RESEARCH ARTICLE

The effect of stevioside on lipid peroxidation and the parameters of water metabolism of spring wheat, under the conditions of water deficit

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Abstract

Aim and Scope: The growth, water exchange parameters, and malondialdehyde content in the leaves of 15 day's plants of spring wheat, under the conditions of soil drought and pretreatment with diterpene glycoside stevioside (10–8 M), were studied in this paper. The cultivar of spring soft wheat (*Triticum aestivum* L.) Omskaya 33, included in the State Register of the Western Siberian and the Middle Volga regions, recommended for cultivation in the Omsk region and in the Republic of Tatarstan of the Russian Federation, as well as the cultivar of spring soft wheat (*T. aestivum* L.) Tamoz 2, bred, certified, and widely used in Iraq, was selected as the objects of the research. **Materials and Methods:** Experimental design included four options: Control, drought, presowing seed treatment with stevioside (10–8 M), and under the conditions of drought and sufficiency of water supply for plants. The moisture content of the soil was 70% in case of normal water supply, and 30% in case of drought. The determination of length of wheat seedlings showed that leaves of the cultivar Tamoz 2 had a lower height, than the cultivar Omskaya 33. **Result and Discussion:** The drought inhibited the growth of plants of two varieties. Pretreatment with stevioside reduced the effect of drought on the growth of wheat plants of two studied cultivars of spring wheat. Stevioside increased the water content in conditions of drought only in Omskaya 33, which was more sensitive to water deficiency. The variety Tamoz 2, in conditions of water deficiency, had less oxidation of lipids of the plasma membrane, compared to variety Omskaya 33. At the same time, stevioside to a greater extent reduced the lipid peroxidation (LPO) in the cultivar Omskaya 33, where the processes of LPO under the influence of a drought were more active. **Conclusion:** The obtained data may be determined by the antioxidant effect of stevioside on plants, the mechanism of which has not been identified to date.

Key words: Drought, growth, lipid peroxidation, parameters of water metabolism, stability, stevioside, *Triticum aestivum L.*

INTRODUCTION

One of the unfavorable factors, prevalent in the zones of risky farming, is drought, which causes various anatomic-morphological and physiologic-biochemical changes in plants. This affects their growth and development and leads to significant yield losses.[1] Application of plant growth and development regulators allows to increase plant resistance to abiotic and biotic stresses.

The list of growth regulators, used in practice, is quite large; nevertheless, the development and the search for new compounds possessing simultaneous growth regulating and antistress activity are extremely urgent tasks for today. In this regard, the attention of researchers is drawn by the compounds of diterpenic nature, among which a special place is occupied by the diterpene glycoside stevioside, obtained from plants of stevia. The main feature of stevioside is the similarity of chemical structure of its aglycon steviol with the well-known phytohormone - gibberellic acid. Phytohormone

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gibberellin in plants performs a number of important functions. Their most typical effect is an increase of stem growth in dwarf forms of plants or stem elongation in normal plants. They activate hydrolytic enzymes (for example, α-amylase) and their synthesis in cereal grains that causes faster transformations of reserve substances and germination of seeds. Furthermore, other physiological effects, more or less significant, are characteristic for them.[2] Based on the structural similarity and the presence of a common precursor in biosynthesis for steviol and gibberellic acid, it can be assumed that steviol glycosides are capable to have some growth regulating effect on plants. It has been shown that stevioside stimulated wheat growth, increased resistance to low temperatures,[3] heavy metals,[4,5] and phytopathogens.[6] Due to this, it was suggested that stevioside could increase plant resistance to drought. The purpose of the work was to identify the characteristics of stevioside effect, the parameters of water metabolism and lipid peroxidation (LPO) in two varieties of spring wheat Omskaya 33 and Tamoz 2, under the conditions of soil drought.

MATERIALS AND METHODS

The objects of the research were 15 day's plants of two varieties of spring soft wheat (*Triticum aestivum* L.) Omskaya 33 and Tamoz 2.

The cultivar of spring soft wheat (*T. aestivum L.*) Omskaya 33 was bred by the Siberian Agricultural Research Institute, included in the State Register of the Western Siberian and the Middle Volga regions, recommended for cultivation in the Omsk region and in the Republic of Tatarstan.

The cultivar of spring soft wheat (*T. aestivum* L.) Tamoz 2 was bred in 1992 in Iraq, by hybridization of varieties Saber beg x Maxibak.[7] The number of grains in the wheatear is 62–64, the weight of 1000 grains is 31–33 g, protein content in the grain is 10.2–10.5%, and yielding capacity is 5–6 t/ha.[8] The cultivar is certified and widely used in Iraq.

Experimental design included four options: Control, drought, presowing seed treatment with stevioside (10^{-8} M), and under the conditions of drought and sufficiency of water supply for plants. Seeds were planted by 40 pcs in pots, containing gray forest soil. The seeds of experimental variant were previously kept in stevioside (10^{-8} M) for 3 h. The concentration of stevioside was chosen in preliminary experiments. Plants were grown at temperature 23°C and 12-h photoperiod with an illumination of 100 W/m^2. The moisture content of the soil was 70% in case of normal water supply and 30% in case of drought.

Soil drought was created by the method.[9] During the first 10 days, the containers with plants were watered with tap water to the level of 70% of the soil maximum water capacity (SMWC). Soil drought was created by stopping watering of 10 day's plants. Within 5 days, the soil moisture in the test containers was reduced to 30% of SMWC.

For morphological measurements, 15 plants from each variant were taken.

Determination of the total water content, the relative water content, the water content in g/g of dry weight and the dry weight of the leaves, was carried out after drying the averaged weighed portions of leaves in a drying oven at 105°C.

The level of LPO was estimated according to the accumulation of the LPO product – malondialdehyde (MDA). MDA content is evaluated from the accumulation degree of the product of its reaction with thiobarbituric acid.[10]

The experiments were carried out in 4–5 analytical and 5–6 biological replications. For the statistical processing of data, the program Microsoft Excel was used. The significance of differences was determined using the Student's coefficient at $P \leq 0.05$.

RESULTS AND DISCUSSION

Due to the fact, that one of the main physiological characteristics is the growth of plants, we determined the height of spring wheat seedlings under the conditions of moisture deficiency and stevioside treatment (10^{-8} M). As can be seen from Figure 1, the plants of cultivar Tamoz 2 are characterized by a lower height, compared to the cultivar Omskaya 33. Drought inhibits the growth processes of plants of two varieties: The height of plant Omskaya 33 decreases by 14.2% and the height of plant Tamoz 2 by 9.3%, compared with control plants. It is known, that in conditions of prolonged drought, there is a limitation of plant growth.[11,12]

In the conditions of periodically droughts and increasing technogenic load on the soil, the study of the influence of

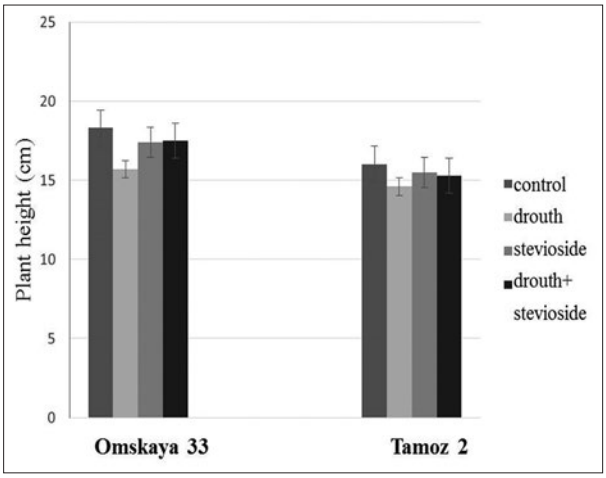

Figure 1: Influence of drought and stevioside (10^{-8} M) on height of spring wheat seedlings

biologically active compounds on the adaptive ability and the increase of plant resistance is of undoubted interest. As a result of the researchers of biological activity of diterpenoid steviol derivatives carried out at the Department of Botany and Plant Physiology of the Kazan Federal University, it was found that diterpene glycoside of steviol – stevioside had the ability to increase stress resistance of plants and to activate their growth.[3-6] In our experiments, stevioside (10^{-8} M) did not affect the growth of plants of two varieties of spring wheat in comparison with the control. In plants, treated with stevioside (10^{-8} M), the influence of drought on growth was not observed. The obtained data may be determined by the antioxidant effect of stevioside on plants, the mechanism of which has not been identified to date.

The resistance of plants to drought is largely determined by the water regime, inherent to this cultivar. The determination of water regime parameters significantly increases the significance of the obtained estimation of plant drought resistance. Various aspects of drought influence on plants are possible on photosynthesis, respiration, enzyme activity, growth, etc. However, the main thing is the impact of drought on the water regime of plants. First of all, there are water-retaining and water-absorbing capacity, water deficiency, change in the general water content of plants, during ontogeny and under conditions of stress.[13]

Determination of dry weight in % of wet weight showed, that in seedlings of Tamoz 2, this indicator is higher in comparison with Omskaya 33 [Table 1]. The drought led to an increase in dry weight in Omskaya 33 by 8.16%; the soil drought did not change this parameter in the seedlings of Tamoz 2.

Stevioside (10^{-8} M) of itself and against a background of soil drought reduced the dry weight only in plants of Omskaya 33 [Table 1].

Water content of control plants of the cultivar Omskaya 33 was 8.17 g/g of dry weight; in plants of Tamoz 2 - 7.43 g/g of dry weight [Table 1]. Under the influence of drought, this indicator decreased by 10% in plants of Omskaya 33; it had not changed in plants of Tamoz 2. The effect of stevioside (10^{-8} M) on the water content of seedlings of two varieties was different in Omskaya 33, on the background of drought, stevioside contributed to an increase in the water content to the level of control plants, while in Tamoz 2, stevioside did not change the water content, i.e., its quantity remained at the level of control, non-stressed plants [Table 1].

Thus, stevioside increased the water content in the variant with drought only in cultivar Omskaya 33, which was more sensitive to water deficiency. Varieties, which are in identical drought conditions, and preserving a higher water content of tissues, create better conditions for the course of all physiological processes in plants.

Peroxide oxidation of membrane lipids is one of the criteria for assessing the degree of oxidative stress in tissue.[14,15]

The influence of soil drought led to a significant increase in the level of MDA in two varieties of spring wheat: In Omskaya 33 - to 230% of the control, in Tamoz 2 - up to 186.13% [Figure 2].

Stevioside (10^{-8} M) had virtually no effect on the MDA content in both varieties (in Omskaya 33 - 106.13% of the control, and in Tamoz 2 - 104.95% of the control) [Figure 2].

Presowing treatment with stevioside (10^{-8} M) reduced the influence of drought on LPO in both varieties of spring wheat: In Omskaya 33 - by 66.45%, in Tamoz 2 - by 37.62%.

Hence, under the conditions of water deficiency, the cultivar Tamoz 2 has less oxidation of lipids of the plasma membrane, compared to the cultivar Omskaya 33. This may indicate that this cultivar is more resistant to drought. At the same time, stevioside decreased LPO in Omskaya 33, where LPO processes were more active, under conditions of drought.

Table 1: Parameters of water metabolism (total water content, relative water content, the water content in g/g of dry weight and dry weight of leaves of two spring wheat varieties, under the conditions of drought and stevioside (10^{-8} M), % of control

BIndicators	Variants							
	Omskaya 33				Тамоz 2			
	Control	Drought	Stevioside	Stevioside +Drought	Control	Drought	Stevioside	Stevioside +Drought
Dry weight content in% of wet weight	10.90±0.39	11.79±0.49*	10.29±0.43	10.41±0.48	11.85±0.41	11.91±0.28	12.23±0.50	12.19±0.62
Total water content, % of wet weight	89.09±0.47	88.20±0.37	89.70±0.42	89.58±0.51	88.14±0.43	88.08±0.52	87.76±0.41	87.80±0.29
Relative water content, %	83.86±0.51	82.83±0.43	85.58±0.52	86.27±0.48	86.25±0.57	84.51±0.61	88.33±0.58	85.29±0.49
The water content in g/g of dry weight	8.17±0.28	7.47±0.26*	8.70±0.32*	8.60±0.30*	7.43±0.24	7.39±0.30	7.17±0.25	7.20±0.26

*Significant value 11.79±0.49

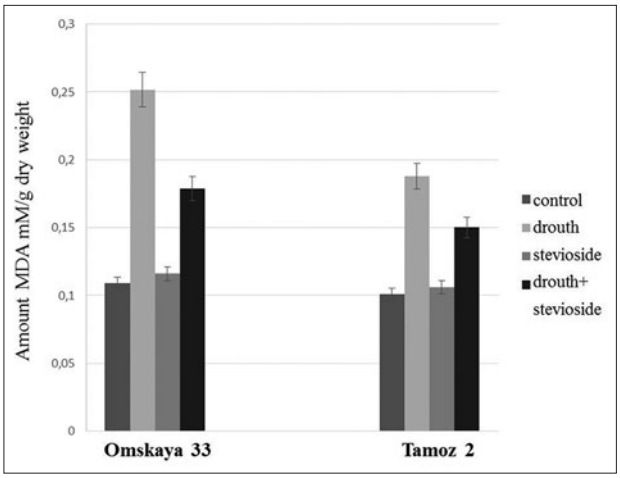

Figure 2: Influence of soil drought and stevioside (10^{-8} M) on the content of malondialdehyde in leaves of spring wheat seedlings

SUMMARY

Based on the performed research, the following conclusions were formulated:

1. It was shown that the pretreatment of spring wheat seeds with stevioside (10^{-8} M) completely removed the inhibitory influence of drought on growth of plants.
2. Stevioside increased the water content after a drought to the level of the control variant (without drought) in the cultivar Omskaya 33, which was more sensitive to water deficiency.
3. Stevioside largely reduced the MDA content, associated with water stress in the cultivar Omskaya 33, where LPO processes were more active under the conditions of drought.

CONCLUSION

Thus, as a result of the conducted studies, it was found that pretreatment with stevioside for increasing drought resistance removed the effect of soil drought on the growth of spring wheat plants of two varieties and reduced the level of LPO (more in the cultivar Tamoz 2). Stevioside had a greater protective effect on a less drought-resistant variety Omskaya 33, cultivated in the Russian Federation. It can be assumed that in the cultivar Tamoz 2, as more drought-resistant, the external signs of damage under the conditions of water stress (plant growth, water content) are observed after a longer impact of stress factor, than in the cultivar Omskaya 33. Probably that was why we did not observe significant changes in the growth of plants and water content of the cultivar Tamoz 2 after 5 days of drought.

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