

Influence of priming concentration on the growth and yield of amaranth (*Amaranthus cruentus* L.) in Sokoto semi-arid zone of Nigeria

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Abstract: Two field trials were conducted during the 2012 cropping season at the Fruits and Vegetable Teaching and Research Farm of the Department of Crop Science, Usmanu Danfodiyo University Sokoto, to evaluate the effect of priming concentration on the growth and yield of Amaranth. Treatments consisted of four priming concentrations (0%, 0.5%, 1% and 2% KNO₃). The treatments were laid out in a completely randomized design (CRD) replicated three times for the germination test and randomized complete block design (RCBD) for the field trial. Data were collected on days to 50% germination, percentage germination, days to 50% emergence, percentage emergence and fresh weight. Results showed significant effect of priming concentration on days to 50% germination, percentage emergence and days to 50% emergence. Soaking seeds in 0.5% KNO₃ reduced the number of days to 50% germination and emergence and also recorded higher percentage germination. Thus, it could be concluded that amaranth seeds should be primed with 0.5% KNO₃ solution for faster and higher seed germination of the crop.

Keywords: Amaranth, Growth and Yield, Priming Concentration, Semi-Arid Zone

1. Introduction

Amaranth (*Amaranthus cruentus*) is an excellent leaf vegetable grown throughout the tropics. The leaves (edible part) represent 76% of the total fresh weight of shoots and one hundred grams contain 84 g water, 4.6 g protein, 1.8 g cellulose, 410 mg calcium, 8.9 mg iron, 5.7 mg beta-carotene and 64 mg vitamin C. The leaves are also rich in vitamin A and potassium and represent the largest source of nutrients among all the vegetables that could be grown in tropical Africa [1, 2].

Despite the role of amaranths as one of the sources of vitamins A, B, thiamine, niacin, riboflavin, and some other dietary minerals such as calcium, iron, potassium, zinc, copper, and manganese which are comparable to common grains such as wheat, oats, and others [1], its production in Nigeria remains low when compared to other countries [2]. There is therefore, the need to improve its production to meet the demand of the consumers. Seed priming before planting is reported to enhance the germination and seedlings growth by controlling moisture imbibition and

minimizing the vagaries of the adverse effects of weather and soil conditions [3]. The effect of priming has been attributed to metabolic repair and activation of seed during water imbibition [4, 5]. Priming methods differ depending on crop species and seed germination condition. Several studies on seed germination and seed emergence showed the beneficial effect of seed priming using different methods [6-8]. Pre-sowing seed treatment is a low risk technique that is being used to increase crop establishment under unfavorable conditions [2]. Paul and Choudhury [9] observed that seed soaked in 0.5 to 1% solutions of KCl or K₂SO₄ significantly increased plant height and yield attributes in wheat. Moosavi *et al.* [10] reported that osmo-priming and hydro-priming of amaranth seeds significantly increased germination percentage, speed of germination and seedling vigour in all cultivars. Recently, Musa *et al.* [2] reported soaking amaranth seed for two hours as best for improving germination and emergence performance of the crop. Thus, this experiment was conducted to study the influence of seed priming concentration on the growth and yield of amaranth in semi-arid environment.

2. Materials and Methods

For both germination and emergence tests, treatments consisted of four priming concentrations (0%, 0.5%, 1% and 2% KNO₃) laid out in a completely randomized design (CRD) replicated three times.

Seed Priming: Seed priming was carried out in the Crop Science Laboratory, Usmanu Danfodiyo University, Sokoto. Seeds of the amaranth cultivar were sourced from Sokoto Agricultural Development Programme in Sokoto, Nigeria. The seeds were primed (soaked) in KNO₃ solution containing 0%, 0.5%, 1% and 2% KNO₃ salt. All the seeds for the various treatments were soaked for a period of 2 hours as suggested by Musa *et al.* [2]. 50 g of the amaranth seeds each were soaked in 500 ml containing the various priming concentrations. After priming, seeds were air-dried back to their initial moisture content. At the time of experiment, the temperature of the KNO₃ solution and the distilled water used as control (0%) during the priming was 28°C and 29°C during the first and second trials respectively. The temperature of the surrounding environment was 29°C and 30°C respectively.

Germination Test: For both trials, 30 seeds were placed on moist filter paper of 90mm in diameter in petri dishes for each treatment and replicated three times. Droplets of water were applied everyday on the filter paper to provide adequate moisture for seed germination. Seed was considered germinated when the radicle emerged through the seed coat. Germination count was taken daily for 14 days. Germination percentage was computed using the following:

$$\text{Germination percentage} = \frac{\text{Total seeds germinated}}{\text{Total seeds sown}} \times 100$$

Field emergence: The emergence test was carried out in 2012 cropping season at the Fruits and Vegetable Teaching and Research Farm of Usmanu Danfodiyo University, Sokoto. Sokoto is located on latitude 14°N-15°N and longitude 4°-5°E [11]. Annual rainfall ranges from 380mm to 763mm. The seeds were sown through drilling method with a row to row spacing of 20cm at a depth of 0.5-1cm. Gross plot size was 2m x 2m (4m²) and the net plot was 1.6m x 1.6m (2.56m²). Emergence test involved counting the number of plants that emerged on the soil surface daily. It was computed using the following:

$$\text{Emergence percentage} = \frac{\text{Number of seedlings emerged}}{\text{Number of seeds sown}} \times 100$$

Data were collected on days to 50% germination, percentage germination, days to 50% emergence, percentage emergence and fresh weight. The data collected were subjected to analysis of variance (ANOVA) procedure for completely randomized design (CRD) and randomized complete block design (RCBD) for the laboratory and field experiments respectively, using SAS® computer package. Means showing significant differences were separated using Duncan's Multiple Range Test (DMRT).

3. Results

3.1. Days to 50% Germination

Days to 50% germination of amaranth as influenced by priming concentration during the first trial, second trial and the mean performance is presented in Table 1.

Significant ($p < 0.05$) effect of priming concentration on days to 50% germination was observed during the second trial. Using KNO₃ salt concentration of 0.5, 1.0 and 2.0% reduced the number of days to 50 % germination from 3.2 days recorded where KNO₃ was not used in the priming media to 2.1 -2.2 days which was similar between the concentration levels (Table 1). But, for the first trial and the mean performance, the number of days to 50% germination which ranged from 1.8-2.1 days and 2.0-2.6 days respectively, were not influenced by priming concentration.

Table 1. Days to 50% germination of amaranths as influenced by priming concentration during the 2012 cropping season.

Treatments	First trial	Second trial	Combined
Concentration (%)			
0	1.9	3.2 ^a	2.6
0.5	2.1	2.2 ^b	2.1
1	2.1	2.1 ^b	2.1
2	1.8	2.1 ^b	2.0
SE(±)	0.13	0.29	0.17
Significance	ns	*	ns

Means in a column followed by same letter(s) in a superscript within a treatment group are not significantly different using DMRT at 5% level; ns=not significant, *=significant

3.2. Percentage Germination

Percentage germination of amaranths as influenced by priming concentration during the first trial, second trial and the combined mean performance is presented in Table 2.

Significant ($p < 0.05$) effect of priming concentration on the percentage germination of amaranth was observed during the second trial and the mean performance. Higher percentage germination was recorded in the treatments primed with KNO₃ salt during the second trial (86.3-88.8%) and the mean performance (81.2-85.6%) than the treatments soaked in water only which recorded 68.7 and 70.9% during the second trial and mean performance respectively. But, the difference in percentage germination among the KNO₃ salt concentrations (0.5, 1.0 and 2.0%) was not observed (Table 2).

Table 2. Percentage germination of amaranths as influenced by priming concentration during the 2012 cropping season.

Treatments	First trial	Second trial	Combined
Concentration (%)			
0	73.1	68.7 ^b	70.9 ^b
0.5	76.17	86.3 ^a	81.2 ^a
1	79.0	88.0 ^a	83.0 ^a
2	82.4	88.8 ^a	85.6 ^a
SE(±)	3.35	2.18	1.76
Significance	ns	*	*

Means in a column followed by same letter(s) in a superscript within a treatment group are not significantly different using DMRT at 5% level; ns=not significant, *=significant

3.3. Days to 50% Emergence

Days to 50% emergence of amaranths as influenced by priming concentration during the first trial, second trial and the combined is presented in Table 3.

Significant ($p < 0.05$) effect of priming concentration on days to 50% emergence of amaranth was observed during the first trial and the combined (Table 3). Days to 50% emergence of the crop was observed in lesser number of days in treatments soaked with 0% and 0.5% KNO_3 during the first trial (2.3-3.1 days) and the combined (2.8-3.0 days) than the treatments soaked in 1.0% and 2.0% KNO_3 solution which recorded 4.4-5.8 days in the first trial and 3.5-4.5 days in the combined. However, for the second trial the days to 50% emergence of the crop which ranged from 2.7-3.3 days was not influenced by priming concentration.

Table 3. Days to 50% emergence of amaranths as influenced by priming concentration during the 2012 cropping season.

Treatments	First trial	Second trial	Combined
Concentration (%)			
0	3.1 ^c	3.0	3.0 ^b
0.5	2.3 ^c	3.3	2.8 ^b
1.0	5.8 ^a	3.2	4.5 ^a
2	4.4 ^b	2.7	3.5 ^a
SE(±)	0.39	0.42	0.39
Significance	*	ns	*

Means in a column followed by same letter(s) in a superscript within a treatment group are not significantly different using DMRT at 5% level; ns=not significant, *=significant

3.4. Percentage Seedling Emergence

The percentage seedling emergence of the crop which ranged from 54.2-78.0%, 56.1-73.6% and 63.5-67.1% during the first trial, second trial and the combined respectively, was not significantly ($p > 0.05$) influenced by priming concentration (Table 4).

Table 4. Percentage emergence of amaranths as influenced by priming concentration during the 2012 cropping season.

Treatments	First trial	Second trial	Combined
Concentration (%)			
0	78.0	56.1	67.1
0.5	65.7	62.5	64.1
1	69.3	63.6	66.5
2	54.2	73.6	63.5
SE(±)	5.99	6.10	4.30
Significance	ns	ns	ns

Means in a column followed by same letter(s) in a superscript within a treatment group are not significantly different using DMRT at 5% level; ns=not significant, *=significant

3.5. Fresh Weight

The fresh weight of the crop which ranged from 10.3-12.5g, 12.8-13.5g and 11.7-12.6g during the first trial, second trial and the mean performance of the two trials combined was not significantly ($p > 0.05$) influenced by the various priming concentrations (Table 5).

Table 5. Fresh weight (g/plant) of amaranths as influenced by priming concentration during the 2012 cropping season.

Treatments	First trial	Second trial	Combined
Concentration (%)			
0	11.3	13.0	12.2
0.5	11.1	13.5	12.3
1	12.5	12.8	12.6
2	10.3	12.8	11.7
SE(±)	0.67	1.42	0.78
Significance	ns	ns	ns

Means in a column followed by same letter(s) in a superscript within a treatment group are not significantly different using DMRT at 5% level; ns=not significant, *=significant

4. Discussion

The finding of this research showed the benefit of seed priming using KNO_3 salt solution as priming media in improving the performance of amaranth in the semi-arid environment where good crop establishment seldom occurs. The remarkable performance of the crop observed from using KNO_3 salt shows that the salt could be used to improve crop establishment in this environment characterized by unfavorable conditions for seedling establishment. This view on improving crop establishment was reported earlier by many researchers [2, 6-8].

The attainment of 50% germination in lesser number of days in the second trial in seeds primed with KNO_3 salt of 0.5-2.0% (2.1-2.2 days) compared to using distilled water alone which recorded 3.2 days shows the beneficial effect of using the salt as priming media and 0.5% was the best concentration that could be used to prime the crop. The finding here could be attributed to the effect of seed priming on the early stages of germination process which causes completion of pre-germination metabolic activities in the seed and makes the seed ready for radicle protrusion once it re-imbibed moisture on the field. This agrees with the findings of Szabolcs, [12] and Sivritepe *et al.* [13] who reported that earlier and more uniform germination are probably due to stimulatory effects of priming on the early stages of the germination process.

The increase in percentage germination of amaranth recorded in the treatments where KNO_3 salt was used compared to using water alone could be attributed to the role of seed priming using KNO_3 salt in seeds repair and removal of germination inhibiting substances commonly found in the seeds of most vegetables plants. This agrees with the findings of Jie *et al.* [14] who reported that osmo-priming activates the processes of germination through affecting the oxidative metabolism. Also, use of KNO_3 salt might have supplied NO_3 to the seed and caused exo-osmosis that resulted in the removal of germination-inhibiting substances. Seed osmo-priming is reported to increase the seed germination potential, resulting in increased stress tolerance of germinating seeds [15]. This is in line with the findings of McDonald [3] who reported that priming may improve germination by accelerating imbibition which in turn would facilitate the radicle protrusion and seed germination.

The reduction in days to 50% emergence of amaranth obtained in the treatments soaked in 0 and 0.5% KNO₃ solution compared to using higher concentrations suggested that faster seedling emergence could be reached without KNO₃ salt concentration and where used to enhance germination as observed above in days to 50% germination and percentage germination, it should not exceed 0.5%. The finding here was contrary to that of Singh *et al.* [16], who observed better seedling performance with osmo-primed seeds in cowpea. The reason could be because of the differences in the crop under investigation and Amaranth is quite a small seed plant compared to cowpea.

5. Conclusion

The finding of this research showed the benefit of using KNO₃ as a priming media in improving germination characteristics of amaranth in the semi-arid tropics. The highest performance was recorded where 0.5% KNO₃ solution was used compared to other concentrations. Thus, it could be concluded that amaranth seeds should be primed with 0.5% KNO₃ solution for faster and higher seed germination of the crop.

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