

Transpiration activity of leaves in buckwheat varieties of different breeding periods

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Abstract. Genotypic aspects of leaf transpiration intensity manifestation in 22 buckwheat varieties from different periods of creation were studied in the field in real time on intact plants. It is shown that their ability to evaporate water has a high hereditary conditionality and plays an important role in increasing photosynthetic activity and crop productivity in the breeding process. Based on this, it is concluded that when creating new varieties, it is very important not only to carry out current control over the state of this process, but also to carry out targeted selection on it, considering photosynthesis activity. In this case, it is necessary to select forms that combine high intensity of leaf photosynthesis with moderate transpiration activity.

1 Introduction

Leaf transpiration ensures active movement of minerals and water from the soil into plants, protecting aboveground organs from overheating and dehydration in dry and hot weather, thereby creating optimal conditions for photosynthesis [1, 2, 3, 4]. Therefore, it is very important to know the peculiarities of changes in its activity as a result of breeding, and how this is related to the photosynthetic and productive process of plants, to identify effective ways of regulation. This scientific article is devoted to the results of the study of these issues in the hydrophilous and photophilous buckwheat crop.

2 Materials and methods of research

The research was carried out at the Center for the Collective Use of Scientific Equipment (CCU) of the Oryol State Agrarian University "Plant genetic resources and their use" within the framework of a joint scientific program with breeders of the Federal State Budgetary Scientific Institution of the Federal Scientific Center for Legumes and Cereals (FSBSI FSC LC).

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22 buckwheat varieties were studied, which were conditionally divided into 4 groups: local (K-406 and K-1709); breeding of the 1930s – 1970s (Kalininskaya, Bogatyr and Shatilovskaya 5), modern varieties (Chatyr - Tau, Dozhdik, Demetra, Bashkirskaya krasnostebelskaya, Dikul, Batyr, Usha, Design, Devyatka and Inzerskaya) and promising varieties (Design 2, R 66, R 69, R 70, R 84, R 85, SPR 52).

The experimental material was grown in a breeding crop rotation on plots with an area of 10 m², placed by a randomized method, the repetition is 4-fold. Crop tending and harvesting were carried out according to methodological recommendations for the region [5].

Transpiration activity (IT) was recorded in the field in real time on intact plants using a portable gas analyzer GFS-3000 FL of the German company WALZ. For the measurement, 5-7 plants typical of the genotype growing in the plot middle, which leaves had no damage, were used. Measurements were carried out in phases: "branching", "flowering + 10 days", "flowering + 20 days", "flowering + 30 days") on the 3rd leaf on top of the main stem from 8 am to 11⁰⁰ am and from 7 am to 7⁰⁰ pm.

Statistical processing of the experimental data obtained was carried out using MS Excel 2013 and Statistica v. 10.0 (StatSoft, Inc., USA) software packages.

3 Results and Discussion

The experimental data obtained indicate that the intensity of leaf transpiration in buckwheat has a high hereditary conditionality. The indicator variation on average for the crop variety samples was 5.53–10.19 mmol H₂ O/m²s in the years of research. Although purposeful selection in this direction was not carried out, nevertheless, the transpiration activity of leaves of culture plants as a result of breeding increased significantly, mainly during the period of mass flower formation and the beginning of fruit formation. In the "flowering +10 days" phase, in terms of this indicator, they exceeded their predecessors by an average of 7.5% (varieties of breeding of the 1930s-1960s) and 16.6% (local varieties - populations) (Fig. 1).

These changes because of breeding are obviously not accidental, because the period of formation of generative organs is the most vulnerable in plants, due to its strong dependence on environmental conditions [14]. For the full development of flowers and fruits, it is necessary to saturate plant cells with water, protect them from overheating and provide them with nutrients, which is largely provided by transpiration [2, 4]. Naturally, these important properties of the process could not remain unchanged when creating new high-yielding varieties.

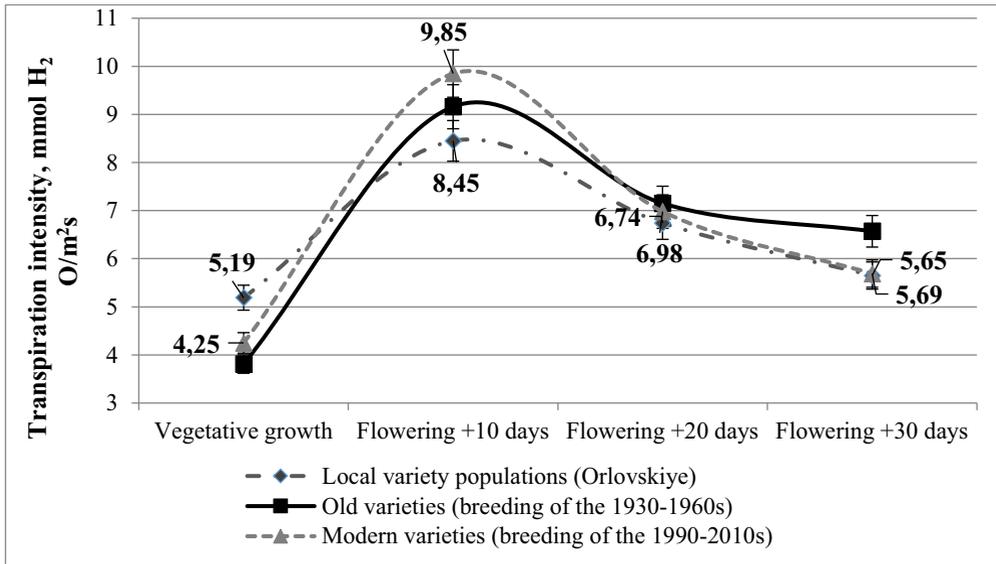


Fig. 1. Leaf transpiration intensity* in plant ontogenesis in buckwheat varieties of different breeding periods, average for 2013-2015. (* in the phase flowering +10 days LSD05 = 0.65).

An increase in transpiration intensity during the mass formation of flowers and fruit formation led to a significant increase in the efficiency of fruit and seed formation in plants, and, consequently, seed productivity. During the period of artificial selection from local populations to the best modern varieties of plants, on average, the number of seeds in the inflorescence increased by 2.5 times, filled seeds - by 1.2 times, and the weight of seeds from the plant - by 1.6 times. At the same time, the transpiration effect on the production and reproduction processes was largely mediated by photosynthesis activity (Fig. 2).

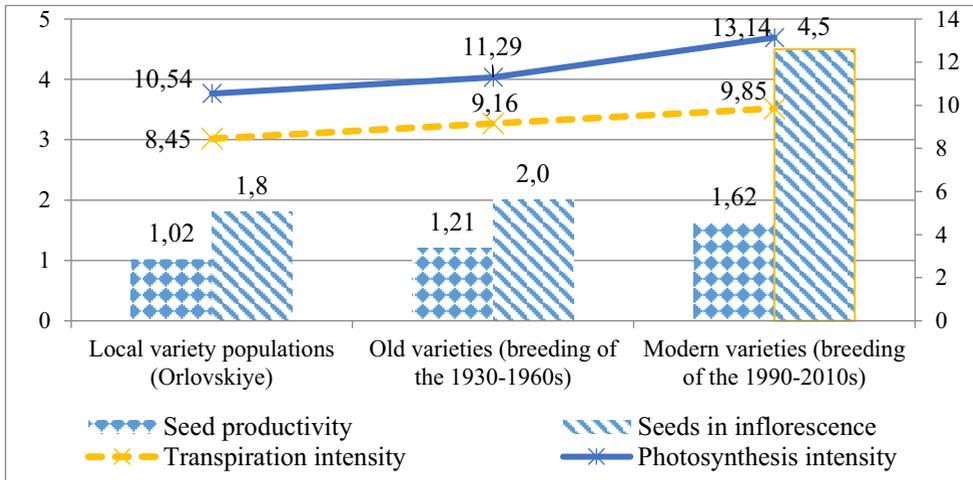


Fig. 2 Changes in transpiration activity (mmol H₂O/m²) and photosynthesis (mmol CO₂/m²) of leaves in the “flowering + 10 days” phase, seed productivity (g/plant), and the number of seeds in the inflorescence (pcs. per plant) in buckwheat plants as a result of breeding.

During the years of research, the correlation coefficient of leaf transpiration intensity with the number of seeds was 0.51, with seed productivity it was 0.70, and with photosynthesis intensity 0.78 at the significance level 05. That is, the increase in

transpiration activity of leaves in the process of buckwheat breeding for high yields is due to not only the need to absorb more mineral elements and water from the soil, but also to provide optimal conditions for photosynthesis, through which about 96% of the dry matter of crops is formed [7].

The efficiency of plant growth and development depends on the interaction of these 2 processes. It was found that the ratio of photosynthesis intensity to transpiration intensity (ATO) of plant leaves in modern buckwheat varieties is on average 13.7% higher during the growing season compared to local populations. The advantage is especially significant during the period of mass seed filling, when the intensity of photosynthesis increases markedly, and transpiration decreases. In the "flowering+20 days" phase, the ratio of photosynthesis intensity to transpiration intensity of plant leaves in modern varieties was 19.5%, and in the "flowering +30 days" phase it was 18.7% higher than in the predecessors (Table 1).

Table 1. Water use efficiency (ATO) in buckwheat varieties of different breeding periods by growth phases, average for 2013-2015.

Groups of varieties	Growth phase :				
	Vegetat. growth	flowering +10 days	flowering +20 days	flowering + 30 days	average for growing season
Local populations	2.02	1.29	1.57	1.45	1.58
Varieties of the 1930-1960s.	2.71	1.13	1.57	1.41	1.71
Varieties of the 1990–2010s.	2.43	1.16	1.95	1.76	1.83

This indicates that because of breeding, buckwheat plants have significantly increased not only the activity, but also the transpiration efficiency in the implementation of photosynthesis by leaves.

In modern crop varieties, the leaves of upper, middle, and lower tiers of plants are characterized by the highest transpiration intensity. In terms of this indicator value, on average, they exceeded the old varieties by 23.7%, and local populations by 66.5% (Fig. 3).

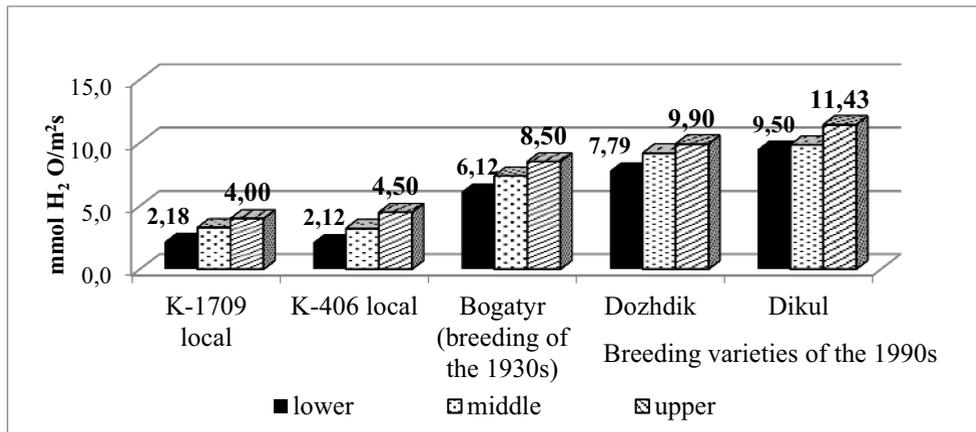


Fig. 3. The intensity of water evaporation by leaves in the "flowering + 10 days" phase, depending on their tiered location in buckwheat varieties of different breeding periods, according to 2 series of vegetation experiments (LSD₀₅ for lower tier = 0.90; for the middle tier – 1.12; for for the upper tier – 1.21).

It was previously shown that an increase in the transpiration activity of leaves has a positive effect on their photosynthetic activity [15]. Together, this gives reason to consider

the transpiration intensity as one of the important criteria for the selection of promising initial forms in the breeding of crops for increased seed productivity. Forms combining high leaf photosynthesis activity with moderate transpiration activity should be considered promising in this case, since more than 60% of the solar energy absorbed by crop can be spent on water evaporation by leaves [16].

According to the experimental data obtained, the buckwheat gene pool has such genotypes, which gives reason to count on achieving certain successes in this breeding direction. These include, first, varieties R 84, Chatyr-Tau, R 69, Design, and others that can be used in breeding as a valuable source material characterized by high transpiration efficiency in photosynthesis (Fig. 4).

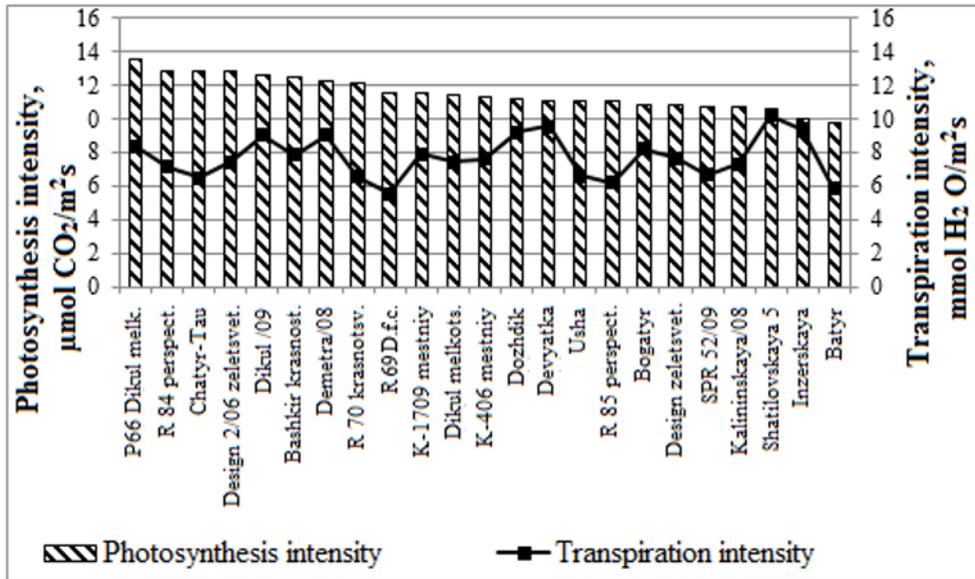


Fig. 4. Activity of transpiration and photosynthesis of leaves in experimental buckwheat varieties in the "flowering + 10 days" phase, average for 2010-2015.

4 Conclusion

In buckwheat crop, the transpiration activity of leaves has a high hereditary conditionality and plays an important role in increasing seed productivity in new crop varieties. During the breeding period from local populations to modern varieties, the transpiration intensity in the "flowering + 10 days" phase increased by an average of 12.0%, and its efficiency in photosynthesis during the period of mass seed filling increased by 19.1%. Therefore, it is very important when creating new varieties to carry out not only current control over the state of this process, but also to carry out targeted selection on it, considering photosynthesis activity. It is reasonable that the selected forms combine a high intensity of leaf photosynthesis and moderate transpiration activity, using the "ATO" indicator, which is the ratio of photosynthesis intensity to transpiration [17]. The assessment should be carried out in the "flowering + 20 days" phase on the leaves of the upper tiers from 9 to 11:00 am.

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