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Biological features of formation of perennial binary grass crops

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Abstract. The paper deals with the impact of binary mixtures of perennial grasses on the productivity and quality of forage crops that differ in their species composition. The studies have shown that mixed crops exceeded single-species crops in all indicators of forage crops productivity. In total over five years binary crops of *Poterium polygamum* exceeded single-species ones in all productivity indicators. The plants safety by the end of vegetation was also slightly lower than in single-species crops, which can be explained by greater competition for light, moisture and nutrients. So the safety of *Medicago sativa L.* was 81.8%, *Onobrýchis* – 83.6%, *Galéga orientális L* – 89.7%, *Poterium polygamum* – 74.6%, which is lower than that of legumes in single-species crops. In all years of herbage use, the binary crops exceeded single-species ones. On average, for 5 years of research, the yield of *Poterium polygamum* was 25.5 t ha^{-1}, *Medicago sativa L.* – 22.5 t ha^{-1}, *Onobrýchis* – 23.7 t ha^{-1}. Among legumes, the maximum yield had *Galéga orientális L* agrocenosis – 26.1 t ha^{-1}. Mixed crops of burnet with leguminous grasses were characterized for yielding the vegetative mass on average 28.5–30.9 t ha^{-1}. Maximum values of binary *Poterium polygamum* crops characterized crops with the leguminous plant component of goat's rue in all years of research. Mixed crops also showed maximum values of dry matter per unit area and amounted respectively 33.52–36.74 t ha^{-1}. The same pattern continued in the yield of fodder units, digestible protein and metabolic energy, their maximum was obtained at the variant *Poterium polygamum*+ *Galéga orientális L.*

Key words: sowing, mixed, grasses, productivity, yield.

INTRODUCTION

An important reserve for increasing the efficiency of feed production in the North Caucasus is perennial grasses, which are the main component of forage crop rotations and an important link of the green conveyor. Perennial grasses are used as hay, silage and green feed (Lewandowski et al., 2003; Navickas et al., 2003; Bekuzarova et al., 2018; Obraztsov et al., 2018). Feeds that contain such crops are rich in essential for growth and development proteins, carbohydrates, vitamins and minerals. As a green feed and raw materials for silage is also used aftergrowth of perennial grasses. Most of these crops are excellent honey plants (Jolayemi et al., 1995; Lafolie et al., 1999; Mengistu et al., 2000; Wilman, 2004).

Perennial grasses are highly competitive, so they are often used for weeds control. They also significantly increase soil fertility, and representatives of the legume family due to symbiosis with nodule bacteria absorb air nitrogen, enriching the soil (Sapoukhina et al., 2010; Epie et al., 2015; Kuznetsov et al., 2018).

The perennial grasses layer through the ability to the soil structuring and drainage prevents water and wind erosion (Williams et al., 2001; Jordan et al., 2003; Bransby et al., 2010; Cui et al., 2014; Stahn et al., 2017).

Mixed crops development in the agricultural production is the most important among the effective ways to manage quantitative and qualitative indicators of plant products, and their further functioning in agroecosystems (Lemanczyk et al., 2002; Obraztsov et al., 2011).

Ignoring the principles of biological diversity in agrophytocenoses, manifested in the transition to monoculture, is a classic example of reducing the heterogeneity in agroecosystems. Therefore, agricultural production should be developed through the refuse of monoculture and transition to multicultural farming. In this regard, mixed crops are an important reserve for the alternative way of intensifying the crop production field (Catt et al., 1998).

Creation of simple and complex agrophytocenoses that ultimately characterize their productivity, in general, depends on a number of factors: correct selection of different species, number and ratio of components, habitat conditions.

To achieve these goals, it is necessary to expand the crops of herbs such as alfalfa, sainfoin, goat and blackthorn, which are most in demand in our agro-climatic zone. The study of the biological characteristics of these crops will further develop the basic elements of the technology of their cultivation in relation to the conditions of the foothills of the RSO-Alania.

Therefore, studying productivity and quality of forage crops in agrophytocenoses differing in their species composition is relevant (Carpenter-Boggs et al., 2003; Das et al., 2016).

The research aim was to study methods of creating highly productive binary mixtures of burnet and leguminous grasses, which provide high-quality feed of North Ossetia–Alania.

Scientific novelty. Productivity of binary burnet and leguminous grasses crops, fodder value, their role in enriching soil with organic matter was firstly determined in the environmental conditions of the foothill zone of North Ossetia–Alania.

MATERIALS AND METHODS

Field studies were conducted in the experimental field of the North Caucasus research institute of mountain and foothill agriculture. The soil of the experimental plot is leached middle thick middle loamy chernozem with 5.8% humus, easily hydrolyzed nitrogen – 80 mg kg^{-1}, available phosphorus – 118 mg kg^{-1}, exchangeable potassium – 120 mg kg^{-1}, pH_{salt} – 5.8–6.

During the years of research (2011–2015) meteorological conditions were different. In 2011–2013, an average of 502 mm of precipitation fell during the growing season, which is lower than the long-term norm by 47 millimeters. In the smaller side deviations from the norm were observed during the growing season for all months except September and August. The most favorable weather conditions were in 2014–2015.

During the growing season, 518 mm of precipitation fell, which is 31 mm below the long-term norm, but their distribution by months was the most optimal. The air temperature during the growing season in 2014 was 14.4 °C, which is 0.2 °C above the long-term norm.

Consequently, the meteorological conditions over the years of research were generally favorable for the cultivation of herbs.

The research objects were binary mixtures of *Poterium polygamum* and grasses: the Slava *Poterium polygamum* variety, the Osetinskaja *Medicago sativa L.*, the Severo-Cavcazskij dvuukosnij *Onobrýchis* variety, the Bimbolat *Galéga orientális L.* variety.

The seeding rate in mono crops was 4 million seeds/ha. In mixed crops the ratio of components was 1:1.

The soil preparation to sowing was conventional for seed swards of perennial grasses in the North Caucasus. After harvesting grasses preceding cropprimary tillage was fulfilled to the depth of 10–12 cm, then in two weeks the soil was plowed using jointer shares to the depth of 25–30 cm. In spring, as far as the soil was ready, we performed early tandem disk harrowing, secondary tillage, soil packing before sowing, coverless wide-row (45 cm) sowing to the depth of 1.0 cm at the seeding rate of 12.0 kg ha^{-1}, and soil packing after sowing. Registration plot area was 10 sq. m., randomized experiments were carried out in fourfold replication. The agricultural equipment complied with the standard for grasses cultivation in this zone.

Organization of field experiments, observations, biometric measurements, laboratory analyses was performed in accordance with the generally accepted guidelines.

The sowing density was determined on three standard of one linear meter, located diagonally plots. Seeds and field germination rate was determined considering the sown and germinated seeds. The dry matter accumulation was determined by the phases of plant growth and development.

Protein (total Kjeldahl nitrogen – 6.25) GOST 51417-99, fat – by method of fat-free residue extracted in Soxhlet apparatus, cellulose – by Henneberg-Stohmann method, ash – by ashing in a muffle furnace were determined in plant samples. Number of root and crop residues calculation was done by N.Z. Stankov method of the soil frame excavation. Yield of digestible protein feed units – by the calculation method based on the data of plants chemical analysis due to Tomme M.F. digestibility coefficient. Metabolic energy concentration in dry matter of forage crops was calculated basing on the percentage of crude fiber (CF) and crude protein (CP) in dry matter of feed according to the formula: ME MJ ha^{-1} DM = 13.4 - 0.14 CF %. + 0.03 CP %. Yield calculation was done by the method of test sites from six points of the plot, followed by its evaluation in 100% purity and normal amount of moisture.

RESULTS AND DISCUSSION

One of the main productivity indicators of perennial grasses is plants stand density. Its importance especially increases in mixed crops, in which plants compete for light and moisture.

In our studies, field germination ranged from 64.8–69.1% in single-species legume crops (Table 1).

The lowest indicators were in burnet crops – 62.6%. In mixed burnet-based crops, the germination indicators of alfalfa, sainfoin and goat's rue were lower than in single-species crops and ranged from 62.2; 64.3; 63.7%.

The plants safety by the end of vegetation was also slightly lower than in single-species crops, which can be explained by greater competition for light, moisture and nutrients. So the safety of *Medicago sativa L.* was 81.8%, *Onobrýchis* – 83.6%, *Galéga orientális L.*– 89.7%, *Poterium polygamum* – 74.6%, which is lower than that of legumes in single-species crops. The same trend continued in the mixed crops: leguminous grasses exceeded burnet in plants safety per unit area.

Analyzing Table 2, it might be concluded that in single-species crops, compared to binary ones, the percentage of overwintered plants was slightly lower and ranged from 79.1–83.4% in the leguminous plant component of the first year of use, and in the *Poterium polygamum* – 80.2%. In this indicator mixed crops of the first year of use that contained *Poterium polygamum* and leguminous grasses ranged between 84.5–86.3%. With the increase in herbage age and years of agrocenosis use, the percentage of overwintered plants has slightly decreased both in *Poterium polygamum* single and binary crops.

Table 1. Field germination and safety of single-species and mixed crops of perennial grasses (2011–2015)

Variant	Field germination, %	Plants safety, %
Poterium polygamum	62.6	74.6
Medicago sativa L.	64.8	84.8
Onobrýchis	66.3	83.6
Galéga orientális L.	69.1	89.7
Poterium polygamum+	62.2	60.3
Medicago sativa L.	47.6	70.2
Poterium polygamum+	64.3	59.5
Onobrýchis	57.4	63.9
Poterium polygamum+	63.7	56.7
Galéga orientális L.	59.2	74.2

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Table 2. Overwintering of single-species and binary crops, %

Variant	1 year of overwintering 2011	2 year of overwintering 2012	3 year of overwintering 2013	4 year of overwintering 2014	5 year of overwintering 2015
Poterium polygamum	80.2	87.4	94.1	96.3	95.2
Medicago sativa L.	79.1	86.9	95.7	97.1	96.0
Onobrýchis	81.2	88.0	96.2	97.6	96.3
Galéga orientális L.	83.4	90.2	96.8	97.4	97.0
Poterium polygamum+ Medicago sativa L.	86.3	92.7	97.7	98.3	97.4
Poterium polygamum+ Onobrýchis	84.5	91.4	95.9	97.8	95.9
Poterium polygamum+ Galéga orientális L.	85.6	92.0	96.7	98.0	96.5

The yield of green mass increased with the increase in age of both single-species and mixed crops. In all the years of herbage use, binary exceeded single species, on average over 5 years of research *Poterium polygamum* yield was 25.5 t ha^{-1}, *Medicago sativa L.* – 22.5 t ha^{-1}, *Onobrýchis* – 23.7 t ha^{-1}. Among legumes, the maximum yield had *Galéga orientális L.* agrocenosis – 26.1 t ha^{-1}. Mixed crops of *Poterium polygamum* with leguminous grasses were characterized for yielding the vegetative mass on average 28.5–30.9 t ha^{-1}. Maximum values of binary *Poterium polygamum* crops characterized crops with *Galéga orientális L.*in all years of research (Table 3).

Table 3. Green mass yield of single-species and binary perennial grasses agrocenoses, t ha^{-1}

Variant	1 year of overwintering 2011	2 year of overwintering 2012	3 year of overwintering 2013	4 year of overwintering 2014	5 year of overwintering 2015	Average
Poterium polygamum	16.7	24.5	28.3	29.2	28.9	25.5
Medicago sativa L.	14.3	21.3	24.7	26.4	25.7	22.5
Onobrýchis	15.8	23.0	26.2	27.0	26.4	23.7
Galéga orientális L.	17.0	26.2	29.6	29.2	28.3	26.1
Poterium polygamum+ Medicago sativa L.	21.4	28.7	32.4	34.7	33.4	30.1
Poterium polygamum+ Onobrýchis	20.9	26.9	31.5	32.8	30.6	28.5
Poterium polygamum+ Galéga orientális L.	21.8	29.8	33.7	35.0	34.1	30.9
LSD_{05}	0.26	0.37	0.42	0.44	0.42	-

Analyzing Table 4, it might be concluded that maximum values for the dry matter yield in single-species crops has *Galéga orientális L.*agrocenosis – 26.73 t ha^{-1}, the for remaining legumes in total over 5 years, dry matter yield was: *Medicago sativa L.* – 23.61 t ha^{-1}, *Onobrýchis* – 24.32 t ha^{-1}. Mixed crops showed the highest values of dry matter per unit area and amounted to 33.52–36.74 t ha^{-1} respectively. The same pattern continued in the yield of fodder units, digestible protein and metabolic energy, their maximum was obtained at the variant *Poterium polygamum+ Galéga orientális L.*

Table 4. Productivity of perennial grasses in total over 5 years (2011–2015)

Variant	Dry matter, t ha^{-1}	Feed units, t ha^{-1}	Digestible protein, t ha^{-1}	ME, GJ
Poterium polygamum	25.79 ± 0.38	13.24 ± 0.63	3.07 ± 0.54	209.14 ± 0.85
Medicago sativa L.	23.61 ± 0.21	10.92 ± 0.56	2.93 ± 0.61	199.36 ± 0.56
Onobrýchis	24.32 ± 0.33	12.10 ± 0.61	2.55 ± 0.38	204.11 ± 0.63
Galéga orientális L.	26.73 ± 0.45	13.87 ± 0.68	2.74 ± 0.47	223.40 ± 0.66
Poterium polygamum+ Medicago sativa L.	34.38 ± 0.41	18.42 ± 0.49	3.81 ± 0.55	311.42 ± 0.61
Poterium polygamum+ Onobrýchis	33.52 ± 0.51	17.94 ± 0.54	3.47 ± 0.59	294.37 ± 0.72
Poterium polygamum+ Galéga orientális L.	36.74 ± 0.37	19.28 ± 0.23	3.92 ± 0.44	314.28 ± 0.61

CONCLUSION

On the basis of the above, it can be stated the fact that perennial leguminous grasses in mixed crops with Poterium polygamum are the most highly productive in relation to their single-species crops.

The most productive option in terms of dry matter content was *Poterium polygamum+ Galéga orientális L.* (36.74 t ha^{-1}). This option is superior to others and the content of digestible protein and feed units.

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