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Interactive Effects of Temperature on Seed Germination Percentage in Selected Eggplant (*Solanum melongena* L.) Cultivars

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Abstract

Eggplant (*Solanum melongena* L.) is a thermophilic vegetable species, and its cultivation in temperate climate regions typically begins with seedling production in protected environments such as greenhouses. Temperature plays a crucial role in the seed germination process, and optimal thermal conditions must be maintained to ensure successful emergence. Scientific literature recommends constant temperature ranges between 25 ± 1–2°C and 27 ± 1–3°C during germination. This study aimed to evaluate the influence of temperature on eggplant seed germination by assessing variations in germination percentage and timing under controlled greenhouse conditions. Three commonly cultivated eggplant hybrids in southern Romania—Barcelona, Habana, and Black Pearl—were subjected to two constant temperature regimes: 23°C and 28°C. The results revealed significant differences in both germination percentage and germination time, defined as the period required to reach 85% germination and the peak germination moment. The highest performance was observed in the Black Pearl hybrid at 28°C, which achieved a germination rate of 98%. These findings underscore temperature as a determining factor in eggplant seed germination, and highlights the substantial variations in germination and emergence parameters across temperature conditions. Overall, the results support the importance of maintaining optimal thermal conditions in seedling production and suggest the need for further research to optimize germination strategies for different eggplant hybrids under varying environmental conditions.

Keywords: Seedlings, Romania, Technology, Temperature, Eggplant

1. Introduction

Eggplant (Solanum melongena L.) is a thermophilic vegetable species native to subtropical regions (Pohl *et al*., 2019) [19] and is now extensively cultivated in both tropical and temperate climates (Shimira & Taşkin, 2022; Alam & Salimullah, 2021) [22, 1]. Due to its high sensitivity to low temperatures, particularly during the early stages of development, eggplant cultivation in cooler climates presents significant challenges. As a result, seedling production typically takes place in protected environments such as greenhouses, where climatic conditions can be carefully controlled. Wan *et al*. (2014) [24] emphasized that eggplant exhibits a higher susceptibility to cold stress compared to other Solanaceae family members, which has led to intensified research efforts aimed at improving its cold tolerance. These efforts include the use of grafting techniques and genetic modifications, with particular focus on introducing cold-tolerant rootstocks to enhance the crop's resilience under suboptimal thermal conditions (Shimira & Taşkin, 2022) [22].

Globally, countries such as China, India, Egypt, and Turkey dominate eggplant production, while significant cultivation also occurs across the Mediterranean and temperate regions (Alam & Salimullah, 2021) [1]. In these cooler environments, the germination of eggplant seeds is particularly problematic due to its irregular and temperature-sensitive nature, necessitating controlled seedling propagation in greenhouses (Pohl *et al*., 2019) [19]. Temperature remains a key environmental determinant in regulating both the rate and success of germination. Research has documented wide physiological variability in the response of eggplant seeds to thermal fluctuations, where deviations from optimal temperature ranges can result in delayed germination and diminished seedling vigor, thereby negatively affecting overall crop establishment (Ghaderi *et al*., 2008; Kamgari, 2009; Finch-Savage & Leubner-Metzger, 2006; Cutti & Kulckyzynski, 2016) [12, 16, 9, 7]. The importance of regulating greenhouse parameters such as temperature and humidity has been demonstrated in other crops, notably tomatoes, where such control has

Led to enhanced germination and early seedling development, suggesting that similar approaches could be effective for eggplant (Jerca *et al*., 2023; Ionuţ *et al*., 2024) [15, 14].

In terms of genetic improvements, several high-performance eggplant hybrids have been developed for commercial cultivation, adaptable to both protected and open-field systems. The Black Pearl F1 hybrid is a semi-early genotype known for its semi-long, dark-colored, intensely glossy fruits, characterized by a firm texture and excellent commercial appeal. Barcelona F1 is recognized as an extra-early hybrid producing thornless, oval-elongated fruits with a deep black gloss, weighing between 380 and 420 grams, and displaying firm, white, seedless flesh that significantly enhances its market value. The Habana hybrid, developed by Semillas Fitó, is an early cultivar that combines strong vegetative vigor with an open plant habit, and produces glossy, oval-elongated fruits weighing approximately 400–430 grams with white, seedless flesh. These attributes contribute to its consistent yield performance in both protected and open-field cultivation systems. In Romania, traditional and modern varieties such as Luiza, Drăgaica, and Belona are widely cultivated. Luiza is a semi-early variety yielding dark violet, almost black, oval-elongated fruits ranging from 250 to 300 grams, with a high-gloss finish. Drăgaica, an early-maturing variety, produces similarly dark violet, glossy fruits averaging around 300 grams and is noted for its high ecological plasticity and yield potential of up to 51 tons per hectare. Belona, a semi-early variety with white fruits, exhibits strong resistance to Phytophthora infestans and Verticillium dahliae, making it particularly suitable for diverse cultivation environments, including both open fields and protected systems. According to Bogoescu and Doltu (2014) [5], hybrids like Black Pearl, Habana, and Barcelona are specifically intended for protected cultivation, with Black Pearl and Habana being early-maturing types and Barcelona classified as extra-early.

Optimal germination temperatures for eggplant are generally reported within the range of 25 ± 1–2°C (Botey *et al*., 2022; Bogoescu & Doltu, 2014; Florescu *et al*., 1998) [6, 5, 10], while some sources suggest slightly higher optimal thresholds of 27–30°C (Vînătoru *et al*., 2019; Popescu & Atanasiu, 2000) [23, 20]. Nevertheless, these proposed ranges must be validated for specific hybrids cultivated in southern Romania, where protected cultivation is gaining prominence. Temperatures falling below 20°C have been shown to significantly reduce germination rates, while those exceeding 30°C may induce thermal stress, compromising seed viability (Haj Sghaier 2022) [13]. To counteract these limitations, recent studies advocate the use of advanced techniques such as seed priming, biostimulant application, and precise environmental optimization, all of which have been effective in mitigating temperature-related germination stress and enhancing uniform seedling emergence in eggplant. Similarly, technological interventions like the use of oxygen-enriched water and LED lighting systems have proven successful in boosting growth and productivity in hydroponically cultivated lettuce, offering promising avenues for application in eggplant seedling production (Niţu *et al*., 2023; Niţu *et al*., 2024 [17]). Moreover, greenhouse-based studies on cherry tomato cultivation indicate that optimal sowing dates and climate-controlled conditions can significantly enhance both yield and quality, providing transferable insights relevant to modern eggplant production systems (Arshad *et al*., 2024a; Arshad *et al*., 2024b) [3, 4].

2. Material and Method

Plant Material

Eggplant seeds were obtained from authorized seed suppliers specializing in vegetable seed material. Two commercial seed companies were used: Semillas Fitó and Enza Zaden. The F1 hybrid cultivars selected for this study included 'Black Pearl' (Enza Zaden), and 'Barcelona', 'Habana', 'Luiza', 'Drăgaica', and 'Belona' (Semillas Fitó). These cultivars are commonly cultivated by farmers in the southern regions of the country due to their adaptability and yield potential.

Sowing Procedure

Sowing was performed using the conventional plug tray method. Seeds were sown in plastic plug trays containing 70 cells per tray, with each cell holding approximately 50 mL of substrate. The growing medium consisted of a standardized mixture of 70% white peat and 30% black peat, with a particle size of 5 mm and a pH of 6. Moisture retention agents were included in the substrate to ensure optimal germination conditions.

Experimental Design

For each cultivar, 100 seeds were sown in three replications. The trays were placed in germination chambers set to four distinct temperature regimes: 20°C, 25°C, 30°C, and 35°C. Germination was monitored and recorded at 3, 6, 7, and 8 days after sowing.

Data Collection

The number of germinated seeds was counted at each of the specified time intervals. Germination percentage was calculated based on the total number of seeds sown per replicate. These data were used to evaluate the influence of temperature on the germination rate of the different eggplant hybrids.

Fig 1: Plug tray used for sowing

3. Results

3.1 Germination Dynamics at 20°C

The germination performance of the six eggplant cultivars (Barcelona, Habana, Black Pearl, Luiza, Drăgaica, and Belona) at 20°C revealed notable variation in seed vigor and emergence timing. Initial germination (day 3) was negligible for most varieties, with only Luiza (2%) and Drăgaica (1%) showing minimal activity. By day 6, germination rates increased across all cultivars, ranging from 19% in Barcelona to 27% in Belona. A significant acceleration occurred between days 6 and 8, culminating in germination percentages between 87% (Habana) and 92% (Drăgaica).

The Romanian cultivars (Luiza, Drăgaica, and Belona) demonstrated higher germination capacity compared to the hybrid varieties, suggesting better adaptation to suboptimal temperatures.

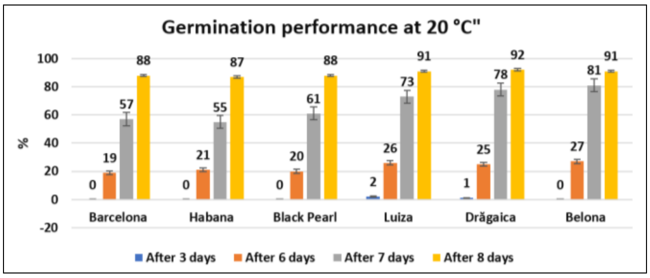

Fig 2: Germination percentage of seeds in the variant maintained at 20°C

3.2 Germination Dynamics at 25°C

At 25°C, all cultivars exhibited enhanced germination, with final rates after 8 days exceeding 90%. Drăgaica (94%), Belona (93%), and Black Pearl (94%) showed superior vigor. Early germination trends favored Belona and Drăgaica, reaching 37–38% by day 6, while Barcelona lagged with just 22%. The results indicate that moderate thermal conditions favored uniform germination and high seed viability across all genotypes, with Romanian varieties again performing strongly.

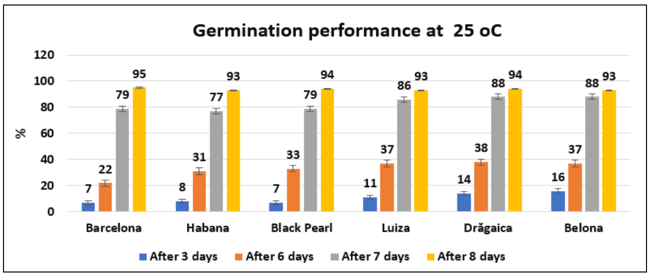

Fig 3: Germination percentage of seeds in the variant maintained at 25°C

3.3 Germination Dynamics at 30°C

Seed germination was optimal at 30°C, with all cultivars surpassing 92% germination as early as day 6. The highest rates were observed in Belona (96%), Luiza (95%), and Drăgaica (95%). By day 7, maximum germination was achieved in all varieties (97–98%), with negligible variation noted on day 8. These results highlight 30°C as the most favorable temperature for rapid and uniform seed emergence in eggplant, suggesting that this thermal regime enhances seed metabolic activity and germination potential across genotypes.

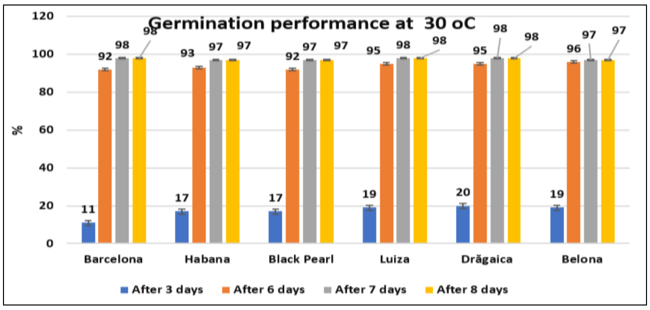

Fig 4: Germination percentage of seeds in the variant maintained at 30°C

At a temperature of 35 °C, eggplant seed germination showed a slower rate and lower final percentages compared to lower temperatures. After 8 days, values ranged between 63% (*Black Pearl*) and 74% (*Luiza*), indicating a negative influence of high temperature on germination. The Romanian varieties *Luiza*, *Drăgaica*, and *Belona* showed better tolerance to heat stress, while *Barcelona* and *Black Pearl* exhibited reduced germination capacity.

3.4 Germination Dynamics at 35°C

High temperature (35°C) had a detrimental effect on seed germination. Delayed emergence and reduced final germination percentages were observed. After 8 days, values ranged from 63% (Black Pearl) to 74% (Luiza). The Romanian cultivars Luiza, Drăgaica, and Belona exhibited relatively better tolerance to thermal stress, maintaining higher germination rates than the hybrids. Conversely, Barcelona, Habana, and Black Pearl showed marked sensitivity, highlighting potential limitations in high-temperature environments.

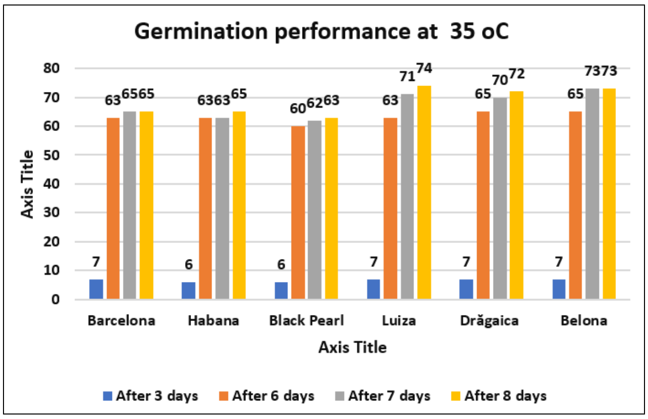

Fig 5: Germination percentage of seeds in the variant maintained at 35°C

Influence of Temperature on Germination

The germination percentage increases significantly with the rise in temperature from 20°C to 30°C. At 35°C, a stagnation or even a slight decrease is observed, suggesting that this temperature approaches the upper limit of tolerance for optimal germination.

At 20°C, the germination percentage after 8 days ranged from 87% (Habana F1) to 92% (Drăgaica). The Romanian varieties showed higher seed emergence rates compared to the analyzed hybrids, indicating better tolerance to lower temperatures.

At 25°C, the germination percentage increased significantly for all varieties after 8 days, reaching values between 90% (Barcelona) and 94% (Drăgaica). Drăgaica (94%) and Belona (93%) stood out with the highest percentages.

At 30°C, the best germination values were recorded, ranging from 97% to 98% as early as day 7, confirming that 30°C is the optimal temperature for eggplant seed germination.

At 35°C, germination was significantly affected, with lower final values ranging between 63% (Black Pearl) and 74% (Luiza). The varieties Luiza, Drăgaica, and Belona showed better tolerance, while Barcelona, Habana, and Black Pearl were more sensitive to high temperatures.

Table 1: Influence of Temperature on Seed Germination Percentage

Temperature	Days after sowing	Cultivars					
		Barcelona	Habana	Black Pearl	Luiza	Drăgaica	Belona
		%	%	%	%	%	%
20 ºC	afrer 6 days	19	21	20	26	25	27
	afrer 7 days	57	55	61	73	78	81
	afrer 8 days	88	87	88	91	92	91
25 ºC	afrer 6 days	22	31	33	37	38	37
	afrer 7 days	79	77	79	86	88	88
	afrer 8 days	95	93	94	93	94	93
30 ºC	afrer 6 days	92	93	92	95	95	96
	afrer 7 days	98	97	97	98	98	97
	afrer 8 days	98	97	97	98	98	97
35 ºC	afrer 6 days	63	63	60	63	65	65
	afrer 7 days	65	63	62	71	70	73
	afrer 8 days	65	65	63	74	72	73

Some studies by international researchers (Botey *et al*., 2022) [6] have also shown large variations in germination percentages (0–25%; 53–87%) for certain eggplant varieties under different temperature conditions (25±2°C).

4. Discussion

The germination of eggplant (Solanum melongena) is strongly influenced by temperature, with a marked increase in germination rates as temperatures rise from 20 °C to an optimal 30 °C, reaching nearly complete germination (97–98%) by day 7. However, at 35 °C, germination declines significantly (63–74%), indicating this as the upper thermal limit for seed viability. A similar temperature-dependent pattern is observed in African eggplant (S. aethiopicum), where optimal germination (~76%) occurs at moderate temperatures, with poor germination at both low (<15 °C) and high (>30 °C) extremes (Botey *et al*., 2016). Romanian cultivars such as Luiza, Drăgaica, and Belona have shown superior performance under both cool (20 °C) and hot (35 °C) conditions, demonstrating notable genotype × environment interactions. Enhancing germination and seedling vigor through physiological priming methods, such as hydropriming and osmopriming, has also proven effective. For instance, Forti *et al*. (2020) [11] found that hydropriming activates antioxidant and DNA repair pathways (e.g., SmOGG1) to boost eggplant seed germination, while Ali *et al*. (2019) [2] showed that priming with garlic extract enhances germination rates and early vigor by modulating reactive oxygen species (ROS) and strengthening antioxidant responses. Rahimi *et al*. (2013) [21] further demonstrated that osmopriming improves seed germination under both temperature and water stress in cumin, suggesting the cross-species applicability of such treatments. These findings carry important agronomic and breeding implications. For nursery practices, maintaining sowing temperatures near 30 °C ensures rapid and uniform emergence, and where thermal control is limited, priming strategies can help mitigate temperature-related stress. From a breeding perspective, integrating Romanian cultivars with broad thermal tolerance into breeding programs could lead to the development of resilient hybrids suited for diverse climatic conditions. Moreover, molecular markers linked to antioxidant and DNA repair activation, as identified by Forti *et al*., offer valuable tools for selecting genotypes with enhanced seed vigor and stress tolerance.

5. Conclusions

Temperature significantly influences eggplant seed germination, affecting both the speed of emergence and the final germination percentage.

The optimal temperature for germination was 30 °C, at which all varieties reached over 95% germination as early as day 6, demonstrating high vigor and uniform germination. At 25 °C, germination was slightly delayed but effective, with high final values (90–94%) by day 8, making it a favorable temperature though with a slower dynamic. At 35 °C, germination was significantly affected, with low percentages (63–74%), suggesting partial inhibition caused by heat stress.

The varieties *Drăgaica*, *Luiza*, and *Belona* showed the best thermal stability, maintaining high germination rates across all three temperature regimes.The varieties *Barcelona* and *Black Pearl* exhibited sensitivity to extreme temperatures, especially at 35 °C, indicating lower thermal adaptability. Temperature is an important germination factor for this thermophilic species, and reports show varying germination and emergence rates, which calls for further investigations.

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