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THE ROLE OF PERENNIAL GRASSES IN THE PROTECTION OF SOIL RESOURCES OF EROSIVE ECOSYSTEMS WITH ACTIVE DEVELOPMENT OF LINEAR EROSION

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Abstract. We evaluated the stability of perennial legume and cereal grass species in artificial plant communities on permanent anti-erosion watercourses in the agroecosystems of the Belgorod region with active development of linear soil erosion. In the conditions of steppe and forest-steppe zones of the Belgorod region on permanently grassed watercourses in 2017-2019. varieties of perennial leguminous and cereal grasses: 'Krasnoyaruzhskaya 1' and 'Krasnoyaruzhskaya 2' (*Medicago varia*), 'Kazatsky' (*Trifolium pratense*), 'Olshanka' and 'Ivica' (*Festuca arundinacea*), 'Streletsky' and 'Stepnyak' (*Lolium perenne*)) obtained using local genetic material were studied. All varieties showed their resistance in agro-ecosystems with active development of linear erosion in the forest-steppe and steppe zones. Projective cover on watercourses in the steppe zone in all variants of experience was on average 83,4 %, in the forest-steppe zone - 86,3 %. In the third year of the tests on permanently irrigated watercourses in the steppe zone, the share of cereal and legume grass species was quite high and varied from 88 % in the variant M. *varia* + *Onobrychis arenaria* to 92 % in the variants M. *varia* + *Bromopsis inermis* and O. arenaria. In the forest-steppe zone, the share of cereal and legume grass species varied from 86 % in the variant L. perenne to 94 % in the variant L. perenne + B. inermis.
Keywords: legume and cereal grass varieties, forage crops, perennial grasses, grass mixtures, grassing of watercourses

1. Introduction

Legume and cereal grass mixtures are widely used to protect and restore soil resources in erosive ecosystems with active development of linear erosion. Grassing is the most effective and low-cost means

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of preventing soil erosion and increasing fertility and productivity of washed away soils. It is proved that multicomponent mixtures (multispecies sowing) are the most promising due to maximum approximation to natural phytocenoses. In multicomponent mixtures, scientists imitate plant communities, which allows to use the soil potential to the full extent due to differentiation of ecological niches [1-5].

The following grass and legume grass species are recommended for artificial grassing of hollows: pasture ryegrass (*Lolium perenne*), meadow fescue (*Festuca pratense),* reed fescue (*Festuca arundinacea*), sandy sainfoin (*Onobrychis arenaria*), alfalfa (*Medicago varia)* and meadow clover (*Trifolium pratense*) and others [6-9].

The area under perennial grasses in Russia does not exceed 10.5 million hectares, which is about 60% of the area sown with fodder crops, the share of legume component does not exceed 30%, and old-age grass crops account for more than 50%. At the same time, only in the forest-steppe and steppe zones of the Belgorod region, the most part of the agricultural lands is situated on slopes: 48.1% on slopes with steepness of 1-3°, 16% - with steepness of 3-5°, and 4.4% - more than 5°. Out of 317 thousand ha of arable lands more than 85 thousand ha are exposed to water erosion. Thus, two thirds of the region's territory require erosion control [1,10,11].

Measures for grassing of eroded lands in conditions of linear erosion contribute to preservation and protection of soil from water flows, formation of phytomass reserves (underground turf) and reserves of useful microflora as well as increase of biodiversity in conditions of high plowing and creation of herbaceous and vegetative resources for fauna.

In the Belgorod region, scientists are working on compositions of multi-component grass mixtures, creating varieties that are resistant to eroded soils and suitable for grassing and creating artificial agro-ecosystems. The initial material for the creation of legume and cereal grass varieties is the forms selected in the ravine and ravine complexes of the region, on chalk outcrops, which have a set of resistance features [12-15].

The aim of the work was to assess the stability of perennial legume and cereal grass species in artificial plant communities on permanent anti-erosion watercourses in the agroecosystems of the Belgorod region with active development of linear soil erosion.

2. Methods and materials

The region is located in the middle part of the European territory of the country on the slopes of the Srednerusskaya Upland and the Oka-Donskaya Depression. According to soil and geographic zoning, the region includes two natural zones - forest-steppe and steppe. These zones cross the territory in the latitudinal direction [1,10].

The climatic conditions of the region are favorable for the development of agriculture, in terms of cultivation of crops. Summers in the region are quite warm and long, followed by cold winters with relative frosts and sufficient snow cover. The average duration of sunshine per year is 1710-1800 hours.

In terms of precipitation, the region belongs to the zone of moderate moisture. The average annual amount of precipitation varies from 500-610 mm. Two-thirds of precipitation (of the annual amount) falls as rain and one-third as snow.

The eroded soils occupy almost 48% of the total arable area of the region. Among them are: weakly washed away; medium washed away; strongly washed away; eroded.

Grass mixtures, the composition of which is given in Table 1, were studied under field conditions on trial plots in the conditions of steppe and forest-steppe zones on the plots with the development of linear erosion on permanently grassed watercourses.

To compose grass mixtures we used the authors' legume and cereal grass varieties bred for the conditions of the region on the basis of local genetic material: varieties 'Krasnoyaruzhskaya 1' and

'Krasnoyaruzhskaya 2' (Medicago varia), variety 'Kazatsky' (Trifolium pratense), varieties 'Olshanka' and 'Ivitsa' (Festuca arundinacea), varieties 'Streletsky' and 'Stepniak' (Lolium perenne).

Table 1. Variants of grass mixtures for creating artificial vegetation communities when grassing watercourses

Steppe zone	Forest-steppe zone
Medicago varia + Bromopsis inermis	Medicago varia + Bromopsis inermis
Onobrychis arenaria	Lolium perenne
Medicago varia + Onobrychis arenaria	Medicago varia + Onobrychis arenaria
Onobrychis arenaria + Bromopsis inermis	Lolium perenne + Bromopsis inermis
Trifolium pratense + Festuca arundinacea	

In each variant, sample plots with an area of 1 m2 were allocated for the counts. Observations and counts were conducted according to standard methods adopted in geobotanical and biogeocenological studies, in field and laboratory experiments with perennial grasses [16,17].

3. Results and discussion

The great role in attenuation of erosion processes on sloping lands is played by density of grass stand, which depends on intensity of tillering and uniform distribution of shoots on the soil surface.

It was established that the projective cover in all studied zones at various and identical vegetative components used at grassing of permanent watercourses was practically at the same level.

In the forest-steppe zone and steppe zone, the average value of projective cover in herbaceous plant communities on the grassed watercourses was 86.3 % and 83.4 %, respectively. The coefficient of variation (Cv, %) for each zone averaged about 13 %.

The share of each species in the total herbage was determined, as well as the dynamics of changes in the share of each species over three years, from 2017 to 2019.

The species composition of the herbage in different variants of the experiments was studied on grassed watercourses. The share of valuable components (legumes and grasses), as well as the presence of vegetation (weeds) of low value in terms of fodder value was assessed separately.

The results of the study of artificial grasses on permanently grassed watercourses in the steppe zone are shown in Table 2.

Table 2. Proportion of participation of perennial legumes and grasses in artificial grass stands on permanently grassed watercourses in the steppe zone

Experience Option	Types	Доля участия видов в травостое, %		
		2017 year (year of sowing)	2018 year	2019 year
M. varia + Br. inermis	M. varia	47	64	39
	B. inermis	18	20	53
	Other herbs	35	16	8
	Total	100	100	100
O. arenaria	O. arenaria	65	88	92
	Other herbs	35	12	8
	Total	100	100	100
M. varia + O. arenaria	O. arenaria	43	47	56
	M. varia	19	38	32

	Other herbs	38	15	12
	Total	100	100	100
O. arenaria + B. inermis	O. arenaria	49	60	51
	B. inermis	17	26	38
	Other herbs	34	14	11
	Total	100	100	100
T. pratense + F. arundinacea	T. pratense	56	64	18
	F. arundinacea	19	24	72
	Other herbs	26	12	10
	Total	100	100	100

On watercourses grassed with cereal-legume grass mixture M. *varia* + B. *inermis* in 2017, alfalfa and weed species dominated in sowing. The cereal component in the first year was relatively poorly developed.

In the second year, the share of the main crop, M. *varia*, increased by 17%. The share of the co-crop B. *inermis* increased insignificantly, by 2%. However, in the third year of life, the share of B. *inermis* increased sharply by 33 %. Accordingly, the share of M. *varia* decreased by 25%. The share of other grass species decreased by 27 % by the third year.

On watercourses grassed with pure O. *arenaria*, in 2017, the main species dominated in seeding, and its share exceeded the share of other grass species by 30 %.

In the second year, the proportion of O. *arenaria* participation increased by 23 %, and in the third year by 4 %, reaching in 2019. 92 %. The proportion of participation of motley grasses in the three years of the study decreased, respectively, by 27 % - to 8 % in the third year.

In the first year of life, it was found that the proportion of O. arenaria in the grass stand was 24 % higher than the proportion of the second legume species, M. *varia*, on watercourses grassed with a mixture of legume species O. *arenaria* + M. *varia*. In the next two years there was a slight increase in the proportion of O. *arenaria,* by 4% and 9%, respectively.

In the second year of life, the share of M. *varia* doubled by 19 %, and in the third year of life, a slight decrease to 32 % was recorded. The total share of legume grass species reached 88 % by the third year. The share of other grass species gradually decreased during the three years from 38 % to 12 %.

The study of the variant with grass-legume grass mixture O. *arenaria* + B. *inermis*, showed that the share of O. *arenaria* species in the grass stand in 2017 was higher than the share of B. *inermis* species by 28 %. The share of other grass species was also high - up to 34 %.

In the second year of life, the share of O. *arenaria* increased by 11%. The share of B. *inermis* increased by 9%.

In the third year of life, the share of B. *inermis* increased by 12%, and the share of O. *arenaria* decreased by 9%. The share of motley grass species in the herbage decreased by 23 % by the third year.

Watercourses grassed with cereal-legume grass mixture T. *pratense* + F. *arundinacea* in 2017 were more than half composed of clover - the share of T. *pratense* in the herbage exceeded the share of F. pretense by 37 %, and the share of motley grass species by 30 %.

In the second year of life, the share of T. *pratense* increased by 8 % and that of grasses by 5 %. Accordingly, the share of herbs in the grass mixture almost halved.

In the third year of life, a sharp decrease in the share of the legume component of T. *pratense* to 18 % and a significant increase in the share of the cereal component to 72 % was noted. The participation of herbs remained approximately at the level of the second year of life of the herbage. The results of the studies carried out in the forest-steppe zone are presented in Table 3.

Table 3. Percentage participation of perennial legumes and grasses in artificial grasses on permanently grassed watercourses in the forest-steppe zone, 2016-2018

Experience option	Types	Share of species in the herbage, %		
		2017 year (year of sowing)	2018 year	2019 year
M. varia + B. inermis	M. varia	51	58	48
	B. inermis	19	26	40
	Other herbs	30	16	12
	Total	100	100	100
L. perenne	L. perenne	68	92	86
	Other herbs	32	8	14
	Total	100	100	100
M. varia +O. arenaria	O. arenaria	30	50	28
	M. varia	44	42	64
	Other herbs	26	8	8
	Total	100	100	100
L. perenne + B. inermis	L. perenne	55	69	41
	B. inermis	14	22	53
	Other herbs	31	9	6
	Total	100	100	100

It was found that on watercourses grassed with cereal-legume grass mixture M. *varia* + B. *inermis* in 2017, alfalfa and species of other grasses dominated in the crop. The cereal component in the first year of life developed relatively weakly and did not exceed 19 %.

In the second year, the share of M. *varia* species increased by 7%. The share of B. *inermis* species also increased by 7%. However, in the third year of life, the proportion of B. *inermis* increased sharply by 14 %. At the same time, the share of M. *varia* decreased by 10%. The percentage of participation of herb species decreased by 18 % by the third year compared to the first year of life.

Watercourses grassed with pure single-species L. *perenne* in the first year had the share of its participation by 36 % higher than the share of other plant species. In the second year, the proportion of L. *perenne* species increased by 24% and decreased by 6% in the third year, reaching 86 %. The proportion of participation of motley grass species in the three years of studies decreased, respectively, from 32 % to 14 % in the third year of life.

On watercourses grassed with a mixture of legumes O. arenaria + M. varia, in the first year of life, it was found that the share of O. arenaria in the composition of the herbage was 14% lower than the share of the second legume component, M. varia. In the second year, the share of O. arenaria increased by 20%, the share of M. varia decreased by 2%.

In the third year, the share of M. *varia* increased by 22%. The total share of legume grass species in the herbage reached 92 % by the third year. The share of other species gradually decreased during the three years from 26 % to 8 %.

On watercourses grassed with cereal species L. *perenne* + B. *inermis* in the first year, the share of L. *perenne* was 55 %, B. *inermis* - 14 %. In the second year of life, there was a slight increase in the participation of both components in the composition of the herbage as a whole by 7% for each component. However, in the third year of life, there was already a significant increase, almost doubling the share of B. *inermis* - up to 53 % and reducing the share of L. *perenne* by 18 %. As for other species, in 2017, their share was 31 %, gradually decreasing to 9 % and 6 %, respectively.

4. Conclusion

1.Author's varieties of perennial legumes and cereals ('Krasnoyaruzhskaya 1' and 'Krasnoyaruzhskaya 1' (M. varia), 'Kazatsky' (T. pratense), 'Olshanka' and 'Ivica' (F. arundinacea), 'Streletsky' and 'Stepnyak'

(L. perenne)), obtained on the basis of local genetic material, selected in gully and ravine complexes of the Belgorod region, have shown their resistance to grassing of watercourses in agroecosystems with active development of linear erosion in the forest-steppe and steppe zones.
2. Projective coverage of watercourses under grassing in the steppe zone in all variants of experiments was on the average 83,4 %, in the forest-steppe zone - 86,3 %.
3. In the third year of tests on permanently grassed watercourses in the steppe zone, the share of cereal and legume grass species was quite high and varied from 88 % in the variant M. varia + O. arenaria to 92 % in the variants M. varia + Br. inermis and O. arenaria. In the forest-steppe zone, the share of cereals and leguminous grasses varied from 86% in the variant L. perenne to 94% in the variant L. perenne + B. inermis. field crop rotation with fertile chernozem soils and in adverse conditions of meadow ecotopes.

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