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RESEARCH ARTICLE

Biological, physiological and economic characteristics of *Onobrychis chorasanica* Bunge ex Bois. (Sainfoin) under sowing conditions

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Abstract

Onobrychis chorasanica Bunge ex Bois. (Sainfoin) is a valuable pasture plant that is resistant to drought, produces high biomass and is not inferior to alfalfa in terms of nutrient content. It is urgent to research the possibilities of cultivation of this plant for the purpose of growing hay in hilly conditions. The presence of nitrogen-fixing Rhizobium bacteria in the roots of plants is important in increasing the fertility of desert soils and this feature increases its role in the creation of artificial grasslands in hilly conditions. In the experiments, it was shown that it is possible to reach 100 % germination by mechanical scarification of the seeds isolated from *O. chorasanica* pods using sandpaper. Germination of unscarred seeds in field conditions depends on the year and the depth of planting them in the soil. In a dry year, the highest fertility was observed to be 13.3-15.0 % in the options where the seeds were buried at a depth of 3-4 cm, and in years with abundant rainfall, this indicator was 35.3 % in the option where the seeds were buried at a depth of 3 cm. The viability of lawns in the 2nd year of life was 72-95 % in different options. Hay productivity of *O. chorasanica* was found to be 41 centners per ha in hilly conditions and seed yield was up to 250 kg. The results obtained in the research are promising for the intensification of feed production of *O. chorasanica* in local conditions. The obtained results serve to increase the biomass yield of pasture plants and the variety of used feeds in farms specializing in animal husbandry.

Keywords

drought resistance; hydration of assimilation organs; *Onobrychis chorasanica* Bunge ex Bois. (Sainfoin); pastures; seed germination; water deficiency

Introduction

In addition to being a component of biological diversity in nature, plants serve as a source of food, medicine, textiles and building materials for mankind (1, 2). Also, there are plant species that are harmful to human health plants (3, 4). Research work on the cultivation of Sainfoin *Onobrychis chorasanica* Bunge ex Bois. (Fabaceae: Faboideae), is carried out in the fields of the Kitob forestry in the foothills of the Kitob district of Kashkadarya region (Fig. 1). In the natural and climatic conditions of the region, this plant is found in the wild. Its valuable nutritional properties and

Fig. 1. *Onobrychis chorassanica* general view.

the ability to accumulate a relatively high yield of hay allow it to accumulate nutritious feed for livestock in local conditions. Another valuable feature of the plant is the formation of nitrogen-fixing bacteria in its roots and the enrichment of the soil with natural nitrogen. Therefore, one of the urgent tasks is to intensify food production by growing plants in local conditions. This, in turn, requires the development of effective agrotechnical measures for its cultivation based on a comprehensive study of the biological, ecological and physiological characteristics and economic characteristics of the plant. Based on the above analysis, we aimed to study some biological, water regime and economic characteristics of *O. chorasanica* under sowing conditions.

The flora of Uzbekistan is diverse (5-8). Taking into account the purpose of the work, it is important to study the condition of different types of pastures in the Kitab district of Kashkadarya region, the degree of degradation, the introduction of *O. chorasanica* pastures into the vegetation cover and ways of their rational use. *Onobrychis chorasanica* crops are planted on an area of 0.5 ha. The obtained materials are used in the development of scientific and practical foundations for the adaptive use of agroecological resources, including optimization of flora composition, assessment of biological diversity and identification of the resource potential of natural vegetation.

Materials and Methods

The source of the study was 2-year-old *O. chorasanica* plants grown under seeding conditions. The study of daily dynamics of the amount of water in plant tissues was studied by determining the absolutely dry mass of samples taken during the period from 7:00 to 17:00 in the morning during the months of active growth (April) and flowering (May) and examined by express measurements. Determining the intensity of water evaporation by plants was carried out by express measurement using Ivanov's method (9). When studying the quality indicators of seeds, generally accepted methods in seed production were used (10-12).

When studying the germination of seeds in laboratory conditions, 100 seeds were sown in 3-fold repetition in Petri dishes in a thermostat at a variable temperature of 10-30 °C. Seed germination in the field was studied by determining the number of germinated seedlings by sowing 100 seeds at different depths (1-5 cm) in 3 repetitions. Sandpaper was used for the mechanical scarification of seeds.

When studying the root system of plants, the method of "deep excavation" was used (13) and when studying economic properties, the methods proposed by (14) were used. In the biostatistical analysis of the results obtained, the methods proposed (15) were used.

Results and Discussion

In April, the amount of water in the assimilative organs of *O. chorasanica* was 78.8 % at 7:00 am, and a slight decrease was observed until mid-afternoon, that is, this amount decreased to 76.8 % at 11:00. From this period, there was a rise in the water level and by the end of the afternoon, that is, at 17.00, it was found that the water

level had risen to 80.2 %. That is, it was noticed that in the evening, the amount of water returned to its morning state.

In April, the amount of moisture in the soil layer to a depth of 120 cm was fixed at 6.71 %, and in May, it was found that this indicator increased to 8.17 %, that is, a large amount of precipitation in April provided soil moisture, in May it was higher than in April. Nevertheless, in May, in the daily dynamics of the amount of water in the assimilation organs of *O. chorasanica*, a significant decrease in the amount of water was observed (Fig. 2).

That is, even in the afternoon, although the soil moisture was significantly higher than in April, the amount of water in the assimilation organs steadily decreased until the evening and only slightly increased by 17 o'clock. In the first decade of June, the maturation of *O. chorasanica* seeds was observed and during this period, there was a sharp decrease in the amount of water in the assimilation organs, that is, it amounted to 63.2 % at 7:00 am, by 15:00 h it decreased to 53.8 % and from 17:00 h a little more growth was observed.

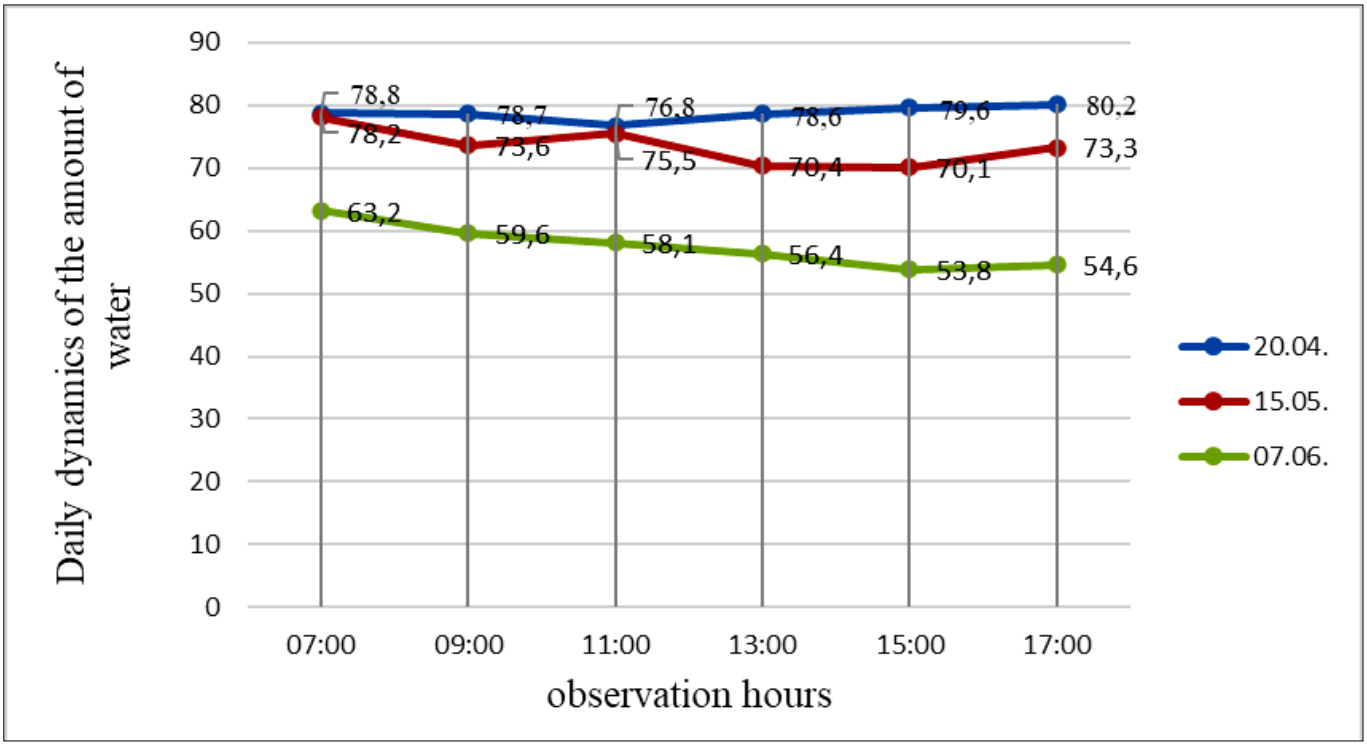

Fig. 2. Daily dynamics of the amount of water in the organs of assimilation *Onobrychis chorassanica*, %.

Therefore, the amount of water in the assimilative organs of *O. chorasanica* gradually decreases due to its ontogenesis; during the period of its rapid growth (April) (78.8-80.2 %), this amount is of the greatest importance and during the period of seed maturation it decreases significantly (63.2-54.6 %).

Water shortage

The daily dynamics of water deficiency of *O. chorasanica* in the months of its rapid growth (April) and flowering (May) have been studied. The maximum indicator of water shortage was observed in April, in the middle of the day, and at 12:00, this indicator was 28.5 %. At 7.00 in the morning, this indicator was minimal, i.e., 17.2 % and at 17.00 in the evening - 19.4 %.

By May, there was a slight decrease in water scarcity; that is, its maximum was observed in the middle of the day, and it was determined that it amounted to 20.01 %. At 7.00 In the morning, this indicator was 9.2 % and at 17.00 in the evening – 16.02 %. A significant decrease in water scarcity by May can be explained by the fact that almost 45-50 % of plant leaves have reached the drying stage (Fig. 3).

It was found that *O. chorasanica* demonstrates the highest rate of water evaporation during the period of rapid growth and flowering, and its yield is inextricably linked with the amount of moisture in the soil during this period. During the period of rapid plant growth (April) at 7:00 am., 324.4 mg of water evaporated from 1 g of wet mass in 1 h and the maximum evaporation rate of water was observed at 11:00 and this amount was 2530.9 mg/g. It was noted that the intensity of water evaporation gradually decreased in the second half of the day and by 17:00 reached the morning state, i.e. 326.6 mg/g h.

By May, despite the fact that the humidity in the 120 cm soil layer was 1.46 % higher than in April, there was a significant decrease in the intensity of water evaporation. The reason for this, in our opinion, is due to the fact that a certain part of the leaves of plants is in a state of drying, i.e., with a significant decrease in the evaporation surface of water.

During all observation periods, it was found that the intensity of water evaporation was significantly lower than in April; that is, at 7:00 am., 296.3 mg of water evaporated from 1 g of wet mass in 1 h, while the highest rate was observed at 11:00 and amounted to 1513.3 mg/g h.

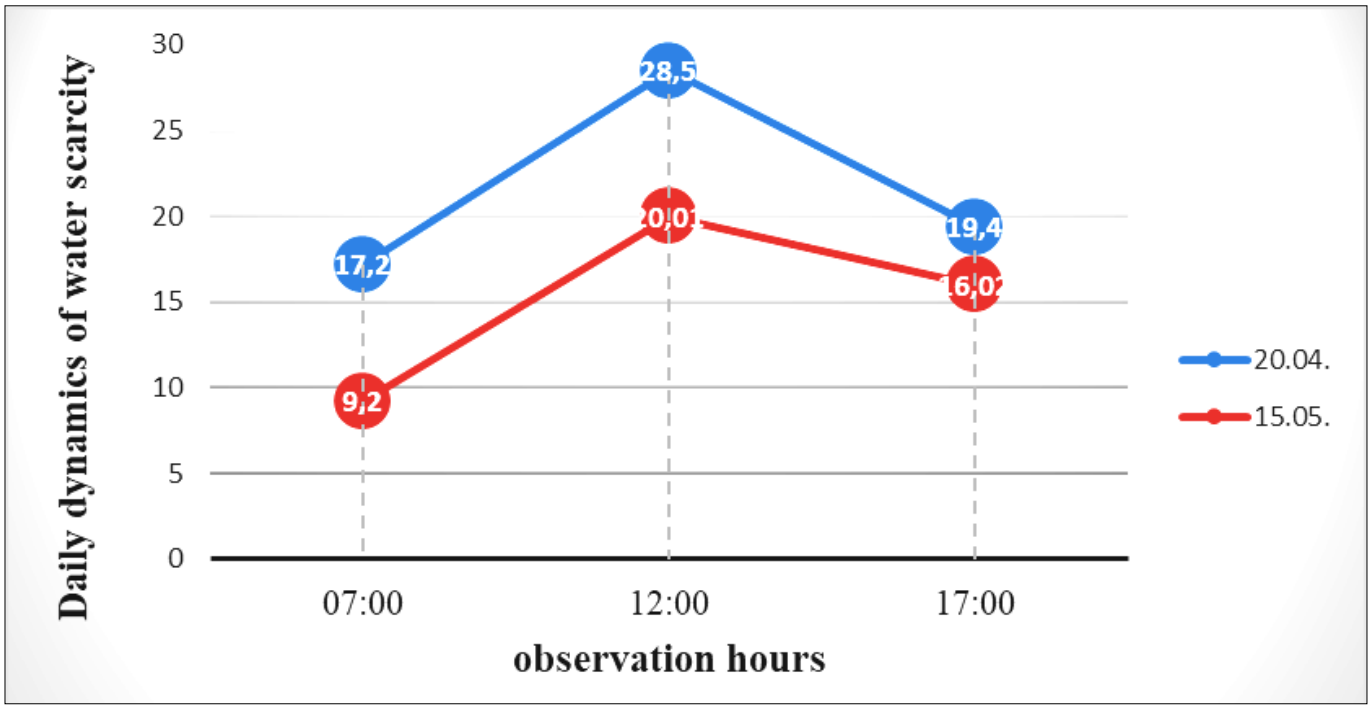

Fig. 3. *Onobrychis chorassanica* daily dynamics of water scarcity, %.

At 13:00, this indicator decreased slightly and amounted to 1202.7 mg/g•h, and by 15:00, it was found that the intensity of water evaporation increased slightly, *i.e.* amounted to 1481.0 mg/g• h. In the evening, i.e., at 17.00, there was another sharp decrease in the intensity of water evaporation (271.8 mg/g h).

So, if the intensity of evaporation of water *O. chorasanica* in April formed a single-vertex curve, that is, the maximum evaporation of water was observed in the 1st half of the day and a sharp decrease was observed in the 2nd half, then by May the maximum indicators of evaporation of water during its flowering were at 11.00 am (1513.8 mg/g h) and were observed at 15.00 (1481.0 mg/g h), that is, they had the form of a □-vertex ÅĻŒĐÅ (Fig. 4).

The beginning of drying of the leaves by the time of flowering indicates the end of the growing season of the plant. The peculiarities of the water regime of *O. chorasanica* in the hilly terrain of the Chust district of the Namangan region were studied (16) and the daily dynamics of physiological indicators, such as the intensity of water evaporation, the amount of water in tissues and water deficiency. When comparing the data with our studies, it was found that the data obtained are similar.

According to the researcher, *O. chorasanica* has a short growing season in the hilly terrain of the Fergana

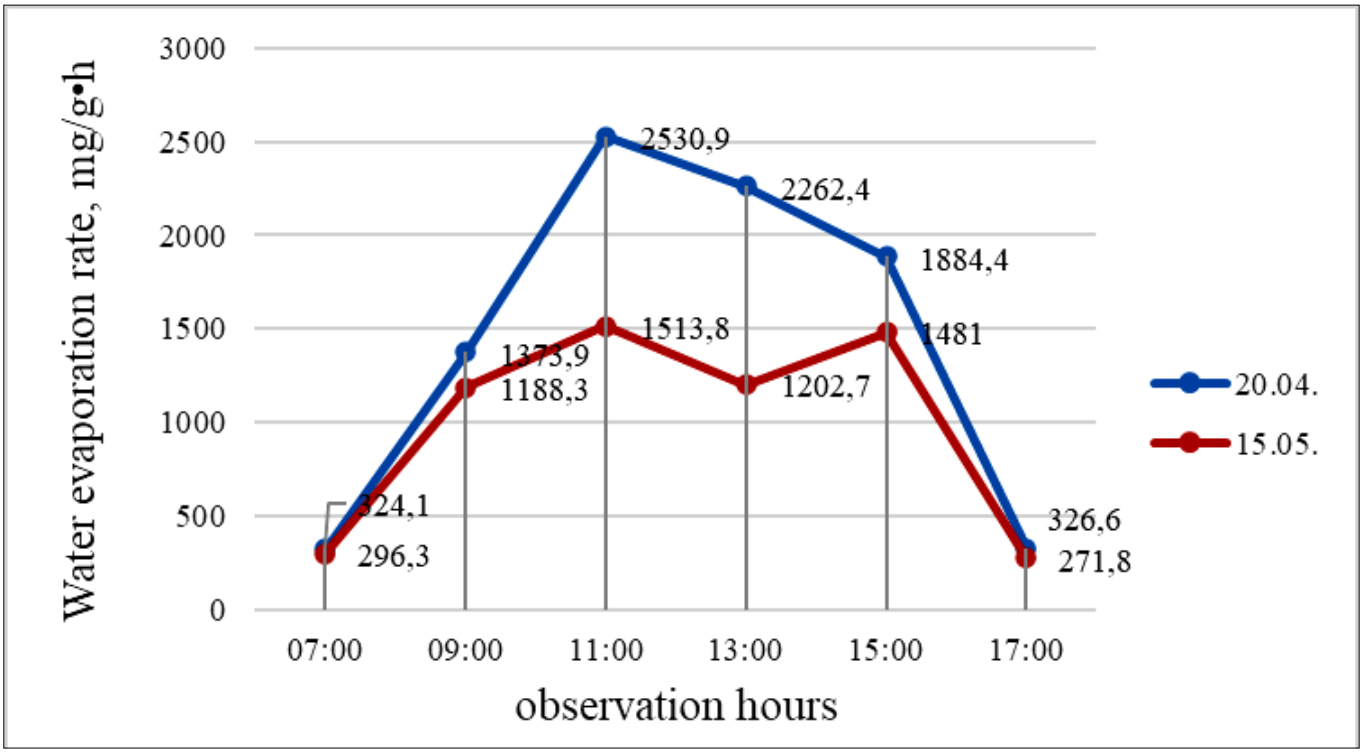

Fig. 4. *Onobrychis chorassanica* water evaporation rate, mg/g.h.

Valley and despite the high water content of its leaves, begins to dry up with a relatively small water deficit and relatively low osmotic indicators. Thus, *O. chorasanica* does not withstand the dry summer season and has the peculiarity of ending the growing season at the end of the spring and the beginning of the summer season. The best time to prepare nutritious hay from *O. chorasanica* is its flowering period, i.e., the second half of May.

The root system

Another important biological feature of *O. chorasanica* is the formation of nitrogen-fixing bacteria in the root system. It is known that there are plant species in nature that increase soil fertility. These include most species of legumes. The soils of desert and semi-desert areas, occupying 62 % of the territory of Uzbekistan, consist of light gray soils; their fertility is very low: the amount of humus in the surface layer is only 0.9-1.17 % and this amount decreases sharply as it deepens. The total amounts of nitrogen and phosphorus, which are the main nutrients in the soil, are also very low: the total nitrogen content is 0.12-0.006 % and the total phosphorus content is 0.19-0.02 %. Extremely low soil fertility and moisture deficiency are the main factors determining the low productivity of desert pastures. Therefore, the search for scientific solutions to increase the productivity of soils in desert regions is one of the urgent problems.

In addition to some free-living bacteria that absorb nitrogen from the air, there are also bacteria belonging to the genus *Rhizobium* (Rhizobiaceae) that live and reproduce by moving from the soil through the root hairs into the parenchymal tissue of the root bark. As a result, the cells of the root parenchyma tissue multiply by division, forming growths wrapped in a shell and they are called root nodules. Inside the nodules, there are many bacteria that help to absorb nitrogen from the atmosphere and accumulate it in the nodules and soil. Usually, nodule bacteria coexist with plant species belonging to the legume family Fabaceae. Plants absorb nitrogen mineral compounds produced by nitrogen-digesting bacteria and bacteria feed on ready-made carbohydrates in the cells of the secondary root shell. Thus, a mutually beneficial symbiosis arises between the plant and bacteria. In addition to substances that ensure the growth and development of nitrogen-fixing nodule bacteria, the root of leguminous plants contains other substances that prevent the penetration of foreign bacterial species. According to the literature, certain types of *Rhizobium* bacteria are characteristic of legumes of certain species, *i.e*., for example, *Lupinus* nodule bacteria cannot form a symbiosis together with the roots of *Glycine*, *Trifolium* and other legumes (17).

Therefore, it is recommended that the seeds of some types of legumes be treated with certain bacteria if they have not previously been grown in such conditions.

In the studies conducted on the cultivation of astragalus species at the foothills of Nurota mountain, the formation of nodules was not observed in the process of studying the formation of nodule bacteria belonging to the *Rhizobium* family in the root system of most Astragalus species (18).

According to the literature, the number of nitrogen-accumulating nodules in the roots of *O. chorasanica* species is significantly higher than that of alfalfa. *O. chorasanica* is adapted to growing in a desert area and *O. chorasanica* is found wild in the foothills and its cultivation in desert areas allows it not only to enrich the soil with nitrogen but also to obtain high-quality hay.

The study of the formation of the root system of *O. chorasanica* showed that there are root nodules on the

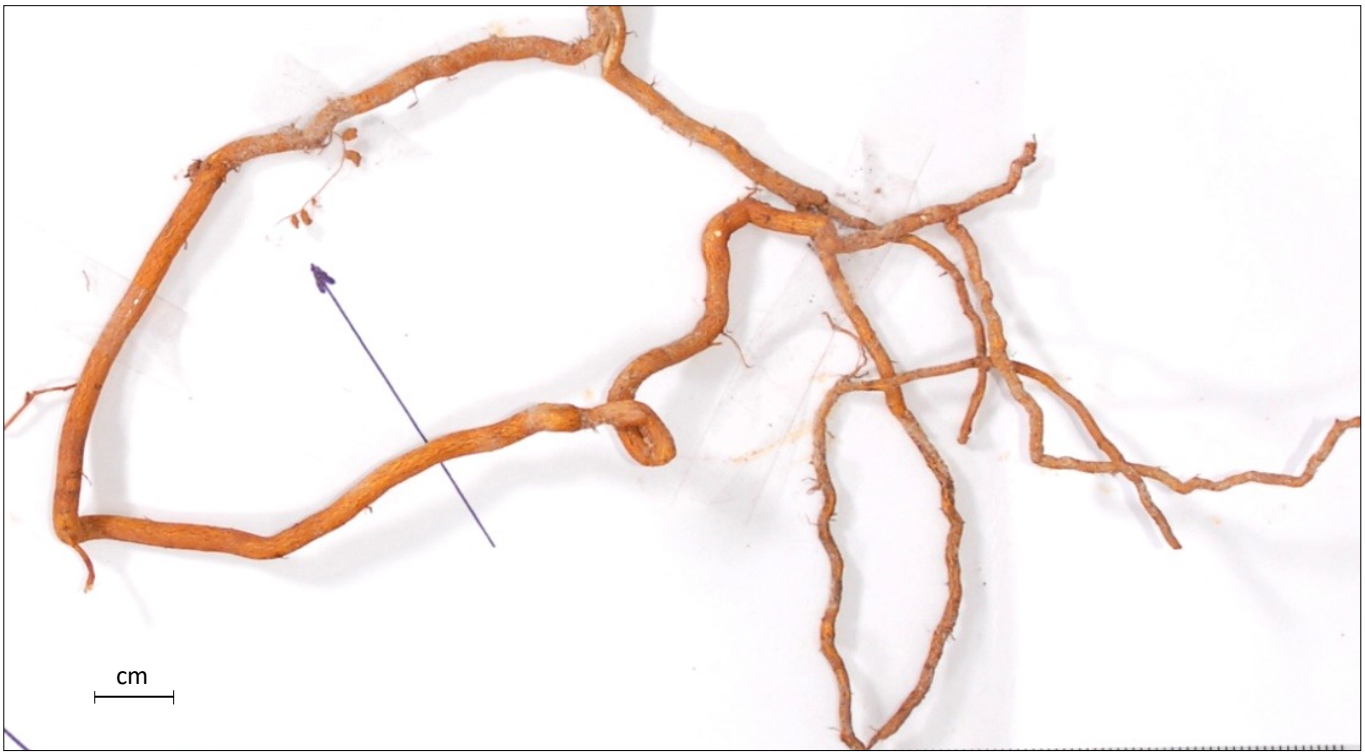

Fig. 5. *Onobrychis chorassanica* is root nodules.

roots of 3-year-old plants, which are localized mainly in the main axial root and secondary lateral roots located at a depth of 10-70 cm in the root system (Fig. 5). Root nodules have a diameter of 3-5 mm; as they penetrate into the deep layers of the soil, their size and number decrease.

Therefore, root nodules develop more in the relatively upper layers of the soil and this is important for providing nitrogen to other plant species. Unlike the species of Astragalus, the presence of nitrogen-accumulating root nodules in the root system of *O. chorasanica* can be explained by the fact that if *O. chorasanica* is considered a wild native species in the foothills of Nuratau, i.e. in these conditions for a long time all acclimatized species of Astragalus were introduced into these conditions, for example, most species of Astragalus are endemic species.

The presence of nodule bacteria accumulating nitrogen in the roots of *O. chorasanica* increases its importance as a promising phytomeliorant. The enrichment of the soil with nitrogen, i.e., increasing its fertility, makes it possible to effectively use infertile desert soils, ensuring high productivity of mountain pastures. Thus, the presence of nitrogen-accumulating Rhizobium bacteria in the roots of *O. chorasanica* is important for increasing the productivity of desert soils and this feature shows the relevance of creating artificial crops of *O. chorasanica* in the foothills.

Sowing qualities of seeds

Seeds of *O. chorasanica* develop inside beans bent in the shape of a kidney (Fig. 6). The diameter of the beans is 1.3 ± 0.09 B̲ B̲ and the mass of 1000 seeds is 14.2 g. Usually, 1 seed develops in the beans and 20-25 %, but can have 2 seeds. *O. chorasanica* seeds have a characteristic hardness characteristic of legumes, which means that they can be attributed to macrobiotic seeds, which means that their viability persists for a long time. When studying the germination of *O. chorasanica* seeds in laboratory and field conditions, the following data were obtained. In laboratory conditions, the seeds were grown in a TS-80M thermostat at a variable temperature of 10-30 °C.

Before sowing, different methods of seed treatment were used: soaking seeds without the pericarp in water for 1-2 days, mechanical scarification of beans (rubbing with sandpaper) and control - separation of seeds from the pericarp of seeds. The results of the experiment showed that soaking seeds in tap water for 1-2 days provided germination of 28-29 %, but the duration of the experiment was extended to 90 days (Table 1).

Germination was 35 % in the variant, the seeds of which were separated from the pericarp (control), the duration of the experiment was 30 days and the germination of mechanically scarified seeds reached 100 % within 30 days. Mechanical scarification also provided higher germination energy (germination rate of 86.6 % in 10 days).

Analysis of the data obtained in the experiment shows that *O. chorasanica* seeds are characterized by hardness and mechanical scarification of seeds before sowing (rubbing with sandpaper and damage to the seed coat), allowing to increase their germination in laboratory conditions up to 3 times and shorten the germination period. Germination of seeds in the field. In experiments to study the germination of seeds in the field, the seeds were sown without separation from the pericarp. In experiments to study the germination of *O. chorasanica* seeds in the field, 100 seeds are sown to a depth of 1, 2, 3, 4 and 5 cm in each variant and the number of seedlings is calculated. The experiment was repeated 3 times. The data of this experiment are presented in Tables 2 and 3. As can be seen from the data in Table 2, the seeds of *O. chorasanica* have a germination feature in all variants (depth 1-5 cm). In the relatively arid 2022, the greatest germination was observed with the variants of sowing seeds to a depth of 2, 3 and 4 cm, at a depth of 2 cm was 10.0 %, at a depth of 3 cm–15 %, at a depth of 4 cm-13.3 %. At a depth of 1 cm, germination was only 5.3 % and at a depth of 5 cm, this fig. was 10.3 %. In the experiments of 2023, the seeds were sown to a depth of 1, 2 and 3 cm.

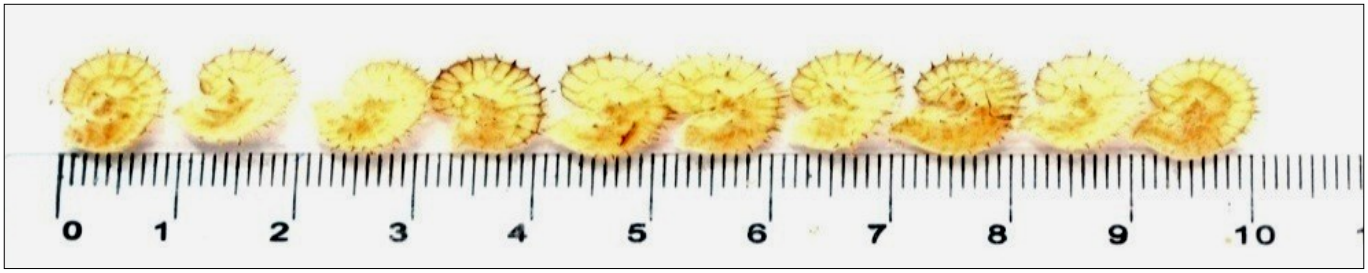

Fig. 6. Beans of *Onobrychis chorassanica*.

Table 1. Germination of seeds of *Onobrychis chorassanica* in laboratory conditions, %.

Experience options	Seed germination and duration of the experiment, days								
	10	20	30	40	50	60	70	80	90
Soaking for 1 day	2,0	4,0	5,3	11,3	15,3	19,2	22,8	23,3	28,7
Soaking for 2 days	2,0	7,1	7,2	9,0	15,0	22	22	29,0	29,0
Seeds without pericarp (control)	16,0	32,0	35,0						
Seeds without pericarp,mechanically scarified	86,6	96,6	100,0						

Table 2. Germination of seeds of *Onobrychis chorassanica* when sown at different depths, % (Kitab experimental field, 2022).

Sowing depth, cm	Number of seedlings, pcs			M ± m
	I	II	III	
1	4	7	5	5,3 ± 1,9
2	10	9	11	10,0 ± 0,8
3	15	14	16	15,0 ± 0,8
4	12	15	13	13,3 ± 1,9
5	9	12	10	10,3 ± 1,9

Table 3. Germination of seeds of *Onobrychis chorassanica* when sown at different depths, % (Kitab experimental field, 2023).

Sowing depth, cm	Number of seedlings, pcs			M ± m	Germination ,%
	I	II	III		
1	30	29	27	28,6 ± 1,9	28,6
2	27	30	25	27,3 ± 5,2	27,3
3	35	38	33	35,3 ± 5,2	35,3

The data obtained (Table 3) show that in 2023, when precipitation is relatively abundant, germination in all variants increased sharply and reached 28.6-35.3 %.

Nevertheless, the highest germination rate (35.3 %) was observed with the option of sowing seeds to a depth of 3 cm. Therefore, regardless of the conditions of the year, in order to achieve high germination, it is advisable to sow them to a depth of at least 3.0 cm.

Table 4. Survival rate of *Onobrychis chorassanica* seedlings, %

Indicators	Second (2022) year	Third (2023) year
Number of plants, thousand pcs./ha	27,3	25,4
Plant survival, %	93,7	91,3
Plant height, cm	60,1 ± 1,3	67,3 ± 1,4
Yield of green mass, t/ha	9,56 ± 0,78	16,37 ± 1,43
Hay yield, tons/ha	2,97 ± 0,46	4,16 ± 0,73
Seed yield, kg/ha	154,4 ± 14,3	261,7 ± 11,2

The survival rate of seedlings

The survival rate of seedlings was determined by comparing the number of existing plants in experiments, sowing in 2021, with the number of preserved seedlings in 2022 (spring) (Table 4).

As can be seen from the data, it was found that the survival rate of seedlings in variants sown at different depths in the 2nd year of life was significantly higher (72.6-95.0 %). However, the highest survival rate was observed in variants with planting seeds to a depth of 3 and 4 cm (90.3 and 95.0 % respectively). These data also indicate that the optimal depth of embedding *O. chorasanica* seeds in the soil is 3-4 cm.

Economic properties of Onobrychis chorassanica

It was found that the yield of the green mass of *O. chorasanica*, cultivated in the foothills of the Kitab district of Kashkadarya region, one of the Southern regions of Uzbekistan, in the 3rd year of life is 16.37 tons/ha and the yield of hay is 4.16 tons, the yield of seeds is 261.7 kg/ha (Table 5). *Onobrychis chorasanica* is a drought–resistant plant. It is adapted for good growth on dry hillsides. It is well eaten by all types of livestock and is considered a valuable hay plant.

Table 5. Indicators of the economic characteristics of *Onobrychis chorassanica* in the conditions of the foothills of the Kitab district (Kitab Experimental Field, 2022-2023).

Indicators	Second (2022) year	Third (2023) year
Number of plants, thousand pcs./ha	27,3	25,4
Plant survival, %	93,7	91,3
Plant height, cm	60,1 ± 1,3	67,3 ± 1,4
Yield of green mass, t/ha	9,56 ± 0,78	16,37 ± 1,43
Hay yield, tons/ha	2,97 ± 0,46	4,16 ± 0,73
Seed yield, kg/ha	154,4 ± 14,3	261,7 ± 11,2

Onobrychis chorasanica is cultivated on large areas in Ukraine, Transcaucasia, Kyrgyzstan, Kazakhstan as valuable nutritious plants. Three of its species are mainly cultivated in culture such as *Onobrychis transcaucasica* Grossh, a perennial plant, harvested twice a year, *O. viciifolia* Scop and *O. arenaria* (Kit.) DC. a perennial plants harvested once a year.

Onobrychis species are not inferior in feed value to alfalfa. Hay of various *Onobrychis* species contains 10.6-25.4 % protein, 1.6-5.6 % fat and 20.9-34.5 % fiber (19, 20). Of particular importance in strengthening the fodder stock of livestock, is the development of agrotechnical measures for its cultivation in the foothill semi-desert region of Uzbekistan. The best time to prepare nutritious hay from *O. chorasanica* is its flowering period, i.e., the 2nd half of May.

Conclusion

An analysis of the available literature shows that *Onobrychis chorasanica* Bunge ex Bois. is a drought-resistant, high-yielding, valuable pasture plant, not inferior in nutritional value to alfalfa and it is desirable to grow it for this purpose for haymaking in the foothills. The presence of nitrogen-accumulating Rhizobium bacteria in the roots of *O. chorasanica* is important for increasing the productivity of desert soils and this feature shows the relevance of creating artificial crops of *O. chorasanica* in the foothills. *Onobrychis chorasanica* seeds have very high sowing qualities and to increase their germination, 100 % germination can be achieved by mechanical scarification of seeds separated from the pericarp using sandpaper. Sowing of non-certified seeds in the field depends on the conditions of the year and the depth of their embedding in the soil. It was noted that in a dry year, the highest germination rate was 13.3-15.0 % on variants where seeds were sown to a depth of 3-4 cm. In years with heavy rains, this indicator was significantly higher, and the highest indicator was 35.3 % in the variant with sowing seeds to a depth of 3 cm. The

survival rate of seedlings in the 2nd year of life is 72-95 % in different variants; the highest survival rate is observed in the variant with planting seeds to a depth of 3 cm (95 %). The yield of *O. chorasanica* hay in the foothills of the Kitab district can reach 4.1 tons per ha and the yield of seeds is 250 kg; by growing it, it is possible to intensify the production. Based on the obtained results, we recommend increasing the diversity of the feed base by creating *O. chorasanica* agrocenoses for livestock farms.

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Authors' contributions

KD, RA, MT and OU performed the experiments. RA, KK and DF analyzed data. AB and MG statistically analyzed the results. All authors wrote the draft of the manuscript. RA and MT conducted the critical revision of the manuscript. KK worked out the concept and design, supervised and funded the experiments. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

References

1. Akramov I, Axanbayev Sh, Alikulov B, Mukhtorova S, Ergashev A, Ismailov Z. Plant growth-promoting properties of endophytic bacteria isolated from some xerophytic plants distributed in arid regions (Uzbekistan). Plant Science Today. 2023;10(4):228-37. https://doi.org/10.14719/pst.2725
2. Alikulov BS, Shuryhin VV, Davranov KD, Ismailov ZF. The halophytic plant *Halostachys belangeriana* (Moq.) Botsch. as a source of plant growth-promoting endophytic bacteria. Microbiological Journal. 2022;4:31-39. https://doi.org/10.15407/microbiolj84.04.030
3. Aqsa A, Mushtaq A, Muhammad Z, Sadia Z, Mohamed FR, Ashwaq TA *et al*. Foliar epidermal and trichome micromorphological diversity among poisonous plants and their taxonomic significance. Folia Hort. 2023;35(2):1-32. https://doi.org/10.2478/fhort-2023-0019
4. Djumayeva Z, Khaydarov Kh, Muhammad Z, Mohamed FR, Mushtaq A, Nozimova A *et al*. Comprehensive study of allergenic tree species: Palynological insights enhanced by HPLC and GC–MS profiling. Biomedical Chromatography. 2023;13:889. https://doi.org/10.3390/membranes13120889
5. Nurullayeva N, Haydarov Kh, Umurzakova Z, Safarova D. Growth and development of *Lycium barbarum* L. in the environment of Samarkand in Uzbekistan. Plant Science Today. 2021;8(2):278-82. https://doi.org/10.14719/pst.2021.8.2.919
6. Shukrullozoda RS, Burxonovich DD, Kudratovich KK, Esanovich KB, Sharobitdinovich TK. Morphology and distribution patterns of *Tulipa fosteriana* and *Tulipa ingens*. Plant Science Today. 2023;10(2):426-38. https://doi.org/10.14719/pst.2296
7. Jurakulov B, Tagaev I, Alikulov B, Axanbayev S, Akramov I, Ismailov Z. Population of *Halocnemum strobilaceum* (Pall.) M. Bieb. in a dry salt lake of the Central Kyzylkum. Plant Sci Today. 2023;10(2):170-77. https://doi.org/10.14719/pst.2062
8. Akhmedov A, Beshko N, Keldiyorov X, Umurzakova Z, Hasanov M, Atayeva S *et al*. Ontogenetic structure of populations of *Phlomis nubilans* (Lamiaceae) in Uzbekistan under drought climate. Ekológia (Bratislava). 2023;42(4):349-53. https://doi.org/10.2478/eko-2023-0039
9. Ivanov LN, Selina AL, Zelniker YY. On the method of rapid weighing for determining transpiration *in vivo*. Bot Journal. 1950;3 (2):171-86.
10. Kuleshov NN. Agronomic seed science. Moscow (Russia). Agricultural Publishing House; 1963.
11. Leurda IG, Belskikh LV. Determination of seed quality. Moscow (Russia). Ear; 1974.
12. Lyushinsky VV, Prizhukov FB. Seed production of perennial grasses. Moscow (Russia). Kolos; 1973.
13. Shalyt MS. Methodology for studying the morphology of the underground part of individual plants in plant communities. Field Geobotany. 1960;2:369-447.
14. Rabbimov A, Khamraeva GU. Methodological recommendations for the introduction and breeding of desert forage plants. Samarkand (Uzbekistan). SamSU; 2016.
15. Dospekhov BA. Methodology of field experience. Moscow (Russia). Kolos; 1979.
16. Tyra Rakhimova. *Onobrychis chorassanica* Bge. Water mode. Tashkent (Uzbekistan). Adaptation of forage plants to the conditions of the arid zone of Uzbekistan; 1983.
17. Zhukovsky PM. Botany. Moscow (Russia); 1982.
18. Khalilov HR. Ecological and biological study of *Astragalus* forage species for the purpose of introduction in the conditions of the foothill semi-desert of Uzbekistan. Abstract Diss Candidate of Biological Sciences. Leningrad (Russia); 1993.
19. Tajiev SF. Ecological and biological features of wild forage legumes promising for introduction into culture in the Adyras of the Fergana valley. Autoref Diss Cand Biol Sciences. Tashkent (Tashgu); 1980.
20. Khasanov OH, Tajiev SF. Economic characteristics of *Khorosan esparcet*. Tashkent (Uzbekistan). FAN Publishing House; 1983.