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АГРОНОМИЯ

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Технология возделывания клевера александрийского (*Trifolium alexandrinum*)

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Аннотация. В статье рассмотрены результаты исследований новой разработанной нами технологии возделывания однолетней культуры клевера александрийского (*Trifolium alexandrinum*), включающей в себя методику предпосевной обработки семян с различными сроками и способами посева. В последнее время, наряду с агротехническими мерами по стабилизации растениеводства, возникает необходимость возделывания нетрадиционных культур, полезных для питания и здоровья человека, и далеко не последнюю роль в этом процессе выполняют однолетние бобовые культуры. Короткий цикл вегетации и интенсивные темпы формирования урожая позволяют возделывать их в повторных посевах в местах с благоприятным биоклиматическим потенциалом. Однолетние кормовые травы имеют многообразное использование и назначение. В зоне достаточного увлажнения это хорошие парозанимающие культуры. Однолетним бобовым травам принадлежит большая роль в создании прочной кормовой базы: в летний период они являются основным источником производства зеленых кормов, служат для приготовления сена, сенажа, силоса, концентрированных кормов в виде травяной муки, резки, полнорационных брикетов и гранул; однолетние бобовые травы можно применять и как концентрированный корм в виде зерна. Уборка трав в ранние фазы вегетации и при многоукосном использовании с применением искусственной сушки дает возможность получить корм, не уступающий по общей калорийности овсу и ячменю, а по содержанию протеина значительно превосходящий их. Однолетние травы отличаются большим разнообразием и по агробиологическим особенностям: широко используются они в качестве предварительных культур на землях коренного улучшения и в виде звеньев пастбищного конвейера. Проведенные нами за четыре года (2017–2020) исследования выявили, что предпосевная обработка семян клевера александрийского двойными и тройными смесями ПАБК, крезацина и настоя цикория (на фоне предварительной стратификации) обеспечивает малозатратный, экологически безопасный путь предпосевной стимуляции семян клевера александрийского с одновременной закалкой, адаптацией и отбором лучших видов для использования в конкретном регионе. Посев клевера на семена целесообразно проводить с шириной междурядий 50 см и нормой высева семян 6 кг/га, а оптимальным сроком посева является начало марта и первая декада сентября.

Ключевые слова: клевер, однолетние кормовые культуры, *Trifolium alexandrinum*, технология возделывания.
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AGRONOMY

Original article

Technology of cultivation of annual Alexandrian clover (*Trifolium alexandrinum*)

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Abstract. The article discusses the results of research on a new technology we developed for the cultivation of an annual crop of Alexandrian clover (*Trifolium alexandrinum*), which includes a method of pre-sowing treatment of seeds with different terms and methods of sowing. Recently, along with agrotechnical measures to stabilize crop production, there is a need to cultivate non-traditional crops that are useful for human nutrition and health, and not the least role in this process is played by annual legumes. The short vegetation cycle and the intensive rate of crop formation allow them to be cultivated in repeated crops in places with favorable bio-climatic potential. Annual forage grasses have a variety of uses and purposes. In the zone of sufficient moistening, these are good fallow-grown crops. Annual legumes play an important role in creating a strong fodder base: in the summer, they are the main source of green feed production, they serve for the preparation of hay, haylage, silage, concentrated feed in the form of grass flour, cutting, full-fledged briquettes and pellets; annual legumes can also be used as a concentrated feed in the form of grain. Harvesting grasses in the early phases of the growing season and with multi-crop use with the use of artificial drying makes it possible to obtain a feed that is not inferior in total caloric content to oats and barley, and in protein content is significantly superior to them. Annual grasses are very diverse in terms of their agrobiological characteristics: they are widely used as preliminary crops on indigenous improvement lands and as links in the pasture conveyor. Our research conducted over four years (2017–2020) revealed that pre-sowing treatment of seeds of Alexandrian clover double and triple mixtures of PABA, the krezatsinom and infusion of chicory (against the

background of preliminary stratification) provides low-cost, environmentally friendly way of pre-sowing stimulation of seeds of Alexandrian clover with simultaneous northering, adaptation, and selection of the best species for use in a specific region. Sowing clover for seeds is advantageously carried out with a width of 50 cm row spacing and seeding rate of 6 kg/ha. The optimal sowing date is beginning of March and the first week of September.

Keywords: clover; annual forage crops; *Trifolium alexandrinum*; cultivation technology; initial material

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Introduction. One of the main reasons for the decrease in acreage and productivity of forage crops was a decrease in the level of material and technical support for feed production and a decrease in the demand for feed, due to a significant decrease in the volume of livestock products manufacturing. In solving the problem of increasing feed production and eliminating protein deficiency, it is important to expand the crops of legumes, in particular, clover [1–5]. In addition, clover crops are a highly effective means of restoring and increasing soil fertility [6, 7]. Among other types of clover, an annual type of clover, the Alexandrian clover (Trifolium Alexandrium), may be of great importance. Like other legumes, the Alexandrian clover not only forms a crop of aboveground mass due to symbiotic nitrogen, but also accumulates a significant amount of it in the feed mass and crop residues [8–10].

To expand the crops of the Alexandrian clover, it is necessary to study the biological features of its development, and especially the agrotechnical methods of cultivation, which allow one to obtain the maximum yield of seeds of this crop with the least material and monetary costs.

The purpose of our research was to substantiate and develop the main elements of agricultural technology of seed production of the Alexandrian clover. The objectives of the study were to determine the optimal variant of pre-sowing treatment of Alexandrian clover seeds, which ensures the formation of a highly productive seed herbage with the best parameters of its structure, to determine the influence of the timing and methods of Alexandrian clover sowing on the features of its development, seed productivity and seed quality, feed mass yield, and the nutritional value of the feed obtained.

Methods of research. In the experiments, the object of our research was the Alexandrian clover (Trifolium alexcandrium L.), introduced from Germany. The area of the experimental plotsis 15 m^2, the repetition is three-fold with a randomized placement of options. The agricultural equipment was generally accepted for the cultivation of grasses in this area. The organization of field experiments, observations, biometric measurements, and laboratory analyses was carried out in accordance with the generally accepted methodological guidelines of the All-Russian Williams Fodder Research Institute.

Experiment 1. Pre-sowing seed treatment. The seeds of the Alexandrian clover were previously kept for three days in a cold room at a temperature of 0–2 degrees. Then they were kept for 24 hours in the freezer at a subzero temperature in the range of 18–20 degrees. After that, the seeds were treated with a mixture of 0.1 % aqueous solutions of PABA stimulants (paraaminobenzoic acid), krezatsinom and chicory plant infusion in a concentration of 0.1 % aqueous solution of each component in a ratio of 1:1:2 at an exposure of 1–2 hours.

Experiment 2. Sowing of Alexandrian clover was carried out in a narrow order of 15 cm with a seed seeding rate of 10 kg/ha, 12 kg/ha, 14 kg/ha and in a wide order of 50 cm with a seed seeding rate of 4 kg/ha and 6 kg/ha in the spring (March 5 and April 5) and autumn (September 5, October 10) sowing periods. The experiment was laid with 10 irrigations, due to the demanding nature of the Alexandrian clover to moisture.

Results of research. It is well known that pre-sowing seed treatment is a mandatory element of agricultural technology for the cultivation of all annual and perennial grasses, since during the period of swelling, sprouting, and the beginning of germination, seeds are particularly sensitive to external conditions. During this important period of life, pre-sowing treatment can cause a number of dramatic changes in the physiological and biochemical processes of clover seeds. Table 1 shows the results of the effect of growth stimulants on the clover seeds germination.

Analyzing the results of Table 1, one can conclude that all variants with treatment with stimulant solutions separately and in mixtures against the background of stratification increased the germination rate, field germination and laboratory germination.

Analyzing the results of Table 2, one can conclude that all variants with treatment with stimulant solutions separately and in mixtures against the background of stratification increased the germination rate, field germination and laboratory germination.

Analyzing the results of Table 3, one can conclude that all variants with treatment with stimulant solutions separately and in mixtures against the background of stratification increased the germination rate, field germination and laboratory germination.

Table 1

The effect of pre-sowing treatment on the germination of Alexandrian clover seeds in wide-row sowing (50 cm) with a seed application rate of 6 kg/ha (2017–2020)

Variants	Laboratory germination, %	Germinating energy, %	Field germination, %
Examining	90	80	73
Stratification + Water	92	83	75
Stratification + PABA	94	84	81
Stratification + Krezatsinom	94	83	80
Stratification + Chicory	95	84	80
Stratification + PABA + Krezatsinom	98	88	85
Stratification + PABA + Chicory	98	88	85
Stratification + Chicory + Krezatsinom	98	89	85
Stratification + PABA + Krezatsinom + + Chicory	99	95	91

Table 2

Economic and biological indicators of Alexandrian clover depending on pre-sowing seed treatment with wide-row sowing (50 cm) with a seed application rate of 6 kg/ha (2017–2020)

Variants	Footstalk height, cm	Number of footstalks per 1 m^2, pcs	Harvest of green mass of 1 mowing, dt/ha
Examining	7	69	12
Stratification + Water	13	76	13
Stratification + PABA	16	89	13
Stratification + Krezatsinom	17	95	14
Stratification + Chicory	19	95	14
Stratification + PABA + Krezatsinom	22	99	22
Stratification + PABA + Chicory	24	99	23
Stratification + Chicory + Krezatsinom	26	100	24
Stratification + PABA + Krezatsinom + + Chicory	28	112	28.2

Table 3

The effect of pre-sowing seed treatment on the biological yield of Alexandrian clover seeds in wide-row sowing (50 cm) with a seed application rate of 6 kg/ha (2017–2020)

Variants	Number of flowering tops, piece/m^2	Biological seed yield, gram/m^2
Examining	59	20,9
Stratification + Water	65	22,8
Stratification + PABA	71	23,1
Stratification + Krezatsinom	70	23,1
Stratification + Chicory	74	23,3
Stratification + PABA + Krezatsinom	75	25,2
Stratification + PABA + Chicory	76	25,3
Stratification + Chicory + Krezatsinom	81	25,1
Stratification + PABA + Krezatsinom + Chicory	86	28,4

Thus, the technology we developed provides a low-cost, environmentally safe way of pre-sowing seed stimulation with simultaneous northering, adaptation and selection of the best species for use in a particular region.

Based on the conducted field studies on leached chernozem, it was revealed that this type of clover is thermophilic, it requires excessive moisture and irrigation (from 10 to 15). Due to the lack of moisture, the emergence of seedlings is delayed for up to 14 days. Diseases and pests are poorly affected.

There are no sharp differences in the origin of the phases: branching, budding, flowering, tops formation, and seed maturation of the Alexandrian clover, depending on different sowing dates and seed seeding rates. There is a tendency for the development phases to pass more quickly on crops with row spacing of 50 cm. So, in the autumn sowing period, the maturation of seeds was on average faster by 2–4 days, in the spring – by 2 – 5 days.

Different seed application rates and row spacing widths were also determined by different number of clover plants before mowing by 1 m^2. The maximum plant stand was at the highest rate of seeding – 14 kg/ha and averaged 337 pcs/m^2 for the autumn sowing period and 203 pcs/m^2 for the spring sowing period over three years. With a minimum seeding rate of 4 kg/ha, the plant stand was 215 and 117 pcs/m^2, respectively.

The height of the plants at the time of accounting for the harvest was 87–90 cm. It is established that the most intensive growth of Alexandrian clover plants occurs between the phases of branching – budding and the beginning of flowering – mass flowering. In the interphase period of budding – the beginning of flowering, the linear growth of clover is somewhat slowed down. Structural analysis of Alexandrian clover plants showed that this crop has 7–13 generative and 2–4 vegetative shoots. The number of clover heads on one shoot ranges from 5 to 12 pieces. There are from 45 to 72 flowers on one head, and from 40 to 70 seeds.

With a wide-row autumn sowing, more favorable conditions are created for the formation of seeds of Alexandrian clover, especially with a small seeding rate. When sowing on September 5 with a row spacing of 15 cm, the number of seeds in the head did not exceed 58 pieces, with the same sowing period, but with a row spacing of 50 cm and a seeding rate of 6 kg/ha – 71 seeds per head of clover. Similar features were noted when sowing on October 10, where this indicator was 53 and 64 seeds, respectively.

One of the main tasks of the research was to determine the possibility of sowing Alexandrian clover in the late autumn period in order to obtain a seed crop for the next year. With this method of cultivation it is important the ability of plants to tolerate winter cold, i.e. winter hardiness.

In these studies, observations were made for clover sown on September 5 and October 10. The loss of plants did not exceed 4.8 % in winter 2017–2018 and 5.2 % in winter 2019–2020. Moreover, when sowing with row spacing of 15 cm, an average of 1.8 % of plants fell, and in wide-row crops – 2.6 %. Obviously, it was affected by the microclimate in the clover crops on the conditions of overwintering. Distant from each other plants with wide-row crops are more susceptible to frost and especially winds.

The yield of the seeds of the Alexandrian clover, which was determined in the second mowing, was directly dependent on the area of nutrition. In the autumn sowing period, with a row spacing width of 15 cm, it did not exceed 1.7 dt/ha, and when sowing on October 10 with a seeding rate of 10 kg/ha, it was on average – 1 dt/ha for 2 years of research. When sown on September 5, the yield of wide-row crops exceeded the average seed yield, when sown after 15 cm at a seeding rate of 4 kg/ha – by 7 %, and at a seeding rate of 6 kg/ha – by 20 %. When sown on October 10, the yield of clover seeds at a seeding rate of 6 kg/ha exceeded the average yield of narrow-row crops by 10 %.

At the spring sowing dates (March 5 and April 5), the seed yield in narrow-row crops was less than in the autumn sowing dates and did not exceed 1.6 dt/ha. The seed yield on wide-row crops at the seeding date of March 5 was 43 % higher with a seeding rate of 4 kg/ha and 73 % higher with a seeding rate of 6 kg/ha than on narrow-row crops. When sowing on April 5, a similar dependence was noted. The seed yield in wide-row crops was 55 % higher at a seeding rate of 4 kg/ha and 92 % higher at a seeding rate of 6 kg/ha (Table 4).

The minimum yield for narrow-row crops was noted with a seed seeding rate of 10 kg/ha of 1.3 and 1.4 dt/ha. The obtained seeds were characterized by high sowing qualities. At the same time, it should be noted that the quality of the seeds was influenced by the width of the row spacing during

sowing. So at all times of sowing, the weight of 1000 seeds and germination were slightly higher with wide-row crops with a seeding rate of 4 and 6 kg/ha. The yield of Alexander clover hay, depending on the timing and methods of sowing, was on average in the range of 18.6-28 dt/ha. In the autumn period (September 5), the highest yield was observed with continuous sowing with a seed application rate of 12 kg/ha – 28.2 dt/ha of hay. The increase in the seeding rate to 14 kg/ha did not give a reliable increase in the yield. The minimum yield at this time of sowing is noted when sowing clover with a norm of 4 kg/ha and a row spacing width of 50 cm – 10.5 dt/ha. When sowing on October 10, the same pattern was noted – the yield of clover with continuous sowing was almost twice as large as when sowing with a row spacing of 50 cm. The yield of clover at the spring sowing dates was also maximum with the close-growing method.

Thus, the conducted studies have shown that the largest yield of the fodder mass of the Alexandrian clover forms with a close-growing method of sowing with a seed application rate of 12 kg/ha.

Table 4

The yield of hay and seeds of Alexandrian clover, depending on the timing and methods of sowing, dt/ha (2017–2020)

Date of seeding	Row-width spacing, cm	Seed application rate, kg	Average crop yield, kg		Weightof 1000 seeds, grams	Germinating energy, %	Germination, %
			hay	seeds			
5.09	15	10	18.6	1.5	2.4	84 %	98 %
		12	28.2	1.5	2.4	84 %	97 %
		14	28.0	1.5	2.2	84 %	98 %
	50	4	10.5	1.4	3.0	86 %	95 %
		6	14.0	1.8	3.0	88 %	100 %
10.10	15	10	25.0	1.0	2.7	84 %	97 %
		12	27.6	1.5	2.8	82 %	98 %
		14	16.8	1.6	2.9	82 %	98 %
	50	4	10.5	1.1	2.9	84 %	95 %
		6	11.3	1.8	2.9	88 %	100 %
5.03	15	10	16.6	1.1	2.6	84 %	99 %
		12	23.0	1.1	2.8	84 %	99 %
		14	15.4	1.2	1.7	84 %	97 %
	50	4	13.8	1.2	2.9	85 %	96 %
		6	12.0	1.3	2.9	88 %	100 %
5.04	15	10	14.2	1.1	2.3	83%	97 %
		12	22.2	1.1	2.5	83 %	97 %
		14	17.0	1.2	2.6	83 %	97 %
	50	4	10.5	1.2	2.8	84 %	94 %
		6	11.4	1.3	2.9	89 %	100 %
LSD				0.5	00.1		

It is impractical to sow Alexandrian clover for fodder purposes with row spacing of 50 cm, since the yield is reduced by 2 times compared to close-growing method of sowing.

Determination of the yield of Alexandrian clover by the phases of its development showed that from germination to budding, Alexandrian clover forms 14–16 % of the potential yield of green mass. Therefore, it is impractical to mow it during this period. By the phase of the beginning of flowering, up to 80 % of the crop is formed, so it is advisable to remove the Alexandrian clover for green food or hay in the phase of the beginning of flowering.

Thus, studies have shown that it is possible to sow Alexandrian clover for seeds in the spring and autumn periods (September – October and March – April). The highest yield of Alexandrian clover seeds was obtained both in autumn and spring sowing periods and in wide-row crops (row spacing is 50 cm) with a seed sowing rate of 6 kg/ha – 1.3 and 1.8 dt/ha, respectively, which is 73 and 92 % more than when sowing with row spacing of 15 cm.

Conclusions. Thus, the conducted studies have shown that this type of clover is thermophilic, it requires excessive moisture and irrigation (from 10 to 15). Due to the lack of moisture, the emergence of seedlings is delayed for up to 14 days. Diseases and pests are poorly affected. Pre-sowing treatment of Alexandrian clover seeds with double and triple mixtures of PABA (paraaminobenzoic acid), Krezatsinom and chicory infusion (against the background of preliminary stratification) is more effective in comparison with separate treatment with biological products, while treatment with a triple mixture was most effective in the ratio of 1:1:2. Thus, the technology we developed provides a low-cost, environmentally safe way of pre-sowing seed stimulation with simultaneous northering, adaptation and selection of the best species for use in a particular region. One can sow Alexandrian clover for seeds in the spring and autumn periods (September – October/March – April). The highest yield of Alexandrian clover seeds was obtained both in autumn and spring sowing periods and in wide-row crops (row spacing is 50 cm) with a seed sowing rate of 6 kg/ha – 1.3 and 1.8 dt/ha, respectively, which is 73 and 92 % more than when sowing with row spacing of 15 cm. The highest yield of Alexander clover hay at the first mowing was obtained when sowing 12 kg/ha with a row spacing of 15 cm. Important for increasing the seed productivity of the Alexandrian clover is the determination of the period of its harvesting for seeds. The optimal harvesting period for seeds is the second mowing when using the first one for hay. Determination of the yield of Alexandrian clover by the phases of its development showed that from germination to budding Alexandrian clover forms 14–16 % of the potential yield of green mass. Therefore, it is impractical to mow it during this period. By the beginning of the flowering phase it is formed up to 97 % of the plant mass. It is advisable to remove the Alexandrian clover for green fodder or hay in the phase of the beginning of flowering of the seed herbage. The wide-row method of sowing Alexandrian clover for seeds provides a conditionally net income than the narrow-row sowing.

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