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Research Article

DETERMINATION OF ECOPHYSIOLOGICAL RESPONSES TO TEMPERATURE SHOCK IN DIFFERENT WHEAT GENOTYPES

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ABSTRACT. Studies about the project mainly consists of two stages as plant breeding in the laboratory and analysis. Within the scope of laboratory studies, germination beds were formed in the Ecophysiology Laboratory of Eskişehir Osmangazi University, Faculty of Science and Literature and where the growth of the plants was ensured. Seeds of different genotypes (Kirik, Bayraktar, Aldane, Kenanbey, Seyhan, Yüreğir89, Uzunyayla, Seri82, Fuatbey, Canik) of *Triticum aestivum* L. were used as alive materials. Within the scope of laboratory studies, some ecophysiological parameters plants indexes. Wheat seeds belonging to different genotypes were left in germination beds for 14 days and applications were divided into 7 groups as control (21°C), 25°C, 30°C, 35°C, 40°C, 45°C and 50°C. At the end of the process, germination experiments were terminated and analyzes were started. As a result of the obtained data from experiments and analyzes; It was determined that applications above 35 °C inhibited vegetative growth in studied genotypes. It has been observed that the seeds can tolerate the increasing heat between the applications of 21-40°C. However, it was determined that the seeds could not tolerate the temperature especially at 45°C. The increase in seasonal temperatures with global warming has increased the importance of heat shock resistant cereal genotypes for humanity. Breeding of heat shock resistant genotypes is recommended to prevent economic losses due to heat shock. This is only possible by determining the high temperature tolerance genotypes by investigations such as in our study. Afterward, researchers should be focusing on the breeding of these determined genotypes.

Keywords: *heat shock, wheat, plant indexes*

INTRODUCTION

Agricultural production in our country and in the world is gradually weakening due to the decrease in agricultural areas due to drought and salinity, and the increase in migration from the village to the city. The main biological event that provides agricultural production is seed germination. The main factors affecting seed germination are light, temperature, water, gases and stimulating and inhibiting substances. One of the main threats to agriculture globally in recent years is water shortage and the other is global warming. In addition to the average increase in temperatures, sudden and short-term (relative to season) temperature increases have a great effect on seed germination and development.

Germination is controlled by many mechanisms in plants and is necessary for the full growth and development of a new plant [1]. For a plant seed to germinate, it must first absorb water. The seed, which can absorb water, swells, and after the emergence of the radicle, the seed is germinated [2]. The main factors affecting seed germination are water, temperature, oxygen, and light [3, 4].

Heat stress, like temperatures above the optimum range for plants, can damage vegetative organs [5]. Heat stress primarily depends on the intensity and duration of the stress, but it is more harmful during the breeding and grain filling stages [6, 7]. Yield losses due to temperature stress start with temperatures > 33°C and are common in various parts of the world [5].

The Intergovernmental Panel on Climate Change (IPCC) predicts an average annual temperature increase of 0.7-0.9°C for ten years (IPCC, 2014; ADB, 2009). Abiotic stress can affect productivity at different stages of plant development [8, 9, 10].

Nowadays, remote sensing methods are used to examine the plants in their development stages effectively and harmlessly [11]. Most plants survive by converting sunlight into chemical energy and form green biomass. "Normalized Vegetative Change Index" (NDVI), "Water Band Index" (WBI), "Simple Ratio" (SR), "Structural Independent Pigment Index" (SIPI) to determine the green biomass and nitrogen content in agricultural applications. Ratio Pigment Index (SPRI), "Adjusted Chlorophyll Absorption Reflectance Index" (MCARI), "Converted Chlorophyll Absorption Reflectance Index" (TCARI), "Zarco and Miller Index" (ZMI), Foliage Index (G), Triangular Vegetation Index ”(TVI),“ Normalized Pheofitinization Index ”(NPQI),“ Photochemical Reflectance Index ”(PRI),“ Normalized Pigment Chlorophyll Index ”(NPCI),“ Carter Indexes ”(CTR1, CTR2),“ Lichtenthaler Indexes ”(Lic1 Spectrophotometric indices such as, Lic2), "Anthocyanin Reflectance Index" (ARI1, ARI2) are now frequently used [12].

The NDVI index allows researchers to comment on healthy vegetation using the radiation of plants. Plants give a high reflection value in the infrared band, while low reflection value in the red band. In short, NDVI is the ratio of radiation reflected from vegetation to radiation reflected from all other sources. The -1 value indicates that there is no healthy vegetation, while the +1 value indicates the presence of healthy vegetation. The resulting values vary between -1, +1 [13]. The Simple Ratio Index (SR) also provides information about healthy vegetation like NDVI. When looking at the SR values, the rising values indicate healthy vegetation, while low values indicate factors such as soil, water and ice mixed into the vegetation. The Simple Ratio Pigment Index (SRPI) is sensitive to low chlorophyll concentrations. Adjusted Chlorophyll Absorption Reflectance Index (MCARI) is the chlorophyll index. MCARI; It is closely linked to the LAI (Green Leaf Area Index). Gives a measure of chlorophyll absorption. We can monitor the changes in chlorophyll concentrations with this index. In addition, MCARI is not affected by external factors. MCARI1, on the other hand, is just like MCARI, but it is considered as a precursor for LAI. TCARI is one of the indexes showing the relative amount of chlorophyll. What is meant by the quantity here is the abundance or scarcity of chlorophyll pigment [14, 15, 16, 17, 18, 19, 20, 21].

OSAVI; considers optimized ground reflections. It is an index that can provide much variability due to the growing environment in the background. The G index, which is the foliage index, gives the plant the rate at which it is green. The Triangle Vegetation Index (TVI) forms a hypothetical triangle. This triangle: The green peak reflectance rate of the plant consists of minimal chlorophyll absorption and binding of the NIR shoulder. It is used for LAI prediction, but its sensitivity to chlorophyll increases due to the increase in canopy. Zarco and Miller Index (ZMI) shows the radiation absorption of pigments. Therefore, information about chlorophyll levels and cellular structures can be obtained indirectly. Normalized Pheophytination Index (NPQI) indicates chlorophyll degradation [14, 15, 16, 17, 18, 19, 20, 21].

Photochemical Reflectance Index (PRI) helps in tracking carotenoid changes in living leaves. For this reason, it is frequently used in stress studies. The Normalized Pigment Chlorophyll Index (NPCI) is used to estimate the nitrogen concentration in mature leaves. Carter Indexes (CTR1, CTR2) are an index used to examine stress factors. Indicates the potentials of the reflectance of vegetation. Lichtenthaler Indexes (Lic1, Lic2) are used in the assessment of vegetation stress. Structural Independent Pigment Index (SIPI) indicates the sensitivity of carotenoids to chlorophyll ratios. It plays a major role in explaining the high variability in canopy and LAI values [14, 15, 16, 17, 18, 19, 20, 21]. Anthocyanin Reflectance Index (ARI1) measures and interprets the reflections of plant stress pigments in the visible spectrum. Anthocyanin reflection index 2 (ARI2) analyzes the anthocyanin concentrations in the plants. Carotenoid Reflectance Index (CRI1) is used to determine the presence of carotenoids higher than chlorophyll concentration. Carotenoid reflection index 2 (CRI2) is the more sensitive version of the CRI1 index [14, 15, 16, 17, 18, 19, 20, 21].

Within the scope of this study, seven experimental groups were established, one of which was a control group, to take wheat seeds belonging to different genotypes to the germination bed, ensuring germination with different growth promoters (Pure water, KNO_3, Boric acid, KNO_3 + Boric acid). The indexes are divided into 7 groups as 25°C, 30°C, 35°C, 40°C, 45°C and 50°C. measurement and analysis were made.

MATERIALS AND METHODS

In this study, seeds of 10 different genotypes of *Triticum aestivum* L. (Kirik, Bayraktar, Aldane, Kenanbey, Seyhan, Yüreğir89, Uzunyayla, Seri 82, Fuatbey and Canik), which are frequently cultivated in our country, were used as study material. Seeds are counted and packaged in 10. Glass Petri dishes with a diameter of 9 cm were used as the seed bed and double layer filter paper was placed in the Petri dishes. The experiments were done in four replicates. The seeds planted in the seed beds were kept in the Sanyo MLR 350 model climate cabin (Eskisehir Technical University, Faculty of Sciences, Department of Biology, Plant Ecology Laboratory) at 12 hours light/12 hours dark photoperiod. After the seed beds were divided into four groups, solutions containing pure water (control), boric acid solution (8 ppm), 1% KNO_3 and Boric acid (8 ppm) + KNO_3 (1%) were added. The first experimental group was kept at 21°C for 14 days, the other experimental groups were kept at 21°C for seven days, to be exposed to increasing temperatures as a heat shock application: The second experimental group was at 25ºC, the third experimental group was at 30°C, the fourth the experimental group was kept at 35ºC, the fifth at 40°C, the sixth at 45ºC, and the seventh at 50°C for seven days. For the seeds to be considered germinated, the radicle was expected to contact the germination bed [22]. The study continued for 14 days, and solutions were added in case of loss.

At the end of 14 days, the plants were carefully removed from the Petri dishes and measurements were made with a spectral reflectometer with PSI PolyPen RP 410 / UVIS model xenon lamp.

RESULTS AND DISCUSSION

In fracture type, NDVI, SR, MCARI1, OSAVI were the highest in 25°C application, and G, MCARI, TCARI values were highest in 35°C application. TVI, ZMI were highest in 25°C application, and SPRI, NPQI, PRI values were highest in 21°C application. While NPCI, CTR1, CTR2 were observed at 35°C application, LIC1 was observed at 25°C highest while LIC2 was observed at 21°C application. SIPI, GM1, GM2 were observed at 25°C application, while ARI1, ARI2 were observed at 35°C application. While CRI1 and CRI2 were observed at 21°C applications, RDVI was observed at 25°C and MCARI2 at 35°C applications.

In Bayraktar variety, NDVI, SR, MCARI1, OSAVI were the highest in 25°C application, while G, MCARI values were highest in 35°C application and TCARI was observed in 30°C application. TVI, ZMI, NPQI, PRI were the highest in 25°C application, and the highest SPRI value was observed in 21°C application. While NPCI, CTR1, CTR2, LIC1 were observed at 35°C application, SIPI, LIC2 were observed at 21°C application. GM1 was observed at the highest application of 30°C. While GM2 was observed at 25°C application, ARI1 and ARI2 were observed at 35°C application. While CRI1 and CRI2 were observed at 21°C applications, RDVI was observed at 25°C and MCARI2 at 35°C applications.

In the Aldane variety, NDVI, SR, MCARI1, OSAVI were observed the highest at 30°C application, while G, MCARI values were observed the highest in 35°C application and TCARI at 30°C application. TVI, ZMI, SPRI PRI were highest in 30°C application, while NPQI value was highest in 21°C application. While NPCI, CTR1, CTR2 were observed at 35°C application, LIC1, SIPI were observed at 21°C application. LIC2, GM1, GM2 were observed at 30°C application. ARI1, ARI2 were observed at the highest application of 35°C. While CRI1 and CRI2 were observed at 21°C applications, RDVI was observed at 30°C and MCARI2 at 35°C applications.

In Kenanbey cultivar, NDVI, SR were observed at 21°C application, and MCARI1, G, MCARI was observed at 25°C application. The highest OSAVI values were observed at 30°C application and TCARI at 35°C application. TVI was highest at 25°C. ZMI, SPRI were highest at 30°C. PRI NPCI, CTR1 was observed at 21°C application, NPQI, CTR2 value was highest in 35°C application, LIC1, SIPI was observed at 21°C application. LIC2, GM1, GM2 were observed at 30°C application. ARI1, ARI2, CRI1, CRI2 were highest at 35°C application. RDVI and MCARI2 were highest in 35°C applications.

In Seyhan variety, NDVI, SR, OSAVI, G, TCARI, ZMI, SPRI, PRI, LIC1, LIC2, SIPI, GM1, GM2, CRI1, CRI2 and RDVI have been observed at 21°C application and MCARI1, MCARI, TVI, NPCI and MCARI2 observed at high 25°C application. CTR1, ARI1, ARI2, NPQI, CTR2 were observed at 35°C application.

In Yüreğir89 variety, NDVI, SR, G, MCARI, ZMI, SPRI, PRI, NPCI, CTR1, CTR2 LIC1, GM1, GM2, CRI1, MCARI2 and CRI2 were seen at 21°C application, MCARI1, TVI, SIPI and RDVI were the highest at 25°C. It has been observed in the application. OSAVI, NPQI was observed at 30°C application highest. TCARI, LIC2, ARI1 and ARI2 were highest at 35°C application.

In Uzunyayla variety, NDVI, SR, OSAVI, G, ZMI, PRI, LIC1, SIPI, GM1, GM2, CRI1 and RDVI have been observed at 21°C application and MCARI1, MCARI, TVI, NPCI, CTR1, LIC2, ARI1, ARI2 and MCARI2 en observed at high 25°C application. The highest CRI2 was observed at 30°C application. SPRI, CTR2, TCARI and NPQI were highest at 35°C application.

In Seri82 variety, MCARI1, G, TVI, NPQI, PRI, SIPI, CRI1, CRI2 and RDVI were highest in 21°C application, while MCARI, NPCI, CTR1, CTR2, ARI2 and MCARI2 were observed at 25°C application. NDVI, SR, OSAVI, TCARI, ZMI, SPRI, LIC1, LIC2, GM1 and GM2 were observed at 30°C application. ARI1, on the other hand, was observed at 35°C application.

In Fuatbey variety, MCARI1, G, TVI, PRI and RDVI were observed highest in 21°C application, and the highest was observed in 25°C application. NDVI, SR, OSAVI, TCARI, ZMI, SPRI, NPQI, LIC1, LIC2, SIPI, GM1 GM2, CRI1 and CRI2 were highest at 30°C application. MCARI, NPCI, CTR1, CTR2, ARI1, ARI2 and MCARI2 were highest at 35°C application.

In Canik variety, MCARI1, MCARI, TVI, PRI NPCI, CTR1, RDVI and MCARI2 were observed at 21°C application, and G, LIC1, ARI1 and ARI2 were observed at 25°C application. NDVI, SR, OSAVI, TCARI, ZMI, LIC2, SIPI, GM1 and GM2 were observed at 30°C application. SPRI, NPQI, CTR2, CRI1 and CRI2 were highest at 35°C application.

In almost every part of Turkey and the world's wheat production made; It is a very important product in that it concerns both the large producer mass, and it constitutes the raw material of bread, which is the basic food of people.

Turkey, an important wheat-producing country in the world is one, occupies an important place in the diet of wheat country. About 8 million hectares of wheat cultivation area in Turkey and in first place with 20 million tons of production from a plant. When the wheat in Turkey, climate and geographical features mostly kept in mind the summers are hot and dry, while winters are cold continental climate in the region is seen as dominated by domestic cultivated in dry farming. The yield in these regions depends largely on precipitation and temperature. Different precipitation and temperatures prevailing in different regions cause considerable differences in wheat yield, and different precipitation and temperatures even in the same regions cause differences in yield. It is very important in the experiment that the amount of precipitation falls as much as the amount of precipitation in efficiency. September, October in autumn, April, May, and June rains in spring are extremely effective in yield. Considering the climatic factors that affect wheat yield as single or multiple are effective methods to explain the relationship between climate and yield. It is very important to reveal these relations, to examine the climatic changes based on plants and to shed light on more current and important agricultural problems.

Heat stress is one of the biggest environmental problems all over the world, and the availability of heat-resistant plant species is very important for both nutrition and agricultural activities. Plant growth depends on some environmental factors such as temperature. The negative effect of global warming causes great damage to the environment [23]. Climate change and more extreme temperature events affect plant productivity [24]. Climate extremes have a major impact on plant life such as regeneration, survival, and diversity [25].

CONCLUSION

In this study, the reactions of 10 different cultivars of *Triticum aestivum* species, which is one of the most agriculturally important species, to heat shock were examined ecophysiologically. Considering the results of all cultivars in general; Uzunyayla, Canik and Bayraktar cultivars were found to have higher tolerance to heat shock. In addition, compared to the application of KNO_3 alone, application with boric acid or only boric acid has increased the resistance of wheat varieties in response to heat shock.

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