

CHLOROPHYLL INDEX IN MAIZE PLANTS GROWN FROM SEEDS TREATED WITH REGLALG AND HYPOTHERMIC SHOCK

Caus Maria

Institute of Genetics, Physiology and Plant Protection, MSU, Chisinau, Republic of Moldova
<https://orcid.org/0000-0001-7914-3482>, e-mail: mcaus2021@yahoo.com

Summary. The article presents the results of studies of the influence of the use of the biostimulator Reglalg and negative temperature stress (NTS) on the chlorophyll index of maize plants grown in field conditions at the experimental area of the Institute of Genetics, Physiology & Plant Protection, MSU. Growing maize from seeds treated before sowing with Reglalg and then subjected to temperature treatment at -4°C for 16 hours showed that the use of Reglalg reduces the negative effect of NTS and contributes to an increase in the chlorophyll index of leaves in the early period of plant growth.

Keywords: maize seeds, biostimulator Reglalg, hypothermic shock, chlorophyll index.

Introduction

At the current conditions of climate change and global warming, much attention is paid to studying the influence of negative environmental factors on the plant's growth and development (7, 12). Among the environmental factors that negatively affect the germination, productivity and quality of the crops, low temperature is one of the most common stresses that have a damaging effect on the plant organism (10,5). The response of different plant species to extreme temperature stresses varies throughout their life cycle (9). Tropical and temperate plant species, including maize, have limited ability to withstand low temperatures (8, 11).

Maize is widely cultivated in the world due to the high demand of various branches of the economy in the varied production of maize, which increases every year. This leads to the need to increase the yield of maize hybrids and expand their area of cultivation. This becomes possible if there are suitable hybrids for cultivation in heat-deficient regions. Therefore, the main conditions for the promotion of maize in the northern regions is the selection for early maturity and frost resistance.

Numerous studies have been conducted to investigate the influence of low positive temperatures on the growth processes and productivity of maize plants (8, 15). Recently (1) five maize hybrids were evaluated for germination and the growth of seedlings, obtained from seeds exposed to treatment with low positive temperatures (from 26°C to 1°C) before placement for germination and growth. It was shown that maize hybrids differed significantly in seed germination and root properties under low temperatures treatments.

Also, there were conducted experiments to study influence of freezing, temperature below 0°C , on maize plants during early seedling growth, or at late stages of ontogeny (14). However, less attention has been paid to the impact of freezing temperatures on maize at the germination stage.

At the same time, less attention was paid to the influence of freezing, sub-zero temperatures on maize at the germination stage.

We have started a series of studies on subjecting seeds of different maize hybrids to negative temperature stress (NTS) before germination (2). NTS, a temperature of -4°C applied to seeds for 16 hours in fourteen maize hybrids before germination, resulted in a decrease in final germination percentage, which depended on the type of hybrid.

In the face of climate changes and to provide the population with food, the development of methods for cultivating maize is important, including the creation of new methods for improving hybrids and maize lines that can acclimatize to relevant environmental conditions. It is also

important to improve agrotechnical cultivation methods through the use of plant growth biostimulators (PGB) (3,13).

The purpose of the study was to study the effect of the use of PGB Reglalg and pre-sowing seeds treatment with negative temperature stress on the chlorophyll index of young maize plants at the beginning of the growing season under field conditions.

Materials and methods

The research was carried out using seeds of the maize hybrids Porumbeni (P.) 310 and P. 374, provided by the Public Institution "National Center for Research and Production of Seeds", Republic of Moldova. The experiments were conducted under field conditions at the experimental area of the IGFP, USM. The experimental design was a Latin square, where the plots were arranged in triplicate with a randomized distribution. Each plot was 2,8 meter wide and 5 meters long. Sowing was carried out in May, manually, at a depth of 5 - 6 cm and at a distance between rows of 70 cm. Before sowing, maize seeds treated with water (control) or the optimal doze (1/50) of PGB Reglalg (experimental) and air-dried were placed for imbibition in water at 5°C for 36 hours. Then, some of the control and experimental seeds, freed from water, were subjected to negative temperature stress (NTS) of -4°C for 16 hours, and the other part of the control and experimental seeds, also freed from water, were placed in a refrigerator at a temperature of 5°C. At the beginning of the growth period, when the plants had 5-6 leaves, the chlorophyll index was measured. The chlorophyll index was determined using a chlorophyll counter CCM-200 Plus (Optic Science), capable of measuring the chlorophyll index from 0 to 999 at a distance. at a distance of up to 1.5 m over an area of 11 cm with a reproducible reading accuracy of $\pm 5\%$. The data were statistically processed by determining the mean value and the standard deviation of the mean was calculated using the program "Statistics 7".

Results and discussion

The resistance of plants to low temperatures largely depends on the possibility of functioning of the photosynthetic apparatus, which provides cellular metabolites necessary for the growth and development of plants both under conditions of optimal growth temperatures and under conditions of adaptation to stressful temperatures (4).

Since maize is a tropicale /temperate crop, the processes occurring in the early stages of ontogenesis will be sensitive to environmental factors, including low temperatures. The processes of germination, emergence of seedlings, development of juvenile leaves and the formation of the photosynthetic apparatus, which ensure the transition from heterotrophic growth to autotrophic growth, will largely depend on soil temperature, humidity and other environmental factors (6).

In order to evaluate the state of the maize crops in the juvenile period and to determine the effect of the use of the biostimulator Reglalg and the treatment of the seeds before sowing with negative temperature stress (NTS), measurements of the chlorophyll index of the plants at the stage of 5-6 -leaf seedlings were carried out (Fig. 1). It was found that the highest accumulation rates of the chlorophyll index were characteristic for plants from the control and from the variant with Reglalg, both without preventive treatment of the seeds with NTS, regardless of the type of hybrid. At the same time, it can be observed that the highest level of the chlorophyll index was characteristic for plants obtained from seeds treated before sowing with the PGB Reglalg (Reg.), compared to the control variant (C). It should be mentioned that in plants grown from P. 374 hybrid seeds treated with Reglalg, the chlorophyll index was significantly higher ($cci=36$), compared to P. 310 hybrid plants ($cci=33$). The results presented in Fig. 1 also demonstrate that the values of the chlorophyll index in the leaves of the plants of both hybrids, obtained from seeds preventively treated with NTS (C+NTS) and (Reg.+NTS), are lower compared to those of the control (C) and Reglalg (Reg.) plants. Literature data (4) from the experience with young maize plants, at the 3-rd leaf appearance seedlings, exposed for seven days at low temperature of 10°C, demonstrated that

this treatment resulted in decreased photosynthetic pigments, lowered efficiency of PSII and reduction in CO₂ assimilation.

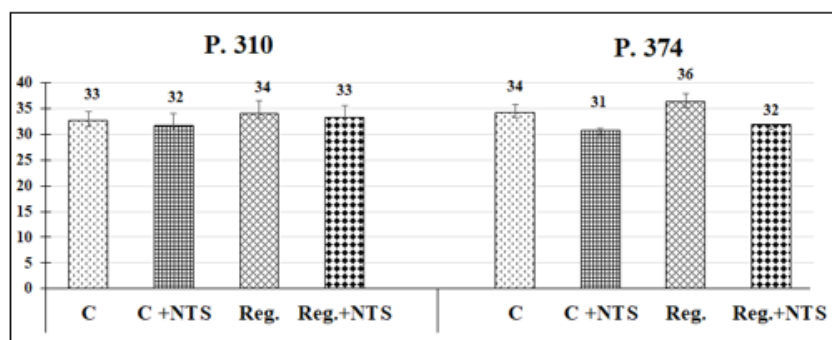


Figure 1. Chlorophyll index of plants under field conditions, grown from seeds treated before sowing with Regalg and NTS

Our results suggest that the treatment of seeds with the solution of PGB Regalg before exposure to NTS action favored the stimulation of the viability of the resulting plants, which was reflected in the chlorophyll content of the leaves of the seedlings in the juvenile stage of ontogenesis. The use of Regalg for seed treatment before their exposure to NTS demonstrates a tendency to have a beneficial effect on the processes of germination and growth of maize seedlings in field conditions, especially in the P. 374 hybrid, which has a higher chlorophyll index coefficient (Fig. 1). It should also be mentioned, that exogenous application of PGB Regalg induces as well cold tolerance in the early maize hybrid, P. 180 and the semi-early maize hybrid, P. 310, promoting to improve the functioning of the photosynthetic apparatus by increasing the content of chlorophyll pigments in the leaves of plants in the 5-6 leaf phase under field conditions (3).

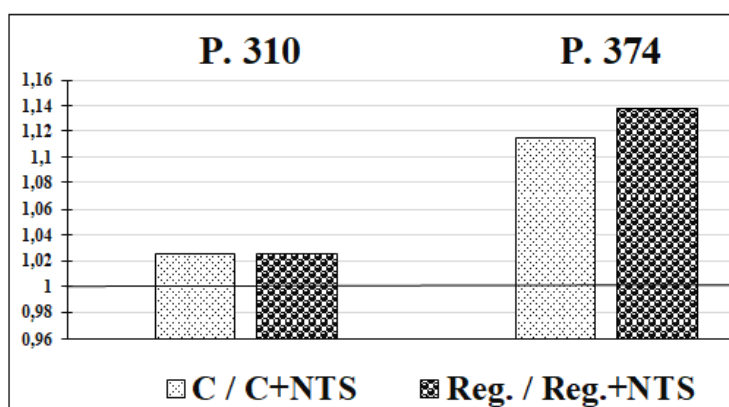


Figure 2. The ratio between the values of the chlorophyll index of the seedlings under field conditions from variants C and reg. to the value of the C+NTS and Reg.+NTS

Determination of the ratio between the chlorophyll indices from the C variant to this index from the C+ NTS variant, as well as the chlorophyll indices from the Regalg variant to the values of this index from the Reg+NTS variant demonstrate (Fig. 2), that the values of this ratio are greater than 1 and that the application of PGB Regalg for seed treatment before sowing showed a greater effect in P. 374 hybrid plants.

Thus, the data on the chlorophyll index in the leaves of maize plants grown from seeds treated with PGB Regalg and then exposed to NTS made it possible to identify the state of the plants under the influence NTS, the role of biostimulatory substances in reducing the negative effects of NTS, as well as the comparison of reactions of the studied hybrids to NTS effects.

Conclusions

Young maize plants of hybrids P. 310 and P. 374, grown from seeds pre-treated with negative temperature stress (NTS) for 16 h before sowing in the field, responded to this treatment with different levels of leaf chlorophyll index, indicating at the same time that hybrid P.374 is more sensitive to NTS than hybrid P.310.

The treatment of maize seeds before sowing with PGB Reglalg conditioned the increase of the chlorophyll index in the juvenile phase in the plants of the two investigated maize hybrids, P. 310 and P. 374.

In addition, the beneficial effect of the biostimulator Reglalg was also manifested in maintaining the chlorophyll index content at a higher level in plants grown in field conditions from seeds exposed to NTS before sowing, compared to those in the control.

Acknowledgements. The research was carried out within the project of the State Program 20.80009.7007.07 "*Determining the parameters that characterize the resistance of plants with different levels of organization to the action of extreme temperatures in order to reduce the effects of climate change*", and of the subprogram 011101 "*Genetic and biotechnological approaches to management of agroecosystems under climate change conditions*", financed by the Ministry of Education and Research of RM.

References

1. Cauș M., Dascaluic A., Borozan P. Responses of seed germination and seedling growth of different maize hybrids to low positive temperature stress. *Ann. Univ. Craiova, Ser. Biol. Hortic. Food Prod. Process. Environ. Eng.*, 2022, vol. 27 (63), p.113-118. ISSN–L 1453 – 1275. Doi: <https://doi.org/10.52846/bihpt.v27i63.19>.
2. Cauș M., Dascaluic A., Borozan P. Effect of negative temperature shock on the primary resistance of maize hybrids. *Ann. Univ. Craiova, Ser. Biol. Hortic. Food Prod. Process. Environ. Eng.*, 2023, vol. 28(64), p. 27-32. I.S.S.N 1435-1275. Doi: <https://doi.org/10.52846/bihpt.v28i64.66>.
3. Cauș M., Platovschii N., Ralea T., Borozan P., Dascaluic A. Efectele șocului de temperatură suboptimală și a preparatului Reglalg la cultura porumbului cultivat în condiții de câmp. *Materialele Conferinței Științifice Naționale cu Participare Internațională “Știința în nordul Republicii Moldova: probleme, realizări, perspective”, (ediția a șasea), Bălți, 19 mai 2022. P. 36-41.* https://ibn.idsi.md/sites/default/files/imag_file/36-41_41.pdf.
4. Cholakova-Bimbalova R., Vassilev A. Effect of chilling stress on the photosynthetic performance of young plants from two maize (*Zea mays*) hybrids. In: *CBU International Conference on Innovations in Science & Education Proceedings*. March 22-24, 2017, vol. 7. Prague, Czech Republic. P. 1118-1123. <http://dx.doi.org/10.12955/cbup.v7.1501>.
5. Georgieva M., Vassileva V. Stress management in plants: Examining provisional and unique dose-dependent responses. *Int. J. Mol. Sci.*, 2023, 24, 5105. Doi: 10.3390/ijms24065105.
6. Grzybowski M., Adamczyk j., Jończyk M. et al. Increased photosensitivity at early growth as a possible mechanism of maize adaptation to cold springs. *Journal of Experimental Botany*, 2019, vol. 70, (10), p. 2887–2904. Doi:10.1093/jxb/erz096.
7. Lippmann R., Babben S., Menger A., Delker C. Development of wild and cultivated plants under global warming conditions. *Current Biology*, 2019, (29), p.1326–1338. Doi: <https://doi.org/10.1016/j.cub.2019.10.016>.
8. Ma Y., Tan R., Zhao J. et al. Chilling tolerance in maize: Insights into Advances-Toward Physio-Biochemical Responses and QTL/Genes Identification. *Plants*, 2022, vol.11, 2082. <https://doi.org/10.3390/plants11162082>.

9. Mangani R., Tesfamariam E.H., Engelbrecht C.J. et al. Potential impacts of extreme weather events in main maize (*Zea mays* L.) producing areas of South Africa under rainfed conditions. *Reg. Environ. Chang.*, 2019, 19, p. 1441–1452. <https://doi.org/10.1071/CP18117>.
10. Parrotta, L.; Cai, G. Environmental Stress and Plants. *Int. Journal Mol. Sci.*, 2022, 23, 5416. <https://doi.org/10.3390/ijms23105416>.
11. Simon A., Moraru P.I., Ceclan A. et al. The Impact of climatic factors on the development stages of maize crop in the Transylvanian Plain. *Agronomy*, 2023, 13, 1612. <https://doi.org/10.3390/agronomy13061612>.
12. Vogel E., Donat M.G., Alexander L.V., Meinshausen M. et al. The effects of climate extremes on global agricultural yields. *Environ. Res., Lett.*, 2019, 14, 054010. Doi:10.1088/1748-9326/ab154b.
13. Waqas M.A., Khan I., Akhter M. J. et al. Exogenous application of plant growth regulators (PGRs) induces chilling tolerance in short-duration hybrid maize. *Environ. Sci. Pollut. Res. Int.*, 2017, 24, 11459–11471. Doi: 10.1007/s11356-017-8768-0.
14. Woltz J.M., Egli D.B., TeKrony D.M. Freezing point temperatures of corn seed structures during seed development. *Agronomy Journal*, 2005, 97, p. 1564–1569. Doi:10.2134/agronj2005.0073.
15. Zhou X, Muhammad I, Lan H., Xia C. Recent Advances in the Analysis of Cold Tolerance in Maize. *Front. Plant Sci.*, 2022, 13:866034. Doi: 10.3389/fpls.2022.866034.