Research Article

Morphological features and economic value of buckwheat varieties with physiological determination of growth

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ABSTRACT

Aim: One of the successful directions of buckwheat breeding in Russia is the creation of varieties with physiological determination of growth. Such varieties have a set of valuable attributes and properties: Earliness of ripening, simultaneity of flowering and ripening, macrocarpousness, resistance to lodging, and shedding. The purpose of this work is to evaluate the morphological features and economic value of new buckwheat varieties with physiological determination of growth. **Materials and Method:** Varieties, significantly exceeding the regionalized standard for the sugar content of nectar, have been identified. Significant influence on this indicator was provided by the time of buckwheat sowing and vegetation conditions of different years. The sugar content of nectar in all studied breeds varied in the same manner, in response to growing conditions changes. **Result and Discussion:** Varieties with the high net productivity of photosynthesis in the second half of generative period, as well as varieties of buckwheat with more simultaneous flowering, were distinguished. The net productivity of photosynthesis was higher in conditions of spaced planting. New studied varieties differed from the standard by the stunting and weak degree of stem branching. Relatively high seed productivity, economic coefficient, ear grain content, and weight of 1000 grains are specific for grade K-890 created on the basis of morphotype TVS. Low values of seed productivity were found in varieties, representing morphotype Kudryavyi-VBS. **Conclusion:** Herewith, these varieties showed high values of indirect parameters of lodging resistance. The results, obtained during the research, can be used in selection and seed production of buckwheat.

KEY WORDS: Common buckwheat, Morphotype, Productivity of photosynthesis, Seed productivity, Sugariness of nectar, Variety

INTRODUCTION

Buckwheat – is valuable food crop, cultivated as a cereal and vegetable. In recent years, interest to this culture has increased in many countries of the world. It is based on the high nutritional properties of buckwheat cereals, associated with high protein content, balanced in amino acid composition, the presence of flavonoids, the ability to grow on poor soils, and the ability to cultivation under conditions of organic farming.[1]

An important direction of the common buckwheat use – is its nectar-bearing capacity. Hectare of buckwheat crop produces from 10 to 120 kg of nectar.[2,3] The secretion of nectar in buckwheat depends on the age of plant, the position of inflorescence on the plant, ploidy,[4,5] and on external factors: Air temperature and humidity, seeding time, and mineral fertilization.[6]

Active selection work on the improvement of buckwheat has been developed since the beginning of the past century. At this time, Russian selectionists created the first selection variety of common buckwheat – Bogatyr. Since then, important practical results have been obtained in the selection of buckwheat: Natural mutations of limited branching, narrow-leavedness, determinacy, green-flowering, and physiological determination of growth have been identified and successfully involved in the selection process. Autotetraploid varieties have been created and are currently cultivated in Belarus. In the early

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90s of the 20th century, studies were begun on the culture of cells and tissues as well as interspecific hybridization of buckwheat. In the late 1990s, the first molecular genetic studies were carried out.[7-9]

One of the ways to limit excess buckwheat growth is the physiological determination of growth, accompanied by earliness and simultaneity of ripening. This line of breeding was established by the Tatar Scientific and Research Institute. For plants with physiologically determined growth, the decrease in number and enlargement of inflorescences, limitation of growth processes in the main stem, fasciation of the axial organs, and resistance to lodging, are characteristic features.[10] Listed characteristics are combined with macrocarpousness, easy hulling of grains and high yield of the large kernel.[11] Physiological determination of growth has very complex genetic control.[8] Such forms, due to their earliness of ripening, also have the ability to "avoid from drought" and form a crop before the unfavorable conditions.[12]

Currently, the breeders have obtained new varieties of buckwheat with physiologically deterministic growth. The work for their comprehensive evaluation for further transfer to the state testing and introduction into production is carried out. The purpose of this work is to evaluate the morphological features and economic value of new buckwheat varieties with the physiological determination of growth.

RESEARCH METHODS

Regional standard - Chatyr Tau and prospective varieties K-683, K-865, K-890, and K-899 of the Tatar Scientific and Research Institute selection were the materials of the studies. These varieties are characterized by physiological determination of growth processes, the presence and different displaying of fasciation of the stem, branches, and flower-bearing axes (Table 1).

The varieties of buckwheat were cultivated on the experimental fields of the Tatar Scientific and Research Institute (near the village of B. Kabany, Laishevsky district, the Republic of Tatarstan). The soils of the site are gray forest, middle loamy. The method of seeding is a unstriped drill. The seeding rate is 1.5 and 2.0 million of germinated seeds/ha. The terms of sowing are the 2nd decade of May (1st period), the third decade of May (2nd period). The seed-plot was established by the method of state variety testing.[13] Meteorological conditions of buckwheat vegetation in 2013 and 2015 were characterized by early summer drought, in 2014, they were favorable for the growth and development of buckwheat plants.

Rinse test and method of Hagedorn-Jensen were used for determining the sugar content of buckwheat nectar.[14] The net productivity of photosynthesis for the first and the second half of generative period was also estimated.[15] A total of 25-30 plants were randomly selected from every variety in the phase of harvest ripeness, to evaluate the morphological features and seed productivity of plants. Mathematical processing of the data was performed using the package of breeding-oriented software AGROS.[16]

RESULTS AND DISCUSSION

Obtained data on the sugar content of nectar in varieties (Table 2) were processed by the method of variance analysis. The calculations showed that the varieties differ significantly in the nectarines of flowers (HCP_{05} = 0.036 mg of sugar/flower). Varieties K-865 and K-890 significantly exceeded the standard for the sugar content of nectar.

The conditions of plants vegetation in different years also significantly affected the nectarity of flowers (HCP_{05} = 0.028 mg of sugar/flower). Studied parameter was significantly higher in the favorable 2014, than in other years of the research.

At the second term of seeding, the sugar content of nectar was significantly higher than at the 1st term. HCP_{05} was 0.089 mg of sugar/flower.

The seeding rate did not affect the nectarines of the flowers in 2013-2015: The average values were practically equal at different rates of seeding. The influence of factors interaction on the result was also unimportant in all cases. This means that all studied varieties reacted to changes in growing conditions in a similar way.

The results of estimation of photosynthesis net productivity in studied buckwheat varieties, on

Table 1: Research materials

Morphotype	Characteristics of morphotype	Varieties
TVS	As a result of the stem fasciation and branches, the flower-bearing axes are grouped at the tips of the shoots, in the form of large complex inflorescences of various shapes and sizes	K-890
Two-tiers	The same as in the TVS morphotype, however, the inflorescences are arranged in two tiers	Chatyr Tau, K-865
Kudryavyi-VBS	All shoots are wavy. The location of the inflorescence is customary; however, the axes of the inflorescences are branched. Grains are lined, thin-filmed	K-683 K-899

average per day for the first and the second half of the generative period, are shown in Figure 1.

The analysis of the results showed that the process of photosynthesis was more productive in the second half of generative period - during the bearing of plants. Apparently, this was due to more favorable weather conditions in this period. The increase in biomass per unit of leaf area was higher in varieties K-890 and K-899, at the first half of generative period, and in the second half of the generative period, on the contrary, it was lower. This indicates a high degree of simultaneous flowering in these varieties. The net productivity of photosynthesis in the second half of generative period was significant for the standard variety, K-683 and especially K-865 varieties, for the studied seeding rates. With a seeding rate of 1.5 million/ha, the differences between varieties were more pronounced.

Comparison of the results, obtained for different seeding rates, showed that at all stages of development the net productivity of photosynthesis was higher at a seeding rate of 1.5 million/ha. In the conditions of spaced planting on a larger area, plants better realize their growth and development potential, due to their belonging to a particular morphotype.

Varieties were evaluated for a number of quantitative characteristics. Table 3 shows the mean values of these characteristics. As can be seen from Table 3, plants of new varieties significantly differed from the standard by stunting. The variety, representing the morphotype TVS, was the most stunted.

According to the number of nodes on the main stem of the plant, all varieties were approximately at the same level. According to the number of the first racemes, studied varieties are worse than the standard. The increase in the branching zone of the stem is accompanied by a slowing down of the flowering inception for 1-2 days. The number of nodes in the vegetative part of the stem is positively correlated with the duration of flowering and vegetation as a whole.[17] Consequently, new varieties are earlier ripening. Among all varieties, K-899 has the lowest value of this feature.

The number of nodes in the branching zone of the stem in all varieties, including the standard, was higher than the number of the first racemes: In fasciated buckwheat plants over the cotyledonary node, there are 1-2 or more unbranched nodes.

All new varieties have more nodes in the field of seed formation than the standard, especially

Table 2: Sugariness of buckwheat varieties nectar, mg of sugar/flower, 2013-2015

Varieties	Seeding rate				Average
	1.5 million/ha		2.0 million/ha		
	The 1st seeding time	The 2nd seeding time	The 1st seeding time	The 2nd seeding time	
Chatyr Tau	0.13	0.12	0.12	0.15	0.132
K-683	0.14	0.20	0.16	0.19	0.170
K-865	0.18	0.24	0.17	0.16	0.188
K-890	0.15	0.19	0.18	0.19	0.180
K-899	0.11	0.18	0.14	0.16	0.148
Average	0.164		0.162		0.163

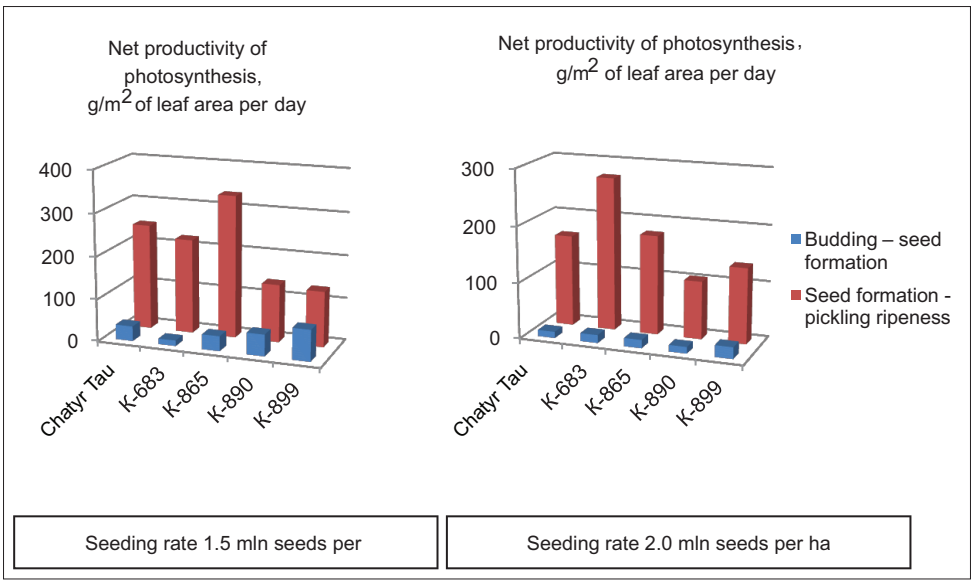

Figure 1: Net productivity of photosynthesis in buckwheat varieties at different seeding rates on average in 2013-2015

Table 3: Mean values of morphological features of new buckwheat varieties, during 2013-2015

Feature	Mean±error of mean				
	Chatyr Tau	K-683	K-865	K-890	K-899
Plant height, cm	76.5±1.9	65.9*±2.1	64.9*±2.1	59.7*±2.4	63.1*±2.3
The number of nodes on the stem	8.8±0.37	9.7±0.28	8.3±0.25	8.4±0.28	9.4±0.28
The number of the first racemes	3.1±0.23	1.8*±0.34	2.3*±0.23	1.5*±0.22	2.4*±0.21
The number of the second racemes	0.71±0.30	0*	0.16±0.08	0.07*±0.05	0.08*±0.05
The number of nodes in the field of stem branching	3.2±0.18	2.7±0.20	2.6*±0.18	1.8*±0.29	3.4±0.41
The number of nodes in the field of seed formation	4.8±0.45	7.9*±0.35	6.4*±0.28	6.5*±0.26	8.3*±0.33
The length of the stem branching field, cm	29.1±1.7	21.4*±1.7	27.6±2.3	17.5*±2.8	26.4±2.4
The number of inflorescences on the plant	15.3±1.6	15.4±1.6	17.3±0.1	14.0±1.5	13.3±1.4
Root weight, g	1.50±0.36	0.66*±0.06	0.68*±0.20	0.65*±0.10	0.62*±0.06
Weight of seeds from one plant, g	3.54±0.44	2.67±0.28	3.49±0.31	4.06±0.68	2.44±0.41
Weight of seeds from the main stem, g	1.41±0.10	2.08*±0.17	2.15*±0.10	2.76*±0.41	1.85±0.22
Seed productivity, pcs.	113.6±13.9	92.3±9.7	121.8±1.6	127.7±19.2	80.2±11.4
Ear grain content pcs/inflorescence	7.71±0.54	6.25*±0.46	7.02±0.50	8.23±0.53	5.73*±0.44
Economic coefficient,%	44.2±2.7	44.4±1.02	44.2±1.56	49.7±1.75	41.0±1.33

Sign "*" indicates the average values of the features, significantly varying from the average value of the standard feature

varieties belonging to the Kudryavyi-VBS morphotype.

According to the number of inflorescences (tiers) on the plant, none of the varieties differed significantly from the standard.

Lower short internodes and high root supportability of plants (the ratio of the root biomass to biomass of entire plant) are known to promote plant resistance to lodging.[18] These features were the best in the varieties of Kudryavyi-VBS morphotype.

According to the productivity of plants (the weight of seeds from the plant), all varieties were at the level of the standard. Kudryavyi-VBS morphotype showed low productivity. Variety K-865 showed productivity equal to the standard (these are varieties representing two-tier morphotype). Variety K-890 (morphotype TVS) slightly exceeded the standard for the weight of seeds from the plant. According to the number of forming full seeds on the plant, varieties were distributed in a similar way. Thus, the previously revealed association of plant architectonics with a yield[19] is confirmed, to some extent. All new varieties have higher productivity of the main shoot that the standard. Three varieties have significant values.

An important technological parameter of buckwheat grain is the size of the seeds characterized by a weight of 1000 pcs. This indicator, obtained by calculation, was maximum in variety K-890.

As shown by earlier studies, among the elements of the buckwheat crop structure, the most closely related to the yield and least dependent on the growing condition indicators are the following: Economic coefficient,[20] grain content and size of inflorescences,[21] and the number of inflorescences on the plant.[22] In our study, the grain content of inflorescence and the economic coefficient of K-890 variety were higher, than standard, but insignificantly. Earlier we showed that the K-890 variety was distinguished among others by a low biomass of plants at the end of the growing season. At the same time, it demonstrated the best productivity indices. Perhaps, this is a confirmation of the view, that seed production is connected not only with the power of plants photosynthetic apparatus but with the system of photosynthesis products distribution in plants.

DISCUSSION

New buckwheat varieties K-865 and K-890 significantly exceeded the standard for sugar content of nectar. Significant influence on this indicator was provided by the timing of buckwheat seeding and vegetation conditions of different years. The rates of seeding were affected on the sugar content of nectar uncertainly. The value of the parameter in all studied varieties differs identically in response to changes in growing conditions.[23]

The high net productivity of photosynthesis in the second half of the generative period was noted in the standard and in varieties K-683 and K-865. Varieties K-890 and K-899, although they formed a smaller biomass during the generative period, were characterized by more simultaneous flowering. Net productivity of photosynthesis was higher with a seeding rate of 1.5 million seeds/ha.

Studied prospective varieties differed from the standard by the stunting and weak branching of the stem. The number of nodes in the zone of seed formation and the productivity of the main stem in the studied varieties proved to be significantly higher than that of the standard. Relatively high seed productivity, economic coefficient, grain content of inflorescences, and weight of 1000 seeds are

characteristic for grade K-890 created on the basis of the morphotype TVS. Low values of seed productivity were recorded in varieties, representing by Kudryavyi-VBS morphotype. Herewith, these varieties showed the best values of the indirect parameters of lodging resistance.

CONCLUSION

Thus, our study showed that among the new studied varieties, with physiological determination of growth, variety K-890, representing the morphotype TVS, has a complex value.

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REFERENCES

1. Ohnishi O. Molecular taxonomy of the genus *Fagopyrum*. Molecular Breeding and Nutritional Aspects of Buckwheat. London: Elsevier Inc.; 2016. p. 1-12.
2. Bocquet M. Flore mellifere: Le Sarrasin. Bull Tech Apic. 1999;26(3):139-42.
3. Naumkin YP. Nectar productivity in buck wheat varieties (*Fagopyrum esculentum* Moench) Penza, Pushcino: Physical-Chemistry. Basis Plant Physiology. Annual Symposium; 1996. p. 139.
4. Cawoy V, Kinet JM, Jacquemart AL. Morphology of nectaries and biology of nectar production in the distylous species Fagopyrum esculentum. Ann Bot. 2008;102(5):675-84.
5. Cawoy VJ, Ledent JF, Kinet JM, Jacquemart AL. Floral biology of common buckwheat (*Fagopyrum esculentum* Moench). Eur J Plant Sci Biotechnol. 2009;3(1):1-9.
6. Alekseyeva ES, Bureyko AL. Bee visitation, nectar and pollen efficiency of common buckwheat. Fagopyrum. 2000:17;77-80.
7. Campbell CG. Buckwheat crop improvement. Fagopyrum. 2003;20:1-6.
8. Fesenko NV, Fesenko NN, Romanova OI, Alekseeva ES, Suvorova GN. Genofond and selection of cereals. Buckwheat. Saint Petersburg: SSC, RF, VIR; 2006. p. 196.
9. Fesenko AN, Fesenko NN, Romanova OI, Fesenko IN. Crop Evolution of Buckwheat in Eastern Europe: Molecular Breeding and Nutritional Aspects of Buckwheat. London: Elsevier Inc.; 2016. p. 99-108.
10. Kadyrova FZ, Kadyrova LR, Khusnutdinova AT. New varieties of buckwheat for arid conditions of the Middle Volga region. Grain Econ Russ. 2014;2:54-7.
11. Kadyrova LR, Kadyrova FZ. Formation of the morphological potential of plants in the early-ripening genotypes of buckwheat. Increasing the stability of crop production in modern conditions: Collection of scientific materials. Orel: PF, Kartush; 2008. p. 212-20.
12. Galiullina GN, Kadyrova FZ. Optimization of the buckwheat plants habit in the selection process for the Middle Volga region conditions. Leguminous Cereal Crops. 2014;4(12):27-9.
13. The Method of State Variety Testing of Agricultural Crops. Moscow: Kolos; 1985. p. 269.
14. Nikitin SA. Recommended practices for assessing the nectar production of the main honey plants. Rybnoe: Publishing House of the Apiculture Research Institute; 1984. p. 22.
15. Bedenko VL, Burdonoch EI, Polonskaya GN, Chigaev AM. Scientific and methodological recommendations for the study of morphophysiological indicators of photosynthetic activity of plants (on the example of winter wheat). Kaluga: KSU; 2000. p. 24.
16. Software package AGROS for statistical and biometric-genetic analysis of plant growing and selection. Version-2.08. Tver: TSU, 1999.
17. Potapov KO, Kadyrova LR, Kadyrova FZ, Nikiforova IY. Evaluation of Resistance to Lodging of Buckwheat Varieties on the Basis of Anatomical Features. Res J Pharm Biol Chem Sci. 2016;7(6):3207-13.
18. Fesenko MA, Fesenko AN. Architectonics of the leafy system of different buckwheat varieties and species. Agrar Russ. 2002;1:58-63.
19. Fesenko NV, Martynenko GE, Fesenko AN, Savkin VY. Some Features of Morphology, Level and Structure of the Yield of Model Buckwheat Varieties. Penza, Pushcino: Physical-Chemistry. Basis Plant Physiology. Annual Symposium; 1996. p. 119.
20. Martynenko GE. Significance of the feature "large inflorescence" in increasing the buckwheat productivity potential. Physiology of plants is the basis of the agriculture work: Oryol branch of the Physiologists Society of the Russian Academy of Sciences. Mascow: Academy; 1999. p. 107-8.
21. Taranenko LK, Yatsyshen OK. Physiological and genetic mechanisms for improving the architectonics of buckwheat genotypes plants by the methods of selection according to index indicators. Leguminous Cereal Crops. 2014;3(11):53-60.
22. Leonov GI, Golyshkin LV. Structural and Functional Features of Leaves of Buckwheat Varieties Physiology of Plants-the Science of the 3rd Millennium: Thesis Report of International Conference, Moscow; 1999. p. 269-70.
23. Martynenko GE, Gurinovich YA. Peculiarity of the adapted polymorphism of buckwheat varieties Penza, Pushcino: Physical-Chemistry. Basis Plant Physiology. Annual Symposium; 1996. p. 121.