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Comparative effect of various concentrations of sodium chloride on germination and growth of spinach (*amaranthus caudatus*) in Dutse Metropolis, Jigawa state, Nigeria.

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Abstract

This research tested the effect of different concentrations of sodium chloride on germination and growth of Spinach (Amaranthus caudatus). The experiment was carried out in Federal University Dutse School Farm from 26th August 2021 to 14th October 2021.Four different salt concentrations were used in millimol i.e 0mM, 50mM, 100mM, 150mM, and 200mM. Completely randomized design (CRD) was used with three replications. There were 12 replications per treatment. Percentage germination rate and the growth parameters such as plant height, number of leaves, shoot fresh weight and shoot dry weight decreases with increase in salt concentrations. Germination was low at 200Mm and high at 0Mm. Amaranthus caudatus showed almost the same Phenomenon at different salt concentration for the growth parameters such as plant height, number of leaves, shoot fresh and dry weight. The significant findings ($P \leq 0.05$) of this study showed that A. caudatus could be cultivated in farmlands contaminated with sodium chloride either due to natural aridity or man-made soil salinization in this study it was discovered that germination of A. caudatus seed is adversely affected with increase in salt concentrations. Seedling growth was positively stimulated at moderate concentrations and adversely affected at higher concentrations (150 and 200Mm respectively).

Keywords: Amaranthus caudatus, Germination, salinity, seedling growth, Sodium chloride,.

INTRODUCTION

Spinach is one of the most famous leafy vegetable crops with minimum growth cycle and is an annual plant, associated to family Chenopodiaceae (Biemond,2006). Spinach was first cultivated in North Africa. After that, it came from Spain to North Europe (Dicoteau, 2000; Swiader & Ware, 2000). Spinach has a high nutritive value due to the presence of important minerals and vitamins. Among nutrients, spinach is a good source of calcium, vitamin C, phosphorous, iron, potassium and sodium (Dicoteau, 2006).

Salinity is known to reduce the growth of glycophytes (salt sensitive species). Salinization of soil is one of the major factors limiting crop production, particularly in arid and semi-arid regions of the world, like Pakistan. It occupies a prominent place amongst the soil problems that threaten the sustainability of agriculture. Salinity occurs through natural or human-induced processes that result in the accumulation of dissolved salts in the soil water to an

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extent that it inhibits plant growth Irrigation water or soil solution with electric conductivity of 4dsm-1 or greater which is equal to 40Mm NaCI is considered as saline one (Cramer, 1993). . Environmental contaminants specifically those containing salt radicals affect crops adversely (Kijne, 2006). Building up of soluble salts in soil column causes serious damage to agricultural production and environmental health (Rengasamy, 2006).

Most of the researches done on spinach are mainly to improve their resistance to pest, drought, and disease. While little has been done to determine their tolerance to over increasing environmental stress like salinity. Soil found in the savanna are experiencing serious climatic changes that affects plant growth and food production. The response of spinach variety under different environmental condition specifically salinity needs to be investigated. Some soils found in the savanna have excessive salt concentrations in them that affects plant growth and food production, (Manchanda and Garg, 2008) . The response of spinach is the bases of the research work. The aim of the research is to assess the effect of different level of sodium chloride salt (NaCl) on germination and seedling growth of Spinach (*Amaranthus caudatus*). The study will investigate how salt stress affect growth of spinach(*Amaranthus caudatus*), assess the germination percentage rate of each of the treated and control seeds of spinach (*Amaranthus caudatus*) and determine the effect of different level of sodium chloride (Nacl) salt on the growth of spinach (*Amaranthus caudatus*).

MATERIALS AND METHODS

Study area

The experimental site was at Agricultural farm Federal University Dutse , Jigawa State found in Sudan Savanna ecological zone which lies between latitude 11.00° N to 13.00° N and longitude 8.00° E to 10.15° E. The commencement of the experiment was from August 26th to 0ctober 2019. Polythene bags were filled with soil collected from Agricultural Farm Federal University Dutse, Jigawa state.

Soil collection

The soil was collected at 0-20cm depth from Agricultural farm federal university dutse. The soil used was sandy loam type. Soil Augar was used to dig 0-20cm depth of the soil.

Experimental Treatments

Treatments used in this experiment were five (5) concentrations of sodium chloride (salt). At 0mM, 50mM,100mM, 150mM and 200mM. Each treatment was replicated twelve times. Spinach (*Amaranthus caudatus)* variety was used for the research. The experiment was laid in completely randomized design with three replications.

Procedure

The collected soil sample was air dried under the sun after which it was mixed with organic manure at the ratio of 3:1 and each polythene bag was filled with one quarter of the prepared soil. A total number of 60 polythene bags were used.
To prepare 1M of Salt solution, 58.8g of NaCl crystals was dissolved in a universal bottle upon which distilled water was added to make up 1L (1000 ml). Corresponding ratios of 50:1000, 100:1000, 150:1000 and 200:1000 gave 50 mM, 100 mM, 150 mM, and 200mM respectively. Distilled water was considered as 0mM, representing the control.

Planting

Spinach seeds were sown in the polythene bag in depth of 1cm on 26th August 2019.The seeds were soaked in cold water for 24 hours (dormancy breaking) and 2 seeds were sown in each polythene bags. They were later thin after two (2) weeks of germination. The plants were watered regularly with one day interval for 4 weeks and two days interval for the other weeks.

Data collection
Data was collected on germination and vegetative growth parameters. The description of the procedure for each is given below:

Germination percentage rate: This was calculated by counting the number of seeds germinated divided by the number of seeds planted multiply by 100 for each of the treated and the control plants.
Germination Percentage rate = Number of germinated seeds/ total number of seeds planted x 100

Seedling Growth parameters: These parameters are as follows:

Plant height in (cm)
The height of the control and treated plants were measured from the ground level to the tip of the stem or terminal bud with the aid of a meter rule and thread and the measurements were recorded.

Number of leaves
Number of leaves on each of the treated and control plants were counted and the mean was recorded.

Plant fresh weight: The fresh weights of the plants were recorded immediately after they were harvested.

Plant dry weight: The dry weight was recorded after drying the plant at temperature higher than the ambient air temperature (around 65-100^{0}c) to drive off the water.

Statistical analysis
At the end of the experiment the data collected was subjected to one-way analysis of variance (ANOVA) and significant differences were further treated to a least significant difference test at ($P \leq 0.05$)

Result
Effect of various concentrations of sodium chloride on germination percentage rate
The result of the effect of the various concentration treatments on germination percentage rate is shown in Table1. The treatments induced different responses in the number of days taken to germinate. The 0mM (control) had the highest germination rate with 83% this was followed by 50mM treatment with 67% followed by 100mM treatment (52%) then 150mM treatment (44%). The least in germination percentage rate was in 200mM concentration treatment with 25%. There was significant difference between all the treatments ($P \leq 0.05$).

Effect of sodium chloride on Plant height
The effect of various concentrations of sodium chloride on Height of the plants of *Amaranthus caudatus* is presented in Table 2. Comparison between the treatments showed that plants treated with 50 mM concentration plants had the highest plant height in all the weeks i.e at

2,4,6 and 8 weeks after sowing with with 9.67cm, 24.33cm, 37.70cm and 44.0cm at 2,4,6 and 8 weeks after sowing this was followed by 100 mM treatment (8.50cm,17.67cm, 31.70cm and 35.0cm) then 150 mM treatment (6.50cm, 16.67cm, 27.70cm and 32.33cm) the least in plant height were those plants treated with 200 mM concentration with 4.50cm, 10.50cm, 23.0cm and 26.67cm at 2,4,6 and 8 weeks after sowing respectively. The difference between all the treatments was significant. The values within columns followed by the same letter are not significantly different at $P \leq 0.05$. (Table 2).

Effect of sodium chloride on number of leaves

The effect of different concentration of sodium chloride on number of leaves of *Amaranthus caudatus* is presented in Table 3. Comparison between the treatments showed that plants treated with 50 mM concentration plants had the highest plant height in all the weeks i.e at 2,4,6 and 8 weeks after sowing with 8.00, 12.33, 16.00 and 21.67 at 2,4,6 and 8 weeks after planting , this was followed by 100 mM treatment (7.00, 10.67, 14.67 and 21.00) then 150 mM treatment (6.33, 10.33, 13.33 and 16.33) the least in number of leaves were those plants treated with 200 mM concentration with 3.33, 6.33, 11.33 and 14.67 at 2,4,6 and 8 weeks after planting respectively. The difference between all the treatments was significant. The values within columns followed by the same letter are not significantly different at $P \leq 0.05$ (Table 3).

Effect of sodium chloride on Shoot fresh weight of *Amaranthus caudatus*

The effect of various concentrations of sodium chloride on Shoot fresh weight of *Amaranthus caudatus* is presented in Table 4. Plants treated with 50 mM concentration gave the highest Shoot fresh weight in all the weeks i.e at 2,4,6 and 8 weeks after sowing with 0.37g, 5.27g, 15.33g and 17.67g respectively this was followed by 100Mm treatment (0.20g, 3.37g, 8.00g and 11.00g) then 150mM treatment (0.16g, 2.83g, 6.67g and 9.00g) the least in Shoot fresh weight were those plants treated with 200mM concentration with 0.05g, 0.70g, 5.00g and 6.00g at 2,4,6 and 8 weeks after sowing respectively (Table 4).

Effect of sodium chloride on Shoot dry weight of *Amaranthus caudatus*

The effect of various concentrations of sodium chloride on Shoot dry weight of *Amaranthus caudatus* is presented in Table 5. Comparison between the treatments showed that 50 mM concentration gave the highest Shoot dry weight with 0.04g, 0.89g, 1.37g and 1.63g at 2,4,6 and 8 weeks after planting, this was followed by 100mM treatment (0.02g, 0.73g, 0.52g and 0.97g) then 150mM treatment (0.01g, 0.57g, 0.80g and 0.93g) the least in Shoot dry weight were those plants treated with 200mM concentration with 0.01g, 0.09g, 0.50g and 0.80g at 2,4,6 and 8 weeks after sowing respectively. The difference between all the treatments was significant. The values within columns followed by the same letter are not significantly different at $P \leq 0.05$ (Table 5).

DISCUSSION

The effect of sodium chloride using five different concentrations were tested on germination percentage rate and vegetative parameters such as plant height, number of leaves, shoot dry weight, and shoot fresh weight of spinach (*Amaranthus caudatus).*

The highest salt concentration 200Mm negatively affect germination percentage rate of *Amaranthus caudatus* this may be due to high concentration of salt that inhibit water uptake by seed for germination, water is crucial for germination and must be absorbed by seed for hydrolysis of seed endosperm to provide nutrient for embryo leading to emergence of radical and establish plumule as seedling.Skirycz and Inze, (2010).

Germination decreases with increasing salt concentration with 50mM 100mM, 150mM, and 200mM compared with the control that had the highest percentage germination. This finding is in line with the findings of Khan *et al* (2000) with their work on some halophytes (*Haloxylon recurvum*), and Othman (2005) with his work on some barley cultivars. The accumulation of Na and Cl ions around the seed prevent the seed germination (Tattersall *et al*, 2001; Murillo-Amodor *et al*, 2002). Ascending salt concentrations not only prevent the germination of the seed but also extend the germination time by delaying the starting of germination (Raafat *et al*, 1991).

The plant height, number of leaves, shoot dry weight, and shoot fresh weight, decreases with increase in salt concentration, 200mM which is the highest concentration had the lowest value followed by 50mM 100 mM and 150mM.This is in line with the findings of (ziska *et al* ,1990, zekri 1991) who reported that once seed germinate the next goal for plant growth is establishment, this is because salinity causes reduction in crop establishment by reducing shoot growth ,blocking leaf development and expansion ,reducing growth of internode and promoting leaf abscission.

However different stages like germination, vegetative growth, behaved differently with salinity, and affect morphology in different ways. These modifications depend on the cultivar used (Khan *et al*., 2003; Munns and James, 2003).

CONCLUSION

Findings in this study showed that *A. caudatus* is a good halophytes that could sustainably be cultivated in farmlands contaminated with sodium chloride either due to natural aridity or man-made soil salinization. The specie responded to varying salt concentration in different ways. The germination of *A. caudatus* seed was negatively affected with increase in salt concentrations. The growth of the spinach was positively stimulated at moderate concentrations and adversely affected at high concentrations (150 and 200Mm respectively). Efforts should be made to find some ways of desalinization of soil as most researchers found that salinity negatively affect germination and some aspect of growth of vegetables. This effort will improve food production and high yield.

Recommendation

There are many vegetables plants that have not being tested for salinity, therefore, research should be conducted on such crop plants to know their adaptation towards salt stress, Likewise efforts should be made in conducting similar researches during dry season because rainfall could affect the salinization of soil, hindering salt activity on plant growth.

Table 1: Percentage germination rate of *Amaranthus caudatus* as affected by different concentrations of sodium chloride

Treatment (mM)	Germination percentage rate (%)
0	83a
50	67b
100	52c
150	44d
200	25e
Mean	54.2
LSD (0.05%)	30.14

Table 2: Effect of different concentrations of sodium chloride on plant height at different weeks after sowing

Treatment **(mM)**	Plant height (cm) 2weeks	4weeks	6weeks	8weeks
0	13.47a	30.67a	52.70a	59.67a
50	9.67 b	24.33b	37.70 b	44.00b
100	8.50 b	17.67c	31.70b	35.00c
150	6.50c	16.67c	27.70 b	32.33c
200	4.50 d	10.50d	23.00 b	26.67d
Mean	8.52	19.96	34.56	39.53
LSD (0.05%)	1.18	3.36	8.23	5.08

Table 3: Effect of different concentrations of sodium chloride on number of leaves at different weeks after sowing

Treatment	Number of leaves 2weeks	4 weeks	6 weeks	8 weeks
Salt conc. in mM				
0	9.33a	13.33a	20.67a	26.00a
50	8.00b	12.33 a	16.00 b	21.67b
100	7.00b	10.67 b	14.67 b	21.00b
150	6.33b	10.33 b	13.33 b	16.33c
200	3.33c	6.33 c	11.33 c	14.67d
LSD ≤ 0.05	1.24	1.33	3.93	2.44

Table 4: Effect of different concentrations of sodium chloride on Shoot fresh weight at different weeks after sowing.

Treatments(mM)	Shoot fresh weight (g) 2weeks	4 weeks	6 weeks	8 weeks
0	1.07a	8.10a	22.33a	25.00a
50	0.37 b	5.27b	15.33 b	17.67b
100	0.20b	3.37c	8.00 c	11.00c
150	0.16b	2.83c	6.67 c	9.00c
200	0.05b	0.70d	5.00c	6.00d

LSD ≤ 0.05	0.28	1.67	3.25	2.05

Table 5: Effect of different concentration of sodium chloride on shoot dry weight of Amaranthus caudatus

Treatments	Shoot dry weight (g)			
	2weeks	4weeks	6weeks	8weeks
Salt conc. In mM				
0	0.11 a	1.57a	2.33 a	2.60a
50	0.04b	0.89b	1.37b	1.63b
100	0.02b	0.73b	0.52c	0.97c
150	0.01 b	0.57b	0.80c	0.93c
200	0.01b	0.09 c	0.50c	0.80c
LSD ≤ 0.05	0.02	0.34	0.69	0.28

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