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Manifestation of elements of seed productivity of plants of the national collection of edible buckwheat (*Fagopyrum Esculentum* Moench.)

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Abstract. Today, a significant part of the zoned varieties of buckwheat (*Fagopyrum esculentum* Moench.) are included in the national collection and are constantly monitored for a complex of economically and breeding-important traits.
The purpose of the study is to investigate the variability and interrelationships of seed productivity indicators in samples of the national collection of buckwheat in terms of productivity and precocity. The research material was 232 samples of the national collection of buckwheat in Ukraine. The research was conducted during 2007–2024 in the conditions of the Forest-Steppe of Ukraine (Ustymivsk Plant Research Station of the V.Ya. Yuryev Institute of Plant Production). According to the results of the research, the selected samples of buckwheat showed a yield level of more than 380 g m^{-2}, plant and inflorescence productivity - more than 2.0 g and 0.05 g, respectively, and a weight of 1,000 grains of more than 22 g. Valuable sources of early maturity with a vegetation period of up to 72 days inclusive were identified.
A high level of variation of the studied traits was established, in particular: yield, plant productivity, inflorescence productivity, lower branch attachment height, lower inflorescence attachment height (V = 23.4–50.0%). The weight of 1,000 grains, plant height, and the duration of the vegetation period had a low coefficient of variation (V = 23.4%), which indicated a stable manifestation of these traits.
A strong relationship was noted between the height of the lower branch attachment and the height of the lower inflorescence attachment (r = 0.75), yield and plant productivity (r = 0.85). Correlations of medium strength were established between plant height and the duration of the growing season (r = 0.41), yield and inflorescence productivity (r = 0.64).

Valuable sources of productivity and precocity were identified among the samples of the national collection of edible buckwheat. Highly productive samples of edible buckwheat were noted - P-470 and KDS-20-23 (in terms of yield, plant and inflorescence productivity); Yuvileyna 100, Yaroslavna and SYN 3/02 (in terms of yield, plant productivity and 1,000-grain weight). Samples of edible buckwheat P-370, P-396 and Sumchanka were identified for precocity.

Key words: buckwheat, source of productivity, source of precocity, duration of the growing season, seed productivity.

INTRODUCTION

Today, scientists from the Institute of Agriculture of the North-East of the National Academy of Sciences of Ukraine, the Scientific Research Institute of Cereal Crops of the Podolsk Agrarian University, the National Scientific Center 'Institute of Agriculture of the National Academy of Sciences of Ukraine', the National Agricultural University 'Antaria' LLC, the Poltava State Agrarian University, private domestic companies and breeders are working with the culture of buckwheat (*Fagopyrum esculentum* Moench.). The result of their work is 29 plant varieties included in the State Register, suitable for distribution in Ukraine, among which only 2 varieties (Eskalar and Esguire) of foreign selection (P.H. PETERSEN Saatzucht Lundsgaard GmbH (Germany)), included in the Register in 2023. Most of the material available in the State Register of Plant Varieties (17 varieties) are new varieties of recent selection, approved for use in the last 10 years, and some are absolutely unique material with unique features - Krupinka (1990), Lilya (1987), Stepova (1999), Sumchanka (1985), Ukrainka (1997) (Kotovych, Kh., 2024; State Register of Varieties ..., 2025).

Most of the zoned varieties are included in the national buckwheat collection and are constantly monitored for a complex of economically and breeding-important traits. In addition, the object of study is a significant amount of geographically diverse material. The list of monitoring criteria includes: economic indicators - assessment of plants in different periods of growth and development (emergence, flowering, before harvesting), plant productivity; technological properties; reaction to environmental conditions - resistance to low and high temperatures, drought, lodging, fruit fall; assessment by the duration of the growing season; morphological traits of the plant (Volkodav, 2001; Didora et al., 2013; Trygub, et al., 2013; Kostenko, et al., 2016).

Natural factors also had a significant impact on the production of buckwheat grain: the dependence of buckwheat crops on the level of soil moisture during sowing and germination, the level of temperature and moisture during the flowering period, moisture during the ripening period (Kvashchuk, et al., 2013; Germ, M. & Gaberščik, A., 2016).

Therefore, it is important to increase the level of yield and its stabilization over the years. This allows to increase the profitability of buckwheat production and increase the demand for the crop among producers (Tomashevsky, 2024).

29 varieties of edible buckwheat (*Fagopyrum esculentum* Moench.) and three varieties of Tatar buckwheat (Fagopyrum tataricum Gaertn.) are included in the State Register of Plant Varieties Suitable for Distribution in Ukraine in 2025 (Shevchenko, 2024; State Register of Varieties …, 2025).

This varietal composition has a different origin (including varieties of foreign selection). The presence of such diversity is a positive factor for producers, which allows them to choose the best of them, apply different production technologies, and form a set of varieties of the most adapted material for the growing zone.

In general, the national buckwheat collection contains over 2.5 thousand samples, it is located in two institutions: the Ustymov Research Station of the Institute of Plant Production named after V.Ya. Yuryev and the Research Institute of Cereal Crops of the Podil Agrarian University (Yatsishen & Taranenko, 2015).

Such areas of research have both fundamental and applied significance. From a fundamental point of view, they are necessary for the detection of already defined marker or anomalous characteristics or levels of manifestation of traits. Further research or introduction of these traits into the breeding process allows for the formation of new approaches to conducting work on improving both varietal material and the gene pool of the crop as a whole.

Regarding the applied nature of the use of the research results, the sources of valuable traits are a necessary base of source material for inclusion in breeding, solving the problem of improving quantitative and qualitative characteristics. Buckwheat is a cross-pollinated crop, which, on the one hand, significantly complicates work with it due to the significant diversity of genotypes in one variety or sample, and on the other hand, allows you to have at your disposal a variety of working material as a basic toolkit for targeted work.

The aim of the study is to investigate the variability and relationships of seed productivity indicators in samples of the national collection of edible buckwheat (*Fagopyrum esculentum* Moench.), to identify sources of productivity and precocity among the studied samples, which will be included in the hybridization program as parental forms.

MATERIALS AND METHODS

The research was conducted during 2007–2024 in the conditions of the Forest-Steppe of Ukraine (Ustymivka Plant Research Station of the V.Ya. Yuryev Institute of Plant Growing). 232 samples of the national buckwheat collection of Ukraine were used as experimental material for the research. The material was selected for the most complete monitoring of biological and economically valuable characteristics, taking into account the ecological and geographical origin (selection and local varieties and forms, linear material, synthetic variety-populations, etc.). The basis for the research is the 'Methodology of scientific research in agronomy' (Didora, et al., 2013), 'Methodology of state variety testing of agricultural crops (Grains, cereals and legume crops)' (Volkodav, 2001), 'Broad unified classifier of the genus Buckwheat (*Fagopyrum esculentum* Moench.)' (Trygub, et al., 2013), 'Methodology of conducting an examination of plant varieties of the legume and cereal group for distinctiveness, uniformity and stability' (Kostenko, et al., 2016).

Field experiments were placed in a breeding and seed crop rotation after the predecessor - winter wheat. The research was carried out according to the control nursery scheme using the generally accepted technology of growing buckwheat. Sowing and plant care, harvesting, cleaning and seed calibration were carried out manually on plots of 1.35 m^2, with three repetitions. Standard varieties Ukrainka and Sofia (after 2018)

were placed every 20 numbers. Sowing - wide-row with a row spacing of 0.45 m and a seeding rate of 1.8 million seeds per ha^{-1}. Sowing dates - the second decade of May (May 13–18). Assessments and observations were carried out on plants growing freely (without individual isolation).

The studied samples were studied according to the following indicators: yield ($g\ m^{-2}$), plant productivity (g), inflorescence productivity (g), weight of 1,000 grains (g), duration of the growing season (days), plant height (cm), height of attachment of the lower branch (cm), height of attachment of the lower inflorescence (cm).

The analysis of the obtained data from the laboratory and field studies was carried out using the statistical analysis package 'Statistica 12.0' (Yeshchenko, et al., 2014).

RESULTS AND DISCUSSION

Many years of description and evaluation of the material have allowed to form a group of samples with the most stable level of manifestation of signs and characteristics, which are standards and are used for assessing the gene pool. In general, up to 20 such standard samples are grown annually, and in the case of special study, standards for 90 characteristics can be used.

The presence of a well-developed methodological base and a wide variety of geographically distant varieties and forms is the basis for both the assessment of the material and the differentiation of the gene pool by a set of characteristics (Bahan et al., 2024; Bahanet al., 2025).

Considering that the directions of buckwheat breeding are determined by a wide range of its use depending on the biological characteristics and modern conditions of agriculture, sowing dates, sources of biologically active components, components of environmentally-oriented production methods, etc., a particularly valuable factor for ensuring different directions of the breeding process is the accumulation of information about a diverse gene pool and its implementation through the creation of collections - sets of sources of individual traits or a complex of traits (Tryhub et al., 2020; Vieites-Álvarez et al., 2024).

Considering the complexity of the formation of the yield indicator, samples were distributed according to each component as marker traits of potential yield. Thus, material with individual seed productivity and high stability in years with contrasting conditions was selected.

An important marker of potential yield is inflorescence productivity (the ratio of grain mass from a plant to the number of inflorescences). The use of these characteristics gives a clearer idea of potential yield (the possibility of forming a significant generative sphere), as well as the possibility of its implementation through the productivity of each formed inflorescence. Analysis of the obtained data from the study of the gene pool allowed us to identify genotypes characterized by the optimal expression of this indicator.

A group of valuable specimens was also identified, which, despite the indeterminate type of plants, were distinguished, first of all, by high inflorescence productivity. The reason for the higher productivity of the inflorescences of these plants is, first of all, the peculiarities of the region of formation of such a variety type - early maturity, a limited number of nodes and nodes in the fruiting zone, a small number of branches (limited branching zone). During the fruiting period of such plants in favorable climatic conditions, they formed an average number of inflorescences on the plant and

ensured their high productivity. It should be noted that plants of this origin had a high harvesting index (ratio of the mass of harvested grain to the dry mass of the plant) during the harvesting period – over 38% (Kharchenko & Trygub, 2018).

Local Ukrainian samples differed significantly from the material of foreign origin. The samples formed plants with a significant leaf-stem mass and a large number of inflorescences. And especially in years with favorable weather conditions, they ensured good productivity of each inflorescence. This indicates the significant potential of this material and, provided that favorable conditions are created during the fruiting period, makes them a unique source material for breeding for productivity.

According to the results of the research, samples from the studied collection of buckwheat were identified as valuable sources of productivity according to the following indicators: yield, plant productivity, inflorescence productivity and weight of 1,000 grains (Table 1).

Table 1. Sources of productivity of the national collection of buckwheat (*Fagopyrum esculentum* Moench.) (average for 2007–2024)

No catalog	Sample	Yield, g m^{-2}	Plant productivity, g	Inflorescence productivity, g	Weight of 1,000 grains, g
UC0100329	P-470	433	3.5	0.18	27.88
UC0101981	Yuvileina 100	423	3.6	0.08	30.10
UC0101993	Yaroslavna	421	3.4	0.05	30.70
UC0102114	Marta	431	3.6	0.08	28.50
UC0102179	Bashkirska Krasnostebelna	412	3.6	0.05	29.60
UC0102195	SYN 3/02	425	3.4	0.12	30.20
UC0102205	Feniks	401	3.3	0.18	25.90
UC0102208	Arno	402	3.4	0.20	27.00
UC0102215	Olga	407	2.9	0.11	29.00
UC0102222	KDM-9-16	402	3.3	0.10	25.00
UC0102229	Pokrovska	400	3.2	0.17	25.68
UC0102231	KDS-19-23	529	3.9	0.13	28.40
UC0102232	KDS-20-23	474	3.8	0.19	26.68
UC0102233	KDS-21-23	414	3.2	0.12	26.72
UC0102230	Sobo	394	2.9	0.10	27.40
UC0102217	Nadiyna	384	2.6	0.19	27.60
UC0102214	Volodar	382	2.8	0.17	29.30
UC0102206	Selyanochka	386	2.7	0.17	29.90
UC0102207	Ruslana	386	3.1	0.12	22.48
UC0102203	Amethyst	387	2.6	0.12	27.70
UC0102204	Laknea	388	3.2	0.16	26.20
UC0102183	Agidel	389	2.7	0.09	27.10
UC0101960	Antaria	386	3.3	0.06	29.60
UC0101712	Zelenokvitkova 12	386	3.3	0.06	29.10
UC0101199	Ukrainka	381	2.1	0.19	26.08
Sample average		408.9	3.2	0.13	27.75

According to the average research data, it was found that the selected samples were characterized by a yield level of more than 380 g m^{-2}, plant and inflorescence

productivity - more than 2.0 g and 0.05 g, respectively, with a mass of 1,000 grains of more than 22 g.

In particular, the following sources can be distinguished by the yield indicator - P-470 (433 g m^{-2}), Yuvileyna 100 (423 g m^{-2}), Yaroslavna (421 g m^{-2}), Marta (431 g m^{-2}), SYN 3/02 (425 g m^{-2}), KDS-19-23 (529 g m^{-2}), KDS-20-23 (474 g m^{-2}).

According to the productivity of the plant, the following samples were selected - P-470 (3.5 g), Yuvileyna 100 (3.6 g), Yaroslavna (3.4 g), Marta (3.6 g), Bashkirska Krasnostebelna (3.6 g), SYN 3/02 (3.4 g), KDS-19-23 (3.9 g), KDS-20-23 (3.8 g).

According to the productivity of the inflorescence, the following sources can be selected - P-470 (0.18 g), Phoenix (0.18 g), Arno (0.20 g), Pokrovska (0.17 g), KDS-20-23 (0.19 g), Nadiyna (0.19 g), Volodar (0.17 g), Selyanochka (0.17 g), Ukrainka (0.19 g).

By the weight of 1,000 grains, the following samples were selected - Yuvileyna 100 (30.10 g), Yaroslavna (30.70 g), Bashkirska Krasnostebelna (29.60 g), SYN 3/02 (30.20 g), Olga (29.00 g), Volodar (29.30 g), Selyanochka (29.90 g), Antaria (29.60 g), Zelenokvitkova 12 (29.10 g).

No less important for the producer is the manufacturability of the variety - suitability for cultivation using various technologies. Factors of the manufacturability of varieties include - friendliness (simultaneity) of ripening, the height of the lower branch and inflorescence (to prevent grain losses during harvesting), fruit fall, etc. (Poltoretsky, 2012; Trygub, et al., 2013).

The beginning of flowering begins at the height of the plant in most buckwheat specimens - from 25 to 40–45 cm, and the height of the plant during harvesting can reach 2 m. One of the directions of modern breeding has been the creation of technological varieties that are distinguished by limited growth processes and simultaneous (friendly) completion of the growing season (end of flowering and fruiting processes, grain filling, etc.) (Trotsenko & Klitsenko, A.V., 2017).

One of the ways to solve the problem of reducing and controlling the duration of the growing season has been to involve determinant varieties in the production, which have a more controlled flowering period than indeterminate varieties. Among indeterminate varieties, a group of early-ripening specimens with a growing season of up to 70 days has been identified. The duration of vegetation of such material is determined by the region of its origin – the need to produce grain products during a limited frost-free period, or may be the result of targeted selection (Yatsyshen, & Taranenko, 2012; Trygub, et al., 2018).

The result of the study in contrasting environmental conditions was the selection of a group of indeterminate-type specimens, which were distinguished by a fairly controlled (at the level of mid-ripening and early-ripening specimens) duration of the growing season. Most of such material was not distinguished by increased plant productivity (especially local varieties and forms), but quite productive material was also selected - modern breeding varieties, which were distinguished not only by increased productivity and a controlled growing season, but also had high characteristics of resistance to lodging and fruit shedding, mutuality (simultaneity) of ripening, etc., belonging to the group of short-growing and medium-growing forms.

According to the research data, samples from the studied collection of edible buckwheat were selected as valuable sources of early maturity with a growing season duration of up to 72 days inclusive (Fig. 1).

The distribution of samples of the national collection of edible buckwheat by the duration of the growing season indicates the predominance of forms with an average duration of ontogenesis:

• 72 days – 57.4% of samples, which constitutes the largest share of the collection. This indicates the dominance of mid-ripening forms, which are universal for most agroclimatic zones.

• 71 days – 24.6% of samples, which also belong to early or conditionally mid-ripening genotypes, suitable for cultivation in conditions of a shorter growing season.

• 70 days – 15.6% of samples. This group is represented by more early-ripening forms, potentially valuable for areas of risky farming or repeated sowing.

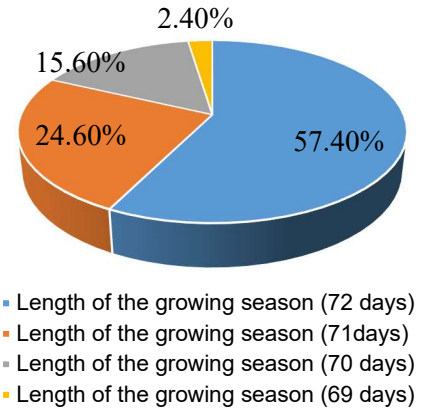

Figure 1. Distribution of samples of the buckwheat collection by the duration of the growing season.

• 69 days – 2.4% of samples. These are the most early-ripening samples, which can be a source of a valuable trait for selection for ultra-earliness.

Thus, over 80% of the samples (collectively those with a growing season of 71–72 days) are concentrated within the moderate precocity range, which is strategically important for adaptation to changing climate conditions. The earliest-ripening samples (70–69 days) constitute smaller groups, but are valuable from the point of view of breeding for precocity.

According to the research data, it was found that the following sources were characterized by the lowest indicator of the vegetation period (less than 70 days) - P-370; P-396; Sumchanka.

According to the research data, the variability of the studied traits in samples of the national collection of edible buckwheat was also established (Table 2).

Table 2. Statistical analysis of seed productivity indicators in samples of the national collection of edible buckwheat (*Fagopyrum esculentum* Moench.)

Indicator	X	*lim* $_{min\text{-}max}$	SX	V, %
Yield, g m^{-2}	288.5	166.7–528.6	67.6	23.4
Plant productivity, g	2.1	0.4–3.9	0.7	33.3
Inflorescence productivity, g	0.08	0.01–0.20	0.04	50.0
Weight of 1,000 grains, g	26.30	18.40–33.20	2.50	9.5
Plant height, cm	119.7	78–144	10.7	8.9
Height of lower branch attachment, cm	17.5	8–43	6.6	37.7
Height of lower inflorescence attachment, cm	35.3	16–69	9.4	26.6
Duration of growing season, days	72.3	68–78	26.6	36.8

According to the results of the research, a high level of variation of the studied traits in the samples of the buckwheat collection was established, in particular: yield (V = 23.4%), plant productivity (V = 33.3%), inflorescence productivity (V = 50.0%),

lower branch attachment height (V = 37.7%), lower inflorescence attachment height (V = 26.6%), duration of growing season (V = 36.8%).

The remaining indicators had a low coefficient of variation, which indicates their relatively stable manifestation - the mass of 1,000 grains (V = 9.5%), plant height (V = 8.9%). In addition, according to the 'Methodology for conducting the examination of plant varieties of the legume and cereal group for distinctness, uniformity and stability', these indicators belong to varietal traits.

According to the results of the correlation analysis, a strong relationship was established between the following indicators: the height of attachment of the lower branch and the height of attachment of the lower inflorescence (r = 0.75), which is an important selection criterion that allows for effective indirect selection for manufacturability and lodging resistance (Fig. 2).

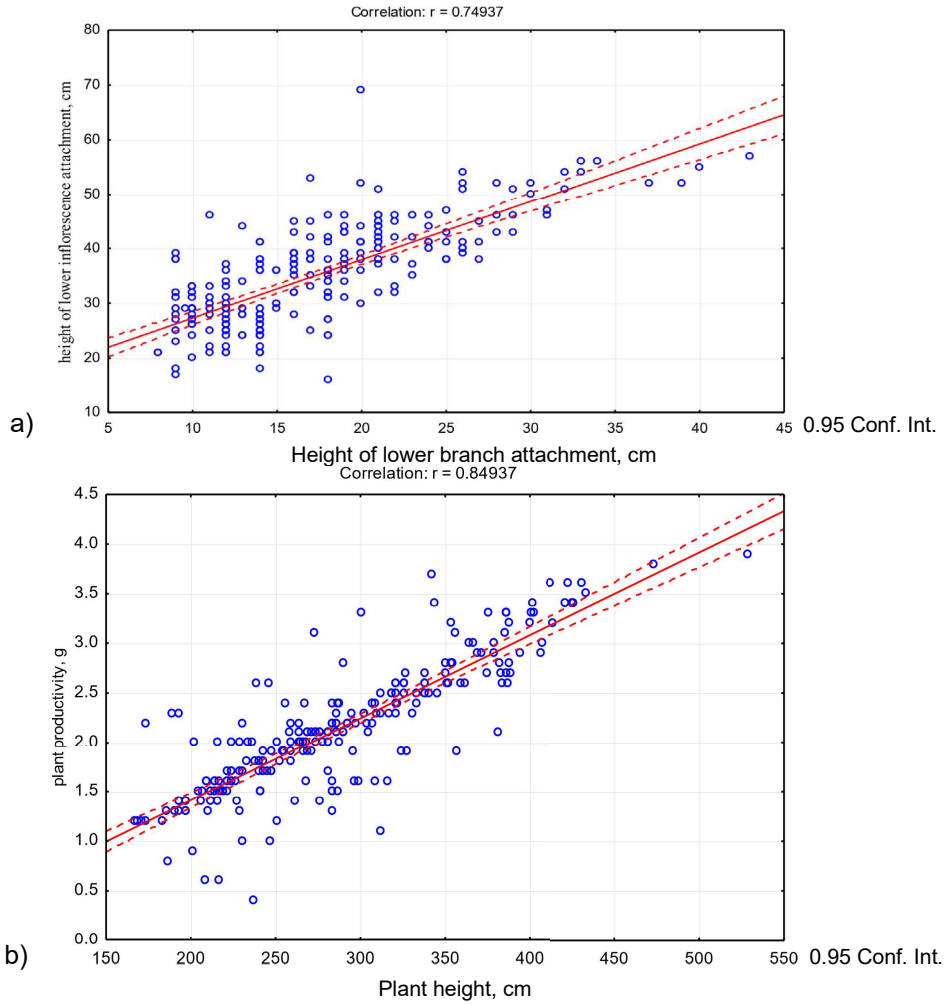

Figure 2. Correlations: a) between the height of the lower branch attachment and the height of the lower inflorescence attachment; b) between yield and plant productivity.

The strong correlation between yield and plant productivity (r = 0.85) will ensure the correct assessment of breeding material and the creation of varieties that combine individual productivity with consistently high yield.

According to Fig. 2, an increase in the height of attachment of the lower inflorescence in buckwheat samples was noted depending on the increase in the height of attachment of the lower branch, as well as an increase in the yield indicator depending on the increase in plant productivity.

Also, a medium-strength correlation was noted between plant height and the duration of the growing season (r = 0.41), i.e., by selecting plants with optimal height, it is possible to partially influence the duration of the growing season (Fig. 3). The obtained medium-strength correlation between yield and inflorescence productivity (p = 0.65) expands the possibility of complex selection of high-yielding varieties.

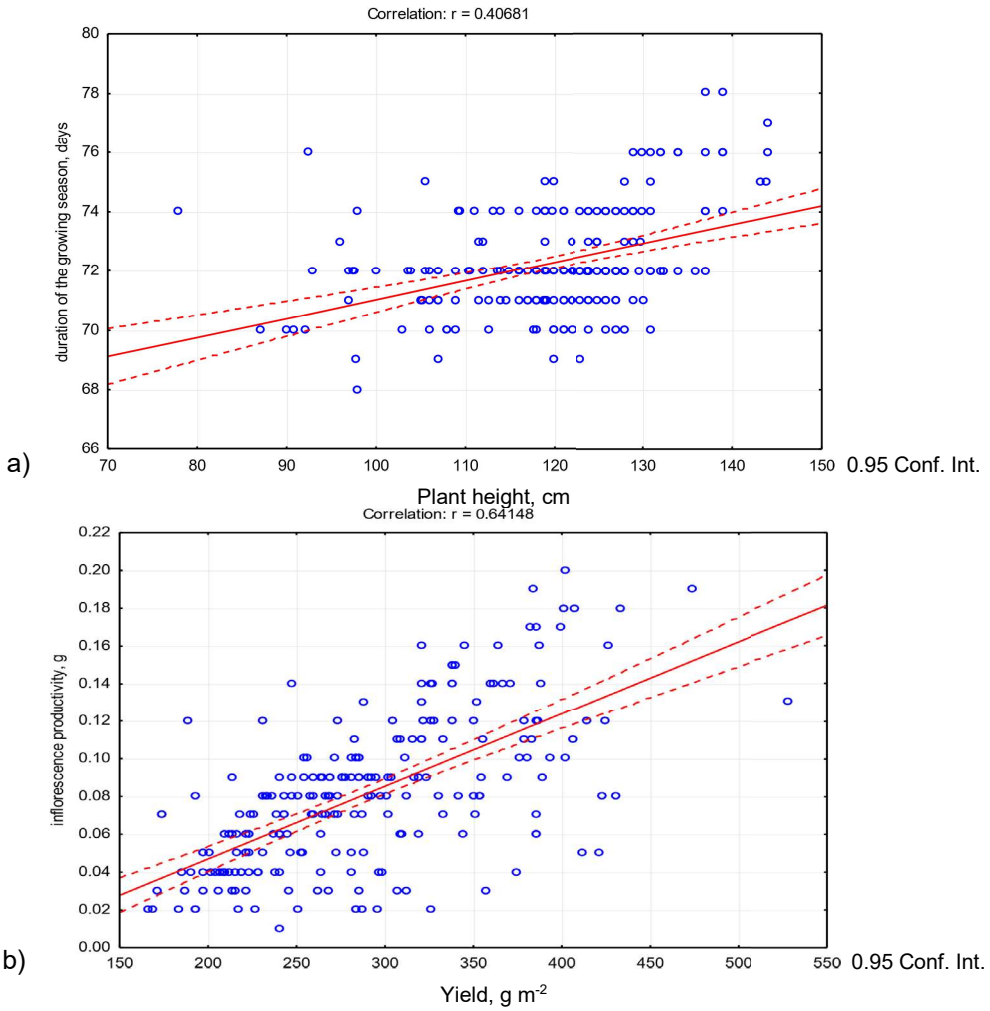

Figure 3. Correlations: a) between plant height and duration of the growing season; b) between yield and inflorescence productivity.

According to Fig. 3, the dependence of plant height increase on the duration of the growing season, as well as the increase in yield level depending on the formation of inflorescence productivity, was established.

CONCLUSION

Valuable sources of productivity and precocity among the samples of the national collection of buckwheat were identified. Highly productive samples of buckwheat were noted - P-470 and KDS-20-23 (in terms of yield, plant and inflorescence productivity); Yuvileyna 100, Yaroslavna and SYN 3/02 (in terms of yield, plant productivity and 1,000-grain weight). Samples of buckwheat P-370, P-396 and Sumchanka were identified in terms of precocity.

The level of variation of the studied indicators in buckwheat samples was established. A low coefficient of variation was noted in terms of 1,000-grain weight, plant height and duration of the vegetation period, which indicates the stability of their manifestation.

Correlations between these indicators were investigated. An increase in the level of yield from the increase in plant and inflorescence productivity, the dependence of the height of attachment of the lower branch and lower inflorescence, as well as an increase in plant height depending on the duration of the growing season, has been established.

A prospect for further research is the study of the quality indicators of buckwheat seeds in the studied samples for their use as valuable sources in breeding practice.

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