². During the same period in 2005 and 2006, the precipitations averaged 655.3 l/m² and 699.4 l/m², respectively. During the 2007 growing

season, the average was 580.3 l/m², being 75 l/m² lower than in 2005 and 119.1 l/m² lower than in 2006.

During 1961-2004, the mean monthly temperature during the growing season (April-October) was 16.4°C. As compared to the long-term average, mean monthly temperatures in 2005, 2006 and 2007 were 0.3°C, 0.7°C and 1.6°C higher.

Since 2005 and 2006 were favourable for cocksfoot cultivation, primarily due to precipitations, three cuttings were attained, as opposed to two in 2007.

Results and Discussion

Dry matter yield – During the first year of cocksfoot utilization (B₁) there were three cuttings, and the highest total yield was obtained with R17-45/6 genotype (16.50 t ha⁻¹ DM). As compared to BL-Krajina (standard), a 2.93 t ha⁻¹ higher DM yield was produced by this genotype. A high yield of dry matter was also reported for genotype R14-39/1 (13.63 t ha⁻¹), however, the differences relative to BL-Krajina (13.57 t ha⁻¹ DM) were not statistically significant (Table 1, Figure 1).

Tab. 1. Dry matter yield in cocksfoot genotypes by different cuts and total yield (t ha⁻¹) in 2005-2007

Genotype (A)	B ₁ : 2005/Year				B ₂ : 2006/Year				B ₃ : 2007/Year			Average (A)
	Cut (C)			Σ	Cut (C)			Σ	Cut (C)		Σ	
	C ₁	C ₂	C ₃		C ₁	C ₂	C ₃		C ₁	C ₂		
R17-45/6	9.35	5.04	2.11	16.50	11.32	3.94	1.19	16.45	3.52	2.34	5.86	12.94
R14-39/1	6.92	4.63	2.08	13.63	8.27	2.86	0.76	11.89	4.14	2.67	6.81	10.78
R-97	4.64	3.41	1.74	9.79	9.84	2.74	0.80	13.38	3.12	2.48	5.60	9.59
BL-Krajina	7.19	4.42	1.96	13.57	8.62	3.47	1.07	13.16	3.45	2.21	5.66	10.80
Average(B)	7.03	4.37	1.97	13.37	9.51	3.25	0.96	13.72	3.56	2.42	5.98	11.02
Cut percentage (%)	52.6	32.7	14.7	100.0	69.3	23.7	7.0	100.0	59.5	40.5	100.0	-
LSD				A		B		AB				
0.05				0.40		0.32		0.67				
0.01				0.52		0.45		0.90				

During the second year of experiment (B₂), there were also three cuttings of cocksfoot. The highest yield was achieved with the genotype R17-45/6 (16.45 t ha⁻¹ DM), therefore the differences in comparison with BL-Krajina (13.16 t ha⁻¹ DM) were statistically highly significant. During this year, a high dry matter yield was achieved with the genotype R-97 (13.38 t ha⁻¹), however, the differences relative to BL-Krajina were not statistically significant.

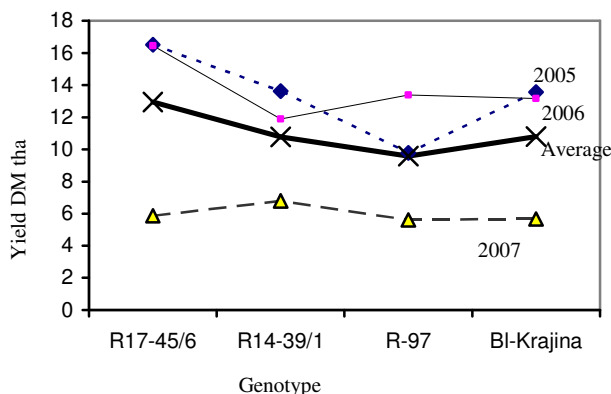


Fig. 1. Dry matter yield in cocksfoot genotypes (t ha^{-1}), 2005-2007

In 2007 (B_3), due to unfavourable conditions during the growing season, including high drought, two cuttings were attained with an average yield of $5.98 \text{ t ha}^{-1} \text{ DM}$. The yield was lowest in genotype R-97 (5.60 t ha^{-1}), and highest in R14-39/1 ($6.81 \text{ t ha}^{-1} \text{ DM}$); therefore, the differences were also highly significant. As in the previous years, the genotype R14-39/1 ($5.86 \text{ t ha}^{-1} \text{ DM}$) gave the highest dry matter yield, which was $1.15 \text{ t ha}^{-1} \text{ DM}$ higher than in BL-Krajina ($5.66 \text{ t ha}^{-1} \text{ DM}$).

According to Lakić *et al.* (2007), an average yield of cocksfoot genotypes of $9.6 \text{ t ha}^{-1} \text{ DM}$ was attained under the agro-environmental conditions of Banja Luka. Sokolović *et al.* (2004) reported the three-year average dry matter yield of cocksfoot to range from 9.20 to 10.59 t ha^{-1} .

Tomić *et al.* (1996) suggested that a yield of 7.0 - $8.7 \text{ t ha}^{-1} \text{ DM}$ was gained with genotypes and varieties of cocksfoot in the first year and 9.5 - $12.5 \text{ t ha}^{-1} \text{ DM}$ in the second. Furthermore, Tomić *et al.* (2000) showed that, on average, $9.1 \text{ t ha}^{-1} \text{ DM}$ was attained by cocksfoot variety Kruševačka Rana, and $7 \text{ t ha}^{-1} \text{ DM}$ by K-6 8. Scurrt *et al.* (2003) produced similar results and suggested that the dry matter yield of cocksfoot ranged from 8.0 - $11.7 \text{ t ha}^{-1} \text{ DM}$.

The obtained results suggest that the average dry matter yield of cocksfoot genotypes during the three-year period was 11.02 t ha^{-1} . The highest yield was produced by the genotype R17-45/6 ($12.94 \text{ t ha}^{-1} \text{ DM}$), the yield being 2.14 t ha^{-1} higher than in BL-Krajina ($10.80 \text{ t ha}^{-1} \text{ DM}$). Therefore, the established differences were highly significant. The yields were lowest in the genotype R-97 ($9.59 \text{ t ha}^{-1} \text{ DM}$), the differences being highly significant.

The rate of increase in dry matter yield of cocksfoot genotypes per cutting and in terms of total yield was 52.6% in the first year, and 47.4% in the second and third. Namely, in the second year, 69.3% was produced in the first cutting, and 47.4% , in the second and third cuttings, whereas in the third year, 59.5% was recorded in the first cutting, and 40.5% in the second (Table 1).

Dry matter quality – During the first cycle of cocksfoot exploitation in 2005-2007 (B_1 – B_3), high-quality dry matter was obtained, having an average content of crude proteins and crude fibre of $109.4 \text{ g kg}^{-1} \text{ DM}$ and $303.3 \text{ g kg}^{-1} \text{ DM}$, respectively (Table 2).

Tab. 2. Crude protein (CP) and crude fibre (CF) contents of cocksfoot genotypes in the first cycle (C_1) during 2005-2007 ($\text{g kg}^{-1} \text{ DM}$)

Genotype (A)	Year(B)						Average(A)	
	B ₁ : 2005		B ₂ : 2006		B ₃ : 2007			
	CP	CF	CP	CF	CP	CF	CP	CF
R17-45/6	129.4	275.6	115.6	291.6	118.7	290.4	121.2	285.9
R14-39/1	108.4	314.2	108.0	308.6	103.5	307.0	106.6	309.9
R-97	105.9	306.4	104.4	309.9	110.0	298.0	106.9	304.8
BL- Krajina	103.1	319.8	101.9	314.2	104.4	304.7	103.1	312.9
Average (B)	111.7	304.0	107.5	306.0	109.1	300.0	109.4	303.3

The average crude protein content was $111.7 \text{ g kg}^{-1} \text{ DM}$ in the first year of study, $107.5 \text{ g kg}^{-1} \text{ DM}$ in the second year, and $109.1 \text{ g kg}^{-1} \text{ DM}$ in the third year. The content of crude proteins was highest in genotype R17-45/6 ($121.2 \text{ g kg}^{-1} \text{ DM}$) and ranged from 115.6 to $129.4 \text{ g kg}^{-1} \text{ DM}$ and lowest in BL-Krajina ($103.1 \text{ g kg}^{-1} \text{ DM}$), i.e. 101.9 - $104.4 \text{ g kg}^{-1} \text{ DM}$. As compared to the genotype R17-45/6 and BL-Krajina, the average crude protein content in genotypes R14-39/1 and R-97 was $106.8 \text{ g kg}^{-1} \text{ DM}$ (Table 2).

As opposed to the content of crude proteins, crude fibre content showed uniformity in the tested genotypes. The highest was recorded for BL-Krajina ($312.9 \text{ g kg}^{-1} \text{ DM}$), being 304.7 - $319.8 \text{ g kg}^{-1} \text{ DM}$. The genotypes R-97 and R14-39/1 gave the average crude fibre content of $307.4 \text{ g kg}^{-1} \text{ DM}$. Conversely, the genotype R17-45/6 had the lowest crude fibre content ($285.9 \text{ g kg}^{-1} \text{ DM}$), ranging from 275.6 - $291.6 \text{ g kg}^{-1} \text{ DM}$, with the differences obtained being statistically significant.

Since the crude protein content of cocksfoot depends on several factors (variety, conditions, growth phase, plant development during cutting, genotype $\times$ environment, etc.), Ferenc (1989) indicates that the CP content of cocksfoot significantly depends on the growth phase and plant development during the cutting period, and it ranges from 100.0 - $194.0 \text{ g kg}^{-1} \text{ DM}$.

According to Fišakov and Meglič (1988), the utilization of cocksfoot during the optimal growth phase and plant development resulted in the crude protein content of 13.4 - 14.7% , and the content of crude fibres of 25.8 - 29.1% .

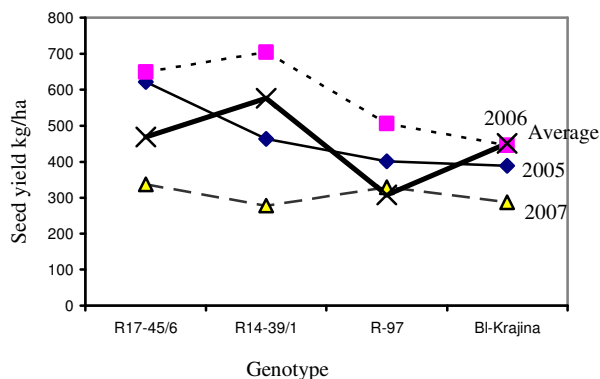
The results of this study suggest that the highest crude protein content was produced by the genotype R17-45/6 ($121.2 \text{ g kg}^{-1} \text{ DM}$ on average). In addition, this genotype gave the lowest crude fibre content ($285.9 \text{ g kg}^{-1} \text{ DM}$ on average) (Table 2).

Seed yield – The seed yield of cocksfoot is dependent on a number of factors inducing high yield variability. The average cocksfoot seed yield in this study was 451.0 kg ha^{-1} (Table 3, Figure 2).

Tab. 3. Seed yield in cocksfoot genotypes (kg ha^{-1}), in 2005-2007

Genotype(A)	Year(B)			Average (A)
	B ₁ : 2005	B ₂ : 2006	B ₃ : 2007	
R17-45/6	621.3	648.8	337.0	535.7
R14-39/1	463.8	704.5	277.8	482.0
R-97	401.5	506.3	329.0	412.3
BL- Krajina	388.8	445.5	288.0	374.1
Average(B)	468.9	576.3	307.9	451.0
LSD				
	A	B	AB	
	0.05	32.13	27.83	55.68
	0.01	43.12	43.12	74.72

During the first year of study, 468.9 kg ha^{-1} of seed was produced on average, ranging from 388.8 kg ha^{-1} (BL-Krajina) to 621.3 kg ha^{-1} (R17-45/6). During the second year, the yield ranged from 445.5 kg ha^{-1} (BL- Krajina) to 704.5 kg ha^{-1} (R14-39/1), giving an average of 576.3 kg ha^{-1} . During the third year, however, the lowest seed yields averaged 307.9 kg ha^{-1} , their range being 277.8 kg ha^{-1} (genotype R14-39/1) to 337.0 kg ha^{-1} (genotype R17-45/6).

Fig. 2. Seed yield in cocksfoot genotypes (kg ha^{-1}), in 2005-2007

The genotype R17-45/6 gave high seed yields and showed stability (535.7 kg ha^{-1} on average), whereas the lowest yield was recorded for variety BL-Krajina (288.0-388.8 kg ha^{-1} i.e. 374.1 kg ha^{-1} on average). Genotype R14-39/1 also produced high seed yields (482.0 kg ha^{-1} on average). Higher variations in seed yield of this genotype were observed; therefore the yield was higher in the second year (704.5 kg ha^{-1} of seed), and lowest in the third year (277.8 kg ha^{-1} of seed).

Đukić *et al.* (2004) reported the average cocksfoot seed yield to range from 300 kg ha^{-1} to 600 kg ha^{-1} . Furthermore, Vučković *et al.* (1998) showed that the average two-year seed yield of cocksfoot ranged from 482.4 -767.7 kg ha^{-1} in the Zapadni Srem region.

The results of the present study show that high seed yields of cocksfoot obtained in cocksfoot genotypes ranged from 307.9 kg ha⁻¹ (2007) to 576.3 kg ha⁻¹ (2006), depending on the genotype, year, and genotype $\times$ year interaction, and the variability ranged from 277.8 kg ha⁻¹ (genotype R14-39/1, 2007) to 704.5 kg ha⁻¹ (genotype R14-39/1, 2006).

In terms of seed yield and seed yield stability, the genotype R17-45/6 showed good performance, R14-39/1 and R-97 performed moderately well and BL-Krajina gave the lowest values (288.0-445.5 kg ha⁻¹ or 374.1 kg ha⁻¹ on average).

Conclusion

The three-year study on dry matter yield and quality and seed yield of cocksfoot suggested the following:

A high yield of dry matter (11.02 t ha⁻¹ DM on average) was produced by the newly developed cocksfoot genotypes and the variety BL-Krajina under the agro-environmental conditions in the Banja Luka region.

The yield of dry matter was highest in genotype R17-45/6 (12.94 t ha⁻¹) and lowest in R-97 (9.59 t ha⁻¹ DM), the differences being highly significant.

As compared to BL-Krajina variety, the newly developed cocksfoot genotypes gave better dry matter quality. In terms of dry matter quality, the genotype R17-45/6 had markedly the highest dry matter content (121.2 g kg⁻¹ DM on average), and the lowest crude fibre content (285.9 g kg⁻¹ DM on average).

The highest seed yield and stability were achieved with the genotype R17-45/6 (535.7 kg ha⁻¹ on average). The genotypes R14-39/1 and R-97 showed moderate performance and the variety BL-Krajina gave the lowest yield (374.1 kg ha⁻¹ on average). The obtained differences were highly significant.

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VARIJABILNOST KVANTITATIVNIH SVOJSTAVA GENOTIPOVA JEŽEVICE (*Dactylis glomerata* L.)

- originalni naučni rad -

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Rezime

U radu se ističu najvažnija kvantitativna svojstva tri eksperimentalna genotipa ježevice (*Dactylis glomerata* L.) u odnosu na sortu BL-Krajina (standard). Ispitivanja su obavljena na oglednom polju Poljoprivrednog instituta Republike Srpske u Banjaluci u periodu 2005-2007.godine. Tokom trogodišnjeg istraživanja, utvrđene su značajne razlike između genotipova ježevice, kako za prinos i kvalitet biomase, tako i za prinos semena. Najveći trogodišnji prosečan prinos suve materije (DM) ostvaren je sa genotipom R17-45/6 ($12,9 \text{ t ha}^{-1}$ DM), ili za $2,14 \text{ t ha}^{-1}$ DM više u odnosu na prinos sorte BL-Krajina ($10,78 \text{ t ha}^{-1}$ DM). Što se tiče prinisa semena, sa genotipovima ježevice ostvareni su visoki prosečni prinosi, a razlike u odnosu na standard BL-Krajina su visoko signifikantne. Sa genotipom R17-45/6 ostvaren je najveći trogodišnji prosečan prinos semena ($535,7 \text{ kg ha}^{-1}$).