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PRIMING SEEDS WITH POTASSIUM NITRATE IS ASSOCIATED WITH MODULATION OF SEED GERMINATION AND SEEDLING GROWTH ECOLOGY OF CUCUMIS METULIFERUS

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Abstract

The horned melon (*Cucumis metuliferus*) is mostly grown in tropical and subtropical countries, where it thrives on deep to shallow, well-drained soils. Seed dormancy, which causes poor and delayed germination, has remained a problem for farmers in several African countries, including Zimbabwe, who have begun producing horned melon. Midlands State University conducted a laboratory experiment to evaluate the effects of potassium nitrate on seed germination and early seedling growth of horned melon. The experiment was set up in a Completely Random Design (CRD) with seven different potassium nitrate (KNO_3) concentrations (0 %, 0.5 %, 1.0 %, 1.5 %, 2.0 %, 2.5 %, and 3.0 %), each duplicated three times. The data was analyzed using a one-way Analysis of Variance (ANOVA) in Genstat 18th edition. The characteristics of germination and early seedling development were assessed. All germination and early seedling development characteristics were significantly affected by potassium nitrate. Germination %, mean germination rate, germination index, mean daily germination percent, synchronization of germination, peak value for germination, and germination value all had a significant influence. Potassium nitrate had a significant influence on mean germination time and time to 50 % germination, with the lowest values obtained on seeds primed with 3 % KNO_3. There was a significant difference in seedling height, root length, seedling length, fresh biomass, and dry weight between seeds primed with 2.5 % KNO_3 and seeds not primed with 2.5 % KNO_3. Farmers are advised to use 2.5 % KNO_3 concentration for seed priming for optimal germination and early plant development of horned melon.

Keywords: Horned melon (*Cucumis metuliferus*), seed dormancy, potassium nitrate, germination, seedling.

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1. Introduction

Cucumis metuliferus E. Mey. Ex Naudin, often known as the Kiwano or African horned melon, belongs to the Cucurbitaceous family native crop produced in much of Africa and predominates in tropical and subtropical climates with sandy soils ranging from deep to shallow and well-drained [1]. The crop is widespread in Africa's central and southern semi-arid areas. Many rural communal farmers in Zimbabwe grow this indigenous crop mostly in Agroecological zones III, IV, and V [2]. These Agroecological zones are vulnerable to a variety of environmental challenges, including moisture and heat stress [3]. Because of its health and nutritional benefits, horned melon is popular among many rural farmers. The crop boasts high vitamin content, notably complex B vitamins and vitamin C [4–6]. Several researchers also report its high mineral content, particularly iron, calcium, zinc, sodium, potassium, magnesium, phosphorus, and copper.

Horned melon is now gaining popularity in export markets, opening market opportunities for native growers. Communal farmers in Zimbabwe are well-positioned to benefit from such market opportunities. To fast-track, the commercialization of horned melon by rural farmers, cheap and simple techniques to improve germination under environmental stress are required. Seed priming has been seen as a useful technique in improving seed germination and early seedling growth [7]. Waqas et al. [8] defined priming as a physiological strategy involving hydrating and drying seeds to improve the pre-germination metabolic process for quick germination, seedling development, and eventual yield under normal and stressful conditions. It has been effectively established that seed priming enhances the speed and uniformity of germination and seedling emergence in various stressful situations, such as salt, drought, and temperature. This is especially true for seeds of vegetables and tiny seeded grasses [9, 10].

Various priming techniques have been developed, including halo priming, which is the soaking of seeds in organic salts [7]. Various authors have shown potassium nitrate (KNO_3) as an effective priming agent that improves seed germination and early crop development. Armin et al. [11] noted that KNO_3 effectively increased the germination rate and plumule length of watermelons (*Citrullus lanatus*). Priming tomato seeds with KNO_3 increased mean germination time, final germination percentage, and physiological attributes [12]. Ahmadvad et al. [7] reported a significant increase in germination and emergence percentages, plumule and radicle length, plant height, and dry seedling weight from soybean cultivars primed with KNO_3. Therefore, this research evaluates the influence of different KNO_3 concentrations on seed germination and early seedling development of horned melons.

2. Materials and Methods

2. 1. Study site

The experiment was carried out at Midlands State University located 19°30'57" S 29°49'58" E and 1457 m above sea level. The area receives an average annual rainfall of 400–600 mm and an annual temperature of 25 °C. The experiment was conducted in the laboratory with a minimum temperature of 18 °C and 40 % relative humidity.

2. 2. Experimental design

The experiment was laid out in a Completely Randomized Design (CRD). It consisted of seven treatments that were different KNO_3 concentrations (0 %, 0.5 %, 1.0 %, 1.5 %, 2.0 %, 2.5 %, and 3.0 %). The treatments were replicated three times.

2. 3. Preparation of KNO_3 concentrations and priming

Different KNO_3 concentrations (0 %, 0.5 %, 1.0 %, 1.5 %, 2.0 %, 2.5 %, and 3.0 %) were prepared in beakers to test the influence of potassium nitrate KNO_3 on germination and early seedling development of horned melon seeds. For a 1 % concentration, 1 g of potassium nitrate was mixed with 100 ml of distilled water to make the KNO_3 concentration. The other KNO_3 concentrations were prepared using a simple proportion. The seeds were primed in various KNO_3 concentrations for 12 hours and thereafter air dried for 24 hours in Petri dishes. The experiment's negative control (0 % $KNO_{3)}$ was seeds primed with distilled water.

2. 4. Germination experiment

After drying the seeds, 20 seeds from each treatment were placed in Petri dishes with absorbent pads soaked with distilled water to ensure the seeds received enough moisture for germination. Throughout the experiment, a few drops of water were supplied daily to moisten the absorbent pads and ensure that the seeds had enough moisture. Daily germination data were accumulated until final germination was determined by observing a 1 mm protrusion of the radical. The characteristics of germination were tested and computed after 15 days.

2. 5. Early seedling growth experiment

The remaining seeds were sown in float trays (20 seeds per replication) for early seedling growth metrics, and each treatment was replicated three times. To maintain uniformity, pit sand was used as the growth medium. When the seedlings emerged, the float trays were transfered to a shade net. Watering the seedlings in float trays twice a day ensured enough moisture availability. Seedling growth characteristics were monitored and calculated four weeks following emergence.

2. 6. Data collection

Several morpho-physiological parameters were collected and computed as described below:

Germination percentage (*G* %) was determined using a formula by Ruttanaruangboworn, et al. [13] as follows:

$$\text{Germination Percentage} = \frac{\text{Number of germinated seeds}}{\text{Total seeds sown}}. \quad (1)$$

Mean Germination Time (*MGT*) was determined using a formula by [14] as follows:

$$\text{Mean Germination Time} = \frac{\sum Dn}{\sum n}, \quad (2)$$

where *D* is the number of days measured from the start of germination and n is the total number of seeds that germinated on day *D*.

Mean Germination Rate (*MGR*) was determined using a formula by Ranal et al. [15] as follows:

$$\text{Mean Germination Rate} = \frac{\sum_{i=1}^{1} n_i t_i}{\sum_{i=1}^{1} n_i}, \quad (3)$$

where $n_i t_i$ is the number of seeds germinated at an i^{th} time interval, and n_i is the number of seeds germinated at the i^{th} time.

Germination index (*GI*) was determined using the formula by ISTA, [16] as follows:

$$\text{Germination index} = \sum_{i=1}^{k} \left(\frac{N_i}{T_i} \right), \quad (4)$$

where T_i is the length of time from the experiment's beginning to the i^{th} time interval, N_i is the number of seeds that germinated during the i^{th} time interval [as opposed to the overall number], and *k* is the total number of time intervals.

Synchrony of germination. It was calculated as follows:

$$\text{Synchrony of germination} = \frac{\sum_{i=1}^{k} C_{\Sigma N_{i,2}}}{C_{\Sigma N_{i,2}}}, \tag{5}$$

where $CN_{i,2}$ is the partial combination of the two germinated seeds from among Ni, the number of seeds germinated on the i^{th} time interval estimated as $CN_{i,2}=N_i[N_{i-1}]/2$ and $C_{\Sigma Ni,2}$ is the partial combination of the two germinated seeds from among the total number of seeds germinated at the final count, assuming that all seeds that germinated did so simultaneously.

Time to reach 50 % *germination* (*T*50 %). It was calculated on day 15 using the results recorded daily. It was calculated as follows [17]:

$$\text{Time to 50 \% germination} = T_i + \frac{\left[\frac{N+1}{2} - N_i\right]\left[T_j - T_i\right]}{N_J - N_i}, \tag{6}$$

where t_{50} is the median germination time, N is the final number of germinated seeds, and N_i and Nj are the total numbers of seeds germinated in adjacent counts at time T_i and T_j respectively, when:

$$N_i < \frac{N+1}{2} < N_i.$$

Mean daily germination percent (*MDG*). It was calculated as follows:

$$\text{Mean Daily Germination} = \frac{GP}{T_k}, \tag{7}$$

where GP is the final germination percentage, Tk is the time at the kth time interval, and k is the total number of time intervals required for final germination.

Peak value for germination [18, 19]:

$$\text{Peak Value} = \max\left[\frac{G_1}{T_1}, \frac{G_2}{T_2}, \ldots \frac{G_k}{T_k}\right], \tag{8}$$

where T_1 is the time from the start of the experiment to the i^{th} interval, G_i is the cumulative germination percentage in the ith time interval, and k is the total number of time intervals.

Germination value (G_{value}) [18, 20]:

$$\text{Germination value} = PV \times MDG, \tag{9}$$

where PV is the maximum value, and MDG is the average daily germination rate from the time when germination began. By substituting MDG with the mean germination percentage per unit time, it may also be calculated for various periods between succeeding germination counts (GP).

Seedling height. Seedling height was measured using a ruler from the base of the main stem to the end of the woody growth.

Root length. Root length was measured by first dipping the seedling root zone in a beaker with water to remove all attached soil particles. The longest root was then measured using a ruler from the tip of the root to where it attaches to the main stem of the seedling.

Fresh biomass. The fresh weight of seedlings was determined by weighing ten seedlings and recording the weight on an electronic scale, then getting an average by dividing by 10.

Dry biomass. Ten seedlings were dried in a hot air oven for 24 hours at 70±1 °C. The seedlings were then removed and placed in a desiccator for 30 minutes to cool. The weighing was done in grams (g) on an electronic balance scale, and the weight was divided by 10.

2. 7. Data analysis

Data were analyzed using a one-way Analysis of Variance (ANOVA) using GenStat 18th edition software. Treatment means were separated using the least significant difference (LSD) at 5 % significance.

3. Results

3. 1. Effect of KNO_3 on germination percentage of horned melon seeds

There was a significant difference (P<0.05) in the germination percentage of horned melon seeds exposed to varied KNO_3 concentrations (**Table 1**). Germination improved as the concentration of KNO_3 increased up to 2.5 %. Priming horned melon seeds with 2.5 % KNO_3 resulted in a maximum germination rate of 92 %, while the control had the lowest germination percentage of 77.0 %. Except for the control treatment, seeds primed at 0.5 %, 1.0 %, and 1.5 % KNO_3 were not statistically (P>0.05) different from each other, and seeds primed at 2.0 %, 2.5 %, and 3.0 % KNO_3 were not statistically (P>0.05) different from each other either (**Table 1**).

Table 1

Effect of KNO_3 on germination percentage (G **%**), mean germination time (MGT), mean germination rate (MGR), germination index (GI), Synchrony of germination index (Z) of horned melon seeds

KNO_3 concentrations	Germination index				
	G %	*MGT*	*MGR*	*GI*	*Z*
0 [control]	77.0^{a}	3.57^{d}	0.28^{a}	6.22^{a}	0.23^{a}
0.5	81.0^{ab}	2.38^{bc}	0.44^{cd}	10.81^{c}	0.36^{a}
1.0	82.0^{ab}	2.66^{c}	0.39^{bc}	8.58^{b}	0.36^{a}
1.5	83.0^{bc}	2.75^{c}	0.37^{b}	8.63^{b}	0.34^{a}
2.0	91.0^{cd}	2.07^{ab}	0.48^{d}	11.94^{c}	0.63^{b}
2.5	92.0^{d}	2.03^{ab}	0.50^{d}	14.50^{d}	0.30^{a}
3.0	88.0^{bcd}	1.71^{a}	0.59^{e}	15.29^{d}	0.38^{a}
Mean	84.9	2.45	0.43	10.85	0.37
P value	0.015	<0.001	<0.001	<0.001	0.001
$LSD_{0.05}$	8.68	0.3848	0.06665	2.158	0.1524
CV %	6.9	10.6	10.4	13.4	27.6

3. 2. Effect of KNO_3 on mean germination time of horned melon seeds

The mean germination time of horned melon seeds was substantially (P<0.05) influenced by KNO_3. Priming seeds with 3 % KNO_3 resulted in the shortest mean germination time of 1.76 days, whereas the control (0 % KNO_3) resulted in the longest mean germination time of 3.57 days. There was no significant difference between seeds primed with 1 % KNO_3 and 1.5 KNO_3 (**Table 1**).

3. 3. Effect of KNO_3 on the mean germination rate of horned melon seeds

Potassium nitrate had a significant (P<0.05) effect on the mean germination rate in horned melon seeds. Seeds primed with 3 % KNO_3 had the greatest mean germination rate of 0.59, whereas seeds primed with 0 % KNO_3 had the lowest mean germination rate of 0.28 (**Table 1**). The mean germination rate of horned melon seed primed with 2 % KNO_3 and 2.5 % KNO_3 concentrations was not significantly different (P>0.05).

3. 4. Effect of KNO_3 on germination index of horned melon seeds

There was a significant difference (P<0.05) in the germination index of horned melon seeds primed at various levels of KNO_3. Seeds primed with 3 % KNO_3 had a germination index value of 15.29, while seeds primed with 0 % KNO_3 had a germination index value of 6.22. Seeds prepared with 1 % and 1.5 % KNO_3 showed no significant difference from each other, and seeds primed with 2.5 % and 3.0 % KNO_3 did not vary substantially as well (**Table 1**).

3. 5. Effect of KNO_3 on Synchrony of germination index of horned melon seeds

Potassium nitrate exhibited a substantial ($P<0.05$) influence on the synchrony of germination. The control (0 % KNO_3) had the lowest synchrony of germination, which was not different from the other treatments, except for seeds treated with 2.0 % KNO_3, which had the highest synchrony of germination (**Table 1**).

3. 6. Effect of KNO_3 on time to 50 % germination of horned melon seeds

The effect of KNO_3 concentrations on the time required to reach 50 % germination was significant ($P<0.05$). Seeds primed with 3 % KNO_3 germinated in the shortest amount of time. The control (0 % KNO_3) had the greatest value for time to reach 50 % of germination. There was no difference between seeds primed with 2.0 % and 2.55 % (Table 2). There was also no difference between seeds stimulated with 3.0 % and the control.

Table 2

Effect of KNO_3 on time to reach 50 % germination (T50 %), mean daily germination (MDG), the peak value of germination (P_{value}), germination value (G_{value}) of horned melon seeds

Treatment	Germination index			
	***T*50 %**	***MDG***	***P*$_{value}$**	***G*$_{value}$**
0 [control]	2.99^{d}	5.50^{a}	15.58^{a}	85.60^{a}
0.5	1.767^{bc}	5.79^{ab}	28.75^{b}	168.40^{b}
1.0	1.97^{c}	5.86^{ab}	23.75^{b}	140.90^{b}
1.5	1.98^{c}	5.93^{abc}	23.00^{b}	137.30^{ab}
2.0	1.52^{ab}	6.50^{cd}	39.50^{c}	257.40^{c}
2.5	1.41^{ab}	6.57^{d}	37.00^{c}	244.30^{c}
3.0	1.15^{a}	6.29^{bcd}	40.00^{c}	251.70^{c}
Mean	1.88	6.06	29.65	183.70
Significance	<0.001	0.015	<0.001	<0.001
$LSD_{0.05}$	0.4413	0.6202	7.152	53.34
CV %	16.3	6.9	16.2	19.5

3. 7. Effect of KNO_3 on Mean Daily Germination percent of horned melon seeds

The effect of KNO_3 treatments on the mean daily germination of horned melon seeds was statistically different ($P<0.05$). The results demonstrate that seeds primed with 2.5 % KNO_3 had the greatest mean daily germination value (6.57), whereas the control (0 % KNO_3) had the lowest mean daily germination value (5.50). There was no difference between seeds primed at a concentration of 0.5 % and 1 % KNO_3 (Table 2).

3. 8. Effect of KNO_3 on Peak value for germination of horned melon

The influence of KNO_3 concentrations on the peak value of germination was significant ($P<0.05$), with seeds primed at 2.0 %, 2.5 %, and 3 % KNO_3 having the greatest peak value of germination but also not statistically different from each other. Seeds primed with 0 % KNO_3 had the lowest peak value of germination of 15.58 (**Table 2**). Seeds primed at a concentration of 0.5 %, 1 %, and 1.5 % KNO_3 did not differ statistically from each other.

3. 9. Effect of KNO_3 on Germination value of horned melon

The germination value of the horned melon differed significantly ($P<0.05$). Seeds primed with 2 % KNO_3 had the greatest germination value, whereas seeds primed with 0 % KNO_3 had the lowest (85.60) (**Table 2**). Seeds primed with 2.0 %, 2.5 %, and 3 % KNO_3 had the greatest germination value, for germination, with means that were not statistically different from each other.

3. 10. Effect of KNO_3 on the seedling height of horned melon

There was a significant difference ($P<0.05$) in the seedling height of horned melon subjected to different KNO_3 concentrations (**Fig. 1**). Seedling height increased with an increase in concentration up to 2.5 % KNO_3. Priming horned melon with 2.5 % potassium nitrate had the highest seedling height whilst the control recorded the least seedling height. Seeds primed at 1.0 % and 1.5 % were not statistically different, while those primed at 1.5 %, 2.0 %, 2.5 %, and 3.0 % did not differ statistically (**Fig. 1**).

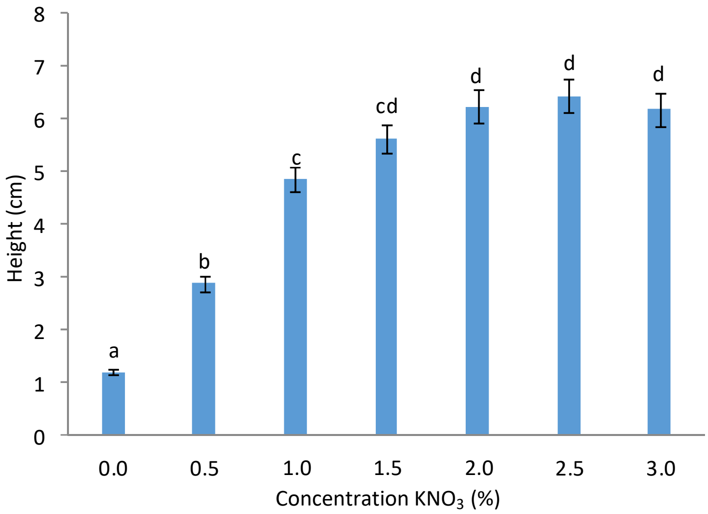

Fig. 1. Effect of KNO_3 concentrations on the seedling height of horned melon

3. 11. Effect of KNO_3 on root length of horned melon

There was a significant difference (P<0.05) in the root length of horned melon subjected to different KNO_3 concentrations (**Fig. 2**). Root length increased with an increase in concentration up to 2.5 % KNO_3. Priming horned melon with 2.5 % potassium nitrate had the highest root length whilst the control recorded the least root length. Seeds primed at 1.5 %, 2.0 %, and 3.0 % were not statistically different from each other, and also those primed at 1.0 %, 1.5 %, 2.0 %, and 3.0 % did not differ statistically (**Fig. 2**).

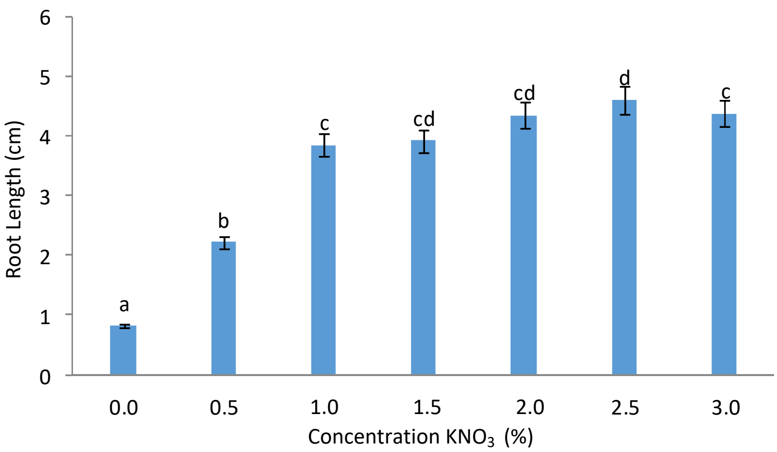

Fig. 2. Effect of KNO_3 concentration on root length of horned melon

3. 12. Effect of KNO_3 on fresh biomass of horned melon seedlings

Different potassium nitrate concentrations caused a significant (P<0.05) effect on the fresh biomass of horned melon seedlings. Seedling fresh biomass increased with an increase in concentration up to 2.5 % KNO_3. Seeds primed with 2.5 % KNO_3 showed the highest biomass, whilst the control (0 % KNO_3) had the least biomass (**Fig. 3**). Horned melon seed primed with 2 % KNO_3, 2.5 % KNO_3, and 3.0 % KNO_3 concentrations had statistically similar seedling fresh biomasses.

Seeds primed with 1.0 % and 1.5 % had seedling fresh biomasses that were not significantly different (**Fig. 3**).

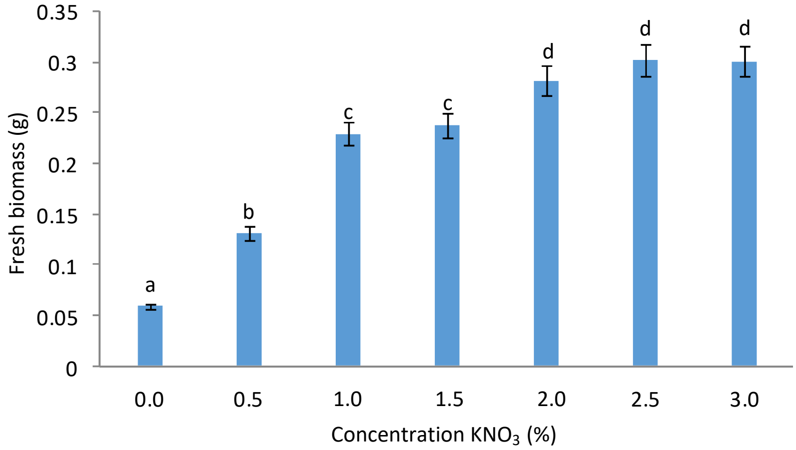

Fig. 3. Effect of KNO_3 concentration on fresh biomass of horned melon

3. 13. Effect of KNO_3 on the seedling dry weight of the horned melon

There was a significant difference (P<0.05) in the dry weight of horned melon seedlings of seeds primed with different KNO_3 concentrations (**Fig. 4**). Seedling dry weight increased with an increase in concentration up to 2.5 % KNO_3. Priming horned melon with 2.5 % potassium nitrate had the highest dry weight (0.0532g), whilst the control recorded the least (0.0121 g). Seeds primed with 0.5 %, and 1.0 % were not statistically different from each other and also, those primed with 2.5 % and 3.0 % KNO_3 did not differ statistically (**Fig. 4**). Seed primed at 2.0 % and 3.0 % were also statistically similar.

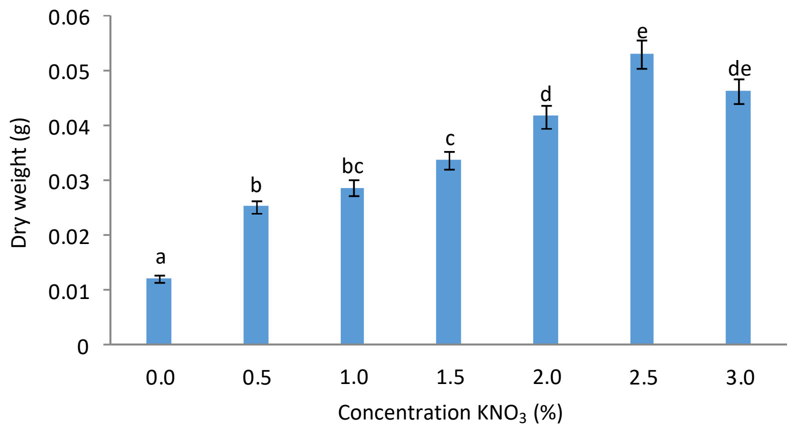

Fig. 4. Effect of KNO_3 concentration on the seedling dry weight of the horned melon

4. Discussion

4. 1. Effect of KNO_3 on germination indices of horned melon

The gradual increase in germination percentage showed the efficacy of KNO_3 in seed priming of horned melon because of an improvement in water imbibition by the seeds due to the presence of KNO_3, which is essential at the beginning of the germination process. This can be attributed to the potential of KNO_3 in breaking seed dormancy [21] as potassium nitrate inhibits the action of abscisic acid (ABA) in seeds which reversibly arrests embryo development at the brink of radicle growth initiation, inhibiting the water uptake which accompanies embryo growth [22]. Results in this study corroborated with the findings of Dhillon et al. [23], who found that tomato seed priming with 2 %

KNO_3 improved seed germination by 3–4 % compared to unprimed seeds. The results of this study are also in agreement with the findings of Mohammadi [24], who noted that soybean seeds primed with 1 % KNO_3 for 1 day had a higher emergence percentage compared to untreated seeds.

A gradual decrease in the mean germination time of primed seed with different potassium nitrate concentrations shows the effectiveness of KNO_3. Seeds primed with 3 % KNO_3 had the least mean germination time, while unprimed seeds had the highest mean germination time, due to the quick release of ABA in the seeds paving the way to seed germination in a short period unlike where KNO_3 was not applied. Thus potassium nitrate minimized the time taken for the seeds to germinate. This study's results agree with the results obtained by Kaya et al. [25] on seed priming of melon seeds which showed an overall decrease in mean germination periods suggesting that KNO_3 has a positive influence on melon seed germination times in general. The results of this study also authenticate with Dev et al. [26] findings that the application of 0.5 % KNO_3 greatly reduces the time it takes for germination to begin (4 days). Asaadi [27] also observed that potassium nitrate caused *Lepidium latifolium* seeds to emerge from their physical dormancy faster.

The influence of potassium nitrate on the mean germination rate of horned melon could be attributed to improved water uptake by the seed hence quickening germination process. The potassium component could have contributed to the activation of enzymes which are responsible for germination hence, the presence of KNO_3 resulted in the quickening of germination. The results in this study are also in line with the results found by Kanatas et al. [28] in a study on *Achillea millefolium* L. Seed priming with potassium nitrate enhanced the germination rate. Results from this study also agree with Hoseini et al. [29], whose study results showed that seeds primed with KNO_3 had the greatest observed germination rates.

Horned melon seeds primed with 3.0 % KNO_3 had the highest germination index when compared to the ones primed with 0 % KNO_3. Potassium nitrate affected the synchrony of germination index where seeds primed with 2.5 % KNO_3 concentration recorded the highest synchrony of germination. This could be attributed to the speeding up of the germination process by potassium nitrate; hence per given time interval, the germination index was high for seeds primed with potassium nitrate. Theresults of this present study are in agreement with those of Thongtip et al. [30], who found that potassium nitrate improved the germination index of three varieties of holy basil seed.

The effect of potassium nitrate on the time taken to reach 50 % germination of horned melon could be attributed to quick germination induced by potassium nitrate that enhances the release of ABA, which retards germination; hence less time was taken for a 50 % germination to be reached. This study's results corroborate Miladinov et al. [31] on soya bean seeds, where the highest T50 % values were observed on unprimed seeds, whereas the least were recorded on seeds primed with potassium nitrate.

The effect of potassium nitrate on the mean daily germination of horned melon, with seeds primed with 2.5 % KNO_3 recording the highest value for mean daily germination and the control recording the least, could be attributed to the quick germination rate of seeds primed with potassium nitrate. Germination and Peak values also showed a significant effect on seeds primed with KNO_3 compared to those primed with 0 % KNO_3. This could be attributed to the high germination percentage induced by potassium nitrate, thereby also quickening the germination rate.

Moreover, exogenous KNO_3 was demonstrated to boost the gene expression associated with in nitrogen and carbon metabolism as well as energy synthesis [32]. Induction of nitrate reductase is also linked to antioxidative reactions and N assimilation [21, 33]. Seeds absorb a growing quantity of oxygen during imbibition, resulting in the production of reactive oxygen species [ROS] and a change in the redox state [34]. The scientific literature is replete with evidence of ROS's stimulatory effect on germination and seedling development processes [35–42]. The authors demonstrated in these articles that regulated ROS formation during seed absorption of water may have a signaling function during germination as well as the dormancy release process. Uncontrolled ROS buildup, on the other hand, might delay or even prevent seed germination [42]. This might explain why, at higher doses of KNO_3 (3 %), there was a dramatic decrease in germination indices of horned melon seeds in this current study.

4. 2. Effect of KNO_3 on early seedling growth of horned melon

The efficacy of potassium nitrate on the seedling height of horned melon, with 2.5 % KNO_3 recording the highest, could be attributed to nitrogen in potassium nitrate, which induces and speeds vegetative growth. The results from this study agree with the findings of Oliveira and Steiner [43] in an experiment on cucumber seed priming. The hypocotyl length rose from 59.0 to 62.8 mm when the seeds were primed with KNO_3. The results of this study are also in parity with the results obtained by Gupta et al. [44] in a seed priming experiment of pearl millet with potassium nitrate where the seedling height of KNO_3 primed seeds was 38.17 cm compared to seeds primed with water which recorded 36.72 cm.

The significant effect on the root length of horned melon seedlings, with seeds primed with 2.5 % KNO_3 recording the highest could be attributed to the increase of root length developed by the potassium and nitrate in KNO_3 as it favors the initiation and ramification of the seedling root system. The results from this study tally with the results found by Badu et al. [45]. The root length of cucumber seeds (*Cucumis sativus* L) demonstrated a substantial effect of KNO_3 priming treatments over unprimed seeds. The results of the present study are also in parity with the results obtained by Pradhan et al. [46] that potassium nitrate had a significant impact on root and shoot length in cowpea seed variants primed with potassium nitrate.

Potassium nitrate proved to affect the fresh biomass of horned melon. This could be attributed to the role of nitrogen in KNO_3 in increasing plant biomass and reducing water loss through regulation of the closing and opening of the horned plants. The results from this study corroborate with results found in an experiment on chickpeas seeds (*Cicer arietinum* L.). Seeds primed with potassium nitrate obtained the highest fresh biomass compared to unprimed seeds. This study agrees with the results observed in a study by Hernández et al. [47]. Maximum seedling fresh weight in pea seedlings was noted with 0.25 mM KNO_3. Thus, priming pea seeds in potassium nitrate resulted in a 15 % increase in fresh weight.

The effect of KNO_3 on the dry weight of horned melon seedlings could be because of plant development due to the nitrogen in KNO_3, leading to more build-up of the plant biomass. Results from this study are in parity with the results obtained by Kanatas et al. [28]. Earlier studies demonstrated that, the dry biomass of the seedlings was substantially increased after seed priming of *Achillea millefolium* L with KNO_3 The results of this study also are in agreement with the results obtained where seed priming increased the dry weight of soybean seedlings [48].

Excess supply of KNO_3 was found to inhibit growth of the horned melon seedlings and this result is consistent with other findings by Xu et al. [49] and Hernández et al. [47]. Xu et al. [49] found that for a certain range, with the increase of K supply, GS activity of roots and NR activity of leaves of seedlings gradually increased, which promoted the assimilation of NO_3^-. However, when the K supply is too high, the activity of these enzymes will decrease, which may be related to the inhibition of photosynthesis and the reduction of energy supply. High K levels were not conducive to NO_3^- transport from root to leaf, which was consistent with previous studies [50].

5. Conclusions

Results from this study indicate that seed priming with potassium nitrate affects seed germination and early seedling growth of horned melon. Priming with KNO_3 increased germination percentage, mean daily germination, germination index, germination value, peak value, synchrony of germination index as well as mean germination rate. Mean germination time was reduced. Seed priming with 2.5 % KNO_3 concentration increased seedling height, root length, and fresh and dry weight as well as seedling length. Farmers who are into horned melon production are recommended to use a seed priming concentration of 2.5 % KNO_3. Further research on other concentrations of potassium nitrate is necessary for priming and also on different horned melon varieties.

Conflict of interest

The authors declare that there is no conflict of interest in relation to this paper, as well as the published research results, including the financial aspects of conducting the research, obtaining and using its results, as well as any non-financial personal relationships.

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Data availability

Data will be made available on reasonable request.

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