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COMBINED EFFECTS OF DROUGHT AND LOW TEMPERATURE ON GERMINATION AND SEEDLING GROWTH OF MELON CULTIVARS

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Abstract: The study aimed to determine the effects of drought (0.0, -2.0, -4.0, and -6.0 bar PEG 6000) and low temperature (18°C) on the germination and early seedling growth of three melon cultivars (Kırkağaç 589, Hasanbey 1, and Toros Sarıbal). Germination percentage, mean germination time, germination index, root length, shoot length, fresh and dry weight of the seedling, and vigor index of the melon cultivars were investigated. The results showed significant effects of low temperature and drought stress on the germination and seedling growth of melon cultivars. As temperature decreased and drought increased, the germination percentage decreased, and mean germination time was delayed. Drought stress led to a decrease in germination percentage, index, and all investigated seedling growth parameters, while the response of melon cultivars to drought stress varied. Seedling growth was more affected by low temperature than germination. Low temperature decreased germination percentage from 87.2% to 63.7% and seedling fresh weight from 140 mg/plant to 64 mg/plant. Each increase in drought levels resulted in a decrease in germination and seedling growth parameters of melon cultivars. Any seedling growth was not observed in Hasanbey 1 and Toros Sarıbal at -6.0 bar at 18°C. Melon cultivars showed different levels of tolerance to drought stress during germination and seedling growth stages, while they could maintain it up to -4.0 bar. It was concluded that Kırkağaç 589 germinated and grew better under drought stress at both optimum and low temperatures.

Keywords: *Cucumis melo* L., Germination, Genotype, Drought, Cold

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1. Introduction

Melon (*Cucumis melo* L.) is a summer season crop commonly grown for fresh ripe fruit and baby fruit is widely used for pickles in Türkiye (Vural et al., 2000). It is an important alternative crop in arid and semi-arid regions in open-field, where climatic conditions are characterized by drought and low annual rainfall (Aragão et al., 2023). It can be grown under rainfed conditions without irrigation in crop rotation with wheat, barley, and sunflower, while late spring and early autumn frosts limit the vegetation period of melon. For these reasons, it is generally sown in unfavorable seedbed conditions such as suboptimal temperature, salinity, and lack of moisture (Ergin et al., 2021).

Low temperature and drought are the main factors that inhibit moisture uptake by seeds and cause irregular and inadequate seedling emergence, resulting in yield limitations (Copeland and McDonald, 1995). These conditions reduce and delay germination and emergence, and inhibit seedling growth (Finch-Savage, 2010). In melon, Pinheiro et al. (2017) found that increasing drought stress led to a reduction in germination and seedling growth in four seed lots. Also, Edelstein and Kigel (1990) found that water uptake by melon seeds was inhibited by low temperature, and no germination was observed at 14°C in Noy Yizre'el accession, suggesting genotypic variation among melon genotypes in response to low temperature (Hutton and Loy, 1991). Similar observations were identified in pea (Okçu et al., 2005), sunflower (Ergin and Kaya, 2020), muskmelon (Xu et al., 2017), and maize (Khaeim et al., 2022) under drought stress. However, it remains unclear which stresses have a greater impact on melon germination. This study aimed to determine the combined effects of drought and suboptimal temperature on the germination and growth of melon seedlings and to determine which stress is more harmful than the other.

2. Materials and Methods

An experimental study under laboratory conditions was planned to determine the response of melon (*Cucumis melo* L.) cultivars to different drought levels under optimum and low-temperature conditions during germination and early seedling growth. The experiment was carried out in 2023 at the Seed Science and Technology Lab., Department of Field Crops, Eskişehir Osmangazi University, Türkiye. The seeds of three melon cultivars (Kırkağaç 589, Toros Sarıbal, and Hasanbey 1) were germinated under different levels of drought stress, using various concentrations of polyethylene glycol 6000 (PEG) with 0.0 (distilled water), -2.0, -4.0, and -6.0 bar under optimum (25°C) and low (18°C) temperatures according to Michel and Kaufmann (1973).

2.1. Germination Conditions

Germination procedures were performed according to the ISTA (2003) rules. A total of two hundred (4×50) seeds of each melon cultivar were used for each treatment, and 50 seeds were placed on two layers of filter paper and then covered with a sheet. They were moistened with 21 mL of the respective solutions. After rolling, the samples were placed in sealed plastic bags to prevent water evaporation. The papers were replaced with new ones every 2 days during incubation to prevent PEG accumulation. The packages were transferred to incubators set at optimum 25°C and low 18°C temperatures in the dark. Germination was determined by a 2 mm radicle elongation and recorded every 24 hours for 8 days. The mean germination time (MGT), calculated following the ISTA (2003) guidelines, was used to assess the germination speed. $MGT= \Sigma(Dn)/\Sigma n$, where n denotes the number of seeds that germinated on day D, and D indicates the number of days from the beginning of the germination test. The germination index (GI) was determined by implementing the formula, GI= number of germinated seeds/days of first counting +. . .+ number of germinated seeds/days of final counting (Ahmad et al., 2009). On the eighth day, ten seedlings were randomly selected from each treatment to measure seedling growth characteristics including root length (RL), shoot length (SL), seedling fresh weight (SFW), and seedling dry weight (SDW). To calculate the vigor index (VI), the germination percentage (%) was multiplied by the seedling length (cm).

2.2. Statistical Analysis

The data analysis involved a three-factor factorial (drought × temperature × cultivar) using a completely randomized design (CRD) with 4 replicates. Analysis of variance and mean comparison was performed using Duncan's multiple range test (P<0.05) with the Mstat-C v. 2.10 software program.

3. Results and Discussion

The main effects of cultivar, temperature, and drought stress on germination and seedling growth characteristics of melon are shown in Table 1. It is not interesting that low temperature resulted in reduced germination and seedling growth of melon. However, melon cultivars responded differently to drought and low-temperature stress. In general, Kırkağaç 589 generally performed better results under these stress conditions. Similar findings were reported by Pinheiro et al. (2017), who found that drought stress reduced germination and seedling growth in four seed lots of melon.

Table 1. Main effects of cultivar, temperature, and drought stress on germination and seedling growth of melon.

Factor	GP %	MGT day	GI	RL cm	SL cm	SFW mg/plant	SDW mg/plant	VI
Temperature								
18°C	63.7^{b}	3.49^{a}	7.8^{b}	3.31^{b}	0.83^{b}	64^{b}	20.8^{b}	335^{b*}
25°C	87.2^{a}	2.57^{b}	18.5^{a}	9.32^{a}	3.54^{a}	140^{a}	24.6^{a}	1150^{a}
Cultivar								
Kırkağaç 589	91.2^{a}	3.06	16.8^{a}	7.15^{a}	2.88^{a}	126^{a}	26.6^{a}	944^{a}
Toros Sarıbal	68.9^{b}	3.03	11.5^{b}	6.28^{b}	1.95^{b}	92^{b}	22.2^{b}	621^{b}
Hasanbey 1	66.2^{b}	3.00	11.2^{b}	5.52^{c}	1.73^{c}	88^{b}	19.4c	661^{b}
Drought (bar)								
Control	89.5^{a}	2.74^{c}	17.5^{a}	7.19^{b}	5.39^{a}	203^{a}	24.0^{b}	1137^{a}
-2.0	88.4^{a}	3.09^{b}	16.2^{b}	8.59^{a}	1.92^{b}	109^{b}	24.3^{b}	943^{b}
-4.0	74.1^{b}	3.71^{a}	12.4^{c}	6.71^{b}	0.78^{c}	64^{c}	25.4^{a}	626^{c}
-6.0	49.8^{c}	2.58^{d}	6.6^{d}	2.77^{c}	0.65^{c}	31^{d}	17.4^{c}	262^{d}

*Means connected with the same letter(s) in each column are not significant at P<0.05. GP= Germination percentage, MGT= mean germination time, GI= germination index, RL= root length, SL= shoot length, SFW= seedling fresh weight, SDW= seedling dry weight, VI= vigor index.

The effects of different drought levels on germination characteristics and root length of melon cultivars under optimum (25°C) and low (18°C) temperatures are shown in Table 2. A three-way interaction of temperature × drought × cultivar was significant (P<0.05) for germination percentage, mean germination time, germination index, and root length. At optimum temperature (25℃), germination percentage of melon cultivars was different, and Hasanbey 1 had the lowest germination percentage in control. As drought stress increased, the difference between melon cultivars increased. No significant reduction in germination percentage of Kırkağaç 589 was observed up to -6.0 bar. Also, MGT was delayed with decreasing water potential of the solution, and the fastest germination was obtained from Kırkağaç 589 at all drought levels. Our results were confirmed by the findings of Kaya et al. (2006) and Toscano et al. (2017) in sunflower, Magar et al. (2019) in corn, Muscolo et al. (2014) in lentil, and Sadeghian and Yavari (2004) in sugar beet, who determined that drought, caused a reduction in germination and retardation in mean germination time. Germination index was decreased depending on drought stress and melon cultivars and Kırkağaç 589 had the highest germination index. Root length was negatively affected by drought stress, while the root length of Hasanbey 1 enhanced up to -4.0 bar. Under low temperature (18℃) stress, drought stress influenced germination and root length more severely than optimum temperature. This finding aligns with the results observed in zucchini (*Cucurbita pepo* L.) by Gülşen et al. (2022), revealing notable differences in germination traits among 15 breeding lines under low temperatures of 12℃ and 15℃. However, Kırkağaç 589 germinated better than the other cultivars at all drought levels. Germination percentage of Toros Sarıbal and Hasanbey 1 at -4.0 bar dropped below 50%. Also, their MGT could not be calculated due to insufficient germination percentage at -6.0 bar, Kırkağaç 589 had the lowest MGT at all drought levels. The germination index was higher under optimum temperature conditions compared to lower temperature. Among the melon cultivars, Kırkağaç 589 had the highest germination index. Drought affected severely the root growth of melon cultivars under low temperature, and the longest root was also measured in Kırkağaç 589. Muscolo et al. (2014) reported that root growth of lentil decreased when drought stress increased.

Table 2. Effects of different drought stresses on germination characteristics and root length of melon cultivars under optimum (25°C) and low (18°C) temperatures

Drought (bar)	Cultivar	GP (%)		MGT (day)		GI		RL (cm)	
		25℃	18℃	25℃	18℃	25℃	18℃	25℃	18℃
Control	Kırkağaç 589	94.5^{abc}	98.5^{a}	1.97^{i}	2.93^{f}	24.3^{a}	16.3^{d}	13.21^{a}	4.22^{fg}*
	Toros Sarıbal	91.0^{a-e}	89.0^{c-f}	2.10^{hi}	3.54^{de}	21.7^{b}	12.4^{f}	9.11^{cd}	4.72^{efg}
	Hasanbey 1	83.5^{e-h}	80.5^{gh}	2.21^{gh}	3.70^{cd}	19.6^{c}	11.1^{fg}	8.33^{d}	3.56^{gh}
-2.0	Kırkağaç 589	97.0^{ab}	95.5^{abc}	2.01^{hi}	3.45^{e}	24.2^{a}	14.1^{e}	13.28^{a}	5.31^{ef}
	Toros Sarıbal	90.5^{b-e}	81.5^{fgh}	2.23^{gh}	4.27^{b}	21.2^{b}	9.0^{hi}	9.70^{c}	4.31^{efg}
	Hasanbey 1	85.0^{d-g}	81.0^{gh}	2.36^{g}	4.23^{b}	19.3^{c}	9.3^{hi}	13.67^{a}	5.28^{ef}
-4.0	Kırkağaç 589	92.5^{a-d}	95.5^{abc}	2.15^{ghi}	3.89^{c}	22.2^{b}	12.3^{f}	9.22^{cd}	4.47^{efg}
	Toros Sarıbal	90.5^{b-e}	30.5^{k}	2.88^{f}	5.33^{a}	16.3^{d}	1.6^{k}	8.80^{cd}	2.53^{hi}
	Hasanbey 1	89.0^{c-f}	46.5^{j}	2.74^{f}	5.30^{a}	17.5^{d}	4.6^{j}	11.79^{b}	3.46^{gh}
-6.0	Kırkağaç 589	96.5^{abc}	59.5^{i}	2.88^{f}	5.25^{a}	16.7^{d}	4.1^{j}	5.65^{e}	1.83^{i}
	Toros Sarıbal	77.0^{h}	1.5^{l}	3.88^{c}	- ^{j}	10.2^{gh}	- ^{l}	4.99^{ef}	- ^{j}
	Hasanbey 1	59.5^{i}	4.5^{l}	3.52^{de}	- ^{j}	8.7^{i}	- ^{l}	4.15^{fg}	- ^{j}

*Means connected with the same letter(s) in each character are not significant at $P<0.05$. GP= Germination percentage, MGT= mean germination time, GI= germination index, RL= root length.

The effects of different drought levels on seedling growth characteristics of melon cultivars at optimum (25°C) and low (18°C) temperatures are shown in Table 3. The seedling growth of the melon cultivars was significantly different, and Kırkağaç 589 produced the longest shoot, the greatest fresh and dry seedling weight, and the highest vigor index. At 25℃, the shoot length of melon cultivars was significantly depressed at -2.0 bar and reached the minimum values at -4.0 bar. Depending on the reduction in shoot and root length, seedling fresh weight decreased with increasing drought stress. It was reduced by 52% in Kırkağaç 589, by 55% in Toros Sarıbal, and by 61% in Hasanbey 1. However, changes in seedling dry weight were not related to fresh weight. The highest dry weight of seedling (29.6 mg/plant) was recorded in Kırkağaç 589 under drought stress of -6.0 bar. Pinheiro et al. (2017) reported that seedling growth of melon was inhibited by increasing drought stress. These results are in line with findings in maize (Liu et al., 2017), in lentil (Muscolo et al., 2014) and in carrot, eggplant, and watermelon (Steiner and Zuffo, 2019). Vigor index, a valuable screening criterion for genotypes against stress, combines germination performance and seedling growth. In this study, melon cultivars in the control treatment showed that there was a clear difference among melon cultivars; furthermore, each increase in drought stress caused a reduction in the vigor index of melon cultivars. The highest vigor index was calculated in Kırkağaç 589 at all drought stress levels. Under low-temperature stress, a remarkable drop in seedling growth was observed. Shoot length of Kırkağaç 589, Toros Sarıbal, and Hasanbey 1 declined from 12.31 cm to 1.84 cm, from 7.56 cm to 1.72 cm, and from 7.87 cm to 1.82 cm, respectively. No shoot length was measured in Toros Sarıbal at -4.0 bar and -6.0 bar at 18°C, indicating its sensitivity to low temperature, because this cultivar had shoot growth at the same drought levels under 25°C. However, there were no significant differences in seedling fresh weight among the melon cultivars in each drought, and a similar response was observed. Seedling dry weight was not altered by increasing drought stress, while Hasanbey 1 had the lowest dry weight under all drought stresses. Low temperature caused a reduction in the vigor index of melon cultivars. Among the melon cultivars, Kırkağaç 589 had the highest index value at all drought levels and was the least affected cultivar by low temperature and drought.

Table 3. Effects of different drought stresses on seedling growth characteristics of melon cultivars at optimum (25°C) and low (18°C) temperatures

Drought (bar)	Cultivar	SL (cm)		SFW (mg/plant)		SDW (mg/plant)		VI	
		25°C	18°C	25°C	18°C	25°C	18°C	25°C	18°C
Control	Kırkağaç 589	12.31^{a}	1.84^{e}	365^{a}	127de	24.7^{b-e}	27.5^{abc}	2412^{a}	598^{hı}*
	Toros Sarıbal	7.56^{b}	1.72^{e}	265^{b}	126^{def}	23.0^{cde}	26.2^{a-d}	1517^{c}	574^{hı}
	Hasanbey 1	7.87^{b}	1.02^{f}	234^{c}	100^{efg}	20.5^{e}	22.0^{de}	1356^{d}	370^{jk}
-2.0	Kırkağaç 589	4.06^{c}	1.00^{f}	177^{c}	81^{ghı}	25.5^{a-d}	26.7^{a-d}	1685^{b}	603^{hı}
	Toros Sarıbal	1.95^{e}	0.58^{f}	120^{def}	69^{g-k}	25.0^{a-e}	24.4^{b-e}	1055^{ef}	399^{jk}
	Hasanbey 1	2.98^{d}	0.96^{f}	138^{d}	67^{h-k}	22.1^{de}	22.4^{de}	1416^{cd}	505^{hıj}
-4.0	Kırkağaç 589	0.88^{f}	0.94^{f}	96^{fgh}	57^{ıjk}	28.6^{ab}	25.4^{a-d}	934^{fg}	517^{hıj}
	Toros Sarıbal	0.98^{f}	- ^{g}	62^{ıjk}	46^{k}	25.2^{a-e}	27.5^{abc}	884^{g}	80^{mn}
	Hasanbey 1	0.95^{f}	0.94^{f}	77^{g-j}	48^{jk}	22.8^{cde}	23.1^{cde}	1132^{e}	211^{lm}
-6.0	Kırkağaç 589	0.99^{f}	0.99^{f}	57^{ıjk}	44^{k}	29.6^{a}	25.6^{a-d}	642^{h}	165^{lm}
	Toros Sarıbal	1.04^{f}	- ^{g}	45^{k}	- ^{l}	26.5^{a-d}	- ^{f}	467^{ıj}	-^{n}
	Hasanbey 1	0.90^{f}	- ^{g}	40^{k}	- ^{l}	22.4^{de}	- ^{f}	301^{kl}	-^{n}

*Means connected with the same letter(s) in each character are not significant at P<0.05. SL= shoot length, SFW= seedling fresh weight, SDW= seedling dry weight, VI= vigor index.

4. Conclusion

Drought and low-temperature stresses are common in seedbed conditions after sowing. Thus, the germination and early seedling growth performance of melon cultivars were negatively limited by them. In this experiment, significant differences were found among melon cultivars in terms of tolerance to drought and low temperature; however, melon was more sensitive to low temperature than to drought during germination and subsequent growth stage of the seedlings. Among the melon cultivars, Kırkağaç 589 appeared to be more tolerant to drought stress under optimum and low temperature because it germinated and grew better than the others. It was concluded that low temperature was more detrimental to melon cultivars than drought, and the selection of a suitable melon genotype was a critical factor in achieving higher and faster germination in drought-stricken fields.

Author Contributions

The percentage of the author contributions is presented below. The author reviewed and approved the final version of the manuscript.

	G.K.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

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References

Ahmad S, Ahmad R, Ashraf MY, Ashraf M, Waraich EA. 2009. Sunflower (*Helianthus annuus* L.) response to drought stress at germination and seedling growth stages. Pak J Bot, 41(2): 647-654.

Aragão MF, Pinheiro Neto LG, de A Viana TV, Manzano-Juarez J, Lacerda CF, do N Costa JJ. 2023. Evaluation of crop water status of melon plants in tropical semi-arid climate using thermal imaging. Brazilian Journal of Agricultural and Environmental Engineering, 27(6): 447-456.

Copeland LO, McDonald MB. 1995. Seed Germination. In: Principles of Seed Science and Technology. 3rd edition, Chapman and Hall, USA, pp. 59-110.

Edelstein M, Kigel J. 1990. Seed germination of melon (*Cucumis melo*) at sub- and supra-optimal temperatures. Sci Hortic, 45(1-2): 55-63.

Ergin N, Kulan EG, Gözükara MA, Kaya MF, Çetin ŞÖ, Kaya MD. 2021. Response of germination and seedling development of cotton to salinity under optimal and suboptimal temperatures. KSU J Agric Nat, 24 (1): 108-115.

Ergin N, Kaya MD. 2020. Effects of drought and temperature stress on germination and seedling development of sunflower. Turk J Agric Food Sci and Technol, 8(3): 598-602.

Finch-Savage WE. 2010. The use of population-based threshold models to describe and predict the effects of seedbed environment on germination and seedling emergence. In: Handbook of Seed Physiology Applications to Agriculture, Eds. Benech-Arnold RL and Sanches RA. CRC Press, NY. pp. 51-84.

Gülşen O, Demirkaya M, Aslan F. 2022. Determination of germinating properties of zucchini (*Cucurbita pepo* L.) lines at low temperatures. Journal of Erciyes Agriculture and Animal Science, 5(2): 20-25.

Hutton MG, Loy JB. 1991. Muskmelon cultigens evaluated for low-temperature germinability. HortScience, 26: 1333.

ISTA 2003. International Rules for Seed Testing. International Seed Testing Association, Bassersdorf, Switzerland.

Khaeim H, Kende Z, Jolánkai M, Kovács GP, Gyuricza C, Tarnawa Á. 2022. Impact of temperature and water on seed germination and seedling growth of maize (*Zea mays* L.). Agronomy, 12(2): 397.

Kaya MD, Okçu G, Atak M, Çıkılı Y, Kolsarıcı Ö. 2006. Seed treatments to overcome salt and drought stress during germination in sunflower (*Helianthus annuus* L.). Europ J Agron, 24(4): 291-295.

Liu M, Li M, Liu K, Sui N. 2017. Effects of drought stress on seed germination and seedling growth of different maize varieties. J Agric Sci, 7(5): 231-240.

Magar MM, Parajuli A, Sah BP, Shrestha J, Sakh BM, Koirala KB, Dhital SP. 2019. Effect of PEG induced drought stress on germination and seedling traits of maize (*Zea mays* L.) lines. Türk Tarım ve Doğa Bilimleri Dergisi, 6(2): 196–205.

Michel BE, Kaufmann MR. 1973. The osmotic potential of polyethylene glycol 6000. Plant Physiol, 51: 914–916.

Muscolo A, Sidari M, Anastasi U, Santonoceto C, Maggio A. 2014. Effect of PEG-induced drought stress on seed germination of four lentil genotypes. J Plant Interact, 9: 354-363.

Okçu G, Kaya, MD, Atak M. 2005. Effects of salt and drought stresses on germination and seedling growth of pea (*Pisum sativum* L.). Turk J Agric For, 29(4): 237-242.

Pinheiro DT, dos Santos Dias DCF, de Oliveira Araújo J. 2017. Germination of melon seeds under water and thermal stress. Journal of Seed Science, 39(4): 440-447.

Sadeghian SY, Yavari N. 2004. Effect of water-deficit stress on germination and early seedling growth in sugar beet. J Agron Crop Sci, 190(2): 138-144.

Steiner F, Zuffo AA. 2019. Drought tolerance of four vegetable crops during germination and initial seedling growth. Biosci J, 35(1): 177-186.

Toscano S, Romano D, Tribulato A, Patane C. 2017. Effects of drought stress on seed germination of ornamental sunflowers. Acta Physiol Plant, 39: 184.

Vural H, Eşiyok D, Duman İ. 2000. Kavun. In: Kültür Sebzeleri (Sebze Yetiştirme). Ege Üniversitesi Basımevi, İzmir, Türkiye, pp: 364-377.

Xu H, Su W, Zhang D, Sun L, Wang H, Xue F, Zhai S, Zou Z, Wu R. 2017. Influence of environmental factors on *Cucumis melo* L. var. *agrestis* Naud. seed germination and seedling emergence. PLoS ONE, 12(6): e0178638.