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Yields of grass species for large game in the Eu-Mediterranean zone of the North Adriatic

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Abstract
Previous experiences with wild (and mainly allochthonous) ruminants in the Mediterranean area point out on the detrimental impact on indigenous vegetation, mainly indigenous species of grasses and herb species. The analysis of the yields of fresh mass of four species of grasses showed that it is possible to achieve green fodder yields in the Mediterranean (arid) conditions, which by far exceeds the biomass of natural vegetation. A statistically significant difference in the yields of fresh mass in the first and second year of the experiment was found in three of the four species of grasses. The establishment of such grassland draws could reduce the pressure on indigenous vegetation and enable sustainable breeding of wild ruminants in areas where livestock-breeding has been abandoned.

Key words: wild ruminants, grasses, herb species, defoliation, yield, Mediterranean

Introduction

The Mediterranean is one of the most complex parts of the Earth in terms of geology, geography, morphology and natural history (Blondel and Aronson, 1999). Its landscape was influenced by three fundamental factors making it different from other European landscapes. These factors are climate, fires and intense human impact. Grazing has been present in the Mediterranean for 5,000 years (Le Houerou, 1981), and represent one of the most pronounced human influence that has affected the current state of forest vegetation. Since the end of the 20th century, abrupt and often underestimated landscape changes have become visible in this area, resulting from the pronounced depopulation of rural areas (Debussche et al., 1999). In addition to the decline in human population, the decline in the number of small ruminants has been even more rapid, accompanied with the lack of traditional management of forest ecosystems (felling of trees, coal production and grazing in forests). All this has led to the expansion of forest areas. As an alternative to livestock and their positive role in the reclamation of habitats in the area, primarily by reducing the risk of fire, the question of the justification of breeding wild ruminants is raised. Those are mainly species that have so far been traditionally bred in the certain localities of the Mediterranean area, such as fallow deer (*Dama dama*) and the European mouflon (*Ovis gmelini musimon*). Due to the specific environment (aridity and the skeletal nature of the soil) in the Mediterranean hunting grounds, the variety of grass species is generally quite limited, and very little research has been conducted with the intention of raising the trophic capacity for wild ruminants. Therefore, the aim of this paper is to investigate the amount of yields of certain species of grasses that could be sown in particular forest areas of the Mediterranean basin.

Material and methods

The research was conducted in a fenced part (877 ha) of the state hunting ground number VIII/6 "Kalifront" on the island of Rab. According to Köpen's classification, the area belongs to the Cfsax´´ climate type (Seletković and Katušin, 1992), which is a moderately warm

rainy climate with hot summers, and the driest part of the year falls in the summer season. From the vegetation point of view, the hunting ground belongs to the Eu-mediterranean vegetation zone (Trinajstić, 1986), which is dominated by the forest community of holm oak and black ash (*Fraxino orni-Quercetum ilicis* H-ić / 1956/1958). The experiment was carried out on a cleared area of 2 ha surrounded by forest. The soil belongs to an acid brown soil on clastic sediments. Basic tillage (ploughing) was carried out in late autumn (November 1999), and additional processing (discing and tilling) was carried out in spring (March 2000). Before discing and tilling, mineral fertilizer of NPK formulation 7:20:30 in the amount of 300 kg ha^{-1} was applied to the soil. Sowing of grasses was done in separate strips 1 meter wide and 30 meters long with five species of grasses: Italian ryegrass (*Lolium multiflorum* Lam. cv. Amba), English ryegrass (*Lolium perenne* L. cv. Calibra), cocksfoot (*Dactylis glomerata* L. cv. Amba), red fescue (*Festuca rubra* L. cv. Echo) and meadow-grass (*Poa pratensis* L. cv. Balin). Between each repetition, a 1 by 30 metre strip was left for five repetitions in a random block plan. After sowing, the plots were fenced, to prevent the access of big game to the growing grass. Defoliation was carried out on May 20, 2000. (defoliation 1) and on June 6, 2001 (defoliation 2), using a shearing scythe. The meadow grass did not grow at all, so no measurements were taken for it. On each sown strip of fenced area of 1 m^2 and in each repetition, fresh mass weight was calculated and 1 kg of fresh mass was classified according to floral components: sown species of grasses, herb species and weeds. During defoliation, the species of grasses were in different phenophases. The red fescue was in the late phenophase of forking the shoots, the cocksfoot in the full wilting phenophase, the English ryegrass in the late ear formation phenophase, and the Italian ryegrass in the seed maturation phenophase. The area where the research was carried out is inhabited by two species of big game – the European mouflon (*Ovis gmelini musimon*) and the axis deer (*Axis axis*). During the experiment, over 20 mouflons and up to 5 axis deers graze on the sown area (coverts) (Krapinec, 2000), but the game could not penetrate the fence and reach the biomass in the fenced part of the covert, making the crops protected. Statistical analysis was performed by the analysis of variance (ANOVA), i.e. with Sheffé's post hoc test and the Kruskal-Wallis test. A comparison of the fresh mass yields of the sown species of grasses and the yields of herb species and weeds was made by t-test for controlled samples. The data obtained were analysed using the Statsoft 14.0.0.15 program (TIBCO Software Inc., 2020).

Results and discussion

In the first defoliation, the total fresh mass yields was highest on the experimental plots with Italian ryegrass as the sown species of grasses (Table 1). However, after the fresh mass yields of sown species of grasses is separated from the total yield then the yield of Italian ryegrass is no longer statistically significantly higher compared to the other species of grasses. Namely, although the Italian ryegrass in the first defoliation showed apparently the highest fresh mass yield (26.75 t ha^{-1}), even double the yield of the cocksfoot (12.77 t ha^{-1}), statistically it is only significantly higher than the yield of red fescue (4.77 t ha^{-1}; $\chi 2 = 18.362$; $p < 0.001$). The fresh mass yield of herb species and weeds also did not differ between the areas under the Italian ryegrass (0.57 t ha^{-1}) the English ryegrass (0.69 t ha^{-1}) and the cocksfoot (1.18 t ha^{-1}), but it was significantly higher in the area of the red fescue (4.57 t ha^{-1}) in relation to the yield of herb species and weed species in the other areas. The share of weeds and herb species on the red fescue plot during the first defoliation was so high that there was no difference between the red fescue yield and the yield of herb species and weeds (51.38 ± 3.74 % of the total yield, respectively (48.62 ± 3.74 % of the total yield; $t = 0.83$; $p = 0.456$). In other species, the share of biomass of sown grass species in the first defoliation ranged from 91.2 ± 3.14 % (cocksfoot) to 98.0 ± 0.85 % of the total fresh mass yield (Italian ryegrass).

Table 1. Yield of fresh mass of floral components in the first defoliation (20.05.2000).

Species of grass	Yield of grasses t ha^{-1} (Kruskal-Wallis test)	Yield of herb species and weeds t ha^{-1} (Sheffé test)	Total yield t ha^{-1} (Sheffé test)
Lolium multiflorum Lam. cv. Bofur	26.75a	0.57a	27.32a
Lolium perenne L. cv. Calibra	16.49ab	0.69a	17.18b
Dactylis glomerata L. cv. Amba	12.77ab	1.18a	13.95b
Festuca rubra L.cv. Echo	4.77b	4.57b	9.34b

Different letters within the columns indicate a statistically significant difference at the level of $p < 0.05$. All comparisons were made with the Sheffé test.

Table 2. Yield of fresh mass of floral components in the second defoliation (6.6.2001).

Species of grass	Yield of grasses t ha^{-1} (Kruskal-Wallis test)	Yield of herb species and weeds t ha^{-1} (Sheffé test)	Total yield t ha^{-1} (Sheffé test)
Lolium multiflorum Lam. cv. Bofur	12.57a	0.78a	13.35a
Lolium perenne L. cv. Calibra	7.78b	1.19a	8.97a
Dactylis glomerata L. cv. Amba	9.14ab	1.46a	10,60a
Festuca rubra L. cv. Echo	9.12ab	4.15b	13.27a

Different letters within the columns indicate a statistically significant difference at the level of $p < 0.05$. All comparisons were made with the Sheffé test.

In the second year of the experiment (second defoliation) there was no difference in the amount of total fresh mass yield when researching grass species (Table 2). Regarding the yield of sown of grass species, the highest fresh mass yield was again in the case of Italian ryegrass (12.57 t ha^{-1}), although it was not significantly higher than the yield of cocksfoot (9.14 t ha^{-1}) and red fescue (9.12 t ha^{-1}), but had a significantly higher yield than the English ryegrass (7.78 t ha^{-1}). In the yields of herb species and weed species, the highest fresh mass yields measured were again significantly highest in the areas where the red fescue was sown (4.15 t ha^{-1}). Although in the first defoliation no difference was found in the share of fresh mass yield of sown and unsown crops in the area with red fescue, in the second defoliation the difference in the share of yield between sown red fescue in relation to the share of biomass of herb species and weeds in the total biomass was significant (69.18 ± 3.19 %, respectively 30.82 ± 3.19 %; $t = 13.444$; $p < 0.001$). The difference in the fresh mass yields of sown grass between the two defoliations depends a lot on the species of grass (Table 3). There was no statistically significant difference in the fresh mass yields of the first and second defoliation for the cocksfoot. The Italian and English ryegrasses had statistically significantly higher fresh mass yields in the first defoliation, i.e. during the first year of grass growth. In the case of red fescue, the situation was reversed and the fresh mass yields were significantly higher during the second defoliation, i.e. during the second year of grass growth. The difference in fresh mass yields in all three species of grass was almost double. The dynamics of the fresh mass yield ratio of the first and second defoliation of the tested species (varieties) of grasses completely coincides with the experiences given by Šoštarić-Pisačić and Kovačević (1968). This means that ryegrasses (especially Italian), as very penetrating species of grasses, already in the first year gave the maximum yield of voluminous fodder, and later the yield of these species decreases. On the other hand, the same authors describe red fescue as a perennial that is neutral to repressed grass species, which grows slowly after germination and achieves higher yields in later years of cultivation.

Quantitatively, Italian ryegrass is a short-lived tall species of grass that achieves maximum fresh mass yields of 40-80 t ha^{-1} during the growing season in the first year of production, while yields of other species range from 40 t ha^{-1} (cocksfoot) to 60 t ha^{-1} (English ryegrass), with the lowest yields being achieved by red fescue (Stjepanović et al., 2008). However, the latter species for the production of voluminous fodder is most often sown in mixtures with legumes or other grasses, and rarely in monoculture (Stjepanović et al., 2008). The reason for this is that it develops a loose and long-lasting sod, which is why the parts of the turf at ground level remain unfilled, and thus suitable for the development of weed species.

Table 3. Yield of fresh mass of floral components in the first and second defoliation

Species of grass	Yield species of grass t ha		*t*	*p*	Proportion of herb species and weeds in the total yield %		*t*	*p*
	Defoliation				Defoliation			
	1st	2nd			1st	2nd		
LM	**26.75**	12.57	7.16	0.002	2.00	**5.82**	-4.57	0.01
LP	**16.49**	7.78	2.89	0.044	3.74	**13.28**	-8.11	0.001
DG	12.77	9.14	1.75	0.15	8.80	**13.52**	-13.02	0.0002
FR	4.77	**9.12**	-6.08	0.004	**48.62**	30.82	6.096	0.004

All comparisons were made with the Sheffé test. The numbers printed in bold indicate significantly higher values within each species of grass. Denotation species of grass: LM= *Lolium multiflorum* Lam. cv. Bofur; LP= *Lolium perenne* L. cv. Calibra; DG= *Dactylis glomerata* L. cv. Amba'; FR= *Festuca rubra* L. cv. Echo.

Despite the large difference in fresh mass yields, grass species with lower yields should not be excluded from cultivation because experiments have shown that the mouflon prefers English ryegrass and red fescue compared to Italian ryegrass (Krapinec et al., 2019). In addition, in spring compared to autumn sowing, greater weeding of grass crops is possible because weeds are fast growing and overshadow the desired plant species (Byrne et al., 2018), especially those with slower germination and growth (Paterson and Sim, 2000), which was confirmed by the high proportion of weeds in the red fescue monoculture. Due to the significantly faster growth compared to red fescue, other grasses used in this study, especially Italian ryegrass, had a significantly lower proportion of weeds in both years of the research study. Wild ruminants in unconstrained nature consume green fodder directly. Therefore, the expression of yield in fresh mass from the point of view of game breeding is more practical than the expression of yield in dry matter. However, data on fresh mass yields are rather scarce in literature. In the Pannonian part of Croatia, the pure culture of Italian ryegrass gives fresh mass yields from 27.2 to 33.3 t of ha^{-1} (Vodopija, 2017). Moreover, it is much more profitable to establish DTSs (Deep Tiller Seeders) in the production of voluminous feeds (Bošnjak et al., 2013). For comparison, the yields of clover grass mixture for alfalfa, English ryegrass and red fescue harvested in the Pannonian area amounted to 27.72 t ha^{-1} fresh mass (Tadić, 2018), while the yield of clover grass mixture with a dominance of cocksfoot and ryegrasses, also in the Pannonian area, was on average 38.84 t ha^{-1} fresh mass (Knežević et al., 2004). However, compared to these yields, biomass yields in the Eu-Mediterranean are far lower and range from 0.23 to 0.61 t ha^{-1} in forest stands, and 0.12 to 0.23 t ha^{-1} for grasses and herb species on sunlit paths and forest clearings. Thus, the yields of cultivated grasses in the Eu-Mediterranean area in the year of sowing are lower than the yields of the same in more humid areas, but, there again, they greatly exceed the amount of natural supply of fodder in the Mediterranean area. Therefore, the not surprising results are scientific evidence of the harmful effects of the European mouflon on the indigenous vegetation of the Mediterranean area (Rodríguez et al., 1988; Garcia-Gonzalez

et al., 1989; Alfayate et al., 1991) since offering a higher quality (more palatable) and richer-yielding fodder could reduce the pressure of this ruminant on indigenous vegetation.

Conclusion

The results of the research on the yields of fresh mass of four grass species showed that it is possible to achieve green fodder yields in the Mediterranean (arid) conditions, which by far exceeds the biomass of natural vegetation. A statistically significant difference in the yields of fresh mass in the first and second year of the experiment was found in three of the four grass species. The establishment of such grassland draws could reduce the pressure of wild ruminants on indigenous vegetation and enable acceptable breeding of wild ruminants in areas where livestock-breeding has been abandoned.

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