

# Promising collection samples of hops as a basis for breeding work

Inga Ivanova\*, Dmitriy Dementiev, and Julia Osipova

Federal Agricultural Research Center of the North-East named N. V. Rudnitskogo, Kirov, 610007, Russia

**Abstract.** Colleagues from the Chuvash Research Institute of Agricultural Sciences have selected varieties from the existing hop collection with stable yield and quality indicators over the years. The varieties were evaluated by yield, alpha acid content, and phenological characteristics, and the coefficient of adaptability and variability to the natural and climatic conditions of Chuvashia was determined for three years 2021-2023. Based on the Selyaninov hydrothermal coefficient and yield over the past 3 years, the coefficient of correlation of yield with weather conditions for the selected varieties was calculated.

## 1 Introduction

Plant genetic resources are the most valuable source material for agricultural and economic development, food security and national sovereignty of each country and the world as a whole. There is not a single country or region that is independent of the global agrobiodiversity. The development of scientific and technological progress contributes to the accelerated disappearance and depletion of biodiversity, while at the same time the world community recognizes its complete dependence on its conservation and sustainable use. The conservation of the world's natural resources, especially plant resources, is of concern not only to scientists who deal with environmental problems and specialists in resource conservation, but also to government officials and politicians who realized that the main reserves of food and energy are not infinite. National and international organizations recognize the need for a joint policy in the field of conservation of resources in order to prevent their depletion, which can harm the whole of humanity [1].

The preservation of the gene pool of cultivated plants is becoming increasingly important every year. The deterioration of environmental and geophysical factors, a significant increase in anthropogenic impact on the environment, the complexity of maintaining plant collections and natural biocenoses significantly increase the threat of irretrievable loss of valuable plant species and varieties.

The collection of genetic resources of cultivated plants and their wild relatives (relatives) is a systematic and documented collection of plant diversity samples of actual or potential value, preserved alive outside of natural habitats (ex situ) for the purpose of their study and rational use. The collection may also include herbarium collections (due to their scientific

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\* Corresponding author: [m35y24@yandex.ru](mailto:m35y24@yandex.ru)

value) and collections of samples of nucleic acids isolated from plants and/or their cloned forms.

The collection of hops of the ordinary Chuvash Research Institute of Agriculture is a laboratory – a living variety library where scientific and practical work necessary for production conclusions and theoretical justifications can be carried out. Thanks to the work and efforts of many scientists and breeders of the Institute of Hops and Agriculture, currently the collection of world hop varieties includes 244 varieties originating from various regions of Russia – 74 and foreign countries – 170. This is a large gene pool of breeding, local and wild forms of ordinary hops and is on a par with the collections of research institutions in foreign countries [2].

It is possible to preserve and multiply the valuable asset of the hop gene pool for future generations only through regular measures to preserve and support the collection, as well as the induction of new hop samples into the collection. A collection of hop varieties is a population of female plants with a set of phenological, morphological and economically important features. Their preservation is possible only by constant cultivation, there are no other methods of preserving the genetic diversity of this culture.

The collection of the fourth bookmark has been preserved and maintained in the Chuvash Research Institute since 2016. In 2018, it entered the fruiting age, and the next 10-year regulatory period for the use of plantations in the fruiting age will be studied. The collection was laid taking into account modern requirements for the placement of varieties – the samples are grouped by the duration of the growing season, the timing of their maturation.

## 2 Materials and methods

The object of research is cultivars of *Humulus lupulus* L.

The purpose of the research is to replenish and isolate promising cultivars in the collection nursery of *Humulus lupulus* L. to create new varieties of different types with the development of agrotechnological methods of reproduction.

The novelty of the research is qualitative signs that determine the value of collection and expedition material for purposeful use in breeding work with the development of agrotechnical methods of propagation of planting material *in vitro* and *in situ*.

Research objectives:

1. Guaranteed preservation and replenishment of the only collection of ordinary hops in Russia as a gene pool;
2. Selection of cultivars according to economically important characteristics for the creation of new varieties adapted to the natural and climatic conditions of the hop growing regions of the Russian Federation, corresponding to international standards.
3. Development of agrotechnical methods of propagation of planting material *in vitro* and *in situ*.

Practical significance: conservation and replenishment of the biological diversity of common hops with the effective use of genetic resources for the intensification of breeding with the development of the initial stages of nursery breeding.

The hop collection is preserved in the breeding hop house No. 13 of the Chuvash Research Institute. The total area of the collection is 0.44 hectares or 11 rows. The varieties in the collection are grouped by the length of the growing season: early-ripening (100 days or less), medium-early (101-110), medium-ripe (111-120), medium-late (121-130), late-ripening (more than 130 days). Early-maturing ones occupy one row, medium-early ones – 1.5, medium-ripe ones – 4.5, medium-late ones – 1, late-maturing ones – 3. For an objective comparison of the results of the study of varieties by maturity groups, 2 standards included in the State Register and approved for use are placed in each row along the diagonal of the

site. The standard 1 in all maturity groups is the highly productive Podvyazny variety, standard 2: in the early-ripening group – the Feudal variety, the middle-early variety Pharaoh, the middle-ripe variety Flagship, the middle-late and late-ripe variety Krylatsky.

There are 12 spans in each row, 2 samples are placed in one span. Each variety consists of 5 plants. There is a boundary of 2 m between the varieties. Two rows of original hop plantations of the Podvyazny variety are planted along the edges of the hop garden.

The plantings of the hop variety collection are located on dark gray forest heavy loamy soil with an average level of fertility. The soil is slightly acidic, the feeding area is 2.5 m × 1.2 m. The collection nursery uses the recommended hop cultivation technology. In due time, soil tillage, combing, manual pruning of the main rhizomes, framing, planting hops (2 stems per 2 supports), pasting, fertilizing with mineral fertilizers, plant protection measures and other technological operations are carried out. Agrotechnical care is carried out according to the rules generally accepted for this hop growing region.

According to the results of accounting and observations, the passage of phenological phases, the duration of the growing season, and the degree of disease damage are determined. Crop accounting is carried out by the method of selective bushes when the phase of technical ripeness of cones is reached. The mass of raw hop varieties is determined on average per bush. The cones are sampled by manual "pinching" and the content of alpha acids (the main component of the bitter substances of hops) is determined by the conductometric method. Observations and records were carried out according to the methods [3-6].

To obtain a high hop yield, a sufficient amount of atmospheric precipitation and their distribution over the periods of hop growth and development are necessary. The need for them is especially high from the end of May to June during intensive growth and in July, in August – during the flowering period and the formation of cones of varieties of all ripeness groups [7-9].

In the reporting year 2023, the winter was frosty with good snow cover. During the thaw period, an ice crust formed, which prevented air access to plants. Despite this, the overwintering of hop plants went well. In the spring, the main rhizome of each plant was manually pruned, which showed that they were in good condition – 3 points, on a 5-scale. There were no such damages as snow mold, evaporation and soaking of the root system.

In the hop plots, the assessment of the condition of the plants was carried out in the phase of technical ripeness. The planting of hop stems for support was completed by the end of May. The flowering of early-maturing and medium-early varieties took place in the second decade of July. The medium-ripened ones bloomed in the third decade of July and the first decade of August. The flowering of the mid-late and late-ripening varieties took place from the first to the third decade of August. The plants reached the top of the trellises by the end of June and the beginning of July (23.06 - 02.07). The formation of cones coincided with the dry period. Prolonged hot, dry weather delayed the formation of cones. The cleaning started on August 27.

Hops are a moisture-loving crop. During the growing season (April-September), the average air temperature was 17.5 °C, which is 1.9 °C higher than the long-term norm, 248.9 mm of precipitation fell. In general, the weather conditions in 2023 were favorable for the growth and development of hop varieties. The sum of active temperatures during the growing season was 2560 °C. During the period May-August, 122.9 mm of precipitation fell. The GTC for the same period was 0.7, which is an indicator of arid conditions.

### **3 Results and discussion**

The most promising for breeding use is the high-yielding group, which is characterized by an indicator above 3.5 g of raw cones from one bush (30 c/ha and above dry hops).

According to long-term data, it includes the high-yielding variety standard Podvyazny, with a yield (3.8 kg / bush) (Table 1).

**Table 1.** Economically valuable signs of promising varieties for 2021-2023.

The name of the variety	Weight of raw hops, kg/bush				Alpha acid content, %			
	2021	2022	2023	average	2021	2022	2023	average
Early maturing								
Podvyazny St <sub>1</sub>	3.0	2.8	2.5	2.8	9.3	6.4	3.8	6.5
Feodal St <sub>2</sub>	2.0	3.0	3.3	2.8	4.4	3.3	5.0	4.2
Civilskiy	1.9	2.8	3.0	2.6	4.7	6.4	3.0	4.7
Mid-early								
Podvyazny St <sub>1</sub>	3.8	2.5	2.0	2.8	7.0	8.6	3.0	6.2
Faraoh St <sub>2</sub>	1.5	2.5	3.0	2.3	2.0	2.3	3.3	2.5
Podvyazny 21	3.0	2.5	3.5	3.0	9.3	6.2	9.2	8.2
Medium-ri pened								
Podvyazny St <sub>1</sub>	3.8	3.5	4.0	3.8	7.0	9.9	7.8	8.2
Flagman St <sub>2</sub>	2.8	3.5	3.8	3.4	6.4	9.6	5.4	7.1
Druzhnyj	1.4	2.2	2.4	2.0	7.6	5.3	6.5	6.5
Rannij	1.9	2.0	2.5	2.1	4.0	5.6	9.6	6.4
Favorit	2.7	3.2	2.7	2.9	5.2	3.8	1.8	3.6
Mid-late								
Podvyazny St <sub>1</sub>	3.0	3.0	3.6	3.2	8.4	8.6	7.4	8.1
Krylatskij St <sub>2</sub>	1.9	2.5	2.6	2.3	1.3	2.3	4.9	4.3
Salampi	2.8	4.0	3.5	3.4	6.0	7.3	9.3	7.5
Severyanka	2.8	3.2	2.9	3.0	3.4	4.7	3.5	3.9

In order to identify varieties of common hops (*Humulus lupulus* L.) according to adaptive potential and coefficient of variation (V), to the natural and climatic conditions of the Volga-Vyatka region, 15 samples were studied over three years (2021, 2022, 2023) (Table 2).

**Table 2.** Indicators of yield and adaptability of promising varieties for 2021-2023.

The name of the variety	Yield, kg / plant			The proportion of yield relative to the average value, %			The coefficient of adaptability	Variability Cv, %
	2021	2022	2023	2021	2022	2023		
Early maturing								
Podvyazny	3.0	2.8	2.5	120.0	96.6	86.2	1.10	8.00
Feodal St <sub>2</sub>	2.0	3.0	3.3	80.0	103.4	110.0	0.99	3.30
Civilskiy	1.9	2.8	3.0	76.0	96.5	100.0	0.91	22.80
Mid-early								
Podvyazny	3.8	2.5	2.0	152.0	86.2	66.7	1.02	33.58
Faraon St <sub>2</sub>	1.5	2.5	3.0	60.0	86.2	100.0	0.82	32.73
Podvyazny	3.0	2.5	3.5	120.0	86.2	116.7	1.08	16.67
Medium-ri pened								
Podvyazny	3.8	3.5	4.0	152.0	140.0	133.3	1.42	6.68
Flagman St <sub>2</sub>	2.8	3.5	3.8	112.0	140.0	126.7	1.26	15.24
Druzhnyj	1.4	2.2	2.4	56.0	88.0	80.0	0.75	26.46
Rannij	1.9	2.0	2.5	76.0	69.0	83.3	0.76	15.07
Favorit	2.7	3.2	2.7	108.0	110.3	90.0	1.03	10.07
Mid-late								
Podvyazny	3.0	3.0	3.6	120.0	103.4	120.0	1.15	10.83

Krylatskij	1.9	2.5	2.6	76.0	86.2	86.7	0.83	16.23
Salampi	2.8	4.0	3.5	112.0	140.0	116.7	1.23	17.56
Severyanka	2.8	3.2	2.9	112.0	110.3	96.7	1.06	7.02
<i>The average value</i>	2.5	2.9	3.0	102.0	102.8	100.9	1.02	16.1

The maximum coefficient of adaptability in the studied varieties in terms of ripeness groups relative to the standard variety Podvyazny St1 (Russia) 1.42 (Cv = 6.68 %) was revealed.

- in the early maturing group – Podvyazny St1 (Russia) – 1.10 (Cv = 8.00 %);
- in the middle early – Podvyazny 21 (Russia) – 1.08 (Cv = 16.67 %); Podvyazny St1 (Russia) – 1.02 (Cv = 33.58 %);
- mid-season – Flagman (Russia) – 1.26 (Cv = 15.24%); Favorite (Russia) – 1.03 (Cv = 10.07 %);
- mid-late – Salampi (Russia) – 1.23 (Cv = 17.56 %); Severyanka (Russia) – 1.06 (Cv = 7.02 %);

The groups were evaluated according to phenological and economically useful characteristics, the coefficient of adaptability and variability to the natural and climatic conditions of Chuvashia was determined. In three years (2021, 2022, 2023), according to adaptability, the following were distinguished: early-ripening - grade 1, medium-early - grade 2; medium-ripe - grade 2, medium-late - grade 2. The selected cultivars can be used in breeding work.

Based on the Selyaninov hydrothermal coefficient and yield over the past 3 years, the coefficient of correlation of yield with weather conditions for the selected varieties was calculated. It was determined that the greatest positive relationship was identified in the variety Favorit and Severyanka. Slightly lower in the varieties Podvyazny and Salampi. That is, these varieties proved to be the most resistant to the stressful conditions of dry years and show stable yields under various agro-climatic conditions.

## 4 Conclusion

A group of researchers from the Chuvash Research Institute of Agricultural Sciences carried out work to identify promising varieties. The selected varieties have a set of economically valuable features for inclusion in the breeding process. This work is carried out in the conditions of the southern part of the Volga-Vyatka region on perennial plantations of ordinary hops in the fourth bookmark. The purpose of which is to create import-substituting competitive varieties for the industrial agro-complex of the Russian Federation.

According to the results of research in 2021-2023, promising varieties were identified according to economically valuable characteristics. In terms of productivity in the early ripening group of ripeness – Feodal variety-standard 2 (3.3 kg /bush) and Civilskiy (3.0 kg/bush), medium-early – Podvyazny 21 (3.5 kg /bush) and Faraon variety–standard 2 (3.0 kg/bush); medium-ripe – Podvyazny variety-standard 1 (4.0 kg/ bush) and the standard 2 Flagman variety (5.8 kg /bush), the medium-late – Podvyazny variety-standard 1 (3.6 kg / bush) and Salampi (3.5 kg / bush). The most stable productivity indicators were noted in the Feodal variety in the early ripening group (Cv=3.3 %).

According to the coefficient of adaptability, the maximum indicators were obtained in the middle-ripening group according to two standard grades – Podvyazny and Flagman at 1.43 and 1.26, respectively;

With an alpha acid content of more than 6.1%, in early-ripening – grade 1, medium-early and medium-late – grade 2, and in medium-ripening – grade 4.

The preservation, study and maintenance of the collection of world and domestic hop varieties have not only scientific research, but also practical educational significance.

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