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Introduced assessment of agrestic legumes in the middle Urals

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Abstract. Currently, in fodder production industry, there is an acute problem of finding legumes that are well adapted to the natural and climatic conditions of the Middle Urals, possessing great longevity, as well as high fodder values. In the Middle Urals, as well as in the Russian Federation, as a whole, legumes valuable for forage from wild vicia and peavine species are still not used in culture. Both of these genuses are of great practical interest for their introduction into culture. They significantly differ from legumes traditionally used in fodder production in a number of parameters: long longevity (7–10 years in natural phytocenoses), resistance to a complex of natural and climatic conditions (rather high winter hardiness), early regrowth in spring. The **purpose of the experiment** is to reveal the characteristics of the growth and development of perennial wild legumes under conditions of introduction. The **tasks of the study** included the determination of the height and average daily growth dynamics, the timing of the passage of phenological phases, and the productivity of aboveground biomass.
Research methods. The study on the introduction of agrestic legumes was carried out in the 'Uralets' educational and experimental farm (2005–2012), located in the Beloyarsky district of the Sverdlovsk region on the educational and experimental field of the crop production and breeding department. The experimental design includes 3 options: 1 opt. - *Vicia sylvatica* L. (forest vicia - control); 2 opt. - *Lathyrus pisiformis* L. (pea-shaped peavine); 3 opt. - *Lathyrus pratensis* L. (meadow peavine). The use of grass stand is single-cut, mowing carried out in the phase of mass flowering of the plants studied. To identify the floristic composition dynamics, a complete geobotanical description of vegetation was carried out. The following botanical composition was distinguished: introduced (cenose-forming) species: *Vicia sylvatica* L., *Lathyrus pisiformis* L., *Lathyrus pratensis* L.; non-seeded species - this group includes all wild-growing species (grasses and forbs) that have invaded the vegetation cover.
Results. During the study it was established that the earliest regrowth is characteristic of pea-shaped peavine, it significantly outpaced other types of legumes in its development. The different phyto-cenotic stability of the cenose-forming species in the grass stand was discovered, the highest observed in the meadow peavine.
The productivity of aboveground biomass in meadow peavine (by year of study) was significantly higher than in other studied species; on average for 2006–2012 it amounted to 15.3 t ha^{-1}, which is 1.9 t ha^{-1} higher than forest vicia and 4.6 t ha^{-1} more than pea-shaped peavine. Scientific novelty. For the first time, in the conditions of the Middle Urals, the growth and development features of wild perennial species from the family *Fabaceae*: *Vicia sylvatica* L., *Lathyrus pisiformis* L., *Lathyrus pratensis* L., were studied.

Key words: introduction, characteristics of growth and development, forest vicia, pea-shaped peavine, meadow peavine.

Target setting

A balanced fodder base remains the main factor in the development of animal husbandry and the efficiency of agricultural enterprises. Under the conditions of the non-chernozem zone of the Russian Federation, the greatest economic effect in the production of feed is obtained from perennial legumes cultivation, as their energy efficiency coefficient is 2.5–3 times higher than that of cereals and grain forage crops (Belyak, 2008). In addition, perennial legumes are an essential element in the creation of highly productive agrocenosis (hayfields and pastures) (Lazarev et al., 2018; Korsakova et al., 2019). They are excellent precursors for almost all field crops; enrich the soil with organic matter and biological nitrogen; they provide a fairly high productivity yield per area unit and contain native protein (Kalashnikov, 2003; Korsakova et al., 2019).

In the grassland feed industry, the range of legumes used is extremely limited. Mainly in the structure of sowing acreage, clovers (meadow clover, hybrid and their varieties) are common, which differ in a small life expectancy (Kutuzova et al., 2018; Lazarev et al., 2018). Natural and climatic conditions of the Middle Urals are very peculiar. The main factors influencing the climate of the Middle Urals are the large length of the territory from North to South, the meridional direction of the chain of mountains and ridges, the complex rugged terrain adjacent to the mountains, as well as the West-East transport of air masses prevailing over the Urals (Gafurov, 2008). Therefore, in the Middle Urals, in connection with difficult meteorological conditions, as well as in conditions of limited resource provision for the agro-industrial complex, the role of legumes in the feed industry is especially increasing. Most of the newly released varieties have high potential productivity, but under production conditions, due to poor adaptation to natural and climatic conditions, it is less than half realized (Nagibin & Tormozin, 2011; Nagibin et al., 2018). Therefore, the problem of finding legumes with great longevity and high foraging advantages is acute, well adapted to local natural and climatic conditions in the Middle Urals, as well as in the Russian Federation, in whole.

Legumes from wild species of vicia and peavine high-valued in terms of forage are still not used in culture. Both of these species are of great practical interest for introducing them into culture (Abramchuk, 2009; Abramchuk, 2013; Abramchuk, 2014a; Korsakova et al., 2019). Unlike legumes used in forage production, they have a great longevity (7–10 years in natural phytocenoses), resistance to a complex of natural and climatic conditions (rather high winter hardiness), early regrowth in the spring.

In the flora of the Middle Urals, the following perennial agrestic species are common: vicia - sepium, forest, tuberiferous, leptophyllous; peavine - pea-shaped, meadow, Gmelina, etc. The Department of Plant Production and Breeding of the Ural State Agrarian University conducts a multiple-year research on the introduction of agrestic legumes (Belyak, 2008; Abramchuk, 2009; Abramchuk, 2013; Abramchuk, 2014a; Abramchuk, 2014b).

RESEARCH METHODOLOGY AND METHODS

The study on the topic ‘Introductory assessment of agrestic legumes in the Middle Urals’ was carried out in the educational and experimental farm ‘Uralets’, located in the Beloyarsky district, Sverdlovsk region. In 2005 (September) we've conducted an experiment establishment, three wild legumes served as the objects of the study: *Vicia*

sylvatica L. (forest vicia); *Lathyrus pisiformis* L. (pea-shaped peavine); *Lathyrus pratensis* L. (meadow peavine), widely distributed on the natural anthropogenic landscapes of the Middle Urals. Seeds from local populations collected in similar climatic conditions were used for sowing, in close proximity to the site of the study. Bare fallow was used as a precursor. Before sowing the soil was cultivated and rolled. Depth of seed sowing - 2–3 cm. The area of the plots was 10 m^2 (2 m × 5 m), the repetition is three times.

The object of the study is to identify the features of the growth and development of perennial wild legumes in crop conditions. **Research tasks:** determination of the dynamics of height and average daily growth (regularly, once a week, measurements of plant height were carried out); timing of the phenological phases was established visually. To reveal the dynamics of the botanical composition in the studied phytocenoses, a complete geobotanical description of vegetation was carried out, the following botanical composition was distinguished: introduced *(cenose-forming)* species: *Vicia sylvatica* L.; *Lathyrus pisiformis* L., *Lathyrus pratensis* L.; non-seeded species - this group includes all wild-growing species: cereals and forbs that have penetrated into the vegetation cover. The experiment included three variants distinguished by the cenolate-forming species: 1 opt. - *Vicia sylvatica* L. (forest vicia) - taken for control; 2 opt. - *Lathyrus pisiformis* L. (pea-shaped peavine); 3 opt. - *Lathyrus pratensis* L. (meadow peavine). During all years of study, grass stand was mown once per vegetation, in the mass flowering phase of studied species (2nd decade of July). The care of grass stand in the first four years (2005–2008) after sowing, was reduced to the tillage of space between rows and weeding of undesirable plants, of which the most onerous were: common dandelion, quitch-grass. Since 2009 weeding has been excluded, with only one harrowing performed annually in the phase of spring plant regrowth.

To identify the dynamics of floristic composition in the last year of the experiment (2012), a complete botanical description of vegetation was carried out with indication of abundance on the scale of Drude: sol. - plants are single; sp. - plants are rare; var. $_1$ - plants are pretty plentiful; var. $_2$. - plants are abundant; var. $_3$. - plants are very plentiful. Mathematical processing was carried out according to Dospekhov B.A. (Dospekhov, 2014).

STUDY RESULTS

In the introduction of plants into cultivation, such indicators as dynamics of height and average daily growth, which characterize the growth and development of plants during the growing period, make it possible to predict future harvest. The studied species differed quite significantly in height. At the time of harvesting (the second decade of July) the average height of plants was: forest vicia 88 cm - the highest value obtained in the experiment; meadow peavine - 70 cm; plant height of pea-shaped peavine - 59 cm. The average daily increase varied by accounting dates from 0.4 to 2.1 cm.

The earliest regrowth is noted in pea-shaped peavine, in its development it was significantly ahead of other legume species. For forest vicia, beginning of vegetation coincided with the pea-shaped peavine, but was less active; transition to the generative cycle of development (budding phase) was observed 6–8 days later than in pea-shaped peavine. The meadow peavine is characterized by slower and later regrowth from spring. The budding phase occured 4–6 days later than the forest vicia and 10–13 days later than the pea-shaped peavine. In general, the development of the studied plants went with

different intensity: the earliest growth was observed in pea-shaped peavine, the maximum in its development was noted at the end of the first and beginning of the second decade of June.

One of the tasks facing the experiment was to study the dynamics of floristic composition in phytocenoses of introduced species. During the long period of observation, in the absence of weeding (weeding stopped in 2009), agrestic (non-seeded) species of plants were introduced in the grass stand. In 2012 we carried out a complete description of the vegetation, the following botanical composition was identified: introduced (*cenose-forming)* species*: Lathyrus pisiformis* L., *Lathyrus pratensis* L., *Vicia sylvatica* L.; non-seeded species- all agrestic species are included in this group: cereals introduced into the vegetation cover, such as: *Elytrigia repens* (L.) Nevski., *Poa pratensis* L., *Festuca pratensis* L., et al.; legumes: *Trifolium pratense* L., *Trifolium repens* L., *Vicia cracca* L.; the following species are the most widely distributed in the grass stand: *Achillea millefolium* L., *Alchemilla vulgare* L., *Galium boreale* L., *Galium mollugo* L., *Taraxacum officinale* Wigg et al. (Table 1).

Table 1. Floristic composition of studied phytocenoses, 2012

Species and groups of plants	Experiment options (legume types)		
	1. opt. - *Vicia sylvatica* L. (forest vicia) - control	2.opt. - *Lathyrus pisiformis* L. (pea-shaped peavine)	3.opt. - *Lathyrus pratensis* L. (meadow peavine)
Introduced species:			
	Legumes:		
Lathyrus pratensis L.	sp.	sp.	var. $_2$ - var. $_3$
Lathyrus pisiformis L.	-.	var. $_1$ - var. $_2$	-
Vicia sylvatica L.	var. $_2$	-	-
Non-seeded species:			
	Legumes:		
Trifolium pratense L.	sp.	-	sp.
Trifolium repens L.	sp.	sp.	sol.
Vicia cracca L.	sp.	sp.	sp.
	Cereals:		
Elytrigia repens (L.) Nevski.	var. $_1$. - var. $_2$	var. $_2$	var. $_1$
Festuca pratensis L.	var. $_1$	var. $_1$	var. $_1$
Festuca rubra L.	sp.	sp. - var. $_1$	sp.
Poa pratensis L.	sp. - var. $_1$	var. $_1$	sp. - var. $_1$
Phleum pretense L.	sp. - var. $_1$	sp.	sol.
	Herbs:		
Achillea millefolium L.	sp.	sp. - var. $_1$	sp.
Alchemilla vulgare L.	sp.	sp.	sp.
Carum carvi L.	sp.	sp.	sol. - sp
Galium boreale L.	sol.	-	sol. - sp
Galium mollugo L.	sol.	sol.	sol.
Glechoma hederacea L.	sol.	-	-
Linaria vulgaris Mill.	sol.	sol.- sp	-
Plantago major L.	sol.- sp.	sol.- sp	-
Plantago media L.	sol.	sol.	-
Taraxacum officinale Wigg.	sp. - var. $_1$	sp. - var. $_1$	sol.- sp
Total species (pcs.):	20	17	15

The different phyto-cenotic stability of the cenose-forming species is revealed. During the years of research, *Lathyrus pisiformis* L. was the most vulnerable, instead of 90–95% of the plant cover it had in the first years of observation, in 2012 its participation in the addition of the grass stand did not exceed 27% (var. $_1$ - var. $_2$). This option is characterized by active introduction in phytocenosis of non-seeded agrestic plants: cereals began to take a leading position, accounting for 50.5% of all aboveground phytomass; the role of the dominant moved to quitch-grass (var. $_2$). The admixture of different herbs is significant, the proportion of which was 20.5%, especially active introduction in grass stand was noted in *Achillea millefolium* L. and *Taraxacum officinale* Wigg (abundance - sp. - var. $_1$).

The most tolerant species in the experiment turned out to be meadow peavine (*Lathyrus pratensis* L), for it is characterized by high abundance - var. $_2$ -var. $_3$; in the structure of grass stand, peavine accounts for 54%. This variant has significantly lower participation of non-seeded species: cereals- 31.5%, of which the dominants are *Elytrigia repens* (L.) Nevski. - var. $_1$ and *Festuca pratensis* L. - var. $_1$; the lowest participation in grass stand of different herbs is 11.5%; the proportion of non-seeded legumes does not exceed 2.0%, they are dispersed in the grass stand. Meadow peavine better resists to introduction in grass stand of agrestic plants, has high adaptive potential, is quite frost and drought resistant.

The forest vicia (*Vicia sylvatica* L.) in terms of sustainability in the grass stand has proved itself better than the pea-shaped peavine (*Lathyrus pisiformis* L.) but is significantly inferior in terms of this indicator to meadow peavine (*Lathyrus pratensis* L.). In 2012, the participation of forest vicia in grass stand was 35%, which is 8% higher than *Lathyrus pisiformis* L., but 19.0% lower than *Lathyrus pratensis L.* Quite a high abundance of cereals - 37.5%, of them the following predominate: *Elytrigia repens* (L.) Nevski. - var. $_1$. - var. $_2$, *Festuca pratensis* L. - var. $_1$. Significant admixture of different herbs - 16.5%.

During the harvest period, in the studied species the layer distribution of aboveground biomass on the vertical profile was considered. This indicator allows to determine the structure of the aboveground biomass; uniformity of leaves, inflorescences and fruits arrangement in height; ascertain the proportion of biomass that is concentrated to the height of mowing (0–7) cm) and remains in the meadow after harvest in the form of stubble (the amount of crop losses during mowing).

It is found that pea-shaped peavine has the lowest vertical profile, it includes 5 horizons (Table 2). The largest concentration of biomass is observed in three horizons: 15–30 cm - 30.2%; 30–45 cm - 28.1%; 45–60 cm - 22.2%. They account for 80.5%. The largest mass of leaves is also concentrated in these three horizons, with a maximum of leaves marked in the horizon of 30–45 cm - 14.3%. Inflorescences are located at a height of 45–60 cm, their share accounts for - 1.2%. This species is characterized by a low inflorescence content in biomass - 1.2% and the highest fruit mass - 20.3%.

For meadow peavine, the largest concentration of biomass is concentrated at a height of 15–70 cm, accounting for 82.9%. The participation of leaves in the structure of aboveground biomass was 54.3%, the largest mass of leaves is concentrated in two horizons: 30–45 cm - 14.1%; 45–60 cm - 11.9%. In the lower horizon (0–7 cm) there are only stems - 5.0%.

The highest vertical profile is noted for forest vicia, it includes seven horizons, the top one ends at 75–90 cm.

Table 2. Distribution of aboveground biomass of vicia studied species by vertical profile (%), 2012

Experiment options (legume types)	Aboveground biomass vertical profile (horizons, cm)							
	plant organs	0–7	7–15	15–30	30–45	45–60	60–75	75–90
1. opt. - *Vicia sylvatica* L. (forest vicia) - control	leaves	-	5.9	9.7	10.5	10.6	8.8	5.3
	stems	3.7	4.5	4.6	4.1	3.5	3.2	2.3
	inflorescences	-	-	-	-	-	5.9	6.7
	fruits	-	-	-	4.6	3.1	1.9	1.1
2.opt. - *Lathyrus pisiformis* L. (pea-shaped peavine)	leaves	-	7.2	13.9	14.3	12.2	-	-
	stems	5.5	6.8	7.7	5.8	5.1	-	-
	inflorescences	-	-	-	-	1.2	-	-
	fruits	-	-	8.6	8.0	3.7	-	-
3.opt. - *Lathyrus pratensis* L. (meadow peavine)	leaves	-	7.2	10.9	14.1	11.9	10.2	-
	stems	5.0	4.9	5.1	5.0	3.8	3.1	-
	inflorescences	-	-	2.5	4.0	5.4	3.3	-
	fruits	-	-	2.3	1.3	-	-	-

The distribution of aboveground biomass is more uniform. Leaves mass was 50.8%; fruits - 10.7%; inflorescences - 12.6%. Only stems are in the horizon up to mowing height - 3.7%. The forest vicia by all indicators occupies an intermediate position, there is a high participation of leaves and inflorescences in the structure of aboveground biomass.

The analysis showed that at the time of grass stand mowing, the lowest loss of biomass was observed in forest vicia, which amounted to 3.7%; the highest - in pea-shaped peavine - 5.5%.

When introduced, the productivity of the plant introduced into the cultivation is a priority. From the data shown in Table 3 it is evident that higher productivity was obtained in the first years of the study (2006–2008), there was a decrease in aboveground biomass in subsequent years, which is associated with grass stand being introduced with non-seeded low-productive species, such as: *Achillea millefolium* L., *Alchemilla vulgare* L., *Galium boreale* L., *Galium mollugo* L., *Taraxacum officinale* Wigg etc.

Table 3. Productivity of aboveground biomass of perennial legumes (2006–2012)

Options of the experiment (legume types)	Green mass								
	average for 2006–2008			average for 2009–2012			average for 2006–2012		
	productivity, t ha^{-1}	deviation from control, (+, -)		productivity, t ha^{-1}	deviation from control, (+, -)		productivity, t ha^{-1}	deviation from control, (+, -)	
		t ha^{-1}	%		t ha^{-1}	%		t ha^{-1}	%
1. opt. - forest vicia (control)	14.9	-	-	11.9	-	-	13.4	-	-
2.var. - pea-shaped peavine	12.3	-2.6	17.4	9.2	-2.7	22.7	10.7	-2.7	20.1
3.opt. - meadow peavine	16.7	+1.8	12.1	13.8	+1.9	16.0	15.3	+1.9	14.2
LSD_{05}:	2006	0.95	-	2009	0.68	-	-	-	-
	2007	1.05		2010	0.73				
	2008	1.09		2011	0.81				
				2012	0.75				

Quite low productivity was obtained in the pea-shaped peavine (10.7 t ha^{-1}); by the years of research it was significantly lower than in the forest vicia and the pea-shaped peavine. Among the studied species, the best results were provided by meadow peavine, it formed consistently high productivity of aboveground biomass during all years of observations. On average for 2006–2012 productivity amounted to 15.3 t ha^{-1}, which is 1.9 t ha^{-1} higher than that of forest vicia and 4.6 t ha^{-1} more than that of pea-shaped peavine. Mathematical processing of the obtained results gives grounds to assert that by the years of research, the productivity of the meadow peavine is significantly higher than that of the forest vicia and the pea-shaped peavine, the deviation from the control significantly exceeds the value of the LSD_{05}.

CONCLUSION

The study showed that the studied species vary significantly in the intensity of regrowth - early regrowth from spring is typical of pea-shaped peavine (*Lathyrus pisiformis* L.), later - for meadow peavine (*Lathyrus pratensis* L). Inclusion of these species in the 'green conveyor' (constant feed provision) will provide animals with green feed throughout the whole vegetative season.

Phyto-cenotic stability of studied species has been revealed, the forest vicia (*Vicia sylvatica* L.) in terms of resistance in the herbage has proven itself better than the pea-shaped peavine (*Lathyrus pisiformis* L.), but it is way below in this indicator to the meadow peavine (*Lathyrus pratensis* L.). The most stable species in the experiment is the meadow peavine (*Lathyrus pratensis* L), it accounts for 54% in the structure of herbage, it resists the introduction of wild plants into the herbage much better, has a high adaptive potential, is sufficiently winter-hardy and drought-resistant.

Thus, under the same cultivation conditions, the best results were provided by the meadow peavine, which retained its dominance in the phytocenoses and formed a significantly higher productivity during all the years of observation. On average for 2006–2012 productivity was 15.3 t ha^{-1}, which is 1.9 t ha^{-1} (14.0%) higher than that of the forest vicia and 4.6 t ha^{-1} (34.3%) more than that of the pea-shaped peavine.

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