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Full Length Research

Effects of seed priming methods on the germination and seedling growth of plumed cockscomb (*Celosia argentea* L.)

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ABSTRACT: Laboratory experiment was conducted to study the effects of seed priming on seed germination and seedling growth of *Celosia argentea* using different concentrations of potassium nitrate (KNO_3), sodium chloride (NaCl) and distilled water (H_2O). Factorial combination of three concentrations of KNO_3 salt (1, 2 and 3%), NaCl (1, 2 and 3%), distilled H_20 (25, 50 and 75 ml), and three priming durations (2, 12 and 24 hours) with one control of unprimed seeds were laid out in a Completely Randomized Design (CRD) with three replications. Data were collected on germination percentage, germination rates, shoot length, root length and seedling vigour. Results from analysis of variance revealed that priming materials, their concentrations and priming durations were significant for all the seed quality attributes evaluated. Similarly, interaction effect of salt concentrations and priming durations were significant at ($p<0.05$) for germination percentage, germination rate, shoot length, root length and seedling vigour. Germination rates, germination percentage, shoot and root length and seedling vigour were significantly increased in response to priming duration of 12 hours. However, the lowest values on these parameters were recorded for the duration of 2 hours for priming with NaCl salt. The treatment combination involving primed seeds with distilled water had the lowest germination rate, germination percentage, shoot length, root length and seedling vigour as compared to that obtained in the control treatment. Priming celosia seeds with 3% KNO_3 solution for a period of 12 hours significantly enhanced *Celosia argentea* seedling performance.

Keywords: Celosia, germination percentage, priming, seedling vigour, unprimed seeds.

INTRODUCTION

Celosia (*Celosia argentea* L.) commonly known as the plumed cockscomb belongs to the family amaranthaceae. *Celosia argentea* cultivation is well suited to tropical and sub-tropical regions with low labor cost and high rainfall. The composition of *C. argentea* differs with the variety, the nature of soil, environmental condition and the fertilizer applied (Alasiri and Ogunkeye, 1999). The nutritional properties of *celosia argentea* per 100 g edible portion is 83.8 g water, energy 185 kj (44 cal), protein 4.7 g, fat 0.7 g, carbohydrate 7.3 g, fibre 1.8 g, ca 260 mg, p 43 mg, Fe 7.8 mg (Akinyemi and Tijani- Eniola, 1997). Medically, *C. argentea* is used in the treatment of diarrhea, piles, bleeding nose, disinfectant, inflammation, haematological and gynaecological disorders (Wiart., 2000).

C. argentea cultivation is labor intensive especially during transplanting which is often in shortage and thereby increasing the cost of production. Alternative methods that require less labor without sacrificing productivity is therefore needed. Considering the cost and production through transplanting, direct seeding is an appropriate alternative. However, poor germination, uneven crop stand, seed dormancy and high weed infestation are the main constraints to its adoption.

Good crop establishment, rapid and uniform field emergence is important in the production of annual crops from seed, because patchy stands resul t in low yields.

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Priming is a physiological technique of seed hydration and drying to enhance the pregerminative metabolic process for rapid germination, seedling growth, and final yield under normal as well as stressed conditions (Waqas *et al*., 2019). Various seed enhancement approaches, such as coating, pelleting, and priming can be responsible to a major extent for improved quality of seeds (Rhaman *et al*., 2020). Among these approaches, seed priming with suitable priming agents and concentrations can induce some physiological and biochemical changes in the seed which result in improved crop performances in terms of enhanced germination potential, seedling vigour, and final yield (Farooq *et al*., 2008; Afzal *et al.,* 2012). The beneficial effects of priming include; improved seed viability, synchronizes and accelerates germination and sprouting, increases stress resistance and anti-oxidant activity, and improves plant growth and productivity (McDonald, 2000). Seed priming is a process of regulating the germination and managing the temperature and seed moisture content. The seeds are taken through the first biochemical processes within the initial stages of germination. The process involves advancing the seeds to an equal stage of the germination process by imbibition of seeds in water under controlled conditions to initiate early events of germination that will promote fast and uniform emergence when planted.

Due to the increasing population and rising demand for food and vegetables, there has been an increased production of vegetable crops such as *C. argentea*. However, *C. argentea* production in the country is faced with challenges that reduce the total production per farmers; this includes growing requirements colonized by nematodes infestation (Malcom, 1993). These challenges are mostly evident among small scale vegetable crop farmers that do not have sufficient fund to acquire the necessary chemicals that will aid seed germination and proper growth of the *C. argentea* plant. This has led to reduced yield per hectare among these farmers. It became very vital to find cheaper alternative ways to release seed dormancy and improve seedling growth.

C. argentea is now an important component of the Nigerian diet and making up a vital share in the growing economy with an established and growing demand for it in the country. No other vegetable crop is so distributed across Nigeria as *C. argentea.* However, only about half of the demand is met by domestic production. The low productivity is mainly as a result of non-availability of viable seeds. It has become important that farmers seek technological processes to release dormancy in seeds and thereby improve germination and to control seedling growth. Therefore, this experiment was conducted to study the effects of seed priming on germination and seedling growth of *Celosia argentea* and to investigate relative effects of different priming materials, concentrations and priming durations on germination and seedling growth of *Celosia argentea.*

MATERIALS AND METHODS

Study was conducted at the Department of Plant Breeding and Seed Science Laboratory of Joseph Sarwuan Tarka University, Makurdi; Benue State, Nigeria. Plumed cockscomb (*Celosia argentea)* seeds were obtained from the Seed Centre at the Department of Plant Breeding and Seed Science of Joseph Sarwuan Tarka University, under conditions of low temperature (5%) and moisture content 11%.

The seeds were treated with three concentrations of Potassium nitrate salts (KNO_3) (1, 2 and 3%); three concentrations of Sodium chloride (NaCl) (1, 2 and 3%), and H_2O (25, 50 and 75 ml). The percent solutions of potassium nitrate and sodium chloride were prepared by dissolving it in per 100 ml distilled water. Three durations of soaking of the seeds to the priming media KNO_3, NaCl, and H_2O for (2, 12 and 24 hours), with one control unprimed seeds. The experiment was a 3 × 3 factorial arrangement in Randomized Complete Block Design (RCBD)

Prior to the KNO3, NaCl and hydropriming treatments, the moisture contents of the seeds were determined by subtracting the dry weight from the initial weight, and is then calculated as the amount of water divided by the dry weight or total weight.

Seeds of *C. argentea* were fully immersed in the priming media KNO_3, Nacl and H_2O with the use of plastic Petri dishes for 2, 12 and 24 hours of priming, a total of 20 seeds were collected from the priming medium. All seeds were removed from the priming media at the same time, dried at a temperature 27˚C before the emergence of radical.

Twenty primed seeds were dried at a temperature of 27˚C to a moisture content of 10.2% and stored for further seed quality test. During the course of the experiment, data were collected on germination percentage, germination rates, shoot length, root length and seedling vigour.

Germination test was in three replicates of 20 seeds placed on filter paper moistened with distilled water in plastic Petri-dishes and kept in germination room for 12 days. Seed germinationwas monitored daily, and a radicle protrusion of more than 2 mm was taken as germination. The number of normal and abnormal seedlings was counted until the 12th day and germination percentage calculated using this formula:

$$\text{Germination } \% = \frac{\text{Total number of normal seedlings}}{\text{Total number of seeds planted}} x100$$

Normal seedlings were counted starting from 3rd day until all seeds capable of producing normal seedlings were scored on the 12th day. An index was calculated by dividing the number of seedlings counted each day by the number of days in which they were counted (Maguire, 1962).

$$\text{GR} = \frac{\text{Number of normal seedlings}}{\text{Days of first count}} + - - - - + \frac{\text{Number of normal seedlings}}{\text{Days of final count}}$$

Seedling evaluation was carried out after germination test. The height of *Celosia argentea* seedlings were measured after 12 days of planting. Five seedlings were selected for this measurement to represent the whole plant in each petri dish. The measurement was done with a meter rule calibrated in centimeters and values were recorded. Shoot and root lengths were measured in centimeters using a meter rule. Seedling vigour was determined by using the following equation:

$$\text{Seedling Vigour (SVI)} = \frac{\text{Germination Percentage} \times \text{Seedling Length (cm)}}{100}$$ (Adetumbi *et al*., 2019)

The data collected from the experiment were subjected to analysis of variance (ANOVA) using Genstat software. Means that were different significantly were separated by Duncan multiple range test (DMTR) at 5% level of probability.

RESULTS

The effects of priming materials, concentrations and priming duration on germination and seedling growth parameters is presented in Table 1. The result indicated that Potassium nitrate (KNO_3) recorded a highly significant germination percentage (40.9), germination rate (1.02), shoot length (4.00), root length (2.11) and seedling vigour (260.5) different from Sodium chloride (NaCl) and water (H_2O). On the other hand, germination rate and germination percentage were significantly highest at 3% concentration whereas 2% concentration produced the highest shoot length (3.80) and root length (3.80). Priming duration of 12 hours produced significantly highest germination percentage (34.6), germination rate (0.87), shoot length (3.91), root length (2.31) and seedling vigour (221.1) compared to primed for 2 hours and 24 hours.

The effects of priming materials x priming duration interactions on germination and seedling growth parameters of Celosia seeds are is presented in Table 2. The result indicated that KNO_3 at D 12 hours priming duration produced significantly highest values for germination percentage, germination rate, shoot length, root length and seedling vigour compared to priming with NaCl and H_2O at the various soaking durations.

On the other hand, effect of concentration x duration interactions on germination and seedling growth of Celosia seed is shown in Table 3. The result indicated that 3% concentration at 12 hours of priming recorded significantly highest germination percentage (41.6), germination rate (1.00) and seedling vigour (232.3) compared to 1 and 2% concentration at 2 and 24hours of priming duration.

The effect of concentration x priming material x priming duration interactions on Celosia seeds germination parameters is shown in Table 4. The table showed a trend of increasing values for germination percentage, germination rate, shoot length, root length and seedling vigour with increasing concentration of KNO_3 at 12 hours of priming duration. KNO_3 at 3% concentration at 12 hours priming duration had higher germination percentage, germination rate, shoot length, root length and seedling vigour which is also significantly higher than NaCl and H_2O at the various concentrations and priming durations.

DISCUSSION

The highly significant effect of priming material, material concentration and priming duration on germination and seedling attributes of Celosia is an indication that Celosia seeds responded to priming. This result is similar to what was reported by Singh *et al*. (2015); they said that priming influences the quality of germination and seedling growth of seeds of many crops. Similarly, Sadeghi *et al*. (2010) revealed that seed priming had significant effect on germination percentage, germination speed, root and shoot length in two medical plants (marigold and sweet fennel).

Seed priming has potential to improve poor seed emergence in crops, especially in small seeds like *celosia*. Harris and Jone (1997) reported that seed priming results in earlier emergence of seedlings by 1 to 3 days and significantly increased plant stand and initial growth vigour. More uniform and earlier emergence of seedlings were obtained in seeds primed with 3% KNO_3 at 12 hours as shown by higher germination percentage, germination rate, shoot length, root length and seedling vigour. This is in agreement with (Thejeshwini *et al*., 2019), who reported that halo priming seeds with 3% KNO_3 for 12 hours will help in enhancing the growth and yield attributing characters in onion. Anisa *et al.* (2017) reported that priming with 1.0% KNO_3 resulted in seed germination than priming with 2.0% KNO_3. Similarly, Jima *et al.* (2015) reported that priming onion seeds with 1% KNO_3 solution for a period of 12 hours as well as priming the seeds with distilled water for 72 hours significantly enhanced onion seedling performance and the yield of marketable bulbs.

Basra *et al*. (2006) while working on coarse rice reported that invigoration treatments significantly affected the germination rate and spread, fresh and dry weight of roots and shoots and shoot length. Muhammad *et al*. (2018)

Table 1. Effects of priming materials, concentrations and priming duration on germination and seedling growth parameters.

Priming material	Germination rate	Germination percentage	Shoot length (cm)	Root length (cm)	Seedling vigour
KN03	1.02^{a}	40.9^{a}	4.00^{a}	2.11^{a}	260.5^{a}
NaCl	0.35^{b}	14.0^{b}	3.10^{b}	1.75^{b}	66.8^{b}
H20	0.32^{b}	13.7^{b}	2.79^{b}	1.72^{b}	62.5^{b}
Concentration					
C1%	0.52^{b}	21.1^{b}	3.04^{b}	1.46^{b}	117.7^{a}
C2%	0.49^{b}	19.6^{b}	3.80^{a}	2.31^{a}	135.3^{a}
C3%	0.68^{a}	27.9^{a}	3.05^{b}	1.46^{b}	136.7^{a}
Duration					
D2hrs	0.30^{c}	13.3^{c}	2.92^{b}	1.32^{c}	58.0^{c}
D12hrs	0.87^{a}	34.6^{a}	3.91^{a}	2.31^{a}	221.1^{a}
D24hrs	0.52^{b}	20.7^{b}	3.06^{b}	1.94^{b}	110.7^{b}

Means not sharing a letter in a column differ significantly at p<0.05.

Table 2. Effects of interaction of priming materials x priming duration on germination and seedling growth parameters of Celosia seeds.

Priming material	Duration	Germination rate	Germination percentage	Shoot length (cm)	Root length (cm)	Seedling vigour
	D2	0.50^{c}	21.1^{c}	3.42^{abc}	1.46^{cd}	103.8^{cd}
KNO3	D12	1.79^{a}	71.6^{a}	4.54^{a}	2.44^{a}	483.7^{a}
	D24	0.76^{b}	30.0^{b}	4.05^{ab}	2.44^{a}	193.8^{b}
	D2	0.21^{de}	10.0^{d}	2.73^{bc}	0.95^{d}	36.8^{cd}
NaCl	D12	0.40^{cde}	15.5^{cd}	2.76^{bc}	1.95^{abc}	66.0^{cd}
	D24	0.37^{cde}	16.6^{cd}	2.87^{bc}	2.34^{ab}	84.6^{cd}
	D2	0.18^{e}	8.88^{d}	2.62^{c}	1.55^{bcd}	33.2^{d}
H2O	D12	0.43^{cd}	16.6^{cd}	4.42^{a}	2.55^{a}	113.5^{c}
	D24	0.44^{cd}	15.5^{cd}	2.26^{c}	1.05^{d}	53.6^{cd}

Means not sharing a letter in a column differ significantly at p<0.05.

Table 3. Effects of interaction of concentration x priming duration on germination and seedling growth of Celosia seeds.

Concentration (%)	Duration (Hrs)	Germination rate	Germination percentage	Shoot length (cm)	Root length (cm)	Seedling vigour
C3	D12	1.00^{a}	41.6^{a}	3.53^{ab}	2.15^{ab}	232.3^{a}
C2	D12	0.74^{bc}	30.0^{b}	4.41^{a}	2.73^{a}	221.6^{a}
C1	D12	0.87^{ab}	32.2^{b}	3.78^{ab}	2.06^{ab}c	209.4^{ab}
C2	D24	0.51^{cd}	18.3^{cd}	3.86^{ab}	2.54^{a}	134.5^{bc}
C3	D24	0.64^{bcd}	25.5^{bc}	2.61^{b}	1.28^{cd}	107.3^{cd}
C1	D24	0.42^{de}	18.3^{cd}	2.72^{b}	2.01^{abc}	90.2^{cd}
C3	D2	0.40^{de}	16.6^{d}	3.03^{b}	0.95^{d}	70.6^{cd}
C1	D2	0.26^{e}	12.7^{d}	2.61^{b}	1.36^{bcd}	53.4^{d}
C2	D2	0.23^{e}	10.5^{d}	3.13^{ab}	1.65^{bcd}	49.9^{d}

Means not sharing a letter in a column differ significantly at p<0.05.

Table 4. Effects of interaction of concentration x priming material x priming duration on Celosia seed germination parameters.

Concentration	Priming duration	Germination rate	Germination percentage	Shoot length (cm)	Root length (cm)	Seedling vigour
	2hrs	0.409^{efghi}	18.3^{def}	2.83^{bcde}	1.66^{abcdef}	85.3^{de}
1% KNO3	12hrs	1.80^{ab}	60.0^{b}	5.30^{ab}	2.50^{abcd}	459.6^{a}
	24hrs	0.465^{efghi}	20.0^{def}	2.66^{bcde}	2.50^{abcd}	104.1^{de}
	2hrs	0.326^{efghi}	15.0^{def}	4.10^{abcd}	1.46^{abcdef}	86.0^{de}
2% KNO3	12hrs	1.380^{bc}	60.0^{b}	5.00^{ab}	2.33^{abcd}	433.3^{ab}
	24hrs	0.81^{de}	30.0^{cd}	6.50^{a}	3.16^{a}	289.1^{bc}
	2hrs	0.780^{def}	30.0^{cd}	3.33^{bcde}	1.26^{bcdef}	140.3^{cde}
3% KNO3	12hrs	2.21^{a}	95.0^{a}	3.33^{bcde}	2.50^{abcd}	558.3^{a}
	24hrs	1.01^{cd}	40.0^{c}	3.00^{bcde}	1.66^{abcdef}	188.3^{cd}
	2hrs	0.19^{gh}i	10.0^{ef}	4.23^{abc}	2.20^{abcde}	65.1^{de}
1% NaCl	12hrs	0.45^{efghi}	16.6^{def}	3.13^{bcde}	2.20^{abcde}	80.0^{de}
	24hrs	0.40^{efghi}	20.0^{def}	3.50^{bcde}	3.03^{ab}	129.1^{cde}
	2hrs	0.22^{ghi}	10.0^{ef}	1.30^{de}	0.50^{ef}	18.0^{e}
2% NaCl	12hrs	0.18^{ghi}	10.0^{ef}	3.23^{bcde}	2.73^{abc}	61.3^{de}
	24hrs	0.10^{i}	10.0^{ef}	2.06^{cde}	3.00^{ab}	25.3^{de}
	2hrs	0.20^{ghi}	5.00^{f}	2.66^{bcde}	0.16^{f}	27.5^{de}
3% NaCl	12hrs	0.56^{defghi}	20.0^{def}	1.93^{cde}	0.93^{def}	56.8^{de}
	24hrs	0.62^{defgh}	25.0^{cde}	3.06^{bcde}	1.00^{cdef}	99.5^{de}
	2hrs	0.19^{ghi}	10.0^{ef}	0.76^{e}	0.23^{f}	9.83^{e}
1% H2O	12hrs	0.38^{efghi}	20.0^{def}	2.93^{bcde}	1.50^{abcdef}	88.6^{de}
	24hrs	0.41^{efghi}	15.0^{def}	20.0^{cde}	0.50^{ef}	37.5^{de}
	2hrs	0.14^{hi}	6.66^{f}	4.00^{abcd}	3.00^{ab}	45.8^{de}
2% H2O	12hrs	0.66^{defg}	20.0^{def}	5.00^{ab}	3.13^{a}	170.1^{cde}
	24hrs	0.61^{defgh}	20.0^{def}	3.03^{bcde}	1.46^{abcdef}	89.1^{de}
	2hrs	0.22^{ghi}	10.0^{ef}	3.10^{bcde}	1.43^{abcdef}	44.1^{de}
3% H2O	12hrs	0.25^{ghi}	10.0^{ef}	5.33^{ab}	3.03^{ab}	81.8^{de}
	24hrs	0.29^{fghi}	11.6^{ef}	1.76^{cde}	1.20^{cdef}	34.3^{de}

Means not sharing a letter in a column differ significantly at $p<0.05$.

worked on cocks comb (*Celosia cristata* L.) and reported that all priming treatments improved germination and emergence under saline and non-saline conditions as compared to non-primed seeds. Similar reports had been made by Mekonnen (2005) that beyond the priming duration of 16 hours, loss of seedling vigour of sorghum began to manifest itself for all cultivars as expressed by slower germination rate. Priming with NaCl failed to improve germination as compared to KNO_3 seed treatment. Robledo (2020) in a review on halopriming of seeds of *Capsicum frutescens* concluded that germination and seedling emergence may be enhanced by halopriming treatments in KNO_3. He further said that NaCl halopriming treatments did not improve the germination and seedling emergence when compared to seed treatment with KNO_3. He attributed the poor performance to stimulation of toxic

effects with the use of NaCl.

Seedlings of primed seed attained more length than the seedlings of unprimed seed. An increase in shoot length was recorded in seeds treated with KNO_3 as compared to other priming materials, which might be the result of higher embryo cell wall extensibility. Patade *et al.* (2011) found that root and shoot lengths increased in seeds due to KNO_3 priming as compared to unprimed seed. Ali *et al*. (2020), while working with tomatoes reported that priming tomatoes seeds with 0.75% KNO_3 improve its seedling establishment, vigour and biochemical traits. Aisha *et al*. (2007) further supports these findings saying that potassium is a major essential element required for physiological mechanism of plant growth.

Conclusion

The result of this study showed that seed germination and seedling growth parameters were influenced by the priming materials, concentration, priming duration or their interaction effects. Priming *Celosia* seeds with KNO_3 at concentration of 3% for duration of 12 hours increased germination rate, germination percentage, shoot length, root length and seedling vigour. Salinity affects water and nutrient uptake during seed germination by creating osmotic and ionic imbalances that reduce germination potential. Therefore, priming seeds with NaCl increases salt concentration which impedes seed germination.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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