PERMANENT AND SOWN GRASSLANDS IN SERBIA: CURRENT STATE AND TRENDS

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Abstract

Number of cattle in Serbia during two decades of the 21st century shows the tendency of decreasing. The main source for sustainable livestock production in Serbia are grasslands. Permanent grasslands occupy approximately 30% of agricultural land in Serbia, thereby playing an important role in forage production and ecosystem services. The majority of natural meadows and pastures are located in hilly-mountainous regions. The general characteristics of grasslands in the central Balkans are low production and insufficient quality. The yield of permanent grasslands in Serbia is influenced very strongly by climatic conditions, type of grassland and level of organic and mineral fertilization. On areas that are not managed by mowing and fertilizing, forbs make up over half of the plant production.

This paper presents some recent experiences and results in livestock feed production obtained from permanent and sown meadows and pastures in Serbia. There is survey of permanent grassland botanical composition and productivity with special emphasis on importance of preserving legume species. Also, recent trials assessed the benefits of mineral and organic fertilizers application in terms of forage production, testing whether the mineral or organic sources improves the stability of the grassland and evaluated response patterns over a large environmental gradient. Nutrient availability in permanent grasslands has a strong influence on plant species biodiversity, plant cover, and species' dominance in the vegetation canopy. Dry matter yield is very low with high variation in crude protein content, which confirms that grasslands need to be maintained through fertilizer application, with special emphasis being given to the new role of manure enriched by zeolite.

The above-stated lead to poor production potential of these grasslands for livestock production, nonetheless offering sustainable means of soil and biodiversity protection in the area.

Key words: fertilizer, grassland, manure, quality, yield

Introduction

Temperate forage grasses are the main components of grasslands occupying 40.5 % of the world's terrestrial area and 30-40% of European agricultural area. They cover the land, providing a habitat and a source of food for domestic livestock, thus ensuring a supply of livestock products, with contributes to rural agricultural and economic development. Grasses are a natural food for ruminants. Rich in fibre, they provide the bulk necessary for good rumen function. Eaten at a sufficiently young stage, they are highly digestible and contain lot of energy. At this stage they also have high mineral and protein contents that cover a large part of animals' requirements. On annual basis, in Europe, it is common for 50 to 75% of cattle and 90 to 95% of sheep fodder requirements to be met by grasslands because grasses are a natural food for ruminants.

In Europe from 2000, many forage systems were deintensified and wild or

hardly selected species became more important in grasslands. Therefore, it is evident that importance of perennial grasses as animal feed will be increased in the future.

Grasslands usually produce the majority of the forage ingested by ruminant animals during grazing season. During winter housing grass hay and silage are often major parts of the staple diets. There are many improved grass genotypes in Serbia that share main characteristics: high yield and quality of dry matter within a target group of environments and in particular agricultural context. Grasslands cover less productive lands on central Balkans, which represent large share of total agricultural areas in Serbia (27%), Montenegro (80%), Bosnia (>50%). In Serbia natural grasslands cover large acreage over 1.45 million hectares, while fields under the sown grasslands are on 150.000ha (Lazarević et al., 2005, Statistical Office of the Republic of Serbia, 2019).

Grasslands in Serbia, biodiversity and role

On Balkan Peninsula and Serbia large species diversity of perennial grasses exists and many of them remained in *refugio* after last ice age. They are acclimatized to change of seasons and different habitats from lowlands with fertile deep soil to mountainous terrains over 1200m a.s.l. with shallow soils and lack of nutrients and humus. Especially this broad adaptability to different agroecological and climatic conditions considerably increases agronomical importance of perennial grasses on the multiple bases. The main fact is that they are the base components of grasslands and rangelands with more than 50% of share (Vučković et al., 2005; Lazarević et al., 2005; Tomić et al., 2009). The Sjenica region is the largest area in southwestern Serbia, covered by grasslands, 89,5% of agricultural land are meadows and pastures (Pavlović and Šabić, 2003).

The grassland vegetation of Serbia as an important resource for agriculture is characterized by exceptional biodiversity of plant and animal species. Due to historical background of vegetation development, geographical position, climate and relief, Serbia represents one of the 158 world biodiversity centres (Sokolović et al., 2017), based upon the number of plant species and territory size (biodiversity index 0.72). On Serbian territory lives 40% of all plant species present today in total European flora (Stevanović et al., 2000). Considering the vegetation diversity of Serbia, about 600 to 1200 plant communities have been identified (Lakušić, 2005), including forests, steppes, meadows, pastures, vegetation of sand dunes and saline soils, swamps, alpine tundra, etc. Among them, after detail analysis, 273 meadow and pasture communities were determined and included in 46 vegetation alliances from 24 orders and 10 classes of grasslands (Kojić et al., 2004). They are especially present in marginal areas which are not used for intensive agriculture and on natural grasslands on uplands of Serbia.

Different types of grassland ecosystems are developed in a variety of habitat types, geological substrates, climates and soils. These eco-systems represent basic prerequisites for sustainable forage production, but very low potential of them is utilized. For example, the most diverse vegetation classes are *Festuco-Brometea* (Br.- Bl. et R. TX. 1943) with 1194 plant species (41.8% of all plant species in Serbia) and *Molinio-Arrhenateretea* (R. Tx. 1937) with 895 species included (Lakušić, 2005, Aćić et al., 2019). Most of the genera and species of plants which build the grassland vegetation of Serbia belong to the families *Asteraceae*, *Poaceae* and *Fabaceae*. Family *Poaceae* is present in Serbia flora with 70 genera and among them from the aspect of forage production and quality, the most important are perennial *Festuca* 21 species, *Lolium* (5 species), *Dactylis* (3 species), *Phleum* (8 species), *Bromus* (14 species), *Arrhenatherum*, *Poa* (17 species) and *Agrostis* (6 species). Many

of them contain numerous sub-species, varieties and forms.

Knowledge of the floristic diversity of the grassland communities of Serbia is important in order to recognize the qualitative and quantitative changes that occur due to the negative impacts of abandonment or inappropriate use of these ecosystems in agriculture and to take appropriate measures to protect and restore the grassland vegetation habitats.

Demonstrating the importance of grassland species it is necessary to define many functions fulfilled by these ecosystems. Firstly, they occupy the land, providing a habitat and a source of food for domestic livestock, thus ensuring a supply of livestock products, with contributes to rural agricultural and economic development (Stošić et al., 2005). Extensive livestock production is characterised by better use of natural resources (primarily pastures) and local livestock breeds which are better accommodated to the environment and better connected to local tradition.

Grasslands are immeasurably significant for the preservation of soil and water quality. Perennial grasses form dense cover with haired root system which preserves soil from water runoff and reduce nitrate leaching by efficient consumption and also improve hydrological cycle and water quality. At the same time they show higher water infiltration rate than arable crops, reducing of rapid soil water evaporation and drying, and protect top soil from water and wind erosion. The older the grassland, the higher infiltration capacity, owing to a better soil structure, more earthworm burrows and a higher organic mater content. Grasses perenniality also determines the exploitation regime and sward persistency. Infrequent need for renovation relaxes the soil and reduces a significant part of the losses during ploughing. Most of perennial grasses and their contemporary cultivars are highly productive and rich yield over 13tha^{-1} of dry matter (Sokolović et al., 2010) of excellent quality. Forage of most of perennial grasses species shows high digestibility, balanced NDF and ADF content and crude protein content over 140gkg^{-1} (Tomić et al., 2007).

Sown grasslands, grass breeding, seed production

Perennial grasses and their associations are, as we recognise them today, product of several hundred thousand years long natural evolution and selection for adaptability and persistency in constantly changing environment. This natural selection was additionally amplify with selection pressure of grazing animals and finalised with few dozen of centuries long period with human influence. All that resulted in huge biodiversity and adaptability to different environments of perennial grasses and their associations, grasslands. Grasses belong to the family which comprise of ecologically dominant plant species, covering waste areas of land and represents most widespread family of plants in the world. Natural features, diverse relief and climatic diversity result in great wealth of grassland plant species (including many endemic plants). The autochthonous populations very often have satisfactory yielding performance in comparison with introduced cultivars, which referred them for direct phenotypic selection for cultivars release. Broadening of forage grasses genotypes collection is permanent objective of Serbian scientists. Collected accessions are being characterized and evaluated for important phenological, morphological and agronomical traits.

Total number of plants species used in Serbian commercial agricultural production without flowers is 233, while as field crops 185 species are used. Among them only few species of perennial forage grasses have been bred and used on sown grassland or field production. The most important perennial grasses species used as fodder crops in Serbian agriculture and breeding are orchardgrass (*Dactylis glomerata* L.), Italian ryegrass (*Lolium multiflorum*

Lam.), meadow fescue (*Festuca pratensis* Huds.), perennial ryegrass (*Lolium perenne* L.), red fescue (*Festuca rubra* L.), timothy (*Phleum pratense* L.), tall oatgrass (*Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl.), tall fescue (*Festuca arundinacea* Schreb.) and smooth brome (*Bromus inermis* Leyss.). Some of mentioned species are characterized by high number of intra-species taxa, such as subspecies, varieties and forms.

Meadow fescue (*Festuca pratensis* Huds.), orchardgrass (*Dactylis glomerata* L.) and perennial ryegrass (*Lolium perenne* L.) are very important perennial fodder grasses with multiple purposes for animal feed production on grasslands and pastures. They are caenobionts of plant associations from the class *Molinio-Arrhenatheretae*, from lowlands to valleys in hilly areas.

Festuca pratensis Huds. is mostly frequent in associations *Cynosuretum cristati*, *Festucetum pratensis* and anthropogenic association *Arrhenatheretum elatioris*, where edificatory species is tall oatgrass, also very important for fodder use. *Dactylis glomerata* L. is characteristic species of grasslands from alliance *Arrhenatherion elatioris* with different presence and covering. Perennial ryegrass, as most important fodder grass in Europe, in Serbia is dominantly present in association *Lolio-Cynosuretum cristati*, especially on places treated upon intensively (Sokolović et al., 2003). *Agrostietum* and *Poetum* associations are also very present and well adapted on hilly and mountainous regions and represent very important natural grasslands for animal nutrition (Kojić et al., 2005; Vučković et al., 2007) and they are very rich in grasses natural genotypes.

All those plant species have been using as forage very long time and they have been improved by breeding many times for better utilization (Tab. 1).

Table 1. Number of created and active varieties of fodder grasses in Serbia

Species	Total	Active
Cocksfoot	6	3
Perennial ryegrass	2	1
Italian ryegrass	3	2
Timothy	2	1
Smooth brome	1	1
Tall oatgrass	3	1
Tall fescue	3	1
Red fescue	2	1
Meadow fescue	1	1
Festulolium	1	1
Meadow foxtail	1	1
Total	25	14

Based on long lasting investigation of genetic resources of perennial forage grasses it can be concluded that region of Serbia is extremely rich with all species with high degree of intra-species and population variability. This fact allows collecting of huge number of accessions and breeding and selection of best genotypes for different purposes, from fodder use (grazing, hay making and ensiling) to special use (turfs, erosion protection, etc). Based on many expeditions conducted recent years across Serbia, large gene pool of perennial grasses was formed with high amount of collected material (230 accessions). The most important areas for collecting are hilly-mountainous regions of East and Central Serbia which hasn't been used for intensive agriculture and represent most important centres of perennial grasses biodiversity in Serbia. Most of collected accessions are already characterised and evaluated. Lot of their genotypes show excellent traits for fodder production, but also good special characteristics for alternative usage of perennial grasses (turf and amenity use, erosion protection and orchards and degraded land greening etc). (Sokolović et al., 2017)

An important factor for the cheaper production of livestock feed is the possibility to provide sufficient quantities

of quality seeds at affordable prices. Production of quality seeds of local varieties of perennial legumes is possible to obtain sufficient amounts of good quality forage. Current situation in forage crop seed production of the Republic of Serbia is unsatisfactory because the seed of perennial grasses are mostly imported. Otherwise, researches confirmed high potential in grass seed production in Serbian conditions, especially of Italian ryegrass seed (Simić et al., 2009, 2010, Stanisavljević et al., 2010). Domestic production of alfalfa, red clover and birdsfoot trefoil met domestic needs only in some years. Seed of imported varieties are often not satisfactory because those varieties are not adapted to Serbian agro-ecological conditions. Institute for forage crops Kruševac is making a significant contribution to the development of technology of seed productions, especially alfalfa, red clover and perennial grasses (Đokić et al., 2013).

Grassland improvement

The main problems in Serbian grasslands have been focused on plant nutrition, weed control, microbiological activity in soil and soil protection, sown grassland establishment, appropriate grass-legume mixture.

Results of researches carried out over the long period regarding the effect of phosphorus fertilizers on change of natural and sown grasslands in hilly-mountainous regions of Serbia showed that without the phosphorus higher biological production can not be achieved (Stošić et al., 2004). However, it is of great importance to realize correct ratio between this nutrient and nitrogen and potassium, not only in order to achieve better efficiency, but also more rational use of mentioned nutrients. This ratio depends on the type of the natural grassland or leguminous-grass mixture, focusing on the leguminous species, if they are present and in which proportion. If legumes are present on natural grasslands, phosphorus fertilizers, with or without potassium contribute to the increase of their presence. Also, P fertilizers induce increase of yield, however in the absolute value yields are not high. Higher rates of phosphorus fertilizer affect the increase of yield, but only if leguminous plants are present in floristic composition. Different response of species from the *Fabaceaea* and *Poaceae* families is registered in double fertilizing combinations. On natural grasslands, treated with PK, yield is always lower if there are no legumes present. Also on sown grasslands, P and PK treatments stimulate the growth of leguminous components. If also nitrogen is introduced, especially in higher quantities (over 50 kg ha^{-1} N) legumes are suppressed from the mixture. It is recommended in years when legumes are present in projected quantities or more, to use PK or smaller N rates of fertilizer, and in conditions without legumes to give advantage to the nitrogen.

Recent researches on Serbian grasslands revealed plant quality for livestock and wild game consuming, what are their nutritious values and digestibility, are they poisonous and in which degree, and if they are suitable in regard to the morphological structure for use by domestic and wild animals (Tomić et al., 2009). The most productive was ass. *Festuco-Agrostietum* Horv. (1952) with 2.93 t ha^{-1}, and the highest content of crude proteins of 12.01% was established in ass. *Trifolio Agrostietum stoloniferae* LJ. Mark. 1973., in which also the leguminous species were the majority. For the purpose of revitalization of investigated grasslands it is necessary to apply agro-technical melioration measures – drainage, fertilization with mineral fertilizers and undersowing the seed of adequate species and cultivars for hay production and grazing.

Despite the significant plant diversity in Serbian grasslands, the general impression of low utility value of meadows and pastures in southeastern Serbia is further strengthened by a lack of leguminous species that are considered

to be the most favourable forage plants on grasslands. The territory of Serbia is a reservoir of the *Vicia* biodiversity (Simić and Vučković, 2014). On the other hand, it is noteworthy that meadow-pasture communities with dominating *Nardus stricta*, a species of poor quality from the aspect of livestock nutrition, occupy huge areas in that region (Kojić et al., 2001a).

Many researches show a very high participation of weed species in grassland areas. Weeds, which make a significant but undesirable component of natural meadows and pastures, increasingly cause reductions in productivity and quality of biomass. The natural meadows and pastures in Western Serbia were in an advanced stage of degradation, as suggested by high distribution of weeds, and even harmful and toxic species (an average of 39.85%), the proportion of quality grasses and legumes being 40.53% and 19.62%, respectively (Ilić et al., 2008). Weed distribution ranged from 8.48% to 68.06%, depending on soil properties, location, cultural practices, grassland utilization methods, etc. An analysis of floristic composition on non-fertilized meadows indicated a high share of weeds and minor grass species (71.13%). Conversely, considerably higher grass and legume percentages, 62.38% and 34.12% respectively, were recorded on fertilized meadows. Fertilization contributed to the improvement of botanical structure by increasing the grass percentage in the detriment of the legumes and other species, similar to results in Romanian agroecological conditions (Samuil and Vintu. 2012).

Kojić et al. (2001b, 2006) analysed 48 meadow-pasture plant communities which belong to the classes *Phragmitetea*, *Molinio-Arrhenatheretea*, *Festuco-Brometea*, *Festucetea vaginatae*, *Nardo-Callunetea* and *Juncetea trifidi*, and concluded that weeds grown on natural grasslands significantly participate in floristic composition of meadow and pasture phytocoenoses, ranging between 50.7 in the class *Festuco-Brometea*, and, even, 91.3 % in the class *Phragmitetea* in relation to the total number of present species. From point of view of natural grasslands utilization, all coenobionts could be divided into the two following groups: 1. Favorable (useful) species – plants of high fodder value readily taken by cattle in grazing. 2. Unfavorable (useless, harmful) species – plants of low fodder value (consumed by livestock but only reluctantly, e.g. *Nardus stricta*), prickly (with thorns, hooks and emergance growths) such as *Carduus sp*., *Cirsium sp*., *Ononis spinosa*, *Eryngium campestre*, etc., which may cause injury to the mouth, throat, stomach or intestines and poisonous ones (such as *Aristolochia clematitis*, *Atropa belladonna*, *Colchicum autumnale*, *Conium maculatum*, *Euphorbia sp*., *Hyosciamun niger*, *Veratrum album* and many others), which are almost avoided by cattle in grazing. They determined the total of 549 weed species from 231 genera belonging to 52 families; among 8 registered weed life forms, the predominant were hemicriptophytes (56.57 %); the contribution of poisonous plants, as the most harmful group, has been about 4 %. Because of great participation of weed species in entire flora of meadows and pastures of Serbia, it is necessary to treat these plants more intensively both from floristic-phytocoenological and practical point of view, in the sense of undertaking the certain means of weed control and suppression.

Average distribution in fresh biomass of different grass species, legumes and other species in natural grasslands in Western Serbia (Đurić et al., 2007) was 40.53%, 19.62% and 39.85%, respectively. The distribution of legumes ranged from 6.73% to 34.12%, depending on plant nutrition. Average share of crude proteins was 6.04%, of crude fibre 24.20%, crude fats 1.78%, crude ash 8.31%, and the share of nitrogen-free extracts was 59.67%. The crude protein share on fertilised grasslands was

considerably higher compared to that on the non-fertilised ones.

Soil degradation is also very important problem in pastures, especially during intensive exploitation. An investigation established the influence of long-term threading of neat cattle and sheep during intensive grazing on compaction of non-carbonate, smonitza-like meadow black soils in the Kolubara river valley (Gajić, 2005). Bulk density of the soils in the surface layers of the humus horizon of the meadow black soil under grazing land increased significantly ($p<0.05$) due to the grazing. There was increase of 0.29 Mg m^{-3} in the layer between 0 and 10 cm, and by 0.13 Mg m^{-3}, in the layer between 10 and 20 cm, in comparison with the forest black soil (control). The investigated physical characteristics of meadow black soil under pasture do not offer favorable conditions for normal development and health of crops.

Some recent researches on microbiological activity of soil under sown and natural grasslands in Eastern Serbia (Milošević et al., 2004) found that large numbers and variety of microorganisms and high enzymatic activity of soil microbial population are indicators of soils favorable for grassland production. Microbiological activity was higher under the sown grasslands, while natural grassland showed lower activity due to low pH and low contents of P and K.

Investigations on basic agrochemical properties and microelement content of serpentine soils in Serbia which are covered with natural grasslands showed slightly acid reaction of soils (pH in KCl-5-6), high humus content (10-17%) and high content of organic forms of nitrogen (N=0.5-0.9%) (Jakovljević et al., 2004). The content of available forms of N, P and K varies among different locations, amounting: NH_4 and NO_3 nitrogen in total 13-77 $mgkg^{-1}$, P_2O_5 0.3-51 $mgkg^{-1}$ and K_2O 8-40 $mgkg^{-1}$. The content of available Ca is within optimal range, while available magnesium is very high, resulting in very narrow and unfavorable Ca/Mg ratio for optimal plant nutrition (Ca/Mg=0.4-1.4:1).

The research of Belanović et al. (2012) aimed at better understanding of the relationship between soil properties and the availability of trace elements in pasture soils in Eastern Serbia (Stara Planina mountain). In the presence of the *Agrostietum vulgaris (capillaris)* community Z. Pavl., 1955, contents of trace elements (Pb, Cd, Cu and Zn) are lower or within the limits for multifunctional land use.

In the trials carried out on *Agrostietum vulgare* - type meadow in the hilly mountainous region near Valjevo (at an altitude 750 m), six fertilization treatments $N_0P_0K_0$, $N_{50}P_{50}K_50$, $N_{100}P_{50}K_{50}$, $N_{100}P_{100}K_{100}$, $N_{150}P_{100}K_{100}$ and $N_{200}P_{150}K_{150}$ kg ha^{-1} were included (Vučković et al., 2007). The increase in N, P, and K fertilization level resulted in corresponding increases in the quantity of grass dry matter. In particular the increases in N rate had a favorable effect on DM yield. The maximum two-year average dry matter yield of 8.17 t ha^{-1} was achieved with the highest NPK rate (200:150:150 kg ha^{-1}). The increase was 5.94 t ha^{-1} or 365% compared with the control. DM yield ratio between the highest NPK rate and control was similar in 2005 and 2006 (indices 357 and 377, respectively).

In the review paper (Lazarević et al., 2007) of dynamic changes in grassland productivity during vegetation period in different systems of grassland utilization, developed graph which showed daily productivity of natural and sown grasslands has been prerequisite of correct organization of livestock production. Daily production varied depending on the fertilization (18.5 kg ha^{-1} to 48.4 kg ha^{-1}) and utilization system (32.9 $kgha^{-1}$ to 45.8 kg ha^{-1}). The exploitation period in lowland region lasted 200-210 days, and in mountain region 100-120 days with average load of 32 sheep per ha, i.e. 2.59-3.2 livestock unit ha^{-1}. It was determined that grassland productivity was always higher

in conditions of pasture exploitation, compared to cutting of grass in mountain and lowland regions. It was determined that the best system of utilization was pasture-cutting method where through combination of grazing and cutting the best production results were realized as well as better control of weed species.

Conclusion

Perennial forage grasses represent very complex and heterogeneous group of plants in Serbia. They occupy the land, providing a habitat and a source of food for domestic livestock ruminants as their natural food, thus ensuring a supply of livestock products, what contributes to rural agricultural and economic development. Most of perennial grasses and their contemporary cultivars are highly productive and rich yield over 13 tha^{-1} of dry matter of excellent quality. The final aim of exploiting grasses in agriculture is transformation of the herbage into livestock production. From an economic point of view grazed grasslands and perennial grasses continue to be the cheapest forage in Serbia, but grasses stored as hay and silage provides feed for livestock during periods of winter housing.

References

Aćić S. 2019. Floristic analysis of the grassland vegetation of the *Molinio-Arrhenatheretea* and *Festuco-Brometea* classes in Serbia. Acta herbologica 28, (1): 77-86.

Belanović S., Čakmak D., Kadović R., Beloica J., Perović V., Alnaass N., Saljnikov E. 2012. Availability of some trace elements (Pb, Cd, Cu and Zn) in relation to the properties of pasture soils in Stara Planina mountain. Bulletin of the Faculty of Forestry (106): 41-56.

Đokić D., Terzić D., Milenković J., Dinić B., Anđelković B., Stanisavljević R., Barać S. 2013. Importance and condition of forage crops seed production in agriculture of the Republic of Serbia. Plant breeding and seed production, 19(2), 11-25.

Gajić B. 2005. Influence of threading of grazing cattle on pasture soil compaction. Journal of Agricultural Engineering 30, (1): 41-48.

Đurić M., V. Milić, S. Ćurčić, and B. Veljković. 2007. Yield and quality of natural grassland fodder in the Moravički District. Acta agriculturae Serbica 12, (23): 61-68.

Ilić O., Stević V., Đukić D., Đurović D. 2008. Weed distribution on natural grasslands of the Moravica district. Acta herbologica 17, (1): 69-74.

Jakovljević M.D., Stevanović D., Protić N.J. 2004. Fertility of soils formed over serpentine and utilized as natural meadows. Acta agriculturae Serbica 9, (spec. br.): 171-177.

Kojić M., Vrbničanin S., Dajić Z., Mrfat-Vukelić S. 2001a. Weed flora of natural grasslands in Serbia. Acta herbologica 10 (1): 1-22.

Kojić M., Ranđelović V., Dajić Z., Šoštarić I. 2001b. Review of the weed flora of meadows and pastures of Vlasina Plain. Acta herbologica 10 (2): 67-81.

Kojić M., Mrfat-Vukelić S., Dajić Z., Đorđević-Milošević S. 2004. Meadows and pastures of Serbia. Belgrade: Agricultural research institute Serbia, (in Serbian)

Kojić M., Mrfat-Vukelić S., Đorđević-Milošević S. 2005. Basic phytocenological and economical characteristics of natural meadows and pastures of Serbia. Biotechnology in Animal Husbandry, 21(5-6-2): 187-191.

Kojić M., Vrbničanin S., Dajić Z., Mrfat-Vukelić S. 2006. Review of the weed species presented on natural grasslands of Serbia. Acta herbologica 15 (1): 15-20.

Lakušić D. 2005. Relation between species and ecosystem diversity. in: Andjelković M. [ed.] Biodiversity at the onset of the new millennium, Belgrade: SANU, 75-102

Lazarević D., Stošić M., Lugić Z., Terzić 2005. The importance of sown grasslands and share of legume

species in the mixtures for the livestock production. Biotechnology in Animal Husbandry, 21, 5-6, 273-280.
Lazarević D., Stošić M., Dinić B., Terzić D. 2007. Utilization of grasslands in hilly-mountainous and low land regions of Serbia. Field and Vegetable Crops Research, 44 (1): 301-308.
Milošević N.A., Govedarica M.M., Đukić D., Stanisavljević R. 2004. Microbiological activity of soil under planted and natural grasslands. Acta agriculturae Serbica 9, (spec. br.): 195-201.
Pavlović M.A., Šabić D.S. 2003. Perspectives and problems of animal production in the Sjenica's region. Collection of Papers - Faculty of Geography at the University of Belgrade (51): 161-174.
Samuil C., Vintu V. 2012. Management of *Festuca valesiaca* L. grasslands from North Eastern of Romania. Acta agriculturae Serbica 17, (33): 13-20.
Simić A., Vučković S., Maletić R., Sokolović S., Đorđević N. 2009. Impact of Seeding rate and Interrow Spacing on Italian Ryegrass for Seed in the First Harvest Year. Turkish Journal of Agriculture and Forestry, 33(5), 425-433.
Simić A., Vučković S., Petrović S., Sokolović D. 2010. Defining optimum practices for Italian ryegrass seed production in Serbia. Grassland in a changing world. Proceedings of the 23rd General Meeting of the European Grassland Federation, Kiel, Germany, 29th August - 2nd September 2010, Grassland Science in Europe, 15, 286-288.
Simić A., Vučković S. 2014. Pasture and meadow legumes in Serbia. Legume Perspectives, 5, 14-15.
Stanisavljević R., Simić A., Sokolović D. 2010. Seed production of perennial forage grasses in Serbia. XII International Symposium on Forage Crops of Republic of Serbia, Biotechnology in Animal Husbandry 26 (spec. issue), 159-172.
Sokolović D., Tomić Z., Mrfat-Vukelić S., Radović J. 2003. Current state of *Lolium perenne* L. and *Dactylis glomerata* L. collections in Serbia. Czech Journal of Genetic and Plant Breding, 39, pp. 256-259
Sokolović D., Tomić Z., Babić S. 2010. Perennial forage grasses breeding in Serbia: Achievements limits and prospects. Biotechnology in Animal Husbandry, 26, spec. issue, 91-106.
Sokolović D., Babić S., Radović J., Lugić Z., Simić A., Zornić V., Petrović M. 2017. Genetic resources of perennial forage grasses in Serbia: Current state, broadening and evaluation. Plant Breeding and Seed Production, 23, (1): 69-82.
Statistical Office of the Republic of Serbia 2009. Statistical yearbook of Serbia Belgrade
Stevanović V., Vasić V., Regener S. 2000. Biološka raznovrsnost SR Jugoslavije - stanje, ugroženost, politika očuvanja. Beograd: Savezno Ministarstvo za razvoj, nauku i životnu sredinu (in Serbian).
Stošić M., Lazarević D., Terzić D., Simić A. 2004. Effect of phosphorus in grassland-based livestock feed production. Acta agriculturae Serbica 9, 263-272.
Stošić M., Lazarević D., Dinić B., Terzić D., Simić A. 2005. Natural grasslands as basis of livestock development in hilly-mountainous regions of Central Serbia. Biotechnology in Animal Husbandry 21, (5-6): 265-271.
Tomić Z., Lugić Z., Radović J., Sokolović D., Nešić Z., Krnjaja V. 2007. Perennial legumes and grasses stable source of quality livestock fodder feed. Biotechnology in Animal Husbandry, 23, 5-6, 559-572.
Tomić Z., Nešić Z., Vilotić D., Gačić D., Žujović M. 2009. Production and quality of meadow associations in forest hunting grounds in Serbia. Biotechnology in Animal Husbandry, 25(3-4), 251-260.
Vučković S., Simić A., Đorđević N. 2005. Relationship between forage yield and

quality of *Cinosuretum cristati* type meadows and different rates of nitrogen fertilizer. Biotechnology in Animal Husbandry, 21, 5-6, 293-296.

Vučković S., Simić A., Đorđević N., Živković D., Erić P., Ćupina B., Stojanović I., Petrović-Tošković S. 2007. Effect of fertilization on yield of agrostietum vulgaris-type meadows in western Serbia. Field and Vegetable Crops Research, 44, (1): 355-360.