Variation of canopy temperature of the plant depending on water supply in wheat genotypes

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In the presented article, based on the results of research carried out in the "Plant Physiology" department and reference data, the canopy temperature of plants in different phases and genotypes depending on the water supply of wheat genotypes was studied. For the study, 7 local and introduced bread wheat genotypes with different morphological characteristics were taken and they were divided into 3 groups: early, medium, and late heading(spike). It was determined that the canopy temperature of the plant depends on the biological characteristics of the genotype as well as its water supply. In the article, canopy temperature under water scarcity was discussed, it was concluded that the leaves are protected from overheating as a result of high transpiration of the plant in the optimal irrigation regime, and it was shown that the course of normal physiological and biochemical processes leads to the formation of high productivity. Also, as a result of comparing the tolerance of genotypes with vertical and horizontal leaves to drought and heat stress, it was recommended to use the genotypes with vertical leaves in breeding and to give preference to genotypes that collect more biomass until the stress factors are aggravated.

Keywords: *Wheat, genotype, drought, heat, tolerant, selection, productivity*

INTRODUCTION

Against the backdrop of ecological imbalance, environmental stress factors constantly limit crop production, creating a problem for sustainable wheat production in meeting the food demand of the population. Increasing tolerance to abiotic stresses is considered one of the main goals of increasing wheat production in the world. Among the abiotic factors, drought and heat stress or their combination is the main factor limiting productivity and causing disruption of many biochemical and physiological processes, including cell membranes (Tahmasebi et al., 2017).

Drought tolerance mechanisms are divided into 3 major groups: drought avoidance, resistance, and biochemical resistance of cells during water scarcity (Plomion et al., 2016). Heat tolerance in plants results in the accumulation of various metabolites, including antioxidants, osmotic regulators, and heat shock proteins (Fisher, Byerlee, 1990). Despite the fact that drought is a relatively effective process in nature due to the mechanism of action, heat stress occurs rapidly.

As a result of the increasing impact of global climate changes on the agricultural area (drought and heat stress), crop production is limited. Plants try to adapt to these stresses by showing morphological, physiological, biochemical and genetic reactions. In various studies, it is noted that grains are more sensitive in the reproductive stage of development, due to the effects of drought and heat, the grain filling weakens, as a result, the yield decreases.

Researchers indicate that the optimum temperature during flowering is 17.5ºC (Hasanuzzaman et al., 2013). When the air

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temperature is 1-2ºC higher than the optimum temperature for several days, the yield of wheat is significantly reduced (Siebert et al, 2014). At the same time, the importance of the difference between the temperature of the canopy and the air was noted in the studies, and it was shown that its optimal value is 7ºC. The difference between air and canopy temperatures is an indicator of heat resistance and is considered a valuable sign for breeding (Talaiet al., 2011; Neukam et al., 2016).

Quantitative values of drought and heat tolerance in the wheat plant reduce the success of such an approach by reducing the probability of growth and development of genotypes (Lipiec et al., 2013). Cereal producers mainly focus on yield management and its stability under stress conditions due to drought and heat tolerance (Gilliham et al., 2017). In addition to noting that plant phenotypic indicators are important for certain environmental conditions for the regulation of drought and heat stress, the identification of quality trait loci of many genes controlling them is highly appreciated (Tardieu et al., 2012). The effect of stress on crop production is influenced by many signs, including root properties of remobilization of assimilates accumulated in the total biomass, osmotic regulation, etc. affects and limits productivity (Iqbal et al., 2017).

Researchers note that heat and drought stress are often perceived together (Dreesen et al., 2012). The effect of heat and water stress reduces stomatal permeability in plants and weakens transpiration, resulting in an increase in leaf temperature (Król, 2013). Under the influence of stress factors, the assimilation surface of leaves decreases (Poorter et al., 2009). As a result of morphological changes, the cells in the leaves become smaller, which causes the stoma (pore) to be more closely spaced (Shahinnia et al., 2016). Various morphological, physiological and biochemical adaptations are formed as a response of plants to abiotic stresses (Huber, Bauerle, 2016). In order to avoid stress, the change of root architectonics in plants regulates the permeability of the stoma and the reduction of leaf area, the increase of leaf thickness, and finally the morphological and biochemical adaptation to stress by reducing the level of evapotranspiration (Goufo et al., 2017). The formation of a wax layer on the leaves of the plant is also a manifestation of the response to stress (Lee, Suh, 2013). Studies show that photosynthetic efficiency reduces the effects of heat and drought stress depending on the level of transpiration (Zandalinas et al., 2016). Due to the effect of high stress, the amount of chlorophyll decreases, thylakoid grains are broken and the transport of produced assimilations is disrupted (Kozłowska et al., 2007). In addition to managing yield under stress conditions and implementing irrigation to reduce harmful effects, it is desirable to create more resistant genotypes.

MATERIALS AND METHODS

Researches were carried out in the field of Absheron Subsidiary Experimental Farms of the Research Institute of Crop Husbandry. 7 local and introduced bread wheat genotypes with different morphophysiological characteristics were used for the study and they were divided into 3 groups as early (Gobustan, Giymatli 2/17 and Azamatli-95), medium (Gyrmyzy gul-1 and 12ndFAWWON N97) and late heading (4thFEFWSN N50 and Tale- 38) ones. The studied genotypes were also grouped by having different leaf architectures, i.e. vertical and horizontal to the planting surface. Researches were carried out in optimal irrigation, partial irrigation, drought, partial drought options depending on the water supply. In the optimal irrigation option, the field was irrigated twice in the vegetation year and the moisture content was 65-75%, in the partially irrigated option, irrigation was stopped after the first irrigation, the moisture content was 45-65%, and in the drought option, the moisture content was around 35-65% by creating an artificial drought condition, in the case of partial drought, the field was irrigated only in the second irrigation (at the end of April). During the study, the heading(spike) date of genotypes was recorded in all variants, and plant height was measured at the end of vegetation. Canopy temperature was measured with a portable infrared thermometer and measurements were taken twice during the day at 11^{00} and at 15^{00} - the hottest times of the day, and in three replicates at the beginning of the milk (26.05) and wax ripeness (01.06) phases. The mass of the above-ground part and productivity were calculated according to the bundle taken from a 1 m^2 area (Dospekhov, 1985).

RESULTS AND DISCUSSION

In all studied genotypes, the canopy temperature was lower in the irrigation option compared to the other options in both phases, which is due to the large leaf surface and the opening of the stoma as a result of the optimum amount of water in the soil in the irrigation option. A normal water supply leads to more biomass formation per unit area, which increases the amount of evaporation, keeping the canopy cooler. The canopy temperature depends on the physiological state of plants. So, physiologically active, i.e., late-heading genotypes regulate the temperature better. In the partially irrigated option, the canopy temperature was high in the early heading genotypes, while it was relatively low in the medium and late heading genotypes. This is due to the fact that these medium- and late-heading genotypes are physiologically active.

In the second half of the day (at 15 o'clock), in addition to the regularity mentioned above, the temperature difference was less in varieties with a larger leaf surface, as the water balance in the plants decreased. In drought conditions, transpiration weakens due to high water scarcity in the soil, as a result of which the canopy temperature rises. High temperature in plants was observed mostly in genotypes with early heading and horizontal leaves.

In the partial drought option, the canopy temperature was lower compared to the drought option. This reduction was found to be relatively greater in mid- and late-heading and vertical-leaf genotypes. Plant temperature is also highly dependent on plant architecture. In genotypes with good architecture (vertical leaves - Azamatli-95, Gyrmyzy gul-1 and 12ndFAWWON N97), the sun rays penetrate deeper layers of the crop and as a result, the whole system is involved in the regulation of plant temperature, and in other types of genotypes (horizontal leaf-Giymatli 2/17, 4thFEFWSN N50 and Tale-38) the main function is performed by the 8th leaf, which prevents the sun's rays from penetrating more inside, as a result, the canopy temperature rises (Table).

As can be seen in the table (milk ripeness), the air temperature was 29ºC at 11^{00}, the highest canopy temperature in the optimal irrigation regime was in the Giymatli -2/17 variety with horizontal leaves (22.7ºC), the difference was 6.3ºC. The minimum value was 20.9ºC in genotype 4thFEFWSN № 50 with late-heading(spike) horizontal leaves, the difference compared to wheather was 8.1ºC. This happens due to the fact that the variety is physiologically active, at the same time, the remobilization of nutrients in the root has just started, and as a result of the high absorption power, there are sufficient assimilates in the root. This similar situation is also manifested in other early and late heading genotypes. In the partially irrigated variant, the minimum canopy temperature was 21.1, 21.5, and 21.4ºC in the late-heading 4thFEFWSN № 50, Gyrmyzy gul-1, and Tale-38 genotypes.

In the drought option, the lowest value of canopy temperature in this phase was 22.3ºC in Giymatli -2/17 from the early heading genotypes. This is characterized by high evaporation in the first half of the day as a result of relatively normal water balance in the plant.

In the measurements made at 15^{00} hours during the milk ripeness phase, the weather temperature reached 31ºC and the water reserves in the plants were exhausted, as a result, the value of the canopy temperature increased. In this phase, in optimal irrigation and partial irrigation options, the minimum value was in early-heading Gobustan and Azamatli-95 genotypes, and in late-heading genotypes, 4thFEFWSN №50. In the drought option, the minimum value was observed in the early-heading Azamatli-95, and in the late-heading genotypes, the Gyrmyzy gul-1 genotype.

At the beginning of the phase of wax ripeness, the plants have relatively lost their physiological activity, the water absorption force has decreased due to the transport of assimilates from the root, the weather temperature has increased, and at the same time, the drought has deepened. The regularity observed in the phase of milk ripeness has been shown relatively sharply in this phase as well.

Table. Canopy temperature depending on the water supply of different wheat genotypes

The name of the variety	Options	Heading date	Plant height, cm	26.05				01.06				Mass of bundle, g/m^2	Productivity, g/m^2
				11^{00} weather-29ºC		15^{00} weather-31ºC		11^{00} weather-30ºC		15^{00} weather-32ºC			
				Plant temperature	The difference	Plant temperature	The difference	Plant temperature	The difference	Plant temperature	The difference		
Gobustan	**I**	30.04	102	21.4	7.6	25.2	5.8	27,3	2.7	29.6	2.4	1707	598
	II	30.04	101	21.8	7.2	25.6	5.4	27.6	2.4	29.7	2.3	1690	565
	III	27.04	99.0	23.8	5.2	26.4	4.6	27,8	2.2	30.1	1.9	1560	447
	IV	27.04	100	23.2	5.8	26.1	4.9	27.6	2.4	30.0	2.0	1575	480
Giymatli 2/17	**I**	01.05	90.0	22.7	6.3	25.4	5.6	27,0	3.0	29.7	2.3	1770	525
	II	01.05	88.0	21.8	7.2	25.7	5.3	27.2	2.8	29.8	2.2	1775	490
	III	28.04	83.0	22.3	6.7	26.5	4.5	27.5	2.5	30.2	1.8	1277	320
	IV	28.04	84.0	23.3	5.7	26.2	4.8	27.3	2.7	30.3	1.7	1300	345
Gyrmyzy gul 1	**I**	08.05	80.0	21.2	7.8	24.8	6.2	26,0	4.0	29.1	2.9	1750	577
	II	07.05	80.0	21.5	7.5	25.0	6.0	26.3	3.7	29.4	2.6	1735	460
	III	06.05	76.0	23.0	6.0	25.8	5.2	27,3	2.7	29.9	2.1	1695	407
	IV	06.05	77.1	23.4	6.2	25.0	6.0	26.2	3.8	29.3	2.7	1720	480
Azamatli 95	**I**	30.04	105	21.5	7.5	25.2	5.8	26,1	3.9	29.5	2.5	1597	527
	II	30.04	103	22.0	7.0	25.5	5.5	27.5	2.5	29.6	2.4	1580	495
	III	28.04	95.0	22.9	6.1	25.9	5.1	27,7	2.3	30.2	1.8	1470	430
	IV	28.04	96.0	22.3	6.7	25.7	5.3	27.6	2.4	30.3	2.1	1490	475
Tale 38	**I**	10.05	108	21.1	7.9	24.5	6.5	26,1	3.9	29.3	2.7	1660	565
	II	10.05	105	21.4	7.6	25.1	5.9	26.3	3.7	29.4	2.6	1640	520
	III	08.05	92.0	23.1	5.9	26.0	5.0	26,6	3.4	29.7	2.3	1343	380
	IV	08.05	95.0	21.7	7.3	25.0	6.0	26.2	3.8	29.9	2.6	1475	480
12nd FAWWON N97	**I**	05.05	99.0	21.6	7.4	24.6	6.4	26,3	3.7	29.8	2.2	1413	405
	II	05.05	98.0	21.8	7.2	24.9	6.1	26.7	3.3	29.7	2.3	1380	370
	III	03.05	93.0	22.4	6.6	25.6	5.4	27,5	2.5	30.2	1.8	1240	310
	IV	03.05	94.0	22.2	6.8	25.0	6.0	27.1	2.9	29.9	2.1	1283	365
thFEFWSN N50	**I**	10.05	108	20.9	8.1	24.4	6.6	24,9	3.1	29.2	2.8	1347	510
	II	10.05	106	21.1	7.9	24.8	6.2	24.3	5.7	29.4	2.6	1315	480
	III	08.05	103	21.8	7.2	26.0	5.0	25,4	4.6	29.9	2.1	1117	338
	IV	08.05	104	21.4	7.6	25.0	6.0	25.0	5.0	29.6	2.4	1145	470

Note: *I - optimal irrigation; II – partial irrigation; III-drought; IV- partial drought*

That is, the difference between the canopy temperature and the weather temperature decreased and was higher in the late-heading genotypes.

CONCLUSION

In conclusion, the amount of biomass collected in a single area plays a key role in the regulation of canopy temperature in wheat, along with its physiologically active state. The highest productivity is found in the early-heading or medium-heading genotypes that at the same time, form a high biomass. It is appropriate to choose these types of genotypes as the primary parental form in breeding and to include them in hybridization programs.

At the same time, it is appropriate to individually select the early-heading and medium-heading forms, which form more biomass due to the high coefficient of tillering, and forms with vertical leaves for regular breeding programs.

Depending on the water supply, the decrease in productivity was observed in the early-heading genotypes under partial irrigation, and in the late-heading genotypes under drought. Taking this into account, it is appropriate to select the genotype according to the seasonal distribution of precipitation in rainfed regions.

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