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RESPONSES OF SEED GERMINATION AND SEEDLING GROWTH OF DIFFERENT MAIZE HYBRIDS TO LOW POSITIVE TEMPERATURE STRESS

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ABSTRACT

The article presents an assessment of the resistance of various maize hybrids (Por. 180, Bemo 203, Por. 374, Por. 427 and Por. 310) to the shock of low positive temperatures based on changes in the germination and growth rates of seedlings. Six low positive temperature levels were used, including 1, 2, 4, 9, 16, and 26°C. Shock with low positive temperatures for 24 hours did not cause significantly changes in the final rate of germination.

Treatment of seeds of maize hybrids with shock of positive low temperatures of 4°C, 2°C and 1°C for 24 hours had a significant impact on the radicle's length and epicotyl's height. These low positive temperatures predominantly influenced the growth of the epicotyls. According to the ratio between the biomass of roots and epicycles, it was shown that under the action of shock with low positive temperatures for 24 hours, Por 310 had the highest, and Por. 427 - the lowest root viability.

INTRODUCTION

Maize (*Zea mays* L.) is a thermophilic crop, as it comes from areas with tropical and subtropical climates. Over the past period, the area under maize in the northern regions has been extended significantly. One of the factors limiting the advancement of this crop in the North-Western Europe is the effect of low positive temperatures, in spring, especially at night and in the morning (Meng et al. 2022). In these cases, the effect of low temperatures on plants is short-term and is replaced daily by a period of optimal temperatures, and therefore their effect is not always obviously. The resistance of maize to low temperatures depends on various factors, including species and variety, as well as the stage of development of the plant. However, seed germination and vigor are the main factors that determine their vital activity not only in adverse, but also in favorable environmental conditions (Marcos-Filho, 2015). Low positive temperatures can lead to several types of damage, including delayed emergence and seedling growth of maize, which is vulnerable to cold stress (Antony et al. 2019, Khaeim H. et al.2022). Maize cultivation in cold climates is accompanied by reduced growth rates, shorter growing seasons and lower yields (Aidunl et al. 1991, Greaves 1996 Rodríguez et al. 2010, Zhang et al. 2020). Information on the effect of low positive temperatures on the growth and development of maize seedlings is very important for approaches to increase resistance to low temperatures and for the breeders in creating maize varieties for northern regions (Zhang et al. 2020).

The aim of the work was to study the effect of shock of low positive temperatures on germination and seedling growth of different maize hybrids that differ in resistance to high temperatures and cold.

MATERIAL AND METHODS

Maize seeds used in the studies are represented by 5 hybrids, including Por. 180, Bemo 203, Por. 374, Por. 427 and Por. 310 were offered by the Public Institution «Porumbeni» Institute of Phytotechnics. Investigations were carried out under controlled laboratory conditions. Before germination, control and experimental maize seeds imbibed with distillate water at 5°C. After 36 hours, experimental soaked seeds (freed from water), were laid out in trays for germination and placed in a germination chamber at low positive temperatures of 16, 9, 4, 2 and 1°C for 16 hours. Then they were transferred at 26°C to the control seeds to continue germination and growth of seedlings in the dark and at a humidity of 70–75%. During the experiments, the final percentage of germination was evaluated both in the controls and in the experimental variants. After 5 days, corn seedlings were harvested and used to determine morphological parameters, including measurement of epicotyl height and root length, as well as the fresh biomass of these plant components. Each treatment included three replicates. The data were statistically processed, determining the mean value, standard deviation and credibility of the mean values using the «Statistics 7» software package for computers.

RESULTS AND DISCUSSIONS

Previous studies have reported the mechanism underlying seedling growth in response to low-temperature stress at the seedling stage (Zeng et al., 2021, Khaeim H. et al.2022). Results (Khaeim H. et al. 2022) show that at 10°C, seeds take longer, up to 34 days, to reach the germination measurement point, while at 5°C, no seed germination was observed. However, in spring, when cool nighttime temperatures give way to high daytime temperatures, corn germination can be more sensitive.

In this work, five maize hybrids with different resistance to high temperature and cold were used to study the effects of shock with low positive temperature (SLPT) on germination and seedling growth. Germination of maize seeds at 26°C was used as a control, and germination of corn seeds pre-treated with a shock of 16, 9, 4, 2 and 1°C for 24 hours and then placed at 26°C to continue germination and seedling growth were used as experimental. Pretreatment of seeds of different maize hybrids with SLPT did not have a significant effect on final germination of all investigated hybrids, only a weak downward tendency was observed for Por. 180 and Por. 427 (figure 1). However, it can be observed differences in the germination level between the hybrids under the influence of SLPT. Sensitive hybrids, Por. 427 and resistant - Por.310 to high temperatures, showed the highest level of germination for all tested low temperatures, including the control, and the final germination was 100-86%.

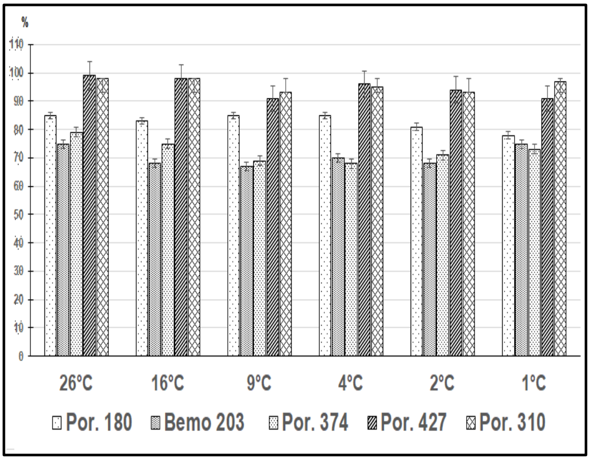

Figure 1. Effect of shock with low positive temperatures (SLPT) for 24 hours to the seeds of different maize hybrids before germination and subsequent seed germination under normal temperature of 26°C on final rate of germination (%). Designation of maize hybrids used: Por. 180 and Bemo 203 are resistant and respective sensitive to cold, and the hybrids Por. 374, Por. 310 and Por. 427 are resistant and respectively sensible to high temperatures.

While the lowest level of germination at all temperatures both in the control and under SLPT was observed in the cold-sensitive hybrids Bemo 203 and Por. 374, resistant to high temperatures, and the final germination for Bemo 203 is from 70 to 63%, and for Por. 374 - 79-68%.

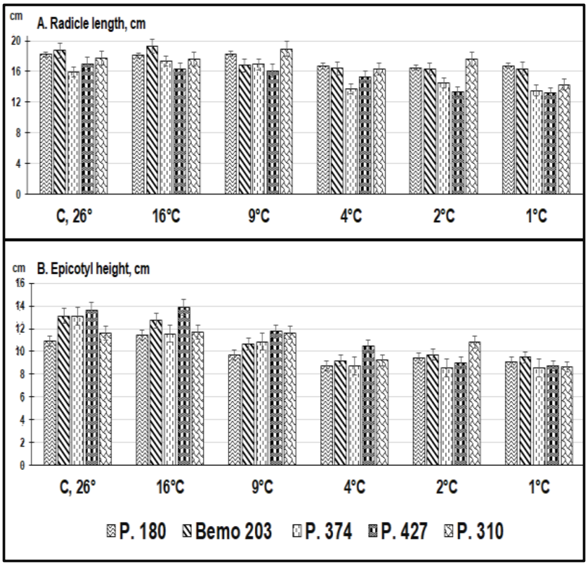

Figure. 2. The influence of shock with positive low temperatures for 24 hours on the length of radicles (cm) and height of epicotyls (cm) of the seedlings of different maize hybrids. Age of seedlings - 5 days.

Though the application of SLPT to hybrid seeds did not significantly affect seed germination, the evaluations of biometric indices highlighted the impact of thermal stress on subsequent seedling growth processes. The results presented in figure 2 show that from the series of low positive temperatures 26°C (control), 16°C, 9°C, 4°C, 2°C and 1°C, applied to the seeds of different maize hybrids before germination with a duration of 16 hours, a significant effect on the length of radicles and epicotyls is observed in the case of treatment with temperatures of 4°C, 2°C and 1°C. Can be noted that the length of the radicle in all hybrids is greater than that of the epicotyl, regardless of the applied temperature.

Table 1.

Determination of the ratio between the length of the radicle and the height of the epicotyl (Radicle, cm / epicotyl, cm)

Temperature	**Por. 180**	**Bemo 203**	**Por. 374**	**Por. 427**	**Por. 310**
26° C	1,7	1,4	1,2	1,3	1,5
16°C	1,6	1,5	1,5	1,2	1,5
9°C	1,9	1,6	1,6	1,5	1,6
4°C	1,9	1,8	1,6	1,5	1,8
2°C	1,7	1,7	1,7	1,5	1,6
1°C	1,8	1,7	1,6	1,5	1,6

Determination of the ratio between the length of the radicles and that of the epicotyls showed that mainly the low positive temperatures 9°C, 4°C, 2°C and 1°C influence more the growth of the epicotyl (table 1). Only a tendency to decrease the initial growth speed of the Por. 180 and Por. 427 hybrid seedlings was observed. Studies of the effect of low-temperature shock on the subsequent growth of seedlings under normal temperature conditions also included an assessment of the fresh biomass of plant material. The results showed that treatment of maize seeds with SLPT at 9°C, 4°C, 2°C and 1°C before germination significantly decreased the fresh mass of maize seedling roots in all hybrids studied, with the exception of Por. 374, designed as resistant to high temperature.

Significant decrease in fresh mass for the aerial part (epicotyls) at SLOPT was also observed (figure 3). The determination of the ratio between the biomass of the roots and that of the aerial part (epicotyls) demonstrates that when applying the low positive temperatures of 4°C, 2°C and 1°C the roots seem to be more vigorous for all the investigated hybrids (table 2). The Por. 310 hybrid is characterized by increased vigor for all temperatures, compared to the other hybrids, as the value of the biomass ratio (roots/epicotyls) is higher than 1 unit and it consisted from 1,1 to 1,6. And the Bemo 203 hybrid shows less vigor of the roots, as the value of the biomass ratio (roots/epicotyls) is between 0,5-0,7 (table 2), compared to investigated hybrids in the work.

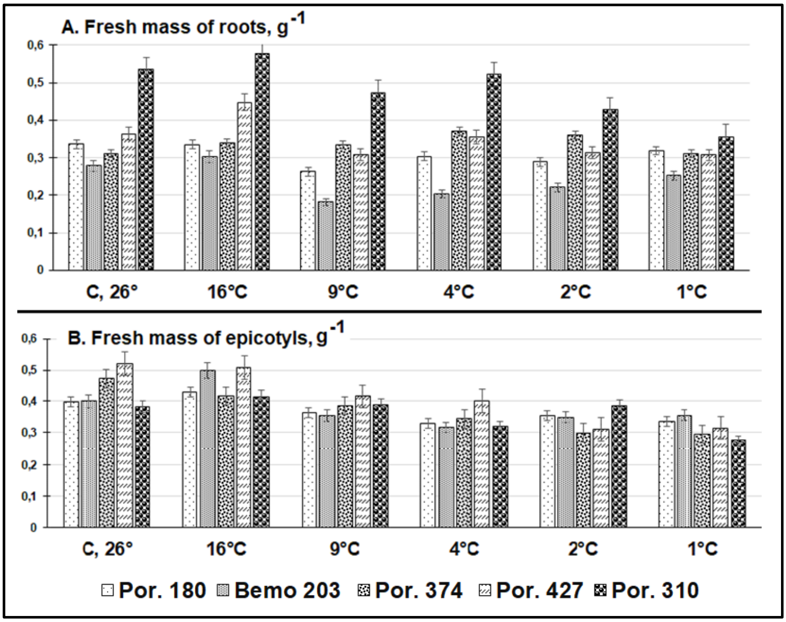

Figure 3. Effect of a 24-h positive low-temperature shock applied to maize seeds before germination on the fresh biomass of roots and aerial parts of 5-day-old seedlings (g/unit^{-1}).

Table 2

Determination of the ratio between the biomass of the roots and that of the epicotyls of seedlings that grew from seeds exposed to shock with low positive temperatures for 24 hours. Age of seedlings - 5 days.

Temperature	Por. 180	Bemo 203	Por. 374	Por. 427	Por. 310
26°C	0,8	0,7	0,7	0,7	1,4
16°C	0,8	0,6	0,8	0,9	1,4
9°C	0,7	0,5	0,9	0,7	1,2
4°C	0,9	0,6	1,1	0,9	1,6
2°C	0,8	0,6	1,2	1,0	1,1
1°C	0,9	0,7	1,1	1,0	1,3

CONCLUSIONS

It was demonstrated that the exposure of the seeds of different maize hybrids before germination to the action of shock with low positive temperatures (16°C, 9°C, 4°C, 2°C and 1°C) for 24 hours does not significantly affect the germination percentage of the investigated maize hybrids, only a slight decrease trend was observed for Por. 180 and Por. 427 hybrids.

Preliminary treatment of seeds of various maize hybrids with shock of positive low temperatures of 4°C, 2°C and 1°C for 24 hours had a significant impact on the radicle length and epicotyl height. These low positive temperatures predominantly influenced the growth of the epicotyls.

According to the ratio between the biomass of roots and epicycles, it was shown that under the action shock with low positive temperatures for 24 hours, Por 310 had the highest, and Por. 427 - the lowest root viability,

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