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Manifestation of Valuable Selective Traits in Alfalfa Collection Samples

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Abstract: The paper presents the results of the manifestation and study of alfalfa in a collection seed plot according to the main valuable selective traits, such as leafiness, susceptibility to diseases, the productivity of green mass and seeds, as well as chemical composition and nutritional value. The study aims to identify promising collection varieties for selection from two types of alfalfa, namely variegated alfalfa (*M. Varia Mart.*) and purple alfalfa (*Medicago sativa L.).* Field and laboratory methods were used in the study. The laying of seed plots, the assessment of economically valuable traits, and the accounting of productivity were carried out according to the methods of the All-Russian Research Institute of Plant Industry (VIR) named after N. I. Vavilov, the All-Russian Fodder Research Institute named after V.R. Williams and State Crop Variety Testing of the Republic of Kazakhstan. A comprehensive assessment of the collection material for the chemical composition of fodder was carried out in the laboratory. The experiments were performed at the station of the "Kazakh Scientific Research Institute of Agriculture and Plant Growing" LLP. 134 varieties of alfalfa, namely purple alfalfa (*M. sativa L.*) and variegated alfalfa (*M. varia Mart.*) of Kazakh and foreign selection from 18 countries of the world were involved in the study. As a result, productive samples by plant height were identified in the material from Italy (k-5677), Russia (k-31885), Kazakhstan (k-6021); productive samples by leafiness were identified in the material from Russia (k-45479), Kazakhstan (k-61324), Italy (k-5677) and productive samples by complex resistance to diseases (yellow leaf spot, brown leaf spot, rust stain) were identified in the material received from Kyrgyzstan (k-6238), Uzbekistan (k-21634) and Italy (k-5975). By harvesting green mass, the following samples were isolated on average over three years: From Uzbekistan (k-267), France (k-315), and Ukraine (k-454). By seed yield, the highest indicator was observed in a sample from France (k-315). The crude protein content was higher in the second cutting. High indicators were observed in samples from Kazakhstan (k-246, 22.6%) and Russia (k-322, 22.3%).

Keywords: Alfalfa, Green Mass, Leafiness, Chemical Composition

Introduction

Kazakhstan alfalfa varieties of tetraploid species *Medicago sativa* L. and *M. varia Mart*. are cultivated. Other species (tetraploid, such as M. falcate L. and M. trianschanica Vass. and diploid such as M. coerulea Less., M. trautvetteri Summ., M. difalcata Sinsk. and others) are found in natural landscapes, which serve as source material for improving cultivated varieties in terms of drought resistance, salt-resistance and disease resistance (Meiirman and Masonichich-Shotunova, 2013).

Purple alfalfa *(Medicago sativa L.)* can form a high yield of fodder mass in a mild warm climate. It is multi-cut, with artificial irrigation it can give 5-6 cuttings in the south and up to 4 cuttings in the south-east. Variegated alfalfa (*M. varia Mart.)* is characterized by increased winter hardiness and ripens better in the northern regions of Kazakhstan since a smaller amount of effective temperatures is required for filling seeds. It is essentially a hybrid species between purple alfalfa *(Medicago sativa L.)* and yellow alfalfa (*M. falcate L.);* therefore, by color, it is divided into three types of varieties: Variegated hybrid variety, yellow hybrid variety, and blue hybrid variety (Meirman *et al*., 2017; Humphries *et al*., 2021; Kalibayev *et al*., 2021).

Yellow alfalfa is characterized by high winter hardiness and drought resistance, ripens well for seeds, and mainly has a creeping bush type, which makes it difficult for mechanized harvesting, both for fodder and seeds.

To increase fodder production, new highly productive varieties are needed that meet the conditions of the cultivation regions, combining high productivity of green mass with seed yield, winter hardiness, and leafiness.

According to the yield of green mass, the power, and nature of vegetative growth, as well as the height of plants in the second and subsequent years of life, there is greater genetic variance than in the year of sowing. Therefore, the selection is more effective when the traits are fully manifested, that is, starting from the second year of alfalfa's life.

The alfalfa gene pool is quite diverse in species and varietal composition. At the same time, it is important to identify the most valuable samples that are more suitable to the soil, climatic, and technological features of cultivation in local conditions for their use in selection as a starting material (Meiirman and Yerzhanova, 2015; Malysheva and Malyshev, 2020; Meirman *et al*., 2017).

The purpose of the study is to identify a collection variety of samples promising for selection from two types of variegated alfalfa (*M. varia Mart.)* and purple alfalfa *(Medicago sativa L.)* by individual properties, as well as by a set of traits and properties.

Materials and Methods

Location and period of the study. The experiments were performed at the station of the fodder crops department of the "Kazakh Scientific Research Institute of Agriculture and Plant Growing" LLP in the village of Almalybak (the Almaty region, the Republic of Kazakhstan) from 2019 to 2021 in the conditions of the foothill zone of the Ili Alatau (altitude above sea level 500-750 m). The soil cover of the experimental site is represented by foothill light chestnut soils. A characteristic feature of these soils is their high carbonate content. According to their mechanical composition, they belong to medium loams. The pH of the soil solution is slightly alkaline pH 7.3-7.5. In the arable horizon, the total nitrogen is 0.15%, phosphorus is 0.21% and the amount in the upper layers of the soil is higher than in the lower ones.

134 varieties of alfalfa (purple alfalfa *(M. sativa L)* and variegated alfalfa (*M. varia Mart.*) of Kazakh and foreign selection were used for the study. The distribution of the samples by geographical origin was the following: Kazakhstan: 25, Ukraine: 19, Azerbaijan: 3, Russia: 23, USA: 12, France: 2, China: 2, Kyrgyzstan: 7, Turkmenistan: 10, Uzbekistan: 12, Armenia: 2, Sweden: 1, India: 1, Pakistan: 6, Estonia: 2, Georgia: 1, Egypt: 1, Canada: 2, Germany: 1, Italy: 2.

The study was conducted for three years. The experiment was based on a modified VIR methodology. The maintenance techniques correspond to the zonal technology of the studied culture in rain-fed conditions. The area of the plot is 1 m^2, in three-fold repetition. The placement of variants is randomized. The Semirechinskaya mestnaya standard was sown after every ten numbers according to the classical methodological guidelines for the study of the collection of perennial fodder plants L: VIR, 1985. During the growing season, phenological observations, care, accounting of green mass and seeds, and other traits and properties for each cutting were carried out during the beginning of the flowering of the herbage.

The seeding rate equaled 2 grams per 1 m^2. The sowing method was by rows with a row spacing of 30 cm, sown in pure form, without cover crops.

The assessment of alfalfa infect ability was carried out on a five-point scale at the beginning of flowering:

- Absence of spots or pustules on the leaves
- The surface of the leaves is covered with spots or hollows up to 10% of their total area
- See above, from 15 to 25%
- See above, 30 to 50%
- See above, over 50%

Statistical data processing was carried out by modern methods using licensed Statistica Desktop software with a named user annual license.

Results

According to the results of the study for 2019-2021, data were obtained for each cutting concerning the plant height, the growth rates, leafiness, resistance to major diseases, and productivity of green mass and seeds. The data have been summarized by the years of the life of alfalfa.

Plant height the study showed that alfalfa samples differed in different growth rates and, accordingly, had significant differences in the height of the herbage by cutting.

Concerning the growth dynamics in all alfalfa samples, a certain pattern was revealed: The maximum increase in samples was observed in the phases of appearance of flower tubercles evident at palpation (the end of branching) and the beginning of plant budding. After budding, the decadal growth of alfalfa decreases.

This is due to the biological feature of alfalfa, where growth slows down when the reproductive phase of development occurs. The maximum daily growth of alfalfa collection plants (2.0-2.5 cm) was observed in the second cutting and the minimum daily growth (0.6-0.7 cm) was observed in the third cutting.

The greatest growth in the alfalfa collection was observed in the first cutting in the second year of life (Table 1).

Among the alfalfa collection, the highest daily increase of 2.5-2.8 cm in the second cutting was observed in medium-ripened samples from Italy (k-5677), Russia (k-31885), and Ukraine (k-1721) and Kazakhstan (k-6021).

Concerning the plant height, the highest indicators were observed in the variety samples from Italy (k-5677), Russia (k-31885), Kazakhstan (k-6021), Estonia (k-38914), Ukraine (k-1721), and the USA (k-46451) (the average height for three years equaled 81.5-86.4 cm). The deviation from the standard in these variety samples averaged 15.1-20.0 cm over three years Leafiness. The most valuable fodder part of alfalfa is the leaves, which amount to about half the mass of plants and contain 2 times more protein than the stems. Alfalfa leaves increase the overall productivity of the variety, as well as the fodder quality of hay. The higher the leafiness of the variety before cutting, the higher the productivity and nutritional value of the fodder.

Many alfalfa diseases develop on the leaves, which leads to withering.

When harvesting alfalfa in the later phases of development, leaf infestation with fungal diseases and pests increases, which leads to the withering and shedding of leaves during hay harvesting. As a result, alfalfa varieties have a reduced overall yield and hay quality.

To identify the selection of the leafiest samples, we determined the content of leaves in the total mass of the crop in the samples of the alfalfa collection. At the same time, changes in the size of the leaves by cutting were determined by measuring the length and width of the leaf surface taken from the middle tier of plants.

The leafiness of the alfalfa collection samples in our studies is not the same and depends on the cutting (Table 2). The leafiness of plants in the first cutting is lower than the average and higher leaf content is characteristic of the herbage of the second cutting. The low percentage of leaves (to the total weight) in the first cutting is explained by the formation of coarse stems with long branches that increase the stem part and high leaf damage caused by fungal diseases. By the second and third cutting, the thickness of the stems and branches decreases, and, as a result, the weight of the stem part decreases.

In the control variety Semirechinskaya mestnaya, the leafiness in the first cutting equals 45%, in the second cutting 47%, and the third cutting 46%.

The following samples had a high leafiness: The leafiness of the samples from Russia (k-45479), Kazakhstan (k-61324), and Italy (k-5677) averaged 51.0-52.3%, which exceeded the control variety on average by +5.0-+6.3%.

Resistance to major diseases one of the main factors affecting the productivity of fodder and seed alfalfa is diseases of individual vegetative organs and the plant as a whole. Alfalfa mainly suffers from diseases caused by fungi and viruses.

The following diseases were found in the crops of the collected samples of alfalfa: Yellow leaf spot *(Pseudopeziza jotiesti),* brown leaf spot *(Pzeudopeziza medicaginis fusk),* leaf rust *(Uromyces striatus schr),* ascochytosis *(Ascochita imperfacta peck*) and false mildew *(Peronospora aestivalis sydov G*).

The year 2020 was the most favorable for the development of fungal pathogens and most of the samples in the collection were significantly affected by brown and yellow leaf spots (Fig. 1).

A yellow leaf spot is characterized by the formation of yellowish blurry spots on alfalfa leaves, followed by faded appearances of more small black dots, later merging into a black spot. Yellow leaf spots spread very quickly from the tender leaves upwards and, in severe cases, covered all the emerging young alfalfa leaves. Several spots appeared on the same leaves and increased in size. They captured the entire leaf plate. The affected part of the leaf gradually dries up and the weight of the leaf takes on a dark brown color, slightly curls, and falls off. In most cases, dark leaves fell off. With the high development of the disease during flowering and bean formation, some highly susceptible specimens had yellow spots on the stems. In this case, blurry dark spots with numerous black dots formed on the stem.

Yellow leaf spots appeared early in spring in late April and early May, first on highly susceptible alfalfa samples and then on other ones. Brown leaf spot is characterized by the appearance of brownish dark, rounded spots with a diameter of 1-3 mm on alfalfa leaves. Spots were mainly found on the upper side of the leaf, but in severe cases, they were also observed on the tender side of the leaf (single small ones).

This disease is also observed on the leaves of the lower tier and gradually passes to the middle and upper leaves.

Brown leaf spots spread in the spring in May, during the shooting and budding of alfalfa.

Rust leaf was the least widespread disease. The external traits of the disease are that small dark brown pustules of 0.2-0.3 mm in diameter appear on the leaves. Spore clusters were found on the lower part of the leaves and in severe cases, also on the upper part of the leaves. In our conditions, this disease was often encountered in the second cutting, i.e., at the end of June, and progressed on seed plants in August. False mildew affects the leaves. Dense light brownish to purple mold forms on the leaves.

This disease was found on some samples in the first decade of May and in the second decade of June. The development of diseases was mainly observed in the first and second cutting. The third cutting was less affected.

To identify the relationship of alfalfa to diseases during the study period, we assessed two cuttings per year (Table 3). Samples of the alfalfa collection (sown in 2019) were affected slightly. In some samples, yellow and brown leaf spots were found to a small extent on the leaves. In 2020, when precipitation in the spring and relative humidity was high, there was a significant development of fungal diseases in all varieties, especially in the first cutting.

Among the studied samples, we identified the ones most resistant to fungal diseases. Varieties from Kyrgyzstan (k-6238), Uzbekistan (k-21634), and Italy (k-5975) had complex resistance to fungal diseases (yellow leaf spot, brown leaf spot, leaf rust). The resistance equaled 0-2 points.

Resistance to yellow leaf spots was observed in samples from Russia (k-122571), Uzbekistan (k-19972), and Estonia (k-25487) within 0-2 points.

Resistance to brown leaf spots was observed in samples from India (k-21368), Estonia (k-25487), and Italy (k-5975) within 0-2 points.

Leaf rust resistance was shown by samples from Russia (k-43777), Kyrgyzstan (k-6238), Russia (k-122571), and Ukraine (k-30829) within 0-2 points. Timely harvesting of alfalfa for fodder no later than the beginning of the flowering phase reduces the overall level of fungal diseases.

Green mass productivity. The fodder productivity of the alfalfa collection is the main indicator in the evaluation of samples and their selection for breeding purposes.

The main need for alfalfa cultivation is to obtain as much high-quality green mass and dry mass as possible. Therefore, the identification of the variety of samples with high fodder productivity to use them as a source of this trait is an important part of selection work.

The yield of green mass and alfalfa hay depends on the biological properties of the varieties, as well as on soil and climatic conditions, the presence of moisture, and nutritional elements in the soil.

Alfalfa belongs to the mesophytic type of plant. High drought resistance is combined with good responsiveness to moisture. Optimal conditions for the formation of a highly productive cutting herbage for fodder are created when maintaining moisture in the root-inhabited soil layer at the level of 70-80% during the growing season. With a decrease in humidity to 50%, the growth processes of alfalfa slow down. Rainy and cloudy weather, accompanied by a decrease in temperature, causes intensive herbage growth. The collected samples were tested for productivity under rain conditions with an average annual precipitation of 500 mm.

The following variety samples had a significant superiority compared to the standard for the average yield of green mass for three years: Uzbekistan (k-267), France (k-315), Ukraine (k-454), Bashkiria (k-9), China (k-11), and Kazakhstan (k-191) (132.5-151.1% to the standard) (Table 4). When analyzing the peculiarities of the formation of the yield of green mass over the years, we noted significant variability in the fodder productivity of the best varieties of alfalfa compared to the standard variety, Semirechinskaya mestnaya. At the same time, we isolated samples with the least reaction to adverse weather conditions. All these samples can be used as highly productive source material of green mass.

Seed productivity increasing the yield of alfalfa seeds at this time is one of the important problems. The seed yield depends both on the agricultural technology of cultivation and on the biological characteristics of the variety, its seed-forming ability, and the completeness of pollination as entomophilic plants. The defining structural elements of seed productivity are the optimal stem density per unit area, the number of brushes per plant, the number of tied beans in each brush, the number of full-fledged seeds in a bean, and the mass of 1,000 seeds.

It should be noted that alfalfa varieties originating from North America and Western European countries are characterized by increased seed productivity. High seed yields are also formed by the selection of alfalfa varieties from France, Sweden, and Ukraine, which have been selected for auto-tripping and self-fertility (Fig. 2). The seed productivity of the most productive samples of the alfalfa collection ranged from 105.1 to 136.3% of the level of the standard variety with its index of 34.7 g/m^2.

In terms of seed yield, the highest indicator for the sample from France (k-315) is 47.3 g/m^2, which exceeded the standard by 36.3%. The samples from the USA (k-365), Ukraine (k-450), Turkmenistan (k-253), Russia (k-473), and Kazakhstan (k-226) exceeded the standard by 15.2% and 21.9%, respectively.

Chemical composition is one of the important indicators of fodder quality. We determined the protein content without nitrogenous extractives, fiber, sugars, and minerals. In the year of sowing, the nutrient content in the aboveground mass by cutting varied slightly (Table 5). The crude protein content in the first cutting varied from 17 to 20.1%. The highest values were observed in samples from Armenia (k-313, 20.1%) and Kazakhstan (k-246, 18.5%). Crude fiber: 26.7-30.9%, crude ash: 7.47-10.23%, crude fat: 2.22-3.32%, NFES: 39.6-43.1%. In the second cutting, samples from Kazakhstan (k-246, 22.6%) and Russia (k-322, 22.3%) had a high protein content.

The protein content, as a rule, in the first cutting is less (17.0-21.7%) than in the second one (17.9-22.6%), while the remaining indicators practically remain at the same level.

The samples of the alfalfa collection have a high content of calcium and low content of phosphorus.

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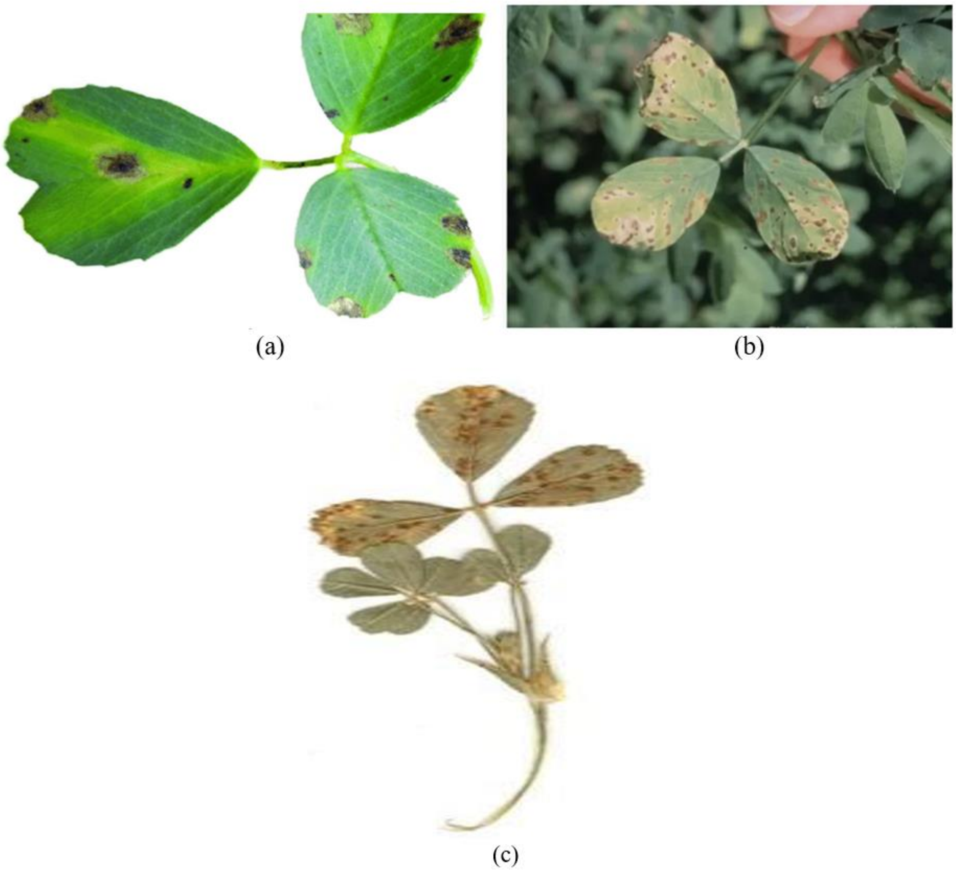

Fig. 1: Alfalfa diseases

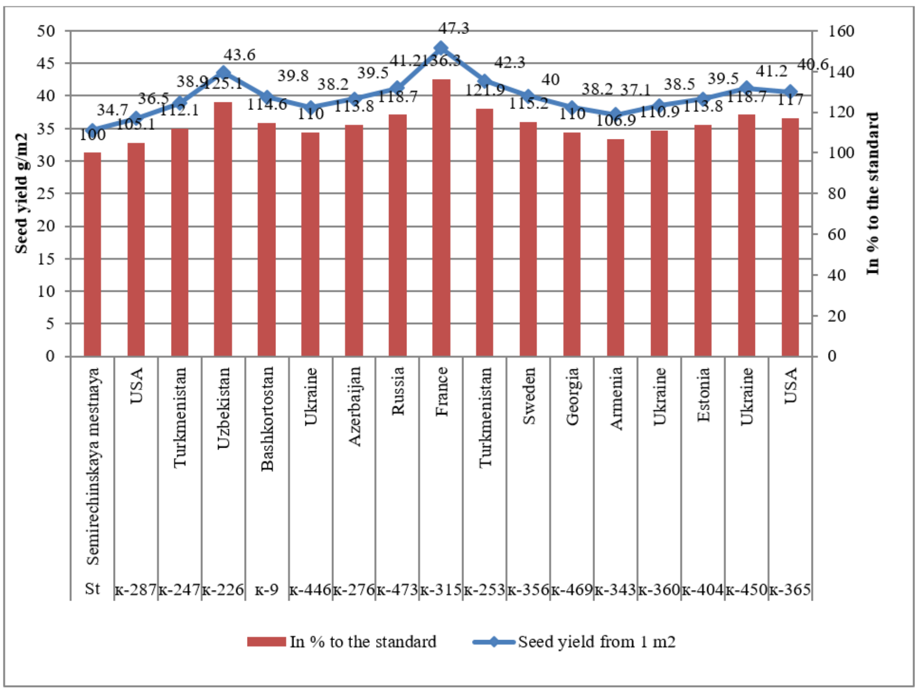

Fig. 2: Seed yield of the most productive alfalfa samples, g/m^2

Table 1: Plant height by years of life in the tallest samples of the alfalfa collection

Catalog number	Origin	Average plant height by years of life, cm				
		1st year of life	2nd year of life	3rd year of life	Average	Deviation from the standard
St	Semirechinskaya mestnaya	55.1	76.0	68.2	66.4	-0.0
k-45254	USA	61.6	77.5	69.5	69.5	3.1
k-8462	Uzbekistan	59.0	78.9	80.3	72.7	6.3
k-46451	USA	62.3	78.0	79.6	73.3	6.9
k-31885	Russia	71.5	97.5	78.4	82.5	16.1
k-20002	Ukraine	67.1	88.0	86.2	80.4	14.0
k-38914	Estonia	67.0	89.2	88.3	81.5	15.1
k-20001	Ukraine	65.2	93.5	75.2	77.9	11.5
k-41985	Pakistan	63.2	87.0	78.1	76.1	9.7
k-2966	Russia	56.3	87.2	86.2	76.5	9.0
k-21787	Ukraine (Eastern)	64.2	83.6	84.0	77.2	10.8
k-61493	Kazakhstan	62.0	86.5	87.2	78.5	12.1
k-27065	Italy	63.5	93.2	89.5	82.0	15.6
k-5677	Italy	70.6	99.0	89.7	86.4	20.0
k-6021	Kazakhstan	69.5	97.5	83.2	83.4	17.0
k-1721	Ukraine	69.0	98.6	86.2	84.6	18.2
k-11416	Russia	65.2	92.0	88.9	82.0	15.6

Table 2: The leafiness of the best varieties of alfalfa in the second year of life

Catalog number	Origin	Leafiness by cutting, %				
		1st cutting	2nd cutting	3rd cutting	Average	Deviation from the standard
St	Semirechinskaya mestnaya	45	47	46	46.0	-0.0
k-45479	Russia	51	54	48	51.0	5.0
k-7350	Turkmenistan	46	51	47	48.0	2.0
k-23858	Ukraine	47	49	47	47.6	1.6
k-8886	Uzbekistan	48	51	49	49.3	3.3
k-61324	Kazakhstan	52	53	49	51.3	5.3
k-765	Tatarstan	47	50	48	48.3	2.3
k-5677	Italy	52	56	49	52.3	6.3
k-46459	USA	48	51	47	48.6	2.6
k-39932	Canada	49	52	47	49.3	3.3
k-45036	Armenia	48	52	48	49.3	3.3
k-20013	Georgia	47	51	47	48.3	2.3
k-45115	USA	49	50	48	49.0	3.0
k-5143	Egypt	49	51	48	49.3	3.3

Table 3: Relatively resistant samples of the alfalfa collection to fungal diseases (in points, on average for two cuttings)

Catalog number	Origin	Yellow leaf spot			Brown leaf spot			Leaf rust		
		2019	2020	2021	2019	2020	2021	2019	2020	2021
1	2	3	4	5	6	7	8	9	10	11
St	Semirechinskaya mestnaya	2	4	2	2	3	3	1	2	2
k-765	Tatarstan	2	3	2	1	2	2	1	3	1
k-46459	USA	2	3	3	2	3	3	2	2	2
k-19972	Uzbekistan	1	2	1	1	3	2	1	2	3
k-21368	India	2	3	0	0	0	1	2	3	1
k-30829	Ukraine	2	3	1	1	3	1	1	1	1
k-28645	Russia	2	3	1	1	2	1	1	3	1
k-25487	Estonia	1	2	0	0	0	0	1	1	1
k-5975	Italy	0	1	0	0	0	0	1	1	0
k-35023	Kyrgyzstan	1	2	0	1	2	2	1	3	2
k-21634	Uzbekistan	0	1	1	1	2	0	0	0	0
k-8142	Azerbaijan	1	2	1	2	3	2	1	1	1
k-122571	Russia	1	0	0	1	0	0	0	1	0
k-19882	Ukraine	2	3	1	1	1	1	2	2	1
k-6238	Kyrgyzstan	1	1	2	1	1	2	1	2	1
k-43777	Russia	1	1	0	1	2	0	1	2	1

Table 4: Green mass productivity in the best samples of the alfalfa collection

		Green mass yield, kg/m^2				
Catalog number	Origin	1st year	2nd year	3rd year	on average for 3 years	In % to the standard
St	Semirechinskaya mestnaya	1.79	5.28	1.98	3.01	100.0
k-261	Uzbekistan	1.91	5.61	2.12	3.90	129.5
k-14	USA	1.93	6.56	3.21	3.90	129.5
k-253	Turkmenistan	2.18	7.12	2.14	3.81	126.5
k-356	Sweden	1.67	6.42	2.32	3.47	115.2
k-469	Georgia	1.83	6.23	2.35	3.47	115.2
k-343	Armenia	2.12	6.76	2.65	3.83	127.2
k-256	Uzbekistan	2.02	6.94	2.44	3.80	126.2
k-538	Russia	2.64	7.13	2.26	4.01	133.2
k-267	Uzbekistan	2.86	8.33	2.47	4.55	151.1
k-473	Russia	2.34	6.72	2.63	3.89	129.2
k-402	Kazakhstan	2.52	5.66	2.11	3.43	113.9
k-315	France	2.27	7.15	3.42	4.28	142.1
k-454	Ukraine	1.95	7.84	2.56	4.11	136.5
k-11	China	2.32	7.30	2.47	4.03	133.8
k-191	Kazakhstan	2.25	7.12	2.62	3.99	132.5
k-406	Russia	2.03	6.81	3.23	4.02	133.5
k-501	Azerbaijan	2.01	5.41	2.92	3.44	114.2
k-24	USA	2.05	7.65	1.74	3.81	126.4
k-9	Bashkortostan	1.97	7.41	2.85	4.07	135.2
k-446	Ukraine	2.35	6.35	2.43	3.71	123.2
k-276	Azerbaijan	1.94	6.54	2.77	3.75	124.5
	$LSD_{0.5}$	0.68	0.84	0.72	0.68	-0.0

Table 5: Chemical composition of fodder from alfalfa samples of the harvest of the 2nd year of life by cutting (recorded in 2020)

			Dry matter content, %							
Catalog number	Origin	Absolute Dry Matter (ADM), %	Protein	Fat	Ash	Fiber	Nitrogen-Free Extractive Substances (NFES)	Ca	P_2O_5	K_2O
1st cutting										
St	Semirechinskaya mestnaya	20.5	16.9	2.13	7.23	26.7	39.9	1.50	0.26	1.57
k-451	Ukraine	21.0	18.0	2.48	10.4	27.1	42.0	2.26	0.19	1.75
k-242	Kyrgyzstan	25.0	18.1	2.92	9.03	27.2	42.7	1.96	0.16	1.61
k-322	Russia	22.6	17.0	2.72	8.45	30.2	41.6	1.75	0.28	1.51
k-246	Kazakhstan	15.9	18.5	3.20	7.05	30.9	40.4	1.24	0.21	1.70
k-167	India	19.9	18.5	3.20	7.08	30.9	40.4	1.24	0.21	1.70
k-390	Canada	21.6	16.8	3.07	7.46	29.6	43.1	1.38	0.20	1.56
k-313	Armenia	22.6	20.1	3.17	9.05	29.6	37.6	2.08	0.20	0.93
k-507	Azerbaijan	21.2	18.4	3.32	7.47	29.8	39.6	1.81	0.32	1.36
2nd cutting										
St	Semirechinskaya mestnaya	20.9	19.9	3.33	7.65	27.5	36.7	1.47	0.17	1.69
k-451	Ukraine	21.5	18.4	3.64	7.57	31.1	39.2	1.60	1.15	1.64
k-242	Kyrgyzstan	20.5	17.9	2.85	7.28	29.9	42.2	1.91	0.28	1.65
k-322	Russia	21.6	22.3	2.90	8.20	29.7	36.9	2.15	0.24	1.83
k-246	Kazakhstan	21.9	22.6	3.05	6.91	24.4	38.5	2.13	0.21	1.63
k-167	India	20.1	19.2	3.35	7.14	28.1	37.4	2.19	0.22	1.72
k-390	Canada	21.4	18.2	3.74	7.95	29.5	39.2	2.14	0.23	1.85
k-313	Armenia	20.2	22.1	2.83	7.27	26.1	36.3	2.14	1.02	1.62
k-507	Azerbaijan	20.1	22.1	3.01	7.62	25.3	38.1	2.41	1.06	1.72

Discussion

Seed productivity and yield of green mass, as well as hay yield within the studied collection, are highly variegated traits. The plant height and the degree of leafiness are important traits affecting the yield of alfalfa green mass (Malysheva and Malyshev, 2020; Humphries *et al*., 2021). These indicators have an average variability on the 20th day after regrowth (Chernyavskikh *et al*., 2019a; Ignatev and Regidin, 2019; Meirman *et al*., 2017). The studies of the following authors are devoted to the selection of the source material: Humphries and Hughes (2006), Humphries *et al*. (2006), Annicchiarico *et al*. (2015), Goryunov (2020), Tormozin and Zyryantseva (2020), Voloshin (2020). The authors from South Australia, the USA, and other countries argue that the success in selection comes from studying and making correct choices of raw material, while other authors (Basigalup *et al*., 2018; Humphries *et al*., 2018; Ignatev *et al*., 2021) emphasize that the source material is the basis of ongoing selection of crops including alfalfa and note that the evaluation of alfalfa samples for adaptive properties based on "the green mass yield" shows greater responsiveness to changing environmental conditions than the choices that are characterized by genotypes.

A preliminary assessment of wild relatives of alfalfa previously bred lines, and hybrids were conducted (Meirman *et al*., 2017; Humphries *et al*., 2021; Kalibayev *et al*., 2021).

In addition, alfalfa plays an important role in the farming system and contributes to the stabilization of the ecosystem by improving the physical, chemical, and biological properties of the soil. However, the use of alfalfa is limited due to its susceptibility to soil conditions (Liatukiene *et al*., 2020). The numerous studies by Mosolova *et al*. (2019), Chernyavskikh *et al*. (2019b) and Solozhentseva (2021) contain the experiments of long-term observations (photo monitoring) of the development of fungal diseases affecting alfalfa and several complex diseases commonly called leaf spot and experiments on the evaluation of aerobiological properties of alfalfa in different soil conditions. They observed that the fungal disease reduced the yield of hay and seeds of alfalfa and the years favorable for disease development could lead to a complete loss of the harvest. They also found that affected alfalfa plants accumulated less organic matter per time unit than healthy plants due to reduced energy photosynthesis and increased respiration.

The plants affected by diseases, in turn, lead to a weakening of the development of the root system, which undoubtedly reduces the nitrogen-fixing ability of nodule bacteria in alfalfa roots and the regenerative ability of the soil structure.

Conclusion

In-plant selection, exceptional importance is given to the study and correct selection of the source material in local conditions. Of the 134 samples considered in the study, as a result of the research, productive samples were identified according to their selection and economic characteristics. Concerning the plant height, the highest indicators were observed in the variety samples from Italy (k-5677), Russia (k-31885), Kazakhstan (k-6021), and Estonia (k-38914), Ukraine (k-1721), and the USA (k-46451). The following samples had a high leafiness: The leafiness of the samples from Russia (k-45479), Kazakhstan (k-61324), and Italy (k-5677). Varieties from Kyrgyzstan (k-6238), Uzbekistan (k-21634), and Italy (k-5975) had complex resistance to fungal diseases (yellow leaf spot, brown leaf spot, leaf rust). These selected samples will be used in the further selection process for the creation of new highly productive varieties adapted to the conditions of the south and southeast of Kazakhstan.

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Author’s Contributions

All authors contributed equally to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues are involved.

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