Comparative characteristics of yellow alfalfa accessions in the nursery of competitive variety testing

S V Saprykin¹, N V Saprykina¹, V N Zolotarev², O N Lyubtseva¹

¹ Federal Williams Research Center of Forage Production & Agroecology, Voronezh experimental station for perennial grasses, Pavlovsk, Dokuchaev str., 1. Voronezh region, Russia.
² Federal Williams Research Center of Forage Production & Agroecology, Lobnya, Moscow region, Russia, Nauchny Gorodok, str., 1

Corresponding author’s e-mail: gnu@bk.ru

Abstract. In the context of the progressive trend of aridization of the climate of the main agricultural regions in the forest-steppe and steppe zones, the problem of increasing and stabilizing the high productivity of forage crops is becoming more acute. Yellow alfalfa (Medicago falcata L.) is highly resistant to abiotic stresses such as drought and low temperatures. This crop is resistant to extremely stressful conditions for cultivation in arid conditions, high production potential for the production of various types of bulky forage. The limiting factor of the effective economic use of yellow alfalfa in the Central Black Earth region of Russia is the insufficient number of zoned varieties, only three. The zoned varieties of alfalfa that exist today do not fully meet the requirements of modern forage production, and the tasks of developing new varieties with increased productivity, competitive ability in grass mixtures and increased longevity are becoming urgent. A highly productive variety of yellow alfalfa Pavlovskaya 7 was previously created at the Voronezh Experimental Station for perennial grasses. The Pavlovskaya 7 variety is characterized by high resistance to fungal diseases and mycoplasmosis, drought resistance, and long (up to 12 years) productive longevity. Currently, the station is completing selection work to develop a new variety of yellow alfalfa with a complex of economically valuable traits and properties for conditions of insufficient moisture.

Key words. Yellow alfalfa (Medicago falcata L.), selection, productivity, variety meter, green mass, dry matter.

1. Introduction

Alfalfa (Medicago sativa L.) is widely cultivated as a fodder plant in many countries of the world [1]. However, the wide use of this species of alfalfa in some agricultural areas is limited due to its low resistance to cultivation in arid conditions [2], as well as low frost and winter hardiness. Yellow alfalfa (Medicago falcata L.), in comparison with other species of the genus Medicago, is characterized by increased resistance to abiotic stresses, such as drought and low temperatures [3, 4, 5]. Thus, in the highly arid conditions of Inner Mongolia, winter hardiness of yellow alfalfa was 98% [6]. The practice of introducing yellow alfalfa into rangeland grasses has shown that this crop is stable for decades and allows for increased production and improved nutritive value of fodder in northern areas where other alfalfa species do not grow well [7].
M. falcatia is a polymorphic, widespread species that occurs naturally in the former USSR from the western borders to the Far East, from Yakutia in the north to the desert zone in the south. The wide distribution of the species implies a wide range of morphological variability [8]. Due to the vast areal of yellow alfalfa, in order to increase the efficiency of its use it is necessary to develop and introduce into production geographically and environmentally differentiated varieties with a wider amplitude of resistance to abiotic stress factors and stable seed productivity [9]. Currently 23 varieties of alfalfa of domestic selection have been registered in the Central Black Earth region of Russia, including nine varieties of alfalfa blue (M. sativa L.), 11 varieties of variegated (M. sativa L. nothosubsp. varia (Martyn) Arcang.) and three varieties of yellow (M. Falcatia), and nine foreign varieties: eight varieties M. sativa L.), and one - M. x varia (Martyn). Existing today zoned alfalfa varieties do not fully meet the requirements of modern fodder production and the tasks of increasing the yield, competitiveness in grass mixtures and longevity of use in crop rotations become urgent. To create new varieties adapted to the conditions of the zone, it is necessary to identify new sources, donors, alfalfa genotypes to increase heat- and drought tolerance and resistance to diseases [10].

The main economic disadvantage of yellow alfalfa compared to varieties of alfalfa sown and variegated is its lower productivity [11]. However, due to the pronounced tendency of climate aridization and long periods without rainfall during the growing season in the steppe zone of the Central Black Earth region, priority is given to drought-resistant grass species, in particular yellow alfalfa.

A highly productive variety of yellow alfalfa Pavlovskaya 7 was previously created at the Voronezh experimental station. Plants of the Pavlovskaya 7 variety are characterized by high resistance to fungal diseases and mycoplasma contamination Acholeplasma laidlawii (mycoplasmosis, or dwarf bushiness), drought resistance (up to 12 years ) productive longevity. The development and introduction into production of fundamentally new alfalfa varieties makes it possible to organize mass production of their seeds in the Central Black Earth region not only for own consumption, but also for supplying to the northern regions of alfalfa sowing in Russia [9].

Purpose of work. Study and evaluation of isolated samples on the level of green matter yield, air-dry matter, seed productivity to create varieties with a complex of economically valuable features and properties in conditions of insufficient moisture.

2. Materials and Methods.

The climate of Voronezh region is moderate-continental, characterized by hot and dry summers, winters with frequent thaws and unstable snow cover, short and intense spring with frequent dry winds. In terms of moisture availability the region belongs to the belt of insufficient moisture. Annual precipitation in most areas is 450 - 570 mm. During the warm period of the year (from April to October), 65% of the annual amount of precipitation falls. Maximum in June-July, minimum in March-April. Uneven precipitation by years and seasons is a characteristic feature. On average 2-3 times per 10 years there are years with low precipitation, which provokes the appearance of droughts. In summer, dry winds are not uncommon, creating scorching dust storms. The average annual temperature varies from +5° C in the north to +7° C in its southern regions. The lowest temperature drops to -40°, the highest +40° (absolute maximum in the south of the region +42°), the sum of active temperatures ranges from 2600° C to 3000° C.

The soils have the following characteristics: floodplain, heavy loamy, buried by low-powered granular carbonate silt with the content of humus in the arable layer according to Tyurin 4,06 - 4,10 %, labile phosphorus 4.0 mg, potassium 32 mg per 100 g of soil according to Machigin (table 1). The soils are moderately supplied with available forms of P₂O₅ and K₂O. The thickness of the humus horizon is up to 1 m. The pH reaction of the water extract of the upper horizon is 7.0. The specific gravity of the upper soil horizon is 2.92 g / cm³, the bulk density is 0.88 g / cm³.
Table 1. Agrochemical and agrophysical soil characteristics

| Soil horizon, cm | Humus, % | P₂O₅ mg/100 g soil | K₂O mg/100 g soil | Specific weight, g/cm³ | Volume weight, g/cm³ | pH |
|------------------|---------|---------------------|------------------|------------------------|----------------------|----|
| 0 - 20           | 5,01    | 4,04                | 24,94            | 2,62                   | 0,94                 | 7,1 |
| 20 - 40          | 4,89    | 2,32                | 16,87            | 2,61                   | 1,04                 | 7,2 |
| 40 - 60          | 4,36    | 1,08                | 10,72            | 2,54                   | 0,95                 | 7,2 |
| 60 - 80          | 3,88    | 0,81                | 7,02             | 2,59                   | 1                    | 6,8 |
| 80 - 100         | 2,72    | 0,39                | 3,71             | 2,68                   | 1,02                 | 6,7 |

The studies were carried out in meadow rotation of the experimental station, the objects of comparison were a complex-hybrid population of alfalfa yellow SGV-12 and individual selection of high-yielding samples from the variety yellow alfalfa Pavlovskaya 7. Placement of variants systematic in fourfold replication, plot 10 m². The method of sowing is ordinary. During the whole vegetation period the development of crops and weed control were monitored. Accounting was two-ukoses- continuous method by plots with sampling sheaves in the phase of the beginning of flowering.

3. Results and Discussion.
Observations showed that the herbage of the presented cultivars did not practically differ in terms of the phenological passage of the developmental phases. According to the data on plant height "Figure 1" for the first ukos of the first year of use, the SP 1-5 variety meter slightly exceeded the standard variety Pavlovskaya 7. In the second ukos, this indicator turned out to be at the control level. In the second year of use in the first ukos, sample SP 1-5 did not stand out, and in the second year it slightly surpassed the standard variety Pavlovskaya 7.

![Figure 1. Height of yellow alfalfa.](image)

In a competitive variety trial of yellow alfalfa in terms of green mass yield in the first year of use the variety number SP 1-5 stood out, which gave an increase relative to the standard +4.69 t/ha in total for two ukoses (Table 2). For the first ukos the gain was +11.7 %, for the second +6.9 % to the control. The first ukos was always higher in actual value compared to the second ukos. The excess in annual average in favor of varietal number SP 1-5 ranged from 4.69 to 7.8 t/ha or 10.5 - 15.7% by year.
Table 2. Yield of green mass of yellow alfalfa in competitive variety tests (data for 2019-2020).

| Year of use | Variety number | Collection of green mass, t/ha | % to St. | Deviation from St., t/ha +/- |
|-------------|----------------|--------------------------------|----------|-----------------------------|
|             |                | 1 ukos | 2 ukos | In total for 2 ukoses |          |                           |
| 2019        | SGV-12         | 35,92  | 12,46  | 48,38              | 108,2    | 3,65                       |
|             | SP 1-5         | 37,1   | 12,32  | 49,42              | 110,5    | 4,69                       |
|             | St. Pavlovskaya 7 | 33,21  | 11,52  | 44,73              | 100      | 0                          |
| 2020        | SGV-12         | 38,52  | 17,34  | 55,86              | 112,8    | 6,35                       |
|             | SP 1-5         | 38,7   | 18,61  | 57,31              | 115,7    | 7,8                        |
|             | St. Pavlovskaya 7 | 35,24  | 14,27  | 49,51              | 100      | 0                          |

Data on dry matter yield of yellow alfalfa show that the variety number SP 1-5 has an increase in each of the ukos. The largest increase relative to the standard was in the second cut of the first year of use (+23.4%), in the first ukos the variety number SP 1-5 was at the level of the standard. In the first ukos of the second year of use the SP 1-5 variety was 16.2% gain relative to the standard, as well as the SGV-12, in the second ukos of the same year the increase was +8.4% of the standard Pavlovskaya 7, and the SGV-12 variety of dry matter yield at the level of the control "Figure 2". In total for the first year of use varietal number SP 1-5 gave an increase of 0.93 t/ha, in the second year of use 1.91 t/ha.

Figure 2. Dry matter yield of yellow alfalfa.

In terms of seed productivity for two years, the variety number SP 1-5 was distinguished. Its advantage over the standard was expressed in the excess of seed yield from 39 to 70 kg / ha or 39-45%. The foliage of plants of the first ukos of the variety was average (42,2-43,6%) and exceeded the standard by 2-5%. In the second cutting the yield of fraction - leaves in air-dry mass was higher and was 52,3-55,2%. (Table 3).
Table 3. Yield of alfalfa yellow seed in competitive variety trials

| Variety number | 2019 year | 2020 year | Foliage, % |
|---------------|-----------|-----------|------------|
|               | Seed yield, kg/ha | % to St. | Seed yield, kg/ha | % to St. | 1 ukos | 2 ukos |
| SGV-12        | 100 | 120 | 220 | 122 | 42,2 | 52,3 |
| SP 1-5        | 122 | 145 | 250 | 139 | 50,4 | 55,2 |
| St. Pavlovskaya 7 | 83 | 100 | 180 | 100 | 41,4 | 51,2 |

4. Conclusion
Evaluation of economically useful features showed that the variety sample of yellow alfalfa SP 1-5 is characterized by higher productivity of green mass, seeds, dry matter for each ukos and year of use. At present, seed multiplication is carried out to the required volume for submission to the State Commission of the Russian Federation for Testing and Protection of Breeding Achievements for registration of the new variety.

References
[1] Singer S. D., Weselake R. J., Acharya S. 2018. Crop Science. Molecular enhancement of alfalfa: Improving quality traits for superior livestock performance and reduced environmental impact. T. 58. № 1. Pp. 55-71.
[2] Hanson A. 2015. The Journal of Undergraduate Research. Evaluating Physiological Responses of Ten Alfalfa (Medicago sativa subsp. falcata) Germplasm to Drought Treatments. T. 13. № 1. Pp. 10.
[3] Liu M., Wang T. Z., Zhang W. H. 2015. Environmental and Experimental botany. Sodium extrusion associated with enhanced expression of SOS1 underlies different salt tolerance between Medicago falcata and Medicago truncatula seedlings. T. 110. Pp. 46-55. doi.org/10.1016/j.envexpbot.2014.09.005
[4] Cui G., Chai H., Yin H. et al. 2019. BMC plant biology. Full-length transcriptome sequencing reveals the low-temperature-tolerance mechanism of Medicago falcata roots. T. 19. № 1. Pp. 1-16. doi.org/10.1186/s12870-019-2192-1
[5] Zhang L. L., Zhao M.G., Tian Q.Y. et al. 2011. Planta. Comparative studies on tolerance of Medicago truncatula and Medicago falcata to freezing. T. 234. № 3. Pp. 445-457. doi.org/10.1007/s00425-011-1416-x
[6] Jia M., GM Yin, SB Liu, et al. 2018. Animal Husbandry and Feed Science (Inner Mongolia). Introduction test of ecotype Medicago falcata L. T. 39. № 3. Pp. 51-54.
[7] Mortenson M. C., Schuman G. E., Ingram L. J. et al. 2005. Rangeland ecology & management. Forage production and quality of a mixed-grass rangeland interseeded with Medicago sativa ssp. falcata .T. 58. № 5. Pp. 505-513. doi.org/10.2111/1551-5028(2005)505:FPAQOA visible2.0.CO;2
[8] Malyshcheva N.YU., Malyshev L.L. 2020. Proceedings on Applied Botany, Genetics and Breeding. An analysis of the Medicago falcata s.l. alfalfas collected in the ex-USSR territories for the fullness of their coverage. № 181 (3). Pp. 17-24. DOI: 10.30901/2227-8834-2020-3-17-24.
[9] Zolotarev V. N., Perepravo N. I., Stepanova G. V. 2016. Vestnik of the Russian agricultural sciences. Biological principles of Luzerne seed production in Russia. № 4. Pp. 44-47.
[10] Popova T.N., Naydovich V.A., Kuznetsov P.A. 2016. Doklady Rossiiskoi Akademii Sel'skokhoziaistvennykh Nauk. Reaction of sorts and populations of Alfalfa on a heat and drought in Volga Region.. № 2-3. Pp. 30-32.
[11] Mela T., Sormunen-Cristian R., Niskanen V. 1996. Proceedings of the 16th General Meeting of the European Grassland Federation. Experiences of the yellow-flowered lucerne (*Medicago falcate* L.) in Finlandgrassland and land use systems. Pp. 515-519.