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GERMINATION, AGRONOMIC CHARACTERISTICS AND YIELD OF *CITRULLUS COLOCYNTHIS* (L.) SCHRAD AS AFFECTED BY OSMOPRIMING AND NUTRIPRIMING

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ABSTRACT

Melon (*Citrullus colocynthis*) is an economic plant known for its nutritional and medicinal purpose. However, seed dormancy and low germination rate have been identified as major drivers for it low yield production. Therefore, the study investigated the influence of osmopriming and nutripriming on seed germination, growth and yield of *C. colocynthis*. Seeds of *C. colocynthis* were soaked in priming agents NaCl and KNO_3 (osmopriming) at 0.5 g/L, 2.5 g/L, and 4.5 g/L; Zn and K (nutripriming) at 0.01%, 0.05% and 0.15% for 12 hours while unprimed seeds served as the control. Percentage germination and germination index were calculated while chlorophyll content, biomass, fruit diameter and yield were obtained using standard procedures. The results showed that application of KNO_3 at 4.5 g/L and Zn at 0.05% increased percentage germination by 39.1% and 41.6%, respectively compared to the control. Using NaCl at 4.5 g/L significantly increased fruit diameter and yield of *C. colocynthis* by 3.4% and 19.3%, respectively; the least *C. colocynthis* yield was obtained under KNO_3 at 0.5 g/L. K at 0.01% also increased the fruit diameter and yield of *C. colocynthis* by 4.5% and 10.7%, respectively compared to the control. Among the nutripriming treatments, K at 0.05% and Zn at 0.01% produced the least yield, but with comparable results with the control. In conclusion, priming *C. colocynthis* seeds with NaCl at 4.5 g/L (osmopriming) and K at 0.01% (nutripriming) significantly increased agronomic characteristics and yield of *C. colocynthis* and could be recommended to agriculturists for optimum yield of *C. colocynthis*.

Keywords: priming agents, melon, seed germination, agronomy, yield components

INTRODUCTION

Melon commonly known as Colocynth (*Citrullus colocynthis* [L.] Schrad), is a native crop of West Africa from the Cucurbitaceae family known for its inedible bitter skin and pulp used for medicinal purposes (Falade *et al.*, 2020). *C. colocynthis* is of high economic importance to farmers, especially in South-western Nigeria, where its seeds are processed into sweet delicacies and eaten with other kinds of food for its nutritional value (Agbulu *et al.,* 2017; Obani *et al.*, 2019; Falade *et al.*, 2020).

Seed viability, seed vigour, and seedling vigour are some factors that influence seed germination, growth and development, and crop yield. However, the seeds of *C. colocynthis* have been reported to show low germination rates and poor seedling growth linked to the functionality and metabolic activity of the seed and other environmental factors (Oliveira *et al.,* 2019); hence a need to improve its germinability and agronomic attributes. Seed germination is faced with different environmental and endogenous challenges ranging from biotic and abiotic stresses to non-activation of metabolic processes due to low concentration of growth promoter and concentration of growth inhibitor (abscisic acid (ABA) (Awatif and Alaaeldin, 2017). To effectively resolve challenges faced by crops during germination and seedling establishment, seed priming has been reported as one of the easiest and most cost-effective approaches that alters and accelerates the biochemical and metabolic process of seeds towards easy radicle protrusion and seedling establishment. Seed priming is considered one of the fastest and most feasible physiological processes used in enhancing seed germination and early seedling growth, and in turn, encourage plant uniformity and better yield. These seed priming techniques prepare the crop with a solid ground ability to establish itself against environmental stresses faced by seed and seedling growth.

Previous studies have reported several priming strategies. These include; biopriming, hydropriming, osmopriming, and nutriprimng (Farooq *et al.,* 2019a; Marthadan *et al.,* 2020). Among the priming techniques, the use of osmopriming and nutripriming has been reported to regulate the osmotic potential of seeds and aid the germination and seedling growth of some recalcitrant seeds (Farooq *et al.*, 2019a). Osmopriming involves the soaking of seeds in osmotic solutions to regulate water uptake and enhance the hydration of seeds while nutripriming involves the soaking of seeds in nutrient solutions to provide essential elements for early seedling emergence and development. Ghassemi-Golezani *et al.* (2010) reported that the influence of priming agents on seed germination and seedling growth largely depends on a variety of factors including water potentiality, duration of the priming agent, temperature, seed vigour, seed storage condition, and medium concentrations. However, use osmopriming and nutripriming agents for the improvement of the seed germination, seedling growth, and yield of *C. colocynthis* has not been reported. The priming concentration of each priming agent that will aid the germination rate and optimum growth of *C. colocynthis* is yet to be established. Therefore, this study aimed to determine the influence of osmopriming and nutriprimng and their varying concentrations on germination, agronomic characteristics and yield of *C. colocynthis.*

MATERIALS AND METHODS

Study area and weather information

Seeds of *C. colocynthis* were collected from the National Institute of Horticultural Research and Teaching Management (NIHORT) Ibadan. Laboratory and field studies were carried out on germination and agronomic attributes of *C. colocynthis*, respectively. The laboratory experiment was conducted at the Department of Pure and Applied Botany laboratory while the field study was carried out at the experimental plots of the Department of Pure and Applied Botany, Federal

University of Agriculture, Abeokuta between April and September, 2021. Average rainfall and temperature during the period of the experiment were 228 mm and 25ºC, respectively while the average relative humidity was 345.5 mmHg.

Treatments and Experimental Design

Assessment of germination of *C. colocynthis* seeds was carried out using different priming methods at varying concentrations. Matured and viable seeds of *C. colocynthis* were soaked in NaCl and KNO_3 (osmopriming) and solutions of hydrated $ZnSO_4$ and KH_2PO_4 (nutripriming) at varying concentrations. Concentrations of NaCl and KNO_3 were 0.5 g/L, 2.5 g/L, and 4.5 g/L representing low, medium, and high concentrations, respectively for 12 hours. Similarly, concentrations of $ZnSO_4$ (Zn priming) and KH_2PO_4 (K priming) included 0.01% (low), 0.05% (medium), and 0.15% (high) concentrations while seeds without priming were taken as control. Twenty pretreated seeds of *C. colocynthis* of each treatment were plated on a petri dish. The experiment was laid out in a Completely Randomized Design (CRD) with 5 replicates to determine the influence of the priming treatments on the germinability of *C. colocynthis.*

A total land area of 400 m² (25 m by 16 m) was cleared and ploughed manually for the field experiment. Total land area was divided into two equal parts to accommodate each of the priming methods (nutripriming and osmopriming). The experiment was set up in a Randomized Complete Block Design (RCBD) with five replicates for each priming method. Each treatment plot under the priming methods consisted of two beds with a size of 2 m × 1.5 m per bed and a spacing of 0.8 m. Similar to the laboratory experiment, seeds were treated and a total of five seeds were sown on each bed. The seeds were sown one per hole at a spacing of 0.4 m on each bed. Fertilizer was not added throughout the experimental period; however, super care insecticide consisting of Cypermethrin 10% EC was applied during the seedling stage of crop growth. Weeding was carried out manually when necessary.

Data Collection

The number of germinated seeds was counted and recorded after 15 days. Percentage germination, mean germination time, and germination index were calculated to assess the influence of the priming treatments on the germinability of *C. colocynthis* seeds. Percentage germination was calculated as the total number of germinated seeds at 15 days after sowing divided by the total number of seeds plated multiplied by 100. However, the Mean Germination Time (MGT) was calculated using the Labouriau equation (Labouriau, 1983):

$$\text{MGT} = \frac{\sum NiTi}{\sum Ni}$$

Where Ni is the number of germinated seeds on a given day and Ti is the time in days from the sowing day (0) (Oliveira *et al.*, 2019).

The germination index was calculated using Maguire's equation as reported by Oliveira *et al.* (2019).

$$GI = \sum \left(\frac{Ni}{Ti}\right)$$

where Ni is the number of germinated seeds on a given day and Ti is the time in days from sowing day (0).

Field data were collected on seedling emergence percentage, seedling vigor index 1 and

2, root length, and vine length.

The seedling emergence percentage (SE%) was calculated as described by Nwonubla and Christo (2021)

$$SE\ \% = \frac{\text{Number of emerged seedlings}}{\text{Number of seeds sown}} \times 100$$

Seedling length and weight were measured at three weeks after planting to determine the Seedling Vigour Index 1 (SVI1) and Seedling Vigour Index 2 (SVI2) as reported by Jhilta *et al.* (2019):

SVI1= SE% × seedling length

SVI2= SE% × seedling dry weight

The length of the longest root and vine length were measured using a metre rule. Chlorophyll content was measured using a chlorophyll meter (SPAD 502 PLUS, Minolta Corporation, Ltd., Japan). Leaf area was measured using a leaf area meter (Portable Leaf Area Meter, Hangzhou Mindfull Technology Co. Ltd, China). Shoots of tagged plants were harvested at flowering stage and oven-dried at 70°C until a constant weight to determine the biomass. The number of fruits per plot was determined by counting while fruit diameter was measured using vernier caliper. The average weight of the total number of fruits per plot was recorded as the fruit weight. Seeds were extracted from the fruits and the seed yield per plot was determined using a weighing balance (Karimi *et al.,* 2020).

Statistical Analysis

Data collected for each priming method were analyzed separately using one-way analysis of Variance (ANOVA) with SPSS version 23.0. Treatment means were separated using Duncan's Multiple Range Test (DMRT) at $\alpha = 0.05$.

RESULTS

Seed Germination Characteristics

The osmopriming agents (KNO_3 and NaCl) significantly influenced seed germination parameters. On average, KNO_3 and NaCl increased the percentage germination of *C. colocynthis* by 25.3% and 21.2%, respectively compared with the untreated seeds. The percentage germination increased as the concentrations of KNO_3 increased and the highest germination percentage was observed at 4.5 g/L. The varying concentrations of NaCl improved the percentage germination of *C. colocynthis* seeds with the highest germination recorded at 0.5 g/L of NaCl (Table 1).

KNO_3 priming at a high concentration significantly decreased the mean germination time of *C. colocynthis* by 70.5% and increased the germination index by 17.9% compared with the control. However, the priming of the seeds with NaCl at low concentration decreased the mean germination time by 59.6% but increased the germination index of the seeds by 21.4% compared with the control (Table 1).

Table1: Effect of varying osmopriming concentrations on seed germination of *Citrullus colocynthis*

Priming Treatment	%Germination	MGT (day)	GI
Control	68.3[c]	7.5[a]	2.8[bc]
0.5 g/L of KNO_3	88.3[b]	4.0[b]	3.2[b]
2.5 g/L of KNO_3	91.0[a]	4.5[b]	3.4[a]
4.5 g/L of KNO_3	95.0[a]	4.4[b]	3.3[ab]
0.5 g/L of NaCl	90.0[ab]	4.7[b]	3.4[a]
2.5 g/L of NaCl	83.3[b]	5.0[b]	3.2[b]
4.5 g/L of NaCl	75.0[bc]	8.2[a]	2.0[c]
$p \leq 0.05$	*	*	*

Mean values with different superscripts in the same column are significantly different at $p \leq 0.05$ using Duncan's Multiple Range Test (DMRT). * indicates significant difference at $p \leq 0.05$, MGT: mean germination time, GI: germination index.

Use of Zn increased the percentage germination of *C. colocynthis* than K and the control. Percentage germination of *C. colocynthis* seeds increased by 5.7% and 27.7% when comprimed with K and Zn, respectively compared with the control (Table 2). Priming of *C. colocynthis* with K and Zn reduced mean germination time by 32.5% and 43.6%, respectively. Zn priming increased germination index of *C. colocynthis* by 27.5% and 6%, compared with K priming and control, respectively (Table 2).

Table 2: Effect of varying nutripriming concentrations on seed germination of *Citrullus colocynthis*

Priming treatment	% Germination	MGT (day)	GI
Control	68.3[d]	7.5[a]	2.8[b]
0.01% K	55.0[e]	4.6[b]	2.1[c]
0.05% K	93.3[ab]	3.2[c]	2.8[b]
0.15% K	68.3[d]	7.4[a]	2.1[c]
0.01% Zn	78.3[c]	4.3[bc]	2.9[ab]
0.05% Zn	96.7[a]	4.6[b]	3.3[a]
0.15% Zn	86.7[b]	3.8[c]	2.7[b]
$p \leq 0.05$	*	*	*

Mean values with different superscripts in the same column are significantly different at $p \leq 0.05$ using Duncan's Multiple Range Test (DMRT). * indicates significant difference at $p \leq 0.05$, MGT: mean germination time, GI: germination index

Agronomic Characteristics

Osmopriming of *C. colocynthis* with KNO_3 significantly increased average seedling emergence percentage, seedling vigour index 1, and seedling vigour index 2 by 9.3%, 6.2%, and 54.7% compared with the control, respectively (Table 3). KNO_3 and NaCl at medium concentration increased SEP and SVI of *C. colocynthis* seeds by (12.5% and 6.3%) and (15.3% and 9.6%), respectively. Notably, the use of osmopriming (KNO_3 and NaCl) promoted root length and significantly reduced vine length.

On the average, the biomass of *C. colocynthis* under the control treatments significantly increased by 154.9% and 91.2% compared with those treated with KNO_3 and NaCl (Table 3).

Table 3: Influence of varying osmopriming concentrations on agronomic

Priming treatment	SEP (%)	SVI1	SVI2	VL (cm)	RL (cm)	Biomass (g)
Control	76.2^{b}	366.7^{b}	27.4^{c}	14.7^{a}	2.3^{c}	13.0^{a}
0.5 g/L of KNO_3	78.6^{b}	371.4^{b}	42.9^{b}	3.3^{e}	3.3^{a}	4.8^{c}
2.5 g/L of KNO_3	85.7^{a}	422.8^{a}	59.7^{a}	6.3^{bc}	2.6^{bc}	6.4^{bc}
4.5 g/L of KNO_3	85.7^{a}	374.3^{ab}	24.6^{c}	4.7^{d}	2.7^{b}	4.1^{c}
0.5 g/L of NaCl	66.7^{c}	297.1^{c}	24.4^{c}	9.4^{b}	2.4^{bc}	7.6^{b}
2.5 g/L of NaCl	81.0^{ab}	401.9^{a}	41.5^{b}	6.7^{bc}	2.2^{c}	6.7^{bc}
4.5 g/L of NaCl	61.9^{c}	329.8^{bc}	39.9^{bc}	5.4^{b}	2.5^{bc}	6.1^{bc}
$p \leq 0.05$	*	*	*	*	*	*

Mean values with different superscripts in the same column are significantly different at $p \leq 0.05$ using Duncan's Multiple Range Test (DMRT). * indicates significant difference at $p \leq 0.05$, SEP: Seedling emergence percentage; SVI1: Seedling vigour index 1; SVI2: Seedling vigour index 2; VL: vine length; RL: root length

Variations exist in the agronomic characteristics of *C. colocynthis* under varying nutripriming concentrations. Use of potassium priming at a medium concentration (0.05%) significantly increased seedling emergence percentage and seedling vigour index; however, use of Zn as a nutri-priming agent decreased seedling emergence percentage and seedling vigour index of *C. colocynthis* compared with the control irrespective of its application concentration (Table 4).

Vine length of *C. colocynthis* was significantly increased by Zn priming by 19.0% compared with the control. On the other, the use of nutripriming agents had no significant influence on the root length of *C. colocynthis.* The nutripriming agents used in this experiment had a significant influence on biomas. 0.15% of K had the highest influence on biomass followed by 0.15% of Zn. At high concentrations, the two nutripriming agents increased the biomass of *C. colocynthis* (Table 4).

Table 4: Influence of varying nutripriming concentrations on agronomic characteristics of *Citrullus colocynthis*

Priming treatments	SEP (%)	SVI1	SVI2	VL (cm)	RL (cm)	Biomass (g)
Control	76.2^{b}	366.7^{ab}	27.4^{c}	14.7^{c}	2.6	13.0^{bc}
0.01% K	57.1^{c}	312.4^{b}	22.4^{c}	10.3^{c}	2.7	8.2^{c}
0.05% K	81.0^{a}	438.1^{a}	39.6^{ab}	5.1^{d}	2.9	3.7^{e}
0.15% K	64.3^{bc}	322.9^{b}	40.3^{a}	22.8^{a}	3.1	14.4^{a}
0.01% Zn	47.6^{d}	241.0^{c}	19.4^{c}	21.3^{a}	3.1	8.6^{d}
0.05% Zn	57.1^{c}	241.9^{c}	24.6^{c}	14.2^{c}	2.6	9.7^{c}
0.15% Zn	57.1^{c}	302.4^{b}	30.3^{b}	17.0^{ab}	3.0	13.7^{b}
$p \leq 0.05$	*	*	*	*	ns	*

Mean values with different superscripts in the same column are significantly different at $p \leq 0.05$ using Duncan's Multiple Range Test (DMRT). * indicates significant at $p \leq 0.05$, ns: not significant at $p \leq 0.05$; SEP: Seedling emergence percentage; SVI1: Seedling vigor index 1; SVI2: Seedling vigor index 2; VL: vine length; RL: root length

The application of 2.5 g/L of KNO_3 significantly increased the leaf chlorophyll content of *C. colocynthis* compared with other treatments and the control, except 0.5 g/L of NaCl (Figure 1). Although there was no significant difference in chlorophyll content with the use of 2.5 g/L of KNO_3 and 0.5 g/L of NaCl, application of 2.5 g/L KNO_3 increased the chlorophyll content of *C. colocynthis* by 35.5% compared with 0.5NaCl. Conversely, use of osmopriming agents irrespective of concentration decreased the leaf area of *C. colocynthis* compared with the control (Figure 2).

Significant differences were also observed in the chlorophyll contents of *C. colocynthis* primed with the different nutri-priming agents at varying concentrations (Figure 3). Chlorophyll content of *C. colocynthis* primed with 0.05% K and 0.15% K increased by 22.3% and 15.8%, respectively compared with the control. Nutripriming agents at different concentrations had no significant effect on the leaf area of *C. colocynthis* (Figure 4).

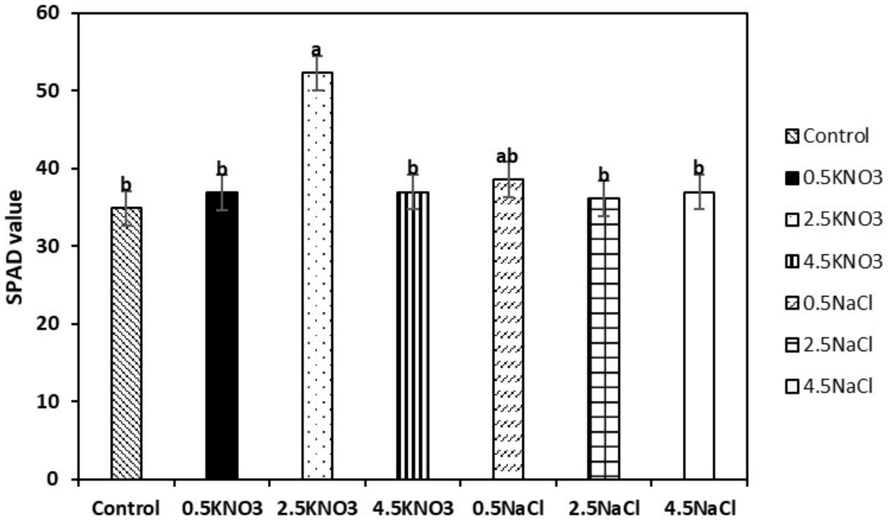

Figure 1: Influence of varying osmopriming concentrations on chlorophyll content of *Citrullus colocynthis.*

The difference in lowercase letters on the bars indicates significant difference at $p \leq 0.05$.

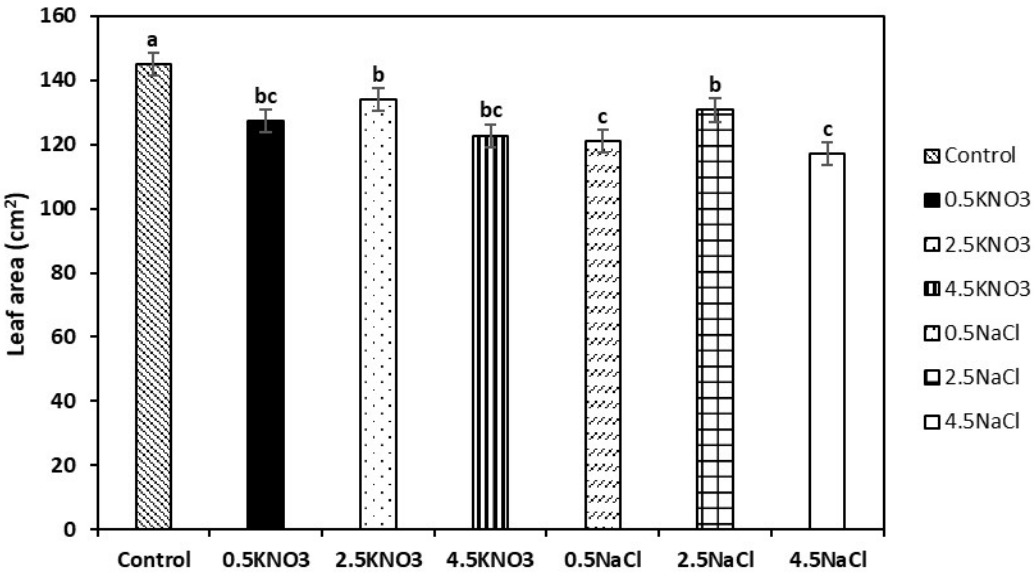

Figure 2: Influence of varying osmopriming concentrations on leaf area of *Citrullus colocynthis.*

The difference in lowercase letters on the bars indicates significant difference at $p \leq 0.05$.

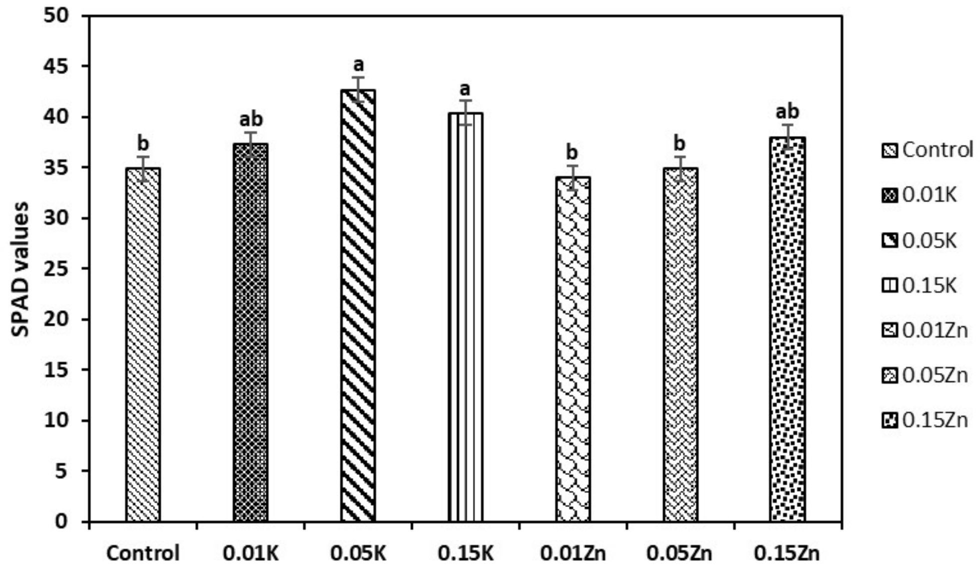

Figure 3: Influence of varying nutripriming concentrations on chlorophyll content of *Citrullus colocynthis*

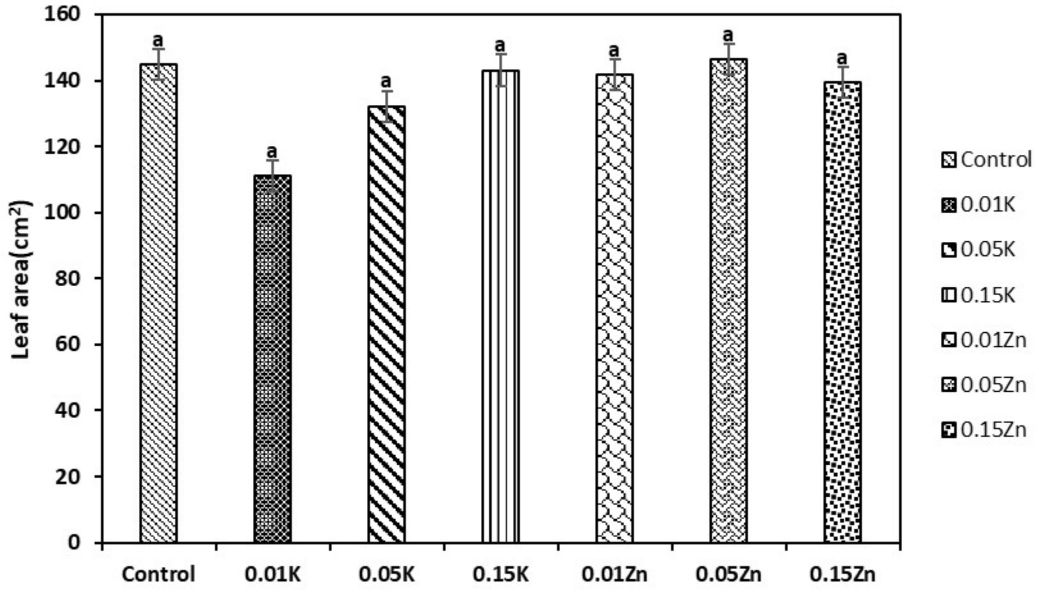

Figure 4: Influence of varying nutripriming concentrations on leaf area of *Citrullus colocynthis*.

Yield characteristics of *Citrullus colocynthis*

NaCl priming of *C. colocynthis* at 4.5 g/L significantly increased the fruit diameter, weight, and yield by 3.4%, 19.7%, and 19.3%, respectively compared with the control. However, the influence of other osmopriming agents at varying concentrations was inconsistent. The least *C. colocynthis* yield parameters were obtained under KNO_3 at 0.5 g/L (Table 5).

There were significant differences in yield characteristics of *C. colocynthis* under varying nutripriming concentrations. The K priming at 0.01% increased the fruit diameter, weight, and yield by 4.5%, 11.7%, and 10.7%, respectively compared with the control (Table 6). The nutriprimed seeds at varying concentrations produced significantly higher yields than the unprimed seeds except for K at 0.05% and Zn at 0.01% which produced comparable yields with the control (Table 6).

Table 5: Influence of varying osmopriming concentrations on yield characteristics of *Citrullus colocynthis*

Priming treatments	FD (mm)	FW (g)	NFP	Seed yield (kg/ha)
Control	154.3^{a}	1.7^{bc}	4.7^{b}	289.6^{d}
0.5 g/L of KNO_3	153.2^{a}	1.1^{b}	3.0^{bc}	288.0^{d}
2.5 g/L of KNO_3	151.5^{ab}	1.1^{b}	4.3^{b}	290.4^{d}
4.5 g/L of KNO_3	137.0^{b}	0.4^{d}	1.3^{c}	446.0^{b}
0.5 g/L of NaCl	148.0^{ab}	1.4^{bc}	5.0^{a}	387.7^{c}
2.5 g/L of NaCl	156.1^{a}	1.8^{c}	4.0^{b}	482.2^{ab}
4.5 g/L of NaCl	159.6^{a}	2.0^{a}	4.5^{b}	532.0^{a}
$p \leq 0.05$	*	*	*	*

Mean values with different superscripts in the same column are significantly different at $p \leq 0.05$ using Duncan's Multiple Range Test (DMRT). * indicates significant at $p \leq 0.05$.

FD: Fruit diameter; FW: Fruit weight; NFP: number of fruit per plot.

Table 6: Influence of varying nutripriming concentrations on yield characteristics of *Citrullus colocynthis*

Priming agents	FD (mm)	FW (g)	NFP	Seed yield (kg/ha)
Control	154.3^{b}	1.7^{b}	2.7	253.7^{cd}
0.01% K	161.3^{ab}	1.9^{a}	3.5	494.7^{a}
0.05% K	119.6^{d}	0.6^{c}	2.7	247.3^{d}
0.15% K	133.5^{c}	0.6^{c}	2.0	289.6^{c}
0.01% Zn	148.0^{bc}	0.9^{b}	2.5	240.3^{d}
0.05% Zn	167.1^{a}	1.6^{a}	3.3	420.0^{b}
0.15% Zn	157.5^{b}	1.1^{ab}	2.7	284.0^{c}
$p \leq 0.05$	*	*	ns	*

Mean values with different superscripts in the same column are significantly different at $p \leq 0.05$ using Duncan's Multiple Range Test (DMRT). * indicates significant at $p \leq 0.05$.

FD: Fruit diameter; FW: Fruit weight; NFP: number of fruit per plot.

DISCUSSION

Roles of seed priming are integral in seed germination and seedling growth. In this study, the use of osmopriming and nutripriming methods had a significant influence on seed germination and agronomic characteristics of *C. colocynthis*.

The increased percentage germination of *C. colocynthis* by KNO_3 and NaCl compared with the control could be attributed to the influence of the osmopriming agents on the metabolic changes in the seed which in turn promotes germination and seedling vigor. Hussain *et al.* (2019) reported that priming facilitates seed germination and alleviates seed dormancy. The germination percentage increased as the concentration of KNO_3 increased; whereas, it decreased gradually by increasing the concentration of NaCl. This observation is attributable to the content in each osmopriming agent. The presence of NO_3^- in KNO_3 possibly promotes Reactive Nitrogen Species (RNS) and other phytohormones in the cucurbit seeds. The RNS suppresses the abscisic acid (ABA) signaling and accelerates the germination of crop seeds (Bailly, 2019). The signaling of protein in proteomic studies of barley revealed that nitric oxide (NO) alters protein involved in ABA (abscisic acid)-biosynthesis and signaling pathway through nitration and hence reduced the ABA synthesis. On the other hand, NaCl increased the percentage of germination compared with control but decreased as the concentration increased. This could be ascribed to the impact of salinity stress on the seeds by altering the seed physiology thereby reducing its germination rate. This is also evident in the mean germination time with delayed germination under higher concentrations of NaCl priming. The delayed germination period may also be due to the stimulation of methionine, cysteine, and oxygenated species during metabolic redistribution in the endoplasmic reticulum of the seed testa. This in essence may result in the shrinking of the seed coat for expansion of the cotyledon (Farooq *et al*., 2019b; Marthandan *et al*., 2020; Mirmazloum *et al*., 2020).

Moreover, the significant increase in the percentage germination of *C. colocynthis* seeds with the use of Zn and K at medium concentration could be ascribed to their ability to improve the nutritional content of the seeds (Pawar and Laware, 2018; Ibrahim, 2019). The priming of *C. colocynthis* with K and Zn also reduced the mean germination time.

The field experiment also showed that the osmopriming of *C. colocynthis* seeds with KNO_3 increased its seedling emergence percentage and seedling vigour index 1 and 2. This is in line with the results of Carrillo-Reche *et al.* (2018) and Chou *et al.* (2019) who reported that KNO_3 priming of seeds could result in high seedling emergence due to the metabolic reaction of nitrate and anhydride with the seed testa that results to the stimulation of high reactive nitrogen species (RNS) production and methionine. This promotes the eruption of radicle in the soil. Moreover, the significant influence of KNO_3 at high concentration on root length of *C. colocynthis* depicts the promotion of auxin at the root region by the osmopriming agent; however, the decrease in the vine length of the osmoprimed *C. colocynthis* compared with the control shows that the osmopriming agents possibly stimulate biochemical reactions that reduced the production of cytokinin (a hormone that is responsible for shoot elongation).

The seedling vigour index 1 and 2 of the crop are representative of the seedling healthiness and status of metabolic activities. The use of K especially at 0.05% significantly increased seedling emergence percentage and seedling vigor index of *C. colocynthis* compared with the control. Also, the seedling vigour index 1 of *C. colocynthis* under KNO_3 depicted that KNO_3 possibly increased the strength of the seed embryo and made it more viable and resourceful. This could be due to NO_3^- displacement in the ATP-tricarboxylic acid cycle production during seed priming (Marthandan *et al*., 2020).

Mustafa *et al.* (2017) reported that seed priming enhances the physiological process and functioning of the crop from the seed germination level to the crop growth and development. Although the leaf area of primed *C. colocynthis* was reduced compared with the unprimed treatment, the chlorophyll content increased significantly with the use of 0.5 g/L of KNO_3. Both osmopriming and nutripriming reduced the leaf area but increased the chlorophyll content of *C. colocynthis.* This result is presumed to be a mechanism through which the priming agents reduced the impact of drought stress on the crop. Khadraji *et al.* (2017) reported that under salinity stress, osmopriming reactivates reactive oxygen species (ROS) and stimulates the metabolic process in seed cotyledon where there is triple nucleation of the 3n sperm in readiness to this particular stress. The use of NaCl stimulates metabolic changes in *C. colocynthis* in readiness for both salinity and oxidative stress. This is evidence in effect having a significant increase in fruit diameter, weight, and yield of the crop. Although, ROS were not evaluated in this study; it was presumed that oxidative stress caused by high production of ROS due to drought and osmotic stress was checked by osmopriming, especially with 4.5 g/L of NaCl.

The priming of seeds with Zn and K is found to characterize the genetic makeup of the endosperm seeds of *C. colocynthis*. However, the use of K at low concentrations increased the seed yield, fruit diameter, and weight due to its ability to improve the resistance of crops to adverse environmental stresses.

CONCLUSION

This study showed that the use of osmopriming (KNO_3 and NaCl) and nutripriming (K and Zn) agents improved germination attributes, agronomic characteristics and yield of *C. colocynthis* than the control. Priming *C. colocynthis* seeds with NaCl and K at 4.5 g/L and 0.01%, respectively produced the optimum yield.

REFERENCES

Agbulu, O.N., Agumu, J.T., Anthony, A. 2017. Competency improvement needs for farmers in melon (*Citrullus colocynthis*) production for sustainable agriculture in North Central, Nigeria. *Discourse Journal of Agriculture and Food Sciences,* 5(4):44-52.

Awatif, S.A., Alaaeldin, A.E. 2017. Metabolic Processes during Seed Germination. *Intechopen* 70653.

Bailly, C. 2019. The signaling role of ROS in the regulation of seed germination and dormancy. *Biochemical Journal,* 476:3017-3032.

Carrillo-Reche, J., Vallejo-Marin, M. and Quilliam, R.S. 2018. Quantifying the potential of 'on-farm' seed priming to increase crop performance in developing countries. A meta-analysis. *Agronomy for Sustainable Development,* 38: 64.

Chou, H., Tian, L., Fukuda, M., Kumamari, T., Okita, T.W. 2019. The role of RNA binding protein O, tudor-SN in post-transcriptional regulation of seed storage proteins and endosperm development. *Plant Cell Physiology,* 60(10): 2193-2205.

Falade, O.S., Otemutiwa, I.O., Adekunle, A.S., Adewusi, S.A., Oluwasefunmi, O. 2020. Nutrient composition of watermelon (*Citrullus lanatus* (Thunb) Matsu mans Nakai) and egusi melon (*Citrullus colocynthis* (L.) Schrad) seeds. *Agriculturae Conspectus Scientificus,* 85(1): 43-49.

Farooq, M., Romdhane, L., Al Suti, M.K.R.A., Abdul Rehman, Al-Busaidi, W.M., Lee, D.J. 2019a. Morphological, physiological and biochemical aspects of osmopriming-induced drought tolerance in lentil. *Journal of Agronomy and Crop Science,* 00:1 -11.

Farooq, M., Usman, M., Nadeem, F., Hafeez ur Rehman, Abdul Wahid, Basra, S.M.A., Siddique, K.H.M. 2019b. Seed priming in field crops: potential benefits, adoption and challenges. *Crop and Pasture Science,* 70: 731-771.

Ghassemi-Golezani, K., Chadordooz-Jeddi, A., Nasrullahzadeh, S., Moghaddam, M. 2010. Influence of hydropriming duration on field performance of pinto bean (Phaseolus vulgaris L.) cultivars. *African Journal of Agricultural Research*, 5(9): 893-897.

Hussain, S., Hussain, S., Khaliq, A., Ali, S., Khan, I. 2019. Physiological, Biochemical and Molecular Aspect of seed priming. In: Hasanuzzaman M. and Fotopoulos V. (eds). Priming and pretreatments of seeds and seedlings. *Springer Nature,* Pp: 43-62.

Ibrahim, E.A. 2019. Fundamental Processes involved in Seed Priming In: In: Hasanuzzaman M. and Fotopoulos V. (eds). Priming and pretreatments of seeds and seedlings. *Springer Nature,* Pp: 63-115.

Jhilta, P., Rana, N., Dipta, B., Dhiman, M., Meenakshi 2019. Physiological assessment of *Acacia catechii* seedlings by computing germination parameters and vigour testing. *International Journal of Chemical Studies,* 7(3): 152-1532.

Karimi, N., Goltapeh, E.M., Amini, J., Mehnaz, S., Zarea, M.J. 2020. Effect of Azospirillum zeae and Seed priming with Zinc, Manganese and Auxin on Growth and Yield parameters of Wheat under Dry land Farming. *Agricultural Research,* 10: 45-55.

Khadraji, A., Mouradi, A., Houasli, C., Qaddoury, A., Ghoulami, C. 2017. Growth and antioxidant responses during early growth of winter and spring chickpea (*Cicer arietinum*) under water deficit as affected by osmopriming. *Seed Science and Technology,* 45: 198-211.

Labouriau, L.G. 1983. *A germinaceao das sementes. Secretaria Geral da OEA*, Washington, Pp: 173

Marthandan, V., Geetha, R., Kimurtha, K., Renganathan, V.G., Ramalingan, J., Karthikeyan, A. 2020. Seed Priming: A feasible strategy to enhance drought tolerance in crop plants. *International Journal of Molecular Sciences* 21: 8258.

Mirmazloum, I., Kiss, A., Erdelyi, E., Ladanyi, M., Nemeth, E.Z., Radaisi, P. 2020. The Effect of Osmopriming on Seed Germination and Early Seedling Characteristics of *Carum carvi* L. *Agriculture,* 10(94).

Mustafa, H.S.B., Mahmood, T., Ullah, A., Sharif, A., Bloth, A.N., Nadeem, M. and Ali, R. 2017. Role of seed priming to enhance growth and development of crop plants against biotic and abiotic stresses. *Bulletin of Biological and Allied Sciences Research Section Plant Sciences,* 2:2.

Nwonubla, A.I., Christo, I.E. 2021. Effect of seed priming on seedling emergence and growth of bitter kola (*Garcinia kola*) in Owerri, Nigeria. *African Journal of Agricultural Research,* 17(5): 365-370.

Obani, F.T., Atechnkang, J., Ikotun, B., Bandyopadhyag, R. 2019. Occurrence of aflatoxin in *Colocynthis citrullus* L. (egusi) kernels in Southwestern Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology,* 13(1): 19-26.

Oliveira, C.E.S., Steiner, F., Zuffo, A.M., Zoz, T., Alves, C .Z., de Aguiar, V.C.B. 2019. Seed priming improves the germination and growth rate of melon seedlings under stress. *Ciencia Rural,* 49:07.

Pawar, V. A., Laware, S. L. 2018. Seed priming: A critical review. *International Journal of Scientific Research in Biological Sciences,* 5 (5):094-101.

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