Alfalfa breeding to increase productivity, disease resistance

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Abstract. The cultivation of alfalfa varieties that are relatively resistant to the effects of negative biotic and abiotic environmental factors sharply reduces crop losses and the cost of forage. Work on the study of productivity, disease susceptibility of alfalfa, longevity, as well as the creation of a promising source material has been carried out by us for more than 30 years under natural conditions and against an artificial background, in clean sowing and in a grass mixture, on acidic soils and at normal acidity. Long-term work made it possible to identify and create in this culture sources of resistance to fusarium, brown spot with increased productivity and use them in further breeding work.

1. Introduction

The production of high-protein feed is the basis for the sustainable development of animal husbandry in Russia. Due to the lack of fodder protein, the productivity of animals decreases, and the cost of production increases [1, 2].

Alfalfa is of great importance in the biologization of agriculture and in increasing the production of high-protein feed. It is distinguished by its ecological plasticity, longevity, high productivity and a number of other valuable qualities. The need for nitrogen in meadows and pastures should to a large extent be met by leguminous and cereal grasses, for which it is necessary to create special varieties of legumes, including alfalfa [3, 4]. An adaptive ecological-evolutionary approach is increasingly used in the breeding strategy of forage crops, including alfalfa.

The source of the initial material for the breeding of alfalfa was the samples of the gene pool and the laboratories of breeding alfalfa of the Federal Research Center V.R. Williams, collection of wild-growing ecotypes in natural conditions and selections carried out from long-term crops, new forms created using various breeding methods (selection, polycross, hybridization, self-pollination, gamete selection). The effectiveness of breeding methods increases with the use of provocative, infectious backgrounds that enhance the effect of unfavorable factors that develop during overwintering and during the growing season. Particular attention was paid to the combination of traits of resistance of alfalfa with high yields and productive longevity. Hybrids with high vigor, rod-branched root system, semi-erect bush were found to be more resistant when cultivated in a grass mixture. By including genotypes selected under different assessment modes in crosses, it is possible to obtain new recombinations of genes combining in one variety resistance to the type of use with yield, a rapid rate of regrowth in spring and after grazing, mowing. Studies have found that the productivity of a promising material depends on its resistance to a complex of stress factors, correlates with the intensity of spring and post-cut regrowth, the height of the herbage [4, 5, 6, 7].
In the Non-Black Earth Zone of Russia, among the fungal diseases on alfalfa, the most common and harmful are fusarium (pathogens - more than 10 species of fungi of the genus Fusarium Lk.) and brown spot (pathogen Pseudopeziza medicaginis Sacc.). During the epiphytotic period, they can reduce the productivity of plants by 30% or more. The work was carried out by us on natural and artificial (fusarium) backgrounds of infection.

2. Results of the research

2.1 Study of samples in breeding nurseries in 2014-2018

In 2014-2018, in breeding nurseries, winter hardiness, power and height of the herbage, the quality of the feed received, the incidence of diseases, and the productivity of plants were studied. During the growing season, the necessary surveys were carried out.

The winter hardiness of the samples was high (from 90.0 to 99.0%), the thickness of the herbage ranged from 3.5 to 5.0 points. The height of plants in samples СГП 61-11, СГП 63-11, СГП 62-71, СГП 80-96, СГП 65-79, etc. exceeded the standard by 10.0-13.0%. The protein content was mainly at the level of the standard, and in 2018 in the plant mass of samples СГП 62-71, СГП 63-11, СГП 61-11, etc. more than the standard by 2.0-3.0%. The populations of CMC-1, C 110, Vela, MN 2, and others had the development of brown spot on average 10.0-15.0 less than the standard.

According to the assessment results, the samples SGP 61-11, Vela, MN 2, SGP 63-11, P 297, S 110, SGP 62-71 were better than the Lugovaya 67 standard in resistance to brown spot: the development of the disease was 8.0 - 19.0% less than the standard.

Many of the samples from breeding nursery No. 1 (SGP 62-71, Vela, SGP 63-11, SGP 61-11) exceeded the standard Lugovaya 67 in seed productivity (Table 1).

Table 1. Disease incidence and seed productivity of alfalfa samples in breeding nursery No. 1 (sowing in 2014, census 2015)

| Sample, grade | Brown spot, R (%) | ± to the standard | Seed yield (g / m²) | % to the standard |
|---------------|------------------|------------------|---------------------|------------------|
| MN 2          | 45,0             | -10,0            | 10,6                | 89,1             |
| S 110         | 43,0             | -12,0            | 11,7                | 98,3             |
| SGP 62-71     | 36,0             | -19,0            | 16,1                | 135,3            |
| Vela          | 47,0             | -8,0             | 13,1                | 110,1            |
| SGP 63-11     | 43,0             | -12,0            | 19,7                | 165,5            |
| SGP 61-11     | 47,0             | -8,0             | 17,2                | 144,5            |
| Lugovaya 67, standard | 55,0       | 11,9             | 100,0               |                  |

In breeding nursery No. 2, samples SP 03, SGP 033, SMS 200, Blagodat, PD 108, MN 1380, SGP 80 - 96, SGP 65 - 79 had seed productivity 23.2 - 89.3% more than the standard.

2.2 Study of samples in breeding nurseries in 2018-2020

In 2018, two breeding nurseries were established to study the promising alfalfa material obtained by various methods (selection, polycross, gamete breeding, etc.).

In 2018-2020 carried out a study of plant resistance to the most common diseases, productivity of green, dry matter and seeds, measuring the height of the stand, indicators of the quality of fodder.

In terms of height, the best were such samples and varieties as LG 2, P 67 (2), SU 85, SU - 9032 (alfalfa changeable), no. 27, no. 28, Pavlovskaya 7 (variety) (yellow alfalfa and variegated hybrid). The greatest superiority in height had a sample of alfalfa variable LH 2 (obtained in the gene pool department of the Institute of Forages), it was 8.0 - 18.1 cm (7.4-20.3% to the standard) (table 2).
Table 2. Height of alfalfa plants in a breeding nursery in the second-third years

| Name sample, grade | 24.06.19 | % to the standard | 30.06.20r | % to the standard | 2.10.20 | % to the standard |
|--------------------|----------|------------------|------------|------------------|---------|------------------|
| Pavlovska ya 7     | 87,7     | 117,7            | 113,0      | 104,6            | 139,6   | 110,0            |
| №26               | 83,6     | 115,6            | 110,0      | 101,9            | 130,2   | 102,6            |
| №27               | 86,8     | 112,2            | 117,0      | 108,3            | 133,5   | 105,2            |
| №28               | 79,3     | 106,4            | 116,0      | 107,4            | 142,2   | 112,1            |
| Vega 87, standard  | 74,5     | 100,0            | 108,00     | 100,0            | 126,9   | 100,0            |
| P 67 (1)           | 87,2     | 117,0            | 108,0      | 100,0            | 132,2   | 104,2            |
| P 67 (2)           | 82,1     | 110,2            | 110,0      | 102,8            | 131,1   | 103,3            |
| SU 9032            | 83,2     | 111,7            | 110,0      | 102,8            | 139,9   | 110,2            |
| SU 85              | 85,4     | 114,6            | 112,0      | 103,7            | 132,8   | 104,6            |
| SU 76              | 89,2     | 119,7            | 102,0      | 94,4             | 139,5   | 109,9            |
| LG 2               | 89,6     | 120,3            | 116,0      | 107,4            | 145,0   | 114,3            |
| NSR 05             | 6,7      | 6,7              | 7,8        |                  |         |                  |

The productivity of green and dry matter of alfalfa samples in the breeding nursery also had significant differences in comparison with the standard (Table 3).

In the breeding nursery for the productivity of green mass, some samples exceeded the standard in 2019 by 35.8 - 96.3%, and in 2020 - by 20.3 - 128.8%. The most productive of them were SU-76, SU-82, SU-9032, SU-413, P-67 (2). The dry matter productivity of most of the studied samples was higher than the standard by 16.7 - 90.0%.

Table 3. The productivity of alfalfa plants in a breeding nursery in the second-third years of life (2019-2020)

| Name sample, grade | Green weight (t / ha) 09/18/19 | % to the standard | Dry matter (t / ha) 24.06.19 | % to the standard | Green weight (t / ha) 9.09.20 | % to the standard |
|--------------------|----------------------------------|------------------|-------------------------------|------------------|-------------------------------|------------------|
| Pavlovska ya 7     | 15,2                             | 187,7            | 5,6                           | 186,7            | 27,2                          | 115,3            |
| №26               | 9,1                              | 112,3            | 3,5                           | 116,7            | 54,0                          | 228,8            |
| №27               | 9,5                              | 117,3            | 3,7                           | 123,3            | 38,0                          | 161,0            |
| №28               | 12,5                             | 154,3            | 4,9                           | 163,3            | 22,0                          | 93,2             |
| Vega 87, standard  | 8,1                              | 100,0            | 3,0                           | 100,0            | 23,6                          | 100,0            |
| SU-413            | 12,3                             | 151,9            | 4,6                           | 153,3            | 28,4                          | 120,3            |
| P 67 (1)          | 11,0                             | 135,8            | 4,5                           | 150,0            | 30,4                          | 128,8            |
| P 67 (2)          | 11,5                             | 142,0            | 4,6                           | 153,3            | 28,8                          | 122,0            |
| SU 90             | 12,4                             | 153,1            | 4,7                           | 156,7            | 32,0                          | 135,6            |
| SU 9032           | 13,2                             | 163,0            | 4,7                           | 156,7            | 49,2                          | 208,5            |
| SU 85             | 15,9                             | 196,3            | 5,7                           | 190,0            | 22,8                          | 96,6             |
| SU 82             | 10,6                             | 130,9            | 4,2                           | 140,0            | 44,8                          | 189,8            |
| SU 76             | 12,5                             | 154,3            | 4,9                           | 163,3            | 30,0                          | 127,1            |
| LG 2              | 12,1                             | 149,4            | 4,9                           | 163,3            | 32,8                          | 139,0            |
| NSR 05            | 2,6                              |                  | 0,45                          |                  |                               |                  |
In terms of protein content and other indicators of feed quality in the breeding nursery, samples SU 90, No. 28 were distinguished.

The incidence of brown spotting in the samples of the breeding nursery SU 9032, SU 85, LG 2 No. 27, No. 28 was less than the standard by an average of 10 - 15%.

In 2019, two breeding nurseries were established in the field, including, together with the standards, a total of 36 accessions of variegated and yellow alfalfa. Of these, samples of yellow hybrid alfalfa (No. 29, No. 30), yellow (Lazurnaya, Alfakora, etc.) were affected by 20% brown spot, and samples of variable alfalfa P 379, S-110, SGP-12, LG 1, LG 4 - 14-18% less than the standard (Lugovaya 67).

Under the conditions of the STC, work continued on the study of the collection and field-selected material of alfalfa (more than 40 samples). Seeds received. Of the samples sown in the greenhouse in 2014 (64 in total), 11 samples were preserved in 2020, mainly related to yellow and yellow-hybrid alfalfa (Mongolian yellow, Dedinevskaya yellow, Orange, Maykop yellow, Orange, etc.). The best of these samples will be used for further selection.

2.3 Study of samples in the control nursery in 2018-2020.
In the control nursery in 2018-2020. The most resistant to diseases were the samples SGP 387, S 63-11, SGP-12. A particularly large excess over the standard was noted during the epiphytotic period at the beginning of October 2020. The development of brown spot was less than the standard by 19.3 - 26.9%, wilting - by 20.8 - 27.5%. The stand of the standard (cultivar Lugovaya 67) was affected by brown spot by 49.5%, wilting by 53.5%.

In 2019, in terms of the productivity of green and dry matter, sample C 63-11 surpassed the standard Lugovaya 67 by 10.0% (41.9 t / ha) and 8.6% (8.7 t / ha), respectively. In 2020 samples SGP-12, S 63-11 and SGP-387 in terms of green mass productivity exceeded the standard by 21.1-25.5%.

2.4 Study of samples in the nursery of competitive variety testing in 2018-2020.
The disease incidence of alfalfa samples in a competitive trial was the highest in the second cut of 2020 (8 months). Sample SGP 387 in August of this year was affected by brown spot and wilting, respectively, 15.3 - 20.5 and 12.0 - 21.5% less than the standard (Table 4).

| Experience options | Disease prevalence (development, %) | 23.07.2019 | 19.08.20 | 31.08.20 |
|--------------------|-------------------------------------|------------|----------|----------|
|                    | Brown spotted | Withering | Brown spotted | Withering | Brown spotted | Withering |
| Chinese 1          | 22.2         | 22.2      | 23.9       | 20.0      | 38.2       | 31.2      |
| S-76               | 21.2         | 20.5      | 21.0       | 20.0      | 35.8       | 31.8      |
| Meadow 67          | 27.6         | 27.0      | 35.3       | 32.0      | 42.8       | 42.2      |
| SGP 387            | 22.3         | 21.3      | 20.0       | 20.0      | 22.3       | 20.7      |
| S-79               | 22.7         | 22.1      | 25.2       | 27.9      | 23.0       | 25.0      |
| NSR 05             | 3.3          | 3.3       | 4.3        | 2.8       | 4.7        | 4.7       |

The productivity of this sample also significantly exceeded the standard.

3. Conclusion
Long-term work on the study of productivity, winter hardiness, resistance to the most common and harmful fungal diseases (fusarium, brown spot), various environmental stress factors (biotic and abiotic) of alfalfa source material and the use of various breeding methods (selection, self-pollination, polycross, gamete selection, hybridization) made it possible to identify and create promising breeding material.

In nurseries of competitive testing and control according to the results of research, the most promising samples according to the results of 2014-2020. and previous years can be considered samples
SGP 387, SGP 12, S 63-11, exceeding the standard in productivity by an average of 15%, resistance to fusarium, brown spot by 15-25%.

Breeding nurseries also have material that is promising for further breeding (samples P 67 (2), LG 2, SU 9032, No. 27, No. 28, SU 85).

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