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Research paper

Research results of local buckwheat varieties and forms of Ukrainian origin

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ABSTRACT

The national collection of buckwheat in Ukraine consists of 578 local samples and forms of Ukrainian origin added into the collection during 1929 to 2012. In 1994-2000 and 2014-2018, the material has been studied and described, the common characteristics of samples peculiar of a certain area of origin, feature manifestation peculiarities, material flexibility and stability of the quantitative and qualitative characteristics depending on the weather in growing years have been identified. The range of studies included sample performance indicators, architectonic values, grain characteristics, and so on. A common characteristic of local buckwheat varieties is a significant sensitivity to changes in growing conditions, which is reflected in the change of growth processes (increase in the plant height by lengthening of internodes, the number of branches of the second and higher orders, the number of leaves per plant) and adjustment of the growth duration (lengthening the duration of the growing season after the onset of more favorable conditions for growth and development). The performance indicators related to the grain characteristics are quite stable. However, the general trends characteristic of plants from a certain origin of the collection material remained unchanged.

INTRODUCTION

Buckwheat has not become one of the most demanded crops by the international community yet. The main reason is its limited distribution around the world and low yields. However, the conclusions made in recent years concerning the maintenance of full-fledged human life, health and outstanding buckwheat plant properties indicate a significant need in buckwheat products (Kreft, 2010, Alekseeva at al., 2005). Gradually, the buckwheat products are distributed from the major regions of its traditional consumption to the new areas, where it gains the status of the core component of a healthy diet and becomes the foundation for a healthy lifestyle.

As a result of in-depth study of biochemical composition of buckwheat grant and the whole plant, involving new types of crops into the research, the scientists around the world have greatly expanded the application areas of buckwheat products from traditional to exotic. To carry out this work, the genetic material with extensive properties and characteristics, most of which is concentrated in banks of plant genetic resources, is used (Alekseeva at al., 2004).

Genetic diversity preservation has long been an imperative of global importance. The work to create the banks of genetic plant resources, launched more than a hundred years ago, not only validated the feasibility of this direction development, but also confirmed an unvalued contribution to ensuring food security worldwide (Alexanian, 2003).

To solve scientific problems, the collection material of various eco-geographical origin and biological status is critical. However, given the importance of addressing the issue of the plant productive potential realization in contrasting environmental conditions, the study of local varieties and forms, the research of adaptive mechanisms and biochemical plant components became of paramount importance.

MATERIALS AND METHODS

A part of the National Buckwheat Collection in Ukraine, which is stored in Ustymivska Experimental Station of Plant Production (Poltavs'ka region), includes over 1,600 authentic samples, of which 1.1 thousand samples are the local varieties and forms of the common buckwheat (*Fagopyrum esculentum* Moench.) (Tryhub at al., 2015). 578 samples in the collection have Ukrainian origin. The material included in the collection is the result of its collection by employees of the N. I. Vavilov All-Union Institute of Plant Genetic Resources (VIR, Leningrad) during the missions (Fesenko at al., 2006), by researchers of Ternopil Breeding and Research Station, the Research Institute of Agriculture and Livestock of the Western Regions of Ukraine led by Olena Alekseeva (Alekseeva, 1967), as well as employees of the National Center for Plant Genetic Resources of Ukraine, assisted by the Ustymivska Experimental Station of Plant Production (Kirjan at al. 2014) in the territory of Ukraine from 1929 to 2012. As regards the ecological and geographical origin, there are samples from 18 regions. These are the representatives of the Carpathian region, Woodlands, Forest Steppe and Steppe zones. The overwhelming majority is the samples from the North, Central and Western parts of Ukraine, and a small number comes from the Eastern and Southern regions (see Table 1 and Pic. 1).

Natural-climatic zones and regions of Ukraine	Number of accesses
Forest Steppe	**294**
Kyivs'ka (part)	12
Sums'ka (part)	60
Khmel'nyts'ka	11
Ternopil's'ka	34
Cherkas'ka	9
Poltavs'ka	70
Vinnyts'ka	58
Kharkivs'ka	40
Steppe	**20**
Kirovohrads'ka	8
Dnipropetrovs'ka	4
Odes'ka	8
Polissya and Carpathian region	**264**
Zakarpats'ka	8
Ivano-Frankivs'ka	19
L'vivs'ka	36
Rivnens'ka	11
Volyns'ka	8
Chernihivs'ka	128
Kyivs'ka (part)	8
Sums'ka (part)	24
Zhytomyrs'ka	22
Total	**578**

Table 1. *Distribution of origin of the local sample collection by climatic zone of Ukraine*

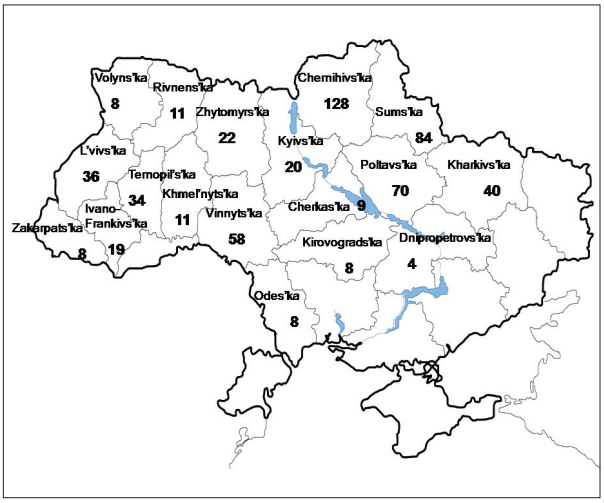

Fig. 1. *Territorial distribution of origin of the local buckwheat samples (name of district and number of samples).*

The research of the collection material of buckwheat varieties and forms was carried out as required by the "Complete unified classifier of the genus Buckwheat (Fagopyrum Mill.)" (Tryhub at al., 2013), "Descriptors for buckwheat (Fagopyrum spp.)" (Descriptors..., 1994) , "Guidelines for the study of collection samples of corn, sorghum and groats" (Krotov, 1968), "Analysis of the structure of buckwheat plants (Methodical recommendations)" (Bochkareva, 1994).

The material study and description was carried out in several stages during 1994-2000 and 2014-2018, and the results obtained were compared to the standard variety of Ukrainka. The common characteristics of samples peculiar of a certain area of origin, feature manifestation peculiarities, material flexibility and stability of the quantitative and qualitative characteristics depending on the weather in growing years have been identified. The range of studies included the sample performance indicators (the number of seeds and buds per plant, inflorescence yield), architectonic parameters (plant height, number of branches and inflorescences, height of attachment of the inflorescences and branches, the length of the branching and grain production zone), grain characteristics (grain size, evenness and husk content), the length of the growing season and its components, and so on.

RESULTS AND DISCUSSION

To obtain high and stable buckwheat yields, it is required to continue creating new varieties combining high performance, friendly maturation, resistance to drought, temperatures below zero, lodging, grain shattering, pests and diseases, as well as a high grain quality. For this purpose, in selection, as noted by N.I. Vavilov, we need to use the local material subjected to prolonged exposure to natural selection and adapted to specific conditions. This material has great value, and is widely used in selection (Korynyak at al., 2017).

It should be noted that in terms of soil and climatic conditions, the research region, namely the south of Poltavs'ka region (central part of Ukraine, Forest Steppe zone) is one of the most favorable for growing buckwheat. Still, it has recently been affected by the ongoing significant climate change towards higher temperatures during flowering and insufficient precipitation during initial growth, which is typical for most areas of buckwheat cultivation in Ukraine. These trends are typical for most regions of the world where the buckwheat is sown. The features of sign manifestation were identified based on a set of researches conducted in two stages. The samples were studied following a three-year cycle during 1994-2000 and 2014-2018. The first cycle of study (1994-2000) was remarkable for more favorable weather conditions with precipitation and temperature regime of the growing season close to the average long-term data. The second cycle of study (2014-2018) was characterized by a high temperature in summer and a significant lack of moisture in the spring.

The data obtained in the course of study indicate a considerable variety of feature manifestations by the local plant varieties and forms. There is a considerable dependence in the levels of feature manifestation on climatic zones of the sample origin. A significant impact on the plant characteristics was exercised by the climatic factors, precipitation and temperature regime during the years of cultivation. However, a set of the studied traits showed the characteristic, genetically determined features of samples and allowed describing the quantitative and qualitative material characteristics.

Given the considerable heterogeneity of the climatic zones of Ukraine in terms of soil conditions, heat and precipitation, the entire buckwheat gene pool of these areas has been further divided into smaller, but more similar regions. To characterize the samples from the western regions of Ukraine, the classification proposed of Olena Alekseeva (Alekseeva, 1999) was applied. For other areas, the author's classification was applied.

Samples from Forest Steppe of Ukraine

In terms of soil and climatic conditions, the Forest Steppe Zone was subdivided into western, central and eastern parts, each with its own characteristics, significantly differing among themselves, but with rather similar buckwheat growing conditions within each part. The western part includes the samples from Khmel'nyts'ka, Ternopil's'ka and Vinnyts'ka regions, having more precipitation as compared to the other parts of the Forest Steppe Zone, and their more even distribution during the vegetation period, lower average daily temperatures and fertile soils. The central part of the Forest Steppe (Cherkas'ka, Poltavs'ka, Sums'ka and Kyivs'ka regions) is characterized by harsher weather conditions in terms of the temperature and humidity. Here is sufficient precipitation during the growing season, but its distribution is very uneven. The cover in most of the area is presented with fertile soil with excellent quality characteristics. The eastern part of the Forest Steppe zone includes Kharkivs'ka region and the south of Sums'ka region. This part shows the most extreme weather conditions with little precipitation and high temperatures, especially during the buckwheat flowering and graining.

In general, the gene pool of this region is represented by 294 samples.

The samples of this group are the most malleable genetic material grown in the area with conditions, which are the most suitable for the buckwheat cultivation. Such a genepool was the source material for most of the modern high-tech varieties, and today the scientists are searching for the forms remarkable for their performance indicators combined with resistance to abiotic environmental factors, grain quality, and so on primarily among these samples.

The samples from the western part of the Forest Steppe Zone of Ukraine show an extensive diversity in terms of the key parameters of the plant organism structure, which requires their subdivision into two subgroups by the growing season duration, i.e. mid-late-ripening (78-85 days) and early-ripening (70-77 days). Mid-late-ripening samples form tall plants (1.5 m high) with a large number of internodes (9-13 pcs.), a large number of leaves and branches (9-16 pcs.). Lower interstitials are thickened, forming resistance to lodging. The samples' yield is 180-220 g/m^2, and the productivity is 1.8-2.6 g/plant. They have medium-sized grain, up to 25.6 g/1000 grain with uniformity up to 82% and husk content 22.7-23.5%. The early-ripening samples have the plants 85-110 cm high with 10 internodes and the ratio of grain formation zone vs. branching zone as 1.0-1.3. The plants form a large number of inflorescences, up to 55 pieces per plant. Samples have large dark brown grain as for the local forms; the weight of 1,000 grains is 25.8-26.9 g, the husk content increased to 23.8%, and a good inflorescences uniformity, i.e. 85%. The yields of these samples is within 165-200 g/m^2, and the productivity is 1.6-2.2 g/plant. Plants have a significant number of leaves and the medium number of branches (5-8 pcs.), are resistant to lodging and moderately resistant to grain shattering after ripening.

The central part of the Forest Steppe Zone has a more form genepool in terms of manifestation of quantitative and qualitative traits of the buckwheat plant organism. Local varieties from this part feature the medium-term ripening (70-80 days), medium and large plant height (100-150 cm), 7 to 16 internodes on the main stem and the ratio of the graining zone vs the branching zone as 1.1-1.3. The plants from this group are resistant to lodging, have many leaves and 8-14 branches (including 5-8 first-order branches) and 85 buds per plant. The grain of these samples is gray and dark brown with an average weight of 1,000 grains as 24.2-27.3 g, grain husk content as 22.1-23.5%, and 90% uniformity. The average grain yield varies between 185-236 g/m^2, and the productivity – within 1.8-2.8 g/plant.

The plants from the local samples of eastern part of the Forest Steppe of Ukraine are potential sources of the variety resistant to abiotic environmental factors (high temperatures and drought). Samples from this part form the medium-term ripening (75 days) plant up to 120 cm high with 5-9 internodes, 5-12 branches and 65 buds per plant. These samples are characterized by high resistance to lodging and medium resistance to the grain shattering. Grain has a dark brown color with a clear or blurry pattern in the form of dots or dashes, the weight of 1,000 grains is 23.5-26.7 g, the medium husk content (up to 23.1%) and evenness (75%). The yield of samples from this group is 168-218 g/m2 with the plant performance at 1.45-2.05 g/plant.

Samples from Polissya and Carpathian region

The material from this zone also features extensive diversity due to a significant difference between the weather, climate and soil conditions within the region. The samples from this area were subdivided into 3 groups: the north-western, western, northern and Carpathian.

The north-western part includes the samples originating from Volyns'ka and Rivnens'ka regions, the climate in which is characterized by excessive precipitation, moderate temperature conditions and poor nutritional composition of their soils. The western part (Ivano-Frankivs'ka, L'vivs'ka and Zhytomyrs'ka region) is characterized by a moderate precipitation and temperature conditions favorable for plant growth and development, with soils of varying fertility. The northern part of the Polissia zone (Chernihivs'ka and a part of Kyivs'ka and Sums'ka regions) has the most fertile soils in this region, sufficient precipitation and heat. The genepool of the Carpathian region (Zakarpats'ka and a part of Ivano-Frankivs'ka region) includes representatives of foothill and mountain areas, featuring moderate and sometimes low temperature during the growing season, often excessive precipitation and poor soils. The collection of local varieties and forms from this region includes 264 samples.

The samples of the north-western part of the region are characterized by a short growing season, low (1.2 m) stem with 4-5 internodes; slight branching (3-7 branches, of which 2-3 are the first-order branches) with a ratio of the graining zone vs the branching zone as 0.8, the medium number of leaves, the sample yield at 120-180 g/m^2 per plant and the productivity as 0.8-1.0 g/plant; the medium grain particle size (up to 23.5 g/1000 grains), uniformity (80%) and husk content (up 23.5%), brown grain with a clear patter; resistant to lodging and having a medium degree of grain shattering after ripening.

The samples from the western part feature a significant heterogeneity by the growing season duration; the samples vegetation varies from early-ripening (70 days) to late-ripening (90 days), and respectively, the plant height and the number of internodes ranged from 80-100 cm and 5-7 pieces. to 125-130 cm and 9-12 pieces. In general, all samples were dark brown and gray, with medium and large grain size (23.7-26.8 g/1000 seeds), medium evenness (85%) and high husk content (24%); the plants have many leaves with a medium degree of grain subsidence and lodging. The samples' yield was 175-210 g/m^2, and the plant productivity – 1.6-2.2 g/plant.

The samples from the northern part feature a high yield (up to 250 g/m^2) and plant productivity (up to 3.0 g/plant); large grain (24.5-26.4 g/1000 grain), good evenness (up to 85%), and medium husk content (22.6-23.1%), brown and dark brown color. The plants of these samples are tall (1.2-1.5 m) with a large number of branches (13-18 pcs.) and buds (70 pcs.) per plant, as well as many leaves. The stem is thick and resistant to lodging.

The samples from the Carpathian region (foothill areas of Zakarpats'ka and Ivano-Frankivs'ka regions) are characterized by a considerable length of the growing period (80-90 days) and tall plants (150 cm) with a significant number of branches (15 pcs.) and internodes (10-13 pcs.); the ratio of the graining zone vs the branching zone is 0.9-1.1; the plants have a large number of leaves and buds (80 pcs.); yield at 180-200 g/m^2 and productivity up to 2.2 g/plant; the medium grain size (up to 25.1 g/plant), medium husk content (23%) and evenness (85%). The plants are remarkable for a low resistance to plant lodging and grain shattering. Samples from the Carpathian mountain areas have a medium length of the growing period (75 days), the plants are lodging heavily due to thin stems and lots of leaves, the medium number of branches per plant (7-10 pcs.) and internodes per stem (6-9 pcs.); the ratio of the graining zone vs the branching zone is 0.6-0.9. The sample yield is medium, 160 g/m^2 per plant, and the productivity is 0.9-1.5 g/plant, while the number of buds is - 50 pcs. The grain features a medium size 21.3-24.6 g/1000, low evenness (70%) and high husk content (23.4-24.6%); gray or brown color with a distinct pattern.

Samples from Steppe of Ukraine

This is the least numerous group of samples available in the National Collection of Ukraine. The total gene pool of the region comprises 20 samples. However, in terms of its climatic conditions, each of the regions included in this group has the contrasting features and requires subdivision into two parts, namely the genepool of Odes'ka region, which was formed in conditions of unstable humidity, relatively poor soils and high temperature during the vegetation period, as well as samples originating from Kirovohrads'ka and Dnipropetrovs'ka regions, where the sample forming conditions are remarkable for unstable, but more moderate precipitation, more favorable temperature conditions and availability of fertile soils.

The samples originating from Odes'ka region feature the early ripening (68-75 days), low height (110 cm), a small number of internodes per stem (48 pcs.), low resistance to lodging due to a thin stem, a small number of branches (5-9 pcs.) and a moderate number of leaves per plant. The graining zone vs the branching zone ratio is 1.1-1.3. The sample productivity level varies considerably, several times, depending on the weather conditions.

The average yield in this group of samples ranged from 68.5 to 174 g/m^2, and the plant productivity was 0.4-2.3 g. Samples form a quite fine grain, 21.6-23.2 g/1,000 grain, with a medium husk content – 22.8-23.4%, and low evenness (75%).

The samples originating from Kirovohrads'ka and Dnipropetrovs'ka regions are more grainful (179-236 g/m^2) with the productivity of 1.9-2.6 g/plant. They also form larger (24.7-26.5 g/1,000 grain), even (85%) grain with thinner husk (up 23.1%). The samples of these plants have more leaves, branches (7-13 pcs.) and buds (80 pcs.) per plant. The plant height is medium, 125 cm, with 9-13 internodes. The plants are more resistant to the grain shattering after ripening and resistant to lodging due to the thickened lower internodes.

A common characteristic of all local buckwheat varieties of Ukrainian origin is a significant sensitivity to changes in growing conditions, which is reflected in the change of the growth processes (increase in the plant height by lengthening of internodes, the number of branches of the second and higher orders, as well as the number of leaves per plant) and adjustment of the growth process duration (extension of the growing season length after the onset of more favorable conditions for growth and development). A quite stable performance is related to grain characteristics (size, husk content and uniformity, color, grain, etc.). However, the general trends, characteristic of the collection material origin, remained unchanged.

Extensive variety options are important for selection, because enables finding a material with specific characteristics among varieties and forms, identifying and examining the same according to a set of indicators. While working to study and describe the sample collection, some contrasting forms in comparison with the original populations were discovered (in terms of the shape of plants and buds, flower color and size, availability and varying degrees of anthocyanin color, initial growth rate, a lack of branching, ability to counter or avoid the extreme environmental factors, etc.). This is the most valuable genepool, because it allows expanding the variety polymorphism, extending the traditional and starting the new areas of buckwheat selection or use of products obtained from its cultivation.

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IZVLEČEK

Zbirko ajde Ukrajine tvori 578 lokalnih vzorcev, ki so bili nabrani in vključeni v zbirko v letih 1929 do 2012. V letih 1994-2000 in 2014-2018 so potekale raziskave in opisovanje vzorcev, zlasti običajnih lastnosti, značilnih za posamezna območja izvora, posebnosti vzorcev, variabilnost in stalnost kvantitativnih in kvalitativnih lastnosti v odvisnosti od vremena in leta pridelovanja. Raziskave so med drugim vključevale kazalce rodnosti, opis zgradbe rastlin in lastnosti zrn. Običajne lastnosti lokalnih varietet ajde so odvisne od sprememb v razmerah pridelovanja, kar se kaže v spremembah poteka rasti (večanje višine rastlin z daljšanjem internodijev, števila stranskih vej drugega in višjega reda, števila listov na rastlino). Kazalci povezani z lastnostmi zrn so precej stabilni. Vseeno pa ostajajo lastnosti rastlin glede na izvor v znatni meri nespremenjene.