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Research article

Determination of the Efficiency of the Thermopriming Treatment in Watermelon in High Temperature Stress Conditions[a]

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ABSTRACT

Due to the worldwide economic importance of watermelon (*Citrullus lanatus* L.), efforts to develop new strategies have increased to increase its tolerance to some types of stress. Significant reductions in germination and emergence times can occur in watermelon seeds under high temperature conditions. In this study, the effectiveness of seed pre-treatments as a solution to temperature increase stress, which is one of the biggest problems of today, was researched in watermelon, which is one of the most grown vegetables in the world. Under high temperature conditions (45 °C), some germination and emergence values were adversely affected compared to the control temperature group (25 °C). Thermopriming treatment showed a positive effect in terms of some parameters in watermelon seeds under control temperature and/or high temperature conditions. On the other hand, in thermopriming seeds, the average number of emergence days could decrease up to 10.0±0.29 under high temperature conditions. In this study, it was concluded that thermopriming seed pre-treatment in watermelon under high temperature conditions can provide advantages in terms of some germination and emergence characteristics.

Keywords: Watermelon, Thermopriming, Abiotic stress

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Araştırma makalesi

Yüksek Sıcaklık Stresi Koşullarında Karpuzda Termopriming Uygulamasının Etkinliğinin Belirlenmesi

ÖZ

Karpuzun (*Citrullus lanatus* L.) dünya çapındaki ekonomik önemi nedeniyle, bazı stres türlerine karşı toleransını artırmak için yeni stratejiler geliştirme çabaları artmıştır. Yüksek sıcaklık koşullarında karpuz tohumlarında çimlenme ve çıkış sürelerinde önemli azalmalar meydana gelebilmektedir. Bu çalışmada dünyada en çok yetiştirilen sebzelerden biri olan karpuzda günümüzün en büyük sorunlarından biri olan sıcaklık artışı stresine çözüm olarak tohum ön işlemlerinin etkinliği araştırılmıştır. Yüksek sıcaklık koşullarında (45 °C) bazı çimlenme ve çıkış değerleri kontrol sıcaklık grubuna (25 °C) göre olumsuz etkilenmiştir. Kontrol sıcaklığı ve/veya yüksek sıcaklık koşullarında karpuz tohumlarında termopriming uygulaması bazı parametreler açısından olumlu etki göstermiştir. Termopriming uygulanan tohumlarda yüksek sıcaklık koşullarında ortalama çıkış gün sayısı 10.00±0.29'a kadar düşebilmektedir. Bu çalışmada karpuzda yüksek sıcaklık koşullarında termopriming tohum ön uygulamasının bazı çimlenme ve çıkış özellikleri açısından avantajlar sağlayabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Karpuz, Termopriming, Abiyotik stres

Introduction

The fruits of watermelon (*Citrullus lanatus* L.), one of the most important members of the Cucurbitaceae family grown in tropical and temperate regions, can be of very different sizes. In addition to fresh consumption, watermelon fruits are widely used in fruit salads, fruit juice and confectionery industries. Edible seeds of watermelon are consumed as a snack (Wehner, 2008; Coşkun et al., 2019; Toprak et al., 2023). Türkiye is one of the most important watermelon growing countries. The world production of watermelon was determined as 101.634.720 tons, and the production in Türkiye was determined as 3.468.717 tons (FAO, 2021).

Seed quality is an important limiting factor in vegetable cultivation. Decreases in seed germination and emergence rates cause significant yield and quality losses in vegetable cultivation. Optimum watermelon seed germination and seedling emergence occur at relatively high temperatures (25-28 °C). However, the upper and lower germination temperature limits for the Cucurbitaceae family vary greatly between cultivars, but are reported to be 45 °C and 15 °C, respectively (Singh, 1991). High temperature conditions reduce the germination rate of watermelon. This situation reveals the necessity of determining the methods that can cope with this stress in watermelon seeds whose germination power decreases at high temperatures.

Priming treatments are one of the most preferred methods for the adaptation of vegetable seeds to stress conditions and to improve their emergence performance. Thermopriming is one of the pre-treatments with the highest efficiency in vegetable seeds. Temperature treatments break the seed dormancy, problems encountered in aquaculture due to climatic conditions can be prevented (Huang et al. 2002; Shin et al., 2006; Markovskaya et al., 2007). Since thermopriming is a process no chemical input is required, it is thought to help protect the ecosystem.

Some studies have previously determined the stress tolerance effectiveness of priming application (Wang et al., 2015; Zhou et al., 2020). It has been determined that thermopriming treatments make positive contributions to the healthy development of melon seeds and seedlings exposed to heat stress (Weng et al., 2021). However, it remains largely unknown whether heat priming can alleviate the negative impacts of subsequent adverse environmental factors on watermelon plants. The hypothesis is that watermelon seeds pre-subjected to high temperatures are better equipped to cope with subsequent stress events than the non-primed seeds. The purpose of the present study was to investigate the difference in some vegetative between the primed and non-primed plants.

Material and Methods

Citrullus lanatus var. *lanatus* were used in this study. The seeds were provided by a commercial company. Seeds were surface sterilized using 0.1% $HgCl_2$ for 10 min, followed by washing with distilled water. For thermopriming, the seeds were kept in a water bath at 50 °C for 60 minutes (Wang et al., 2003). The extracted seeds were planted in petri dishes for germination test and viols for emergence test. Some plant characteristics were measured on samples placed under two different temperature conditions (25 °C and 45 °C) in the climate chamber. The resistance to stress conditions of the seeds of the control group and subjected to thermopriming was investigated. For this purpose, six parameter analyses were carried out repetitively. Germination rate (%), germination time (day), seedling emergence rate (%), seedling emergence time (day), root length (cm) and shoot length (cm) were measured. Statistical analysis was performed with SPSS Version 22.0 statistic software package. Values were expressed as mean ± SE (Standard Error).

Results and Discussion

The germination rate results of the control and thermopriming treatments after the germination test at 25 °C and 45 °C are given in Table 1. After the 25 °C germination test, the average germination rate of the control group was 85±1.08%, and 84±1.87% after the thermopriming treatment. It can be said that thermopriming treatment has no effect on germination rate at 25 °C conditions. After the 45 °C germination test, the average germination rate of the control group was 72±1.47%, and after the thermopriming treatment it was 77±1.48%. It was concluded that thermopriming treatment at 45 °C conditions had a positive effect on the germination rate.

Table 1. Germination rate (%) of control and thermopriming treatments

Test	Treatments	Mean±SE	Minimum-Maximum
25°C	Control	85±1.08a	83-88
	Thermopriming	84±1.87a	80-89
45°C	Control	72±1.47c	68-75
	Thermopriming	77±1.48b	75-81

The changes in the mean germination time after the control group and thermopriming treatments are given in Table 2. After the germination test at 25 °C, the seeds of the control group completed the germination in 5.3±0.15 days, while the thermopriming treatment completed the germination after 4.8±0.11 days. Germination time performances with thermopriming were earlier than the control group. In the 45 °C germination test, seed germination was completed in 4.9±0.12 days in the control group and in 4.7±0.11 days after the thermopriming treatment. Thermopriming application at control temperatures (25 ^{o}C) decreased the germination time. Although thermopriming application decreased the germination time under high temperature conditions (45 ^{o}C), this was not statistically significant.

Table 2. Changes in germination time (day) after control group and thermopriming treatments

Test	Treatments	Mean±SE	Minimum-Maximum
25°C	Control	5.3±0.15a	5.0-5.7
	Thermopriming	4.8±0.11b	4.5-5.0
45°C	Control	4.9±0.12b	4.6-5.2
	Thermopriming	4.7±0.11b	4.6-5.1

The results of the emergence rate of the control and thermopriming treatments after the seedling emergence test at 25 °C and 45 °C are given in Table 3. While the average emergence rate was determined as 68±2.55% in the control group after the 25 °C emergence test, the average emergence rate was determined as 75±1.78% after the thermopriming treatment. In the emergence test performed at 25 °C, it was determined that the thermopriming treatment increased the emergence rate by 7%. In 45 °C conditions, the output rate decreased to 59%. Thermopriming treatments at 25 °C conditions increased the seedling emergence rate. However, at 45 °C conditions, thermopriming treatments could not increase the emergence rate.

Table 3. Seedling emergence rate (%) of control and thermopriming treatments

Test	Treatments	Mean±SE	Minimum-Maximum
25°C	Control	68±2.55b	63-75
	Thermopriming	75±1.78a	70-78
45°C	Control	59±0.9c	58-61
	Thermopriming	58±1.48c	54-61

The changes on the emergence time, after the control group and thermopriming treatments are given in Table 4. After the emergence test at 25 °C, the seeds of the control group completed the emergence in 7.80±0.07 days, while the thermopriming treatment completed in 10.50±0.14 days. In the 45 °C emergence test, emergences were completed in 10.31±0.04 days for the control group and in 10±0.29 days after the thermopriming treatment. It has been concluded that thermopriming treatment has a positive effect by reducing the mean emergence time under high temperature conditions. However, under high temperature conditions (45 °C), the effect of thermopriming on seedling emergence time is not statistically significant.

Table 4. Seedling emergence time (day) of control and thermopriming treatments

Test	Treatments	Mean±SE	Minimum-Maximum
25°C	Control	7.80±0.07c	7.6-7.9
	Thermopriming	10.50±0.14a	10.1-10.7
45°C	Control	10.31±0.04ab	10.24-10.41
	Thermopriming	10.00±0.29b	9.3-10.7

The differences between the root and shoot lengths of the control group and thermopriming treatments are given in Table 5. While the root length of the control group was determined as 3.03±0.02 cm after the 25 °C germination test, it was determined that there was an increase of 2.37 cm to 5.40 cm in the root length compared to the control after the thermopriming treatment.

While the control group had a root length of 3.17±0.01 cm after the 45 °C germination test, the root length was found to be 3.73±0.02 cm after the thermopriming treatment with an increase of 0.56 cm. It was concluded that thermopriming treatments at 25 °C and 45 °C conditions had a positive effect on root growth. After the 25 °C germination test, it was determined that thermopriming treatment caused an increase in shoot length, but after the 45 °C germination test, thermopriming treatment did not make any difference on the shoot length.

Table 5. Root length (cm) and shoot length (cm) values of the control group and thermopriming treatments

Test	**Treatments**	**Root Length Mean±SE**	**Shoot Length Mean±SE**
25°C	Control	3.03±0.02d	3.73±0.02b
	Thermopriming	5.40±0.06a	4.37±0.02a
45°C	Control	3.17±0.01c	2.47±0.01c
	Thermopriming	3.73±0.02b	2.23±0.03c

In this study, it was determined that high temperature stress decreased the germination rate of watermelon, decreased the average emergence rate, decreased shoot length and had a negative effect by increasing the average emergence time. Similarly, high temperature stress negatively affected the germination and seedling stages of the plant in *Brassica juncea* (Samantaray et al., 2023). Similarly, heat stress showed negative effects on *Achillea millefolium* (Liu et al., 2021).

Priming has a critical function in improving germination and growth under various abiotic stressors (Paparella et al, 2015; Zheng et al, 2016; Hussain et al, 2017). Various preparation techniques such as hydropriming, osmopriming, redox priming, halopriming or hormonal priming are used to ameliorate the detrimental effects of different environmental stresses (Hussain et al., 2016). In this study, it was determined that thermopriming treatments had a positive effect on average germination time, average emergence rate, root length and shoot length at 25 °C conditions. It has been determined that thermopriming treatments have a positive effect for watermelon at 25 °C conditions, except for some parameters (germination rate and average emergence time). In 45 °C conditions, thermopriming treatments showed positive effects on germination rate, average germination time, average emergence time and root length. It has been determined that thermopriming treatments have a positive effect on watermelon at 45 °C conditions, except for some parameters (average emergence rate and shoot length). It can be concluded that thermopriming treatment improves seed germination and emergence performance in watermelon under high temperature stress conditions. In some previous studies, it has been determined that seed priming treatments affect plant growth positively under abiotic stress conditions (Jisha et al., 2013; Abid et al., 2018; Günay et al., 2022).

Conclusion

In conclusion, our results show that thermopriming treatments have a curative effect on germination and seedling emergence of watermelon plants under high temperature stress. The results in this study show that thermopriming treatment can be used to improve seed germination in watermelon under high temperature conditions. The results support the hypothesis that watermelon seeds pre-subjected to high temperatures are better equipped to cope with subsequent stress events than the non-primed seeds. Increasing the determination of seed priming efficiency in other horticultural crops exposed to different stress conditions may provide significant advantages. However, the biochemical and molecular mechanisms of seed priming also need to be investigated.

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Conflict of Interest

No known or potential conflict of interest exist for any author.

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