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Effect of hot water priming on the sprouting of carrot (*Daucus carota* L.) seeds

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Abstract

Seed priming alleviates environmental problems such as water and salinity stresses, hence improves seed germination and subsequent growth. This study was conducted to examine the effect of hot water priming on the sprouting of carrot (*Daucus carota* L.) in the Southern Guinea Savannah. The study was conducted at the Crop Production Department Laboratory, Faculty of Agriculture, Ibrahim Badamasi Babangida University, Lapai (Latitude 9°06" and Longitude 6°57). The experiment was laid in completely randomized design (CRD) and replicated three times. The treatments include T_1 (control), T_2 (25°C and T_3 50°C). Evaluated germination traits include germination percentage, germination speed, mean germination time, mean daily germination, peak germination value and germination value. Results showed that there were significant differences among treatments ($p \leq 0.05$) on germination percentage, peak value, mean daily germination (MDT) and seedling length. Moreover, there were no significant differences in the germination speed, mean germination time and germination value ($p > 0.05$). The result of the experiments revealed that priming improved most of the measured parameters of carrot seed over the unprimed one. Priming carrot seeds at 50°C provide higher germination percentage, peak value, mean daily germination and seedling length.

***Keywords*:** priming, carrot, hot water, germination, sprouting

INTRODUCTION

Seed priming involves treating seeds before sowing to improve their physiological responses, enhance germination rates, and promote uniform sprouting (Farooq *et al.*, 2019). Hot water priming, where seeds are soaked in warm water for a specific period, helps soften the seed coat, improves water uptake, and stimulates early metabolic activities in the seed. Studies suggest that this method can break seed dormancy and promote faster and more uniform germination in various crops, including carrots (Bradford, 2016). For direct-seeded vegetables, and especially for carrots, a quick and consistent field emergence is essential for improving yield and product quality. Under demanding circumstances, the emergence and establishment of carrot seeds are sometimes slow and erratic.

In many vegetable and agronomic crops, seed priming has greatly improved seed vigor, producing consistent and fast germination and seedling emergence. It can improve vitality especially under demanding conditions such as excessive temperatures, little water availability, and salinity (McDonald, 2020). In both tropical and temperate climates, a major abiotic constraint is insufficient crop stand establishment. Many elements are involved, including poor quality of seeds, inadequate seedbed preparation, delayed planting, poor sowing methods, abiotic stresses including drought, severe temperatures, salinity, and adverse soil conditions (e.g., crusting). Such restrictions can be reasonably overcome by seed priming.

Carrot (*Daucus carrota* L.) cultivation often faces challenges related to poor germination and uneven sprouting, primarily due to the hard seed coat and dormancy issues inherent in carrot seeds. These factors can lead to delayed germination, low seedling emergence, and ultimately reduced crop yield, especially in environments where optimal growing conditions are not consistently available (Bradford, 2016). Farmers and growers frequently struggle with achieving uniform seed germination, which negatively impacts field establishment and reduces the overall productivity.

Conventional methods of enhancing carrot seed germination, such as mechanical scarification or chemical treatments, can be labor-intensive, costly, or environmentally detrimental (Farooq *et al*., 2019). In this study, alternative pre-sowing treatments like seed priming have been explored as effective and sustainable approaches to improve seed performance. However, despite the potential benefits of hot water priming in promoting faster and more uniform sprouting, its specific effects on carrot seeds remain underexplored, particularly in determining the optimal water temperature and soaking duration required to maximize germination success (Singh *et al*., 2020).

Thus, there is a need to investigate whether hot water priming can effectively overcome the limitations associated with carrot seed germination and establish a practical, cost-effective solution for enhancing early crop growth. This study seeks to address the problem of poor carrot seed germination by evaluating the effectiveness of hot water priming as a simple, eco-friendly technique that could significantly improve sprouting rates and crop establishment.

Farmers can benefit from a simple, low-risk, low-cost intervention called priming, which improves crop emergence rates, accelerates crop development, reduces crop duration, and increases both production and output so influencing their livelihoods. Pre-sowing treatments like seed priming can thus greatly improve the speed and synchronizing ability of germination, hence reducing crop duration, boosting performance, and raising yields in challenging environments (Bennett *et al*., 1992). Carrots (Pelluzio *et al*., 1999; Balbinot & Lopes, 2006) among other vegetable seeds have shown positive results from priming. Still, for some crops the positive effects of priming are more noticeable under field stress conditions, including very low and high temperatures (Demir & Oztokat, 2003; Bittencourt *et al*., 2004).

The main objective of this study was to determine the effect of hot water priming on the sprouting of carrot (*Dacus carrota* L.) seeds.

MATERIALS AND METHODS

The experiment was carried out at the Crop Production Laboratory, Faculty of Agriculture, IBB University, Lapai, Niger State. The experimental site is situated on latitude 9°4’6’’N and longitude 6°34’24”E in the Southern Guinea Savanna zone of Nigeria with mean annual temperature ranging between 21°C and 36.5°C. The materials used for the experiment include: Petri dish, tissue paper, watering bottle, measuring ruler. Carrot seeds were obtained from seed vendor in Minna known for seed quality. The study was laid in a Completely Randomised Design (CRD) and each treatment was replicated in triple. Each replicate consisted of 100 seeds. Various seed treatments that were applied, included: **Control (no treatment) -** The untreated seed were only rinsed with distilled water prior to the germination test to remove debris and dirt. **Priming with Water -** The carrot seeds underwent priming with hot water. The temperature was set at two levels (25°C or 50°C), while the soaking period was set at 5 minutes. For each treatment, thirty seeds were immersed in 100 ml beakers containing water at the corresponding temperature in a water bath with controlled temperatures for five minutes. Treated seeds were removed from the water and surface-dried. Seeds were air-dried for 5 hours before initiating the germination test.

Germination Test

Seeds from each treatment group were subjected to a standard germination test according to Baskin *et al*. (2019) under controlled conditions of temperature and moisture. Germination percentage, germination speed, and different characteristics was recorded.

Data Collection

Observations were made based on the number of days for germination required for the first count, germination percentage, germination speed, mean germination time, mean daily germination, peak value and germination value.

Daily and Cumulative germination count

The seeds showing a radicle growth were classified as germinated. Daily data on seed germination were recorded. The final germination percentage was determined based on the total number of germinated seeds. The daily germination percentages were aggregated to calculate the cumulative germination percentage for each treatment.

Germination Speed

Germination speed was calculated as described by Aldhous (1972), and Djavanshir & Pourbeik (1976):

$$\text{Germination Speed} = \frac{\text{Final Germination Percentage}}{\text{Days of Completion of Germination}}$$

Mean Germination Time (MGT)

Mean germination time was calculated by the formula given by Ellis & Roberts (1981)

$$\text{MGT} = \frac{(\text{n1} \times \text{d1}) + (\text{n2} \times \text{d2}) + (\text{n3} \times \text{d3})}{\text{Total Number of Seeds Germinated}}$$

Where: n= number of germinated seed and
d = number of days

Mean Daily Germination (MDG)

The Mean daily germination was calculated by the formula given by Czabator (1962)

$$\text{MDG} = \frac{\text{Total Number of Germinated Seeds}}{\text{Total Number of Days}}$$

Peak Value (PV)

Peak value was calculated by the following formula given by Czabator (1962).

$$PV = \frac{\text{Highest Seed Germinated}}{\text{Number of Days}}$$

Germination Value (GV)

Germination value was calculated by the formula given by Czabator (1962).

$$\text{GV} = \text{PV} \times \text{MDG}$$

Data Analysis

Analysis of variance (ANOVA) was used to determine significant differences among treatments. Post-hoc comparison tests such as Least Significant Difference (LSD) was used to identify specific treatment effects.

RESULTS AND DISCUSSION

The germination speeds of carrot are presented in Table 1. The result revealed that there was no significant ($p > 0.05$) difference in the germination speed of carrot as influenced by hot water priming. However, priming carrot seeds with hot water at 50°C had the highest germination speed, followed by priming with hot water at 25°C and lastly control.

Effect of hot water priming on the Mean Germination Time of carrot

The result revealed that hot water treatment does not have any significant ($p > 0.05$) effect on the mean germination time of carrot seeds. The result also revealed that priming carrot seeds at 50°C had the highest mean germination time while control had the least.

Effect of hot water priming on Germination percentage of carrot

The cumulative germination percentage (GP) of *Daucus carota* L. seeds indicated a substantial difference in germination percentage (GP) among the pretreatment seeds, with the highest GP (76.76%) achieved in seeds primed with hot water at 50°C, exhibiting less non-germinated seeds relative to the majority of other treatments. Hot water priming at 25°C resulted in a germination rate of 70%, far surpassing the control group, which exhibited a rate of 53.3%. Nonetheless, there was no notable difference in germination percentage between seeds primed with hot water at 50°C and those at 25°C at a 5% probability level.

Effect of hot water priming on Peak value of carrot

The maximum peak value (PV) was achieved in seeds primed with hot water at 50°C in comparison to other pre-sowing treatments. Untreated seeds (Control) exhibited a significant difference at the 5% probability level compared to treated seeds, although *Dacus carota* L. seeds primed with 25°C hot water showed no statistically significant difference ($p > 0.05$) from those primed with hot water at 50°C; the control group recorded the lowest peak value.

Effect of hot water treatment on Mean Daily Germination of carrot

The highest mean daily germination of *Daucus carota* L.seeds occurred with seeds primed in hot water at 50°C, followed by those soaked in 25°C hot water for 5 minutes, while the control exhibited the lowest mean daily germination. No significant differences ($p > 0.05$) were observed between the mean daily germination of seeds soaked in 25°C and 50°C hot water.

Effect of hot water treatment on Germination Value of carrot

The germination data indicated significant variation in seed germination values among the treatments. The germination value of *Dacus carota* L. was highest for seeds immersed in 50°C hot water, followed by 25°C, and then the control group. Nevertheless, there were no significant differences ($p > 0.05$) among treatments.

Effect of hot water treatment on the seedling length (cm) of Daucus carota L.

The seedling length of carrot as influenced by hot water treatment is presented in Table 1. The result revealed that there were significant differences in the seedling length. The seeds soaked in 50°C hot water supported longer carrot seedling followed by seeds soaked in 25°C hot water, while control had the least seedling length.

Table 1. Effect of hot water priming on the Germination parameters of Carrot (*Daucus carota* L.)

Treatment	**Germination Speed (GS) (%/time)**	**Mean Germination Time(MGT) (days)**	**Germination Percent (GP) (%)**	**Peak Value (PV) (seeds/day)**	**Mean Daily Germination (MDG) (seeds/day)**	**Germination Value (GV) (Number)**	**Seedling length (cm)**
Control	8.58a	7.09a	53.33b	1.39b	0.89b	1.88a	4.31b
25℃	9.03a	8.89a	70.00a	2.00a	1.17ab	2.01a	4.83a
50℃	11.96a	9.22a	76.67a	2.34a	1.47a	2.80a	4.89a
SE±	1.583	1.998	9.526	0.300	0.163	0.560	0.059

Legend: Means with same letters(s) along the column are not significantly different at 5% probability level using LSD.

This study aimed to evaluate the effect of hot water priming on the germination of carrot seeds. The results indicated a significant ($p < 0.05$) difference in germination percentage, peak value, mean daily germination, and seedling length; however, no significant differences were observed in germination speed, mean germination duration, and germination value. The maximum germination speed of 11.96 was seen in carrot seeds primed with hot water at 50°C for 5 minutes, while the minimum speed of 8.5 was noted in control carrot seeds. Sung (2019) showed that seed priming led to an increase in antioxidants such as glutathione and ascorbate, which enhance germination speed by reducing lipid peroxidation activity. Completing pre-germination metabolic processes, which prepare the seed for radicle protrusion, is most likely the reason for early emergence of primed seeds.

Hot water priming at 50°C resulted in the most favorable mean germination time, so priming techniques improve the germination rate of carrot seeds. The present results support the findings of Selvarani (2011) who reported that hydro-priming carrot seeds with 45°C hot water improves radicle protrusion percentage, lowers days to 50% germination, lowers days to maximum germination, accelerates germination speed, and increases germination percentage by 10, 22, 25, 11, and 12, respectively, relative to the control. At 35ºC, Nascimento *et al*. (2013) found that the germination percentages of unprimed and primed carrot seeds were 35% and 65%, respectively. Eliminating germination inhibitors and reducing dormancy could help to explain the higher germination rate of primed seeds. Hydro-priming effects DNA and RNA synthesis, ATP availability, alpha-amylase activity, and promotes embryo development. Consequently, improved plant growth results from higher germination rates, consistent growth, aggressive seeding, and development (Basra *et al*., 2006; Harris *et al*., 2019).

Sanches *et al*. (2021) also discovered that hydro-priming enhanced the root length of cucumber and carrot. The average seedling length varied between 4.31 cm and 4.89 cm. This outcome corresponds with the findings of Eisvand *et al*. (2011), who indicated that hydro priming treatment enhanced both shoot and root length of seedlings in two carrot cultivars compared with hormonal treatments.

CONCLUSIONS

By reducing the time needed for germination and seedling emergence, priming improves seed performance and simultaneously increases the uniformity of germination in unfavorable climatic conditions. The studies showed that, over the unprimed one, priming treatment enhances most of the measured characteristics of carrot seed. For germination percent, peak value, mean daily germination and plumule length, priming carrot seeds at 50°C shows to be beneficial. Based on the findings of the study, hence it is advised that seed growers should prime their carrot seeds prior sowing since the technique is simple, cost effective and affordable for carrot seed growers to overcome the problems of poor crop emergence and establishment under unfavorable environmental conditions.

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