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Title

Effect of Salt stress on the germination-post germination of Seeds of *Anabasis articulata* (Amaranthaceae)

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Dedication

To my tender-hearted parents ***Abd alhamed*** *and* ***Rachida*** *my precious siblings I dedicate this dissertation,*

To my strength

My family ***Korichi and Ben karima***

To my ***Husband Abd Elkader***

And my greatest support Lalla,

Also my classmates

To all who has been there for me, I dedicate this work.

Dedication

To my tender-hearted parents ***Mohammed, Fatma*** *and my precious siblings I dedicate this dissertation,*

To my strength

Grandmother and grandfather, exceptionally my supportive family

Ag Boula, Tafris

To the purest of them all, my aunts and uncles,

To my incredible companion

To my greatest support, my besty Tinhinane, Amal.k, Sana

Amina,Hajer,Hayte,Nesrin,Rabia,Amel,Razika and my supportive girlfriends in Ouargla and Djanet,

Also my classmates

To all who has been there for me, I dedicate this work.

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Pr .SALHI.N, *precedent.*

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GK: germination kinetic
GF: germination final
GS: germination speed
SL: shoot length
RL: root length

Summary

CHAPTER ONE: Material and Methods

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Introduction

Introduction:

The two major environmental factors that currently reduce plant productivity are drought and salinity **(SERRANO, 1999).** Salinity is one of the major obstacles to increasing production in crop growing areas throughout the world. In spite of this extensive literature there is still a controversy with regard to the mechanisms of salt tolerance in plants **(NEUMANN, 1995).** Salinity in soil or water is one of the major stresses and especially in arid and semi arid regions, can severely limit crop production **(SHANNON, 1998).** Salinity impairs seed germination, reduces nodule formation, retards plant development and reduces crop yield **(GREENWAY ET AL., 1980).** The plants that grow in saline soils have diverse ionic compositions and a range in concentrations of dissolved salts **(VOLKMAR ET AL., 1998)** These concentrations fl actuate because of changes in water source, drainage, evapotranspiration, and solute availability **(VOLKMAR ET AL., 1998) .** Successful seedling establishment depends on the frequency and the amount of precipitation as well as on the ability of the seed species to germinate and grow while soil moisture and osmotic potentials decrease **(ROUNDY, 1987)** These salts interfere with seed germination and crop establishment [FOWLER, 1991]. Germination and seedling characteristics are the most viable criteria used for selecting salt tolerance in plants **(BOUBAKER, 1996).** Salinity stress can affect seed germination through osmotic effects **(WELBAUM, 1990**

Worldwide agricultural productivity is subjected to increasing environmental constraints **(BARTELS AND SUNKAR, 2005)** in the form of abiotic and biotic stresses that adversely influence plants **(HUSSAIN ET AL., 1990).** In fact, abiotic stresses are the principle cause of crop failure, decreasing average yields for major crops by more than 50% **(BUCHANAN ET AL., 2000)**

Seed germination is a fundamental physiological process in the successful growth and development of plants (**POUDEL ET AL., 2019, NIMBALKAR ET AL., 2020**), and is significantly affected by temperature, soil salinity, etc. **(WEBER,2009, FAROOQ ET AL,2021).** The germination and seedling phases in the plant life cycle are the most vulnerable to extreme environmental stressors, especially for desert plants **(FENNER, 2000, GAIROLA ET AL, 2020)**

Seeds are the main way through which plants propagate, and a seed contains all of the genetic material of the plant. As seed germination is the beginning of the life cycle of plants, seedling emergence is critical for the establishment of plant populations **(KHAN AND GULZAR, 2003).**

Salinity is prevalent in arid regions and impacts seed germination and its subsequent phases such as seedling Establishment and growth (QU ET AL., 2008, EL-KEBLAWY ET AL., 2016).

Germination is a crucial stage in the life cycle of salinity varies according to salinity response of the individual plants inhabiting arid, saline environments (KHAN, M.A. AND S. GULZAR, 2003). Halophytic species (GUL, B. AND D.J. WEBER, 1999, KHAN ET AL , 2001 - Tilki,2007) Although high Salt stress affects germination percentage, germination rate and seedling growth in different ways depending on the plant species (UNGAR, 1996, GUL ET AL., 1999)

Salinity stress disrupts enzymes and other biological functions, causing ionic leakage from cell membranes and hence cell malfunction [Malik et al,2020, Munns et al.,2008]. It also induces inhibition of the chlorophyll biosynthesis pathway, thus, decreasing plant photosynthesis (FAYAZ ET AL., 2021, SOFY ET AL., 2021)

According to their salt tolerance, plant could be classified as halophytes (salt tolerant) and glycophytes (salt intolerant). Halophytes can germinate and complete their life cycle in saline environments, whereas glycophytes cannot (UNGAR, 1991).

The Amaranthaceae a family comprising more than 800 species divided into approximately 75genera. Most Amaranthaceae species contain annuals, shrubs and

Perennials (GUDRUNKADEREITET AL., 2003), among the families represented in the Sahara

Northern Algeria and more precisely in the south-eastern region, the species of this

Family such as *"Anabasis articulata"* represent a resistance to the harsh climate of the

Region requires the development of adaptation strategies (HOUARI ET AL., 2013). Generally the adaptations of desert plants relate to the reduction of the surface foliar, the reduction in speed, and the constitution of water reserves inside the tissues (OZENDA, 1977).

It is in this context that our work takes place, which aims to study the response of an Amaranthaceae halophyte from the arid and non-arid in Algerian, which is Anabasis articulata at salinity.

- ✓ What is the effect of salinity on *Anabasis articulata* seeds at the germination stage?
- ✓ What salt concentrations can these seeds tolerate?

Chapter one

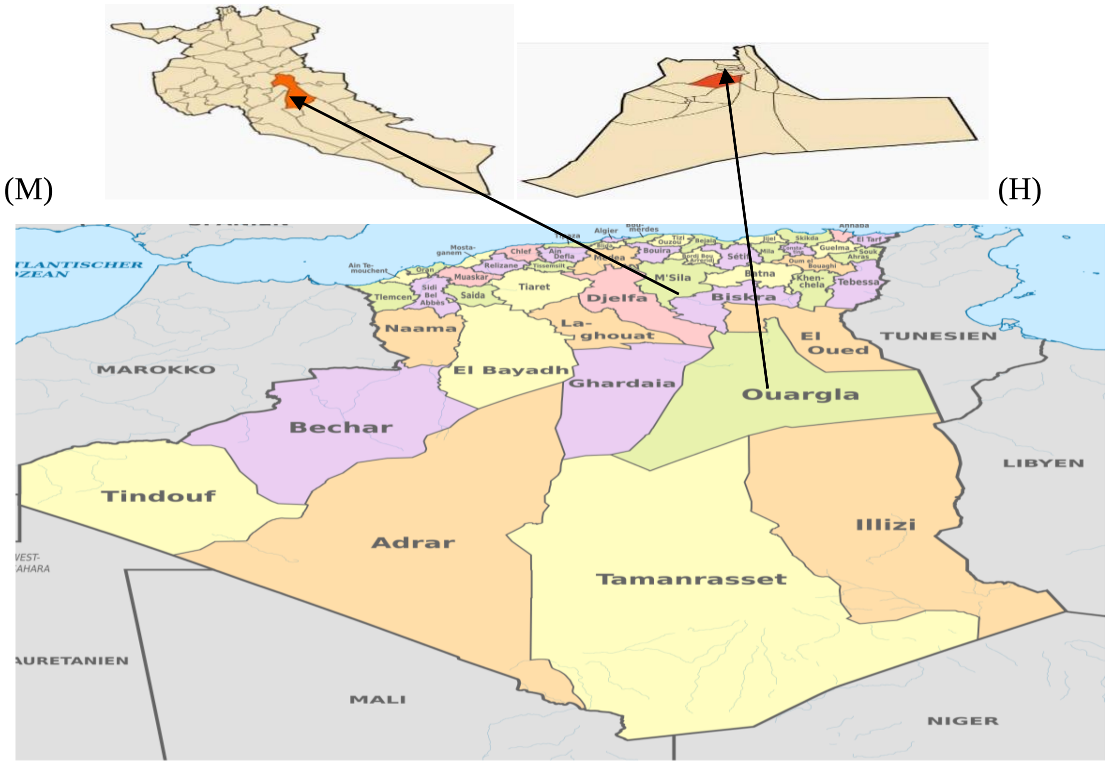
Material and Method

1-Objective

The objective of this work is to study the effect of salinity represented by two types of salt on physio -morphological behaviour of *Anabasis articulata* seeds.

2- Materials used

The plant material is composed of *Anabasis articulata* seeds. Mature seeds were collected in December 2022, from more than 30 individuals' plants from two populations growing on sandy soil in Moudjbara (Djelfa){ 34°**16'27.6"N 3°30'05.5"E}** and El Hadjira (El Hadjira) {**32°34'02.4"N, 5°42'01.5"E** } ,(map01).



Mape01: Location of Moudjbara and El Hajera in Algeria

These regions are semi-arid and arid with a typical Mediterranean climate, characterised by irregular rainfall events and a harsh dry summer period. Annual precipitation is 39 mm of (El Hadjira) and (Moudjbara) is 135 mm.

Five randomly chosen samples soil for each site were taken from 20 cm depth of 5 individual of *A.articulata.*

Photo (1): Seeds of grain *Anabasis articulata*.

3. Preparation of solutions

Salinity is represented by two types of salt: Chloride Sodium (NaCl), Calcium Sulfate (CaSO4) as stressors (Table01). Six saline solutions for each type of salt (100, 200, 300, 400, 500.600 mM) with control by distilled water (0 mM).

Table 01 : Salinity values for salin solutions.

{ C} mM	0	100 mM	200 mM	300 mM	400 mM	500 mM	600 mM
NaCl g/l	0	5.84	11.69	17.53	23.38	29.22	35.06
$CaSO_4$ g/l	0	17.22	34.43	51.65	68.87	86.1	103.30

4 Germination experiments

Seeds were surface sterilized in 1% sodium hypochlorite solution for 1 minute, to avoid fungus attack, washed with distilled water for three replicates. Germination experiment was conducted in 90 mm Petri dishes containing two disks of filter papers with 4 ml of test solution were prepared, in darkness, in incubators set at 25°C.

Seeds were germinated in 0, 100, 200,300,400,500 and 600 mM Chloride Sodium (NaCl) and Gypsum (CaSO4) solutions.

Four replicates of 25 seeds per treatment and per type of salt were used. During 12 days the germinated seeds were counted every two days. A seed was considered to have germinated when the emerging radical elongated to 2 mm. Distilled water equal to the mean water loss from dishes was added if necessary throughout the germination period.

4.1 Methods of germination expression

4.1.1 Physiological Parameters

4.1.1.1 Kenitic of germination

The germination kenitic is a germination curve which describes the progress of the germination of the seed lot considered placed in conditions well precise.

It most often represents the evolution of germination percentages accumulated over time.

4.1.1.2 Final germination Percentage

The final of germinated seeds (FG) or germination capacity expressed in %: On based on the total number of seeds used (Nt), we calculate the final percentage or maximum of germinated seeds (Ni) according to the relationship:

$TG = Ni \times 100 / Nt$.

4.1.1.3 Germination speed

Germination final also expressed by the velocity index, allows to express the germination energy responsible for the depletion of the reserves of the Seed, It is the variation over time of germination rates from the onset of First tip of the radical of one or more seeds until germination stability, Expressed by the germination rate obtained at a given time it can be expressed by different methods:

The germination (VG) is calculated as follows according to

$$VG = i\ (Ni x\ Di)/N$$

Ni: is the number of seeds germinated on day

Di: is the germination period in days

N: is the total number of germinated seeds

4.1.1.4 Morphological Parameters

After 12 days, we take three samples in each concentration in both slate ($NaCl$, $CaSO_4$) the lengths of the aerial parts (Length of stems: LT) and Radicals (LR) of the seedlings are measured using a graduated ruler.

Chapter tow

Result and Discutions

1. Results and Discussion:

The following Results express the parameter studied to show the effected of salt stress on the germination and growth of the species Anabasis articulata.

1. Physiological parameters:

1.1 Effect of saline stress on the germination kinetics of Anabasis articulata:

The evolution of the germination kinetics of *Anabasis articulata* subjected to deferent resorts; Mejbara (welaya Djelfa)**,** Hajera (welaya Hajera) with two salt NaCl, $CaSO4$ concentration as a function of time.

1.1.1 First germination kinetics of station Moudjbara Resort salt (NaCl)

The Cumulative germination percentages of *A.articulata seeds* treated with NaCl represented on Fig (1).

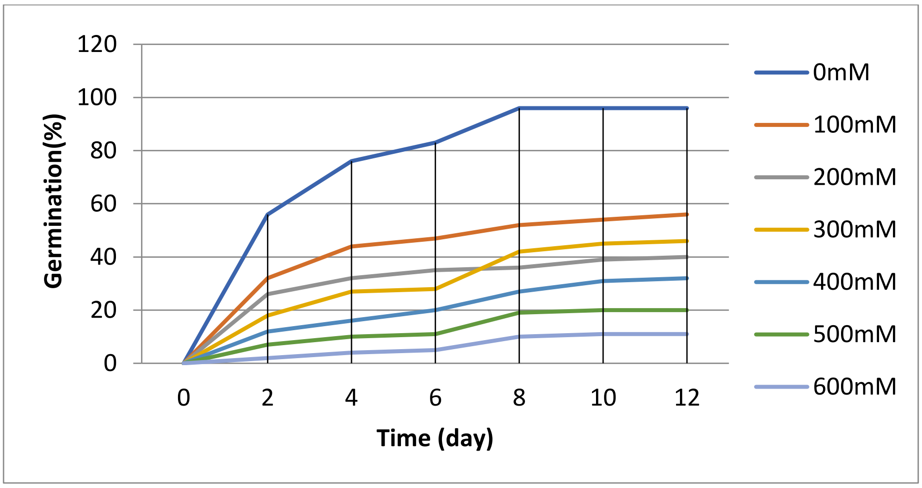


Fig (1): Cumulative germination percentages of *A.articulata seeds* treated with NaCl

- **Phase 1:** During the latency phase we recorded the appearance of the first germinations, this duration is variable according to the concentrations of NaCl, it is short (two days) In the control seeds and those irrigated by concentrations of 100 200, and 300 mM with percentages estimated of 44, 32, 27%, respectively, On the other hand, for the other concentrations (400, 500,600 Mm) the duration of the latency phase is longer.
- **Phase 2:** The increase in germination rates was noted from 56 to 96% in the control batch, which is clearly distinguished from the other batches.
- **Phase 3:** It corresponds to the germination capacity which differs for each concentration where the germination curves stabilize at the germinative capacity.

1.1.2 **Second germination kinetics of station El Hajera salt (NaCl)**

These Fig (2) Cumulative germination percentages of *A.articulata seeds* treated with NaCl.

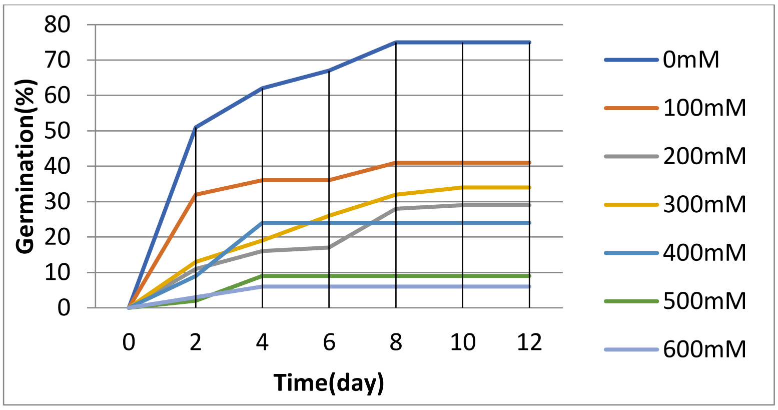


Fig (2): Cumulative germination percentages of *A.articulata seeds* treated with NaCl.

Phase 1: (from 0 to 2 days) This phase begins with the germination of the seeds of *A. articulata* until the first 48 hours, the C0 reached a value of 51%, while for the concentrations 100, 200 and 300 mM the values are 32%, 11%, 13%, while the lower values are recorded in the concentrations higher 600, 500 and 400 mM.

Phase 2: (from 2 to 8 days) it is a small progressive increase in seed germination with a rate of 75%, and the same for the other concentrations.

Phase 3: (from 8 to 12 days) at this stage the germination capacity has reached a stable stage for all concentrations.

1.1.3 First germination kinetics of Mejbara station salt (CaSO4)

The results of the effect of salt stress on the germination kinetics were expressed Fig (3).

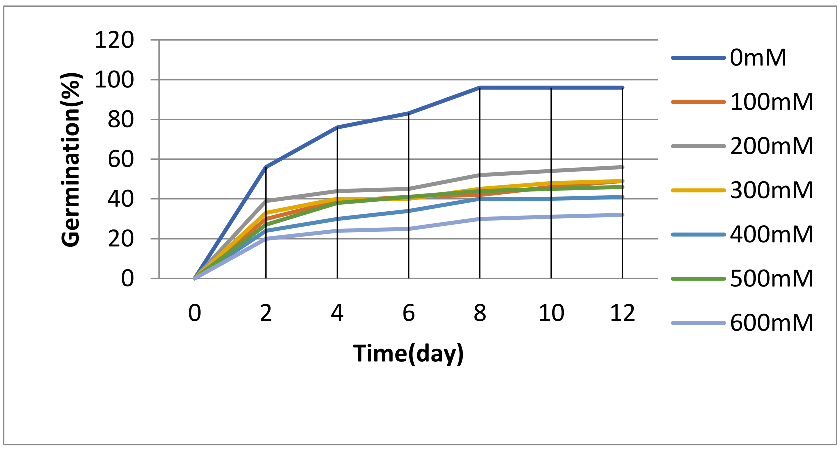


Fig (3): Cumulative germination percentages of *A.articulata seeds* treated with CaSO4.

The kinetics of seed germination under the effect of increasing concentrations of $CaSO_4$ comprising three phases:

Phase 01 (between 0 to 2nd day): The duration of this phase is variable according to the concentrations of $CaSO_4$, it is short (48h) for the control seeds with a rate of 56% and those irrigated by all concentrations of 100 and 200,300,400,500,600 mM of $CaSO_4$ with percentages estimated at 30,39,33,24,27and 20% respectively.

Phase 02 (between 4 and 8th day): The curves vary between the control and for the other treatments which are very close.

Phase 03 (between 8 and 12th day): we notice the stabilization of the curves which shows that the germinative capacity has been reached its corresponding to a germinative capacity.

1.1.4 Second germination kinetics of station El Hajera salt (CaSO4):

These Fig (4) Cumulative germination percentages of *A.articulata seeds* treated with NaCl.

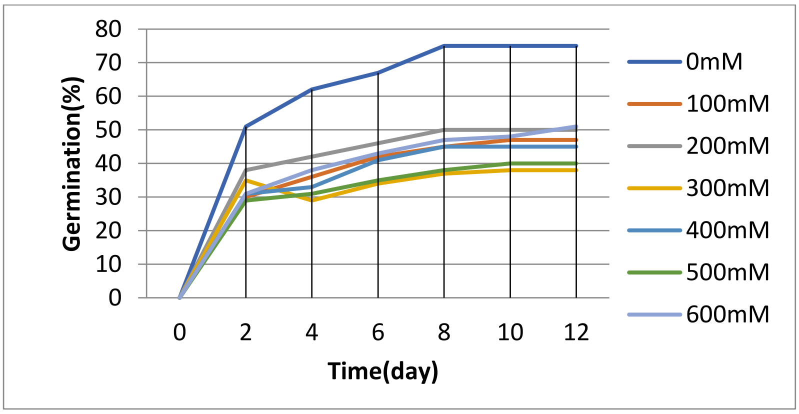


Fig (4): Cumulative germination percentages of *A.articulata seeds* treated With CaSO4.

phase 01 (0 to 2 days); this step is a prelude to the germination of the seeds, because we find that the germination reaches 51% after 48h for the control, concerning the concentrations 100, 200 and 300 mM the recorded values are estimated at 35, 38 and 36% respectively, the high concentrations 400 500 600 mM we recorded low results (31, 29, 31%).

Phase 02 (2 to 8 days); it is observed for this phase the continuation of the progressive increase in the kinetics of germination for all the saline concentrations.

Phase 03 (from 8 to 12 days); it can be seen that the germinative capacity of all the concentrations stabilizes in different proportions, for the control the maximum value is 75%.

Similar results were found in the halophyte plant *Zygophyllum Album* shows that Increasing the salt concentration, delays the rate and slows the Germination kinetics **(CHAOUCH KHOUANE and BOUKHETTA., 2014)** this result on the Germination kinetics which varies distinctly with species and treatment has been shown in Another Amaranthaceae, *Atriplexhalimus*, of Algerian origin from the Oran site **(ZAHI and LAMARA,. 2019)**
These studies and others have indicated that the seeds of glycophytes and halophytes respond similarly to salt stress, reducing the total number of germinated seeds and by showing a delay in the initiation of the germinative process **(MONDAI et al., 1988)**. According to **(BEN MILED et al., 1986)** this seems to be due to a time difference Necessary for the seed to put in place the mechanisms allowing it to adjust its pressure Internal osmotic.

1.2 Effect of saline stress on Final germination of *Anabasis articulata*

The following histograms represent the germination final of seeds of *A.articulata* under different concentrations of NaCl and CaSO4 for two rates (Mejbara, El Hajera):

1.2.1 First Germination Final of station Mejbara salt (NaCl)

The Effect of salinity (NaCl) of incubation on final germination of *A.articulata* seeds.

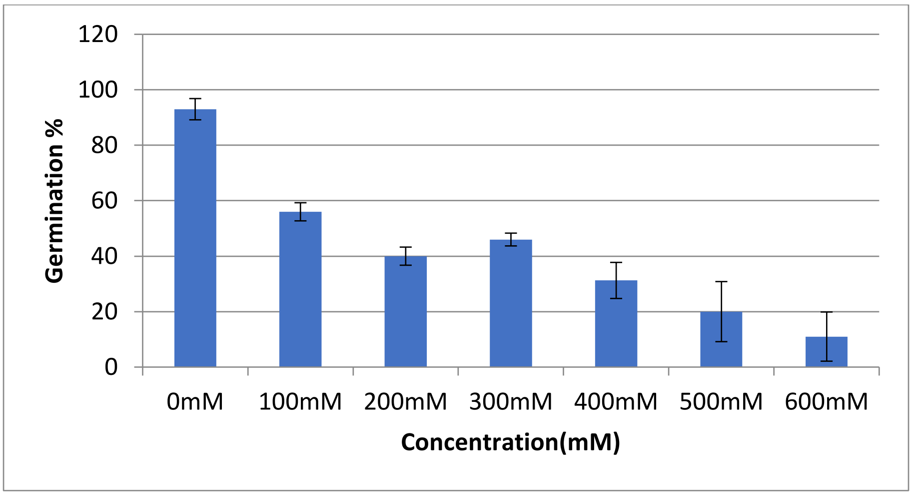


Fig (5): Effect of salinity (NaCl) of incubation on final germination (Mean ± standard error) of *A.articulata* seeds.

The percentages are high for low concentrations of salt (100, 200 and 300 mM) while it reaches a maximum value for the control 93% and decreases at high concentrations 400, 500, 600 mM with rates of 31.25, 20, 11%.

1.2.2 Second the germination final of station El Hajera salt (NaCl)

This Fig **(6) i**s the Effect of salinity (NaCl) of incubation on final germination of *A.articulata* seeds.

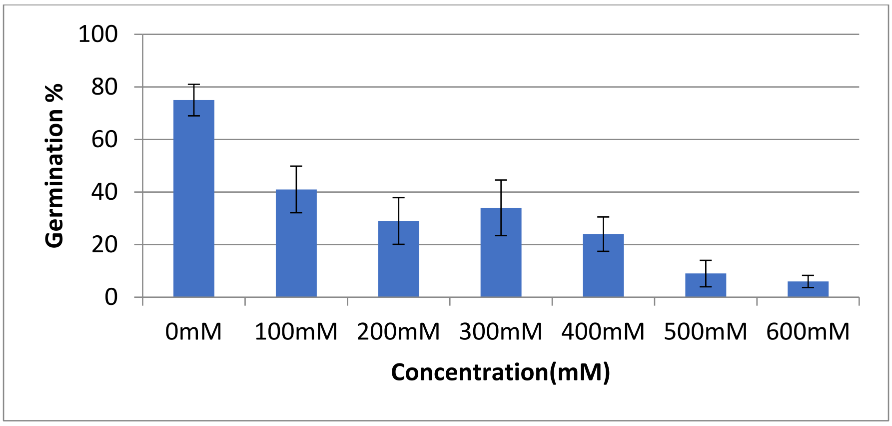


Fig (6): Effect of salinity (NaCl) of incubation on final germination (Mean ± standard error) of *A.articulata* seeds.

We recorded a gradient in the values of the germination final, at C0 we recorded the highest value (75%) for the concentrations of 100,200 and 300 mM, the percentages were 41, 29 and 34%, for the high concentrations of 400,500and 600mM the rates recorded are 24, 9 and 6%.

1.2.3 First the germination final of station Moudjbara salt (CaSO4)

This Fig **(7)** represented the Effect of salinity (CaSO4) of incubation on final germination of *A.articulata* seeds.

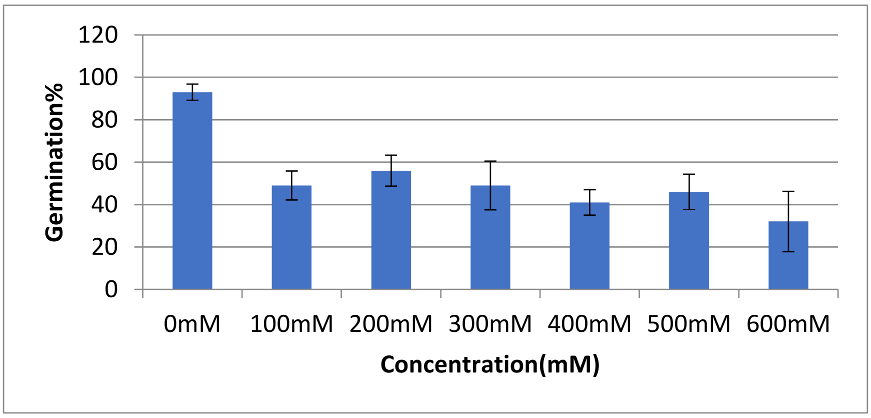


Fig (7): Effect of salinity (CaSO4) of incubation on final germination

(Mean ± standard error) of *A.articulata* seeds

In the control, GF reaches a value of 93%, concerning the low concentrations (100, 200,300 mM) the values are high and correspond to 49, 56 and 49% and at high concentrations of CaSo4, the levels of GF are low by 32 , 46, and 41%.

1.2.4 Second germination final of station El Hajera salt (CaSO4)

The results shown in Fig (8) presented the germination final of *A.articulata* seeds.

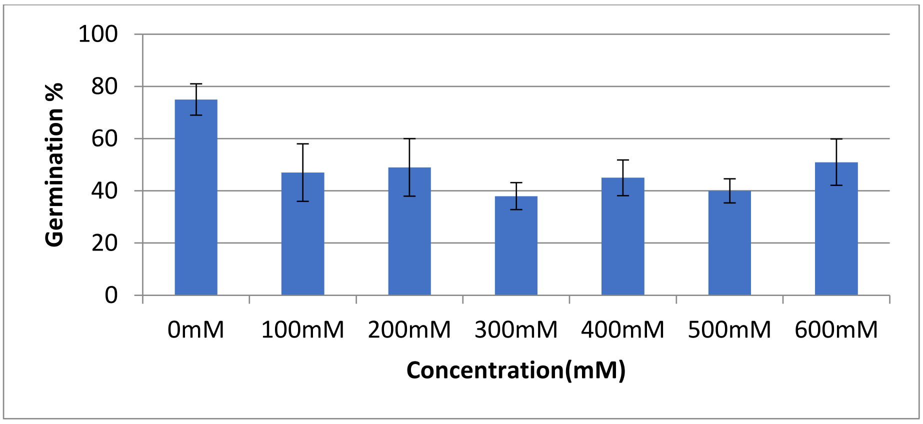


Fig (8): Effect of salinity of incubation on final germination

(Mean ± standard error) of *A.articulata* seeds

The results of the CaSO4 salt gave a maximum value whereas for the other treatments the curves are close to each other.

Similar results were obtained for several halophyte species **(ATIA et al.,(2009)** exposed to concentrations varying from one species to another. Plant germination, whether they are halophytes or glycophytes is affected by salinity **(GHAMNIA, 2013).**

Our result is similar to those obtained by **MAALEM and RAHMOUNE (2009)** who have Shown that salinity affects the final rate of germination of Atriplex seeds, these Results were affirmed by **DJERROUDI., (2015)** on the same species of which they showed that Seed germination is maximal in distilled water and decreases with increasing salt concentration in the medium. Other study on the germination of the halophyte species *Zygophyllum album* made by **BENLIFA and BENMERIEM (2019)** show that the Increase NaCl concentration promotes a significant decrease in final germination rate.

According to **PRADO et al. (2000),** the decrease in the germination rate of seeds subjected to Salt stress would be due to an osmotic dormancy process developed under these conditions of stress, thus representing an adaptation strategy with regard to the constraints environmental. According to **POLJAKOFF et al. (1994)** and **KHAN et al. (2001)** the effect of Salinity on germination is generally attributed to osmotic effects due to the decrease in the potential for soil solute or toxicity effects due to absorption and/or accumulation to certain ions in the form of sodium and chloride.

1.3 Effect of saline stress on the germination speed of *Anabasis articulata*

The following histograms represent the germination rate as a function of the salt concentrations, we note

1.3.1 **First the germination speed of station Moudjbara salt (NaCl)**

The results of the effect of salt stress on the germination speed are presented in the Fig (9).

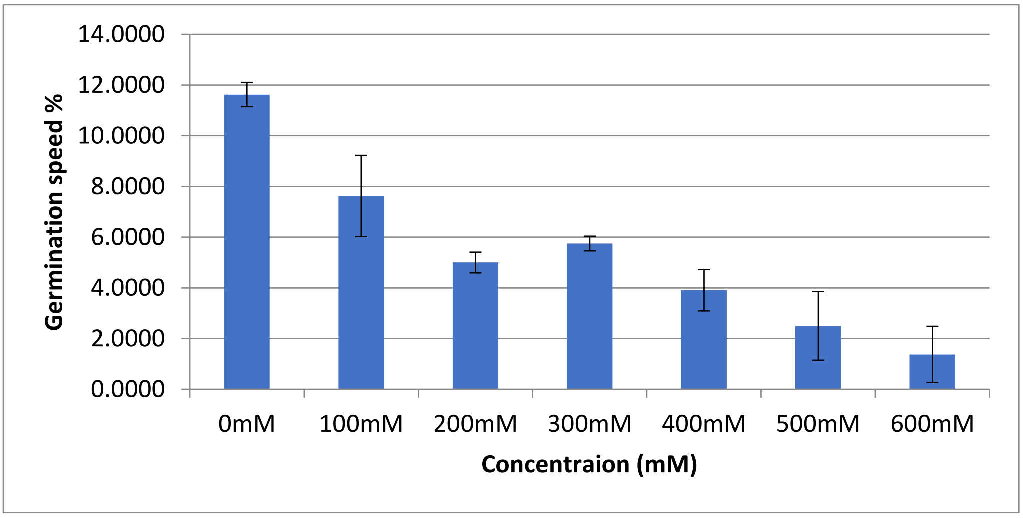


Fig (9): Effect of salinity (NaCl) of incubation on Germination speed (Mean ± standard error) of *A.articulata* seeds

The germination rate reaches 11.6% for the control and gradually decreases for the treatments. At low concentrations (100, 200, 300 mM) it corresponds to the following values: 7.6, 5, 5.7% and for high concentrations it decreases to reach 1.3% for the 600 mM concentration.

1.3.2 **Second the germination speed of station El Hajera salt (NaCl)**

The Effect of salinity (NaCl) of incubation on germination speed of *A.articulata* seeds in Fig (10).

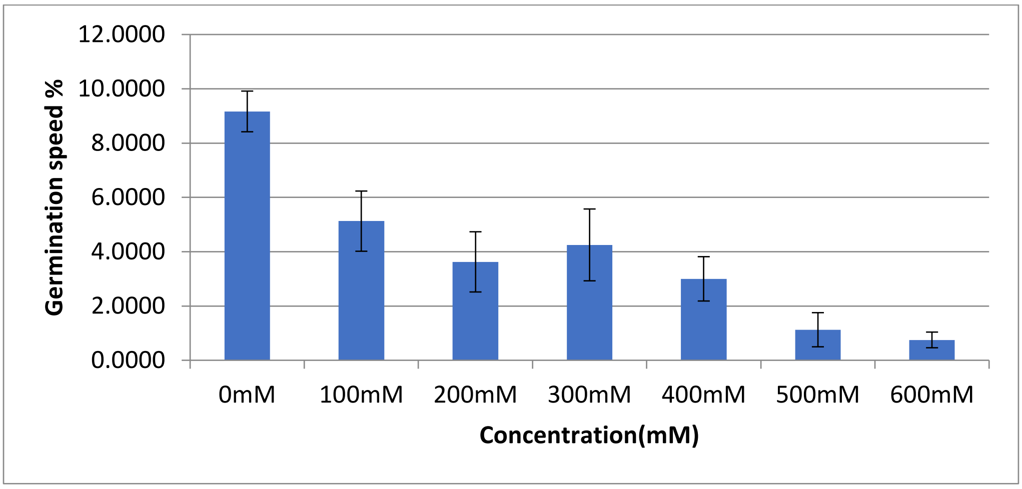


Fig (10): Effect of salinity (NaCl) of incubation on germination speed (Mean ± standard error) of *A.articulata* seeds

A gradual and fluctuating decrease in speed was observed from treatment C1 with a value of 5.12 % until reaching the lowest germination speed for treatment C6 with an estimated value of 0.75%.

1.3.3. First germination speed of station Moudjbara salt (CaSO4)

The Effect of salinity (CaSO4) of incubation on germination speed of *A.articulata* seeds presented in Fig (11).

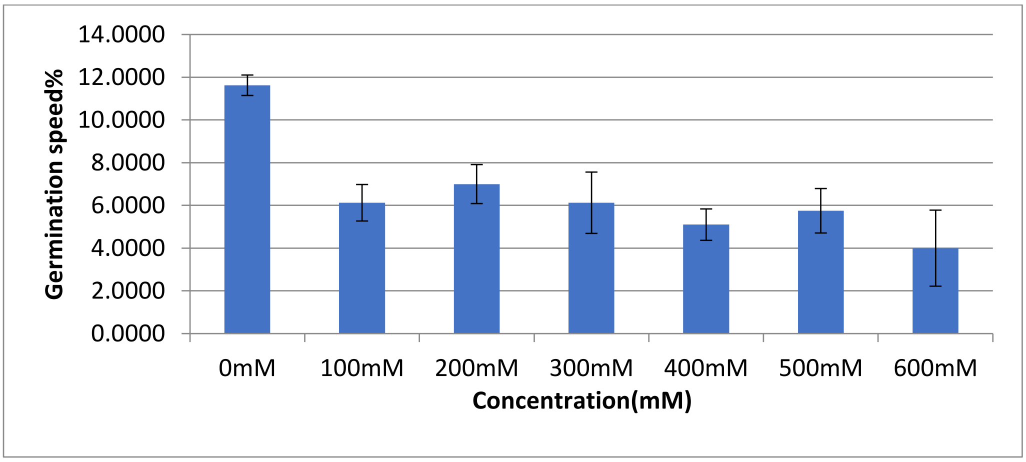


Fig (11): Effect of salinity (CaSO4) of incubation on GS (Mean ± standard error) of

A.articulata seeds

At the concentration C0 the value of GS reaches 11.62% then it gradually decreases for the concentrations 100,200 and 300 mM with values of 6.1%, 7%, 6.1%, and concerning the high concentrations: 600, 500,400 mM we have saved these values 5. 1, 5.7, 4%.

1.3.4 Second germination speed of station El Hajera salt ($CaSO_4$)

The Effect of salinity ($CaSO_4$) of incubation on GS (Mean ± standard error) of *A.articulata* seeds in Fig (12).

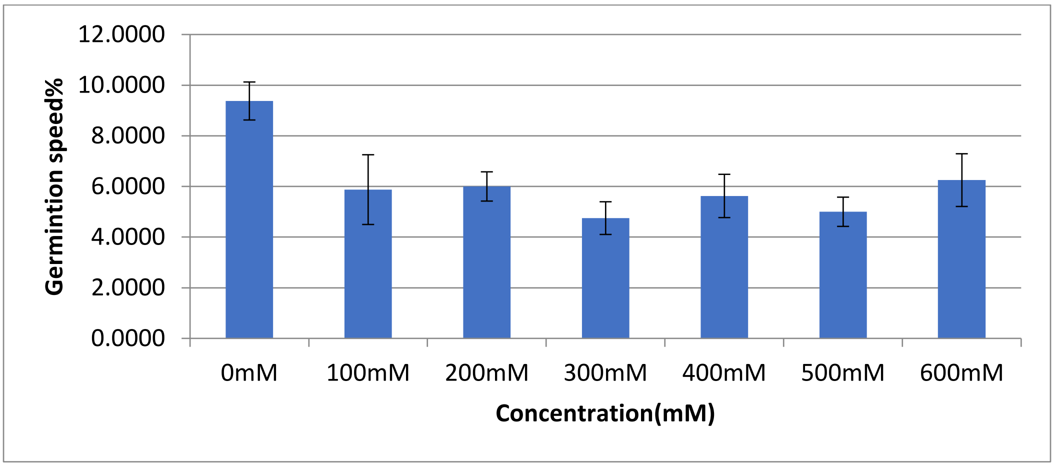


Fig (12): Effect of salinity ($CaSO_4$)of incubation on GS (Mean ± standard error) of *A.articulata* seeds

We note that the germination rate of the control is high with a value of 9.16% similar to the values of GS for the other salt concentrations from 100 to 600 mM.

Our results are In agreement with the data of the literature which indicate that the Seed germination of most halophytes is optimal In distilled water and reduced Under moderate salinity, while it is inhibited with Increasing salinity **(LEE et al., 2010)** Several studies have shown that the application of different salt concentrations on the Seeds of halophytes such as glycophytes negatively affects the rate of germination.

A comparative study was made by **EL-KEBLAWY and ARVIND BHATT (2015)** on the Seeds of two halophytes *Halocnemumstrobilaceum* and *H. perfoliata* show that the different Salinity levels caused a greater increase in GMT this is explained by the slowing down of the speed according to the Increase in NaCl. Although both Species are affected by salt, tolerance was higher In *H.strobilaceum* than in *H.Perfoliate*. Germination at 400 mM NaCl was higher and faster in *H. Strobilaceum (*Rate: 40%, GMT: 4.8 days) than In *H. perfoliata* (Rate: 10% GMT: 7.3 days). According to **BEN GAMRA (2007),** salinity reduces on the one hand, the speed of germination and on the other hand, its germination capacity

(EL HAJJOUJI et al., 2007).

The disturbances observed could be explained by a decrease in the osmotic potential of the medium following the addition of Salt **(MAUROMICAL and LICANDRO, 2002).** It can also be explained by the time needed to the seeds to set up to adjust its internal osmotic pressure **(BLISS et al., 1986). SO That GHRIB et al., 2011,** explained that this delay could be due to the alteration of enzymes and Hormones found in the seed.

1.4 Effect of saline stress on Root and Shoot Length of *Anabasis articulata*

1.4.1 Station Moudjbara

1.4.1.1 For NaCl

1.4.1.1.1 Shoot length: According to the results, the length of the rods is clearly remarkable for the control batch (0 mM) with a value greater than those of the 100 and 200 mM concentrations with values of 22.32 and 18.65 mm respectively, for the remaining concentrations (300,400, 500, 600 mM) the LT decreased regressively (13.43, 13.18, 7.48, 5.87mM),this result presented in the Fig(13).

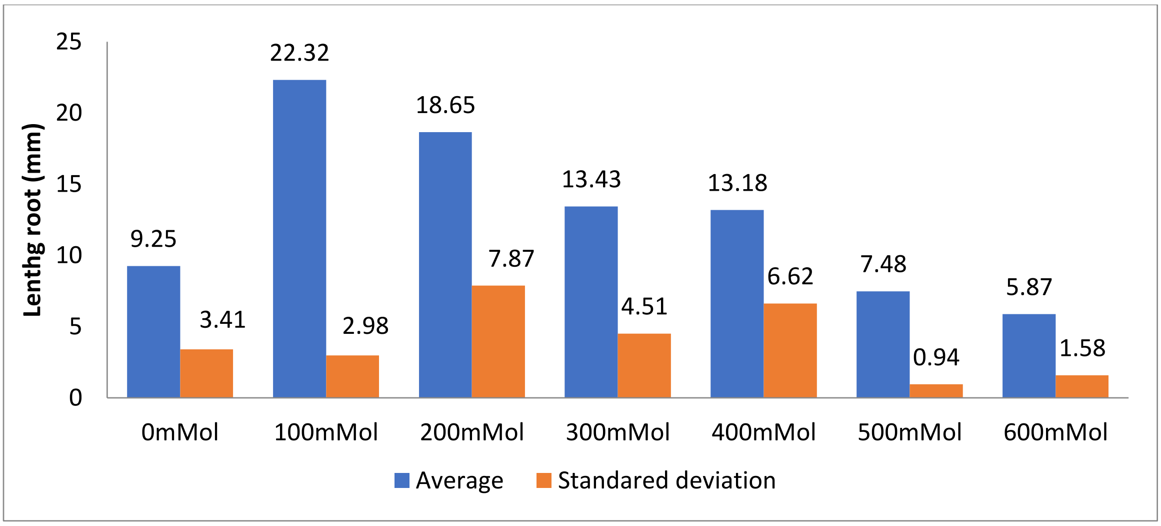


Fig (13): Effects of different NaCl concentrations on shoot length of *Anabasis articulata.*

1.4.1.1.2 Root Length: The results obtained for NaCl concerning the effect of salinity on the length of the roots of the seedlings of *A. articulata* show good results for the concentrations 100 and 200 mM so that the LR reaches respectively 9.01 and 11.23 mm, compared to the control with a value of 4.31 mm, whereas for the high concentrations of 300, 400, 500 and 600 mm, a decrease in rootlets is observed, estimated respectively at (4.51, 3.73, 3.19 and 2.95 mm).

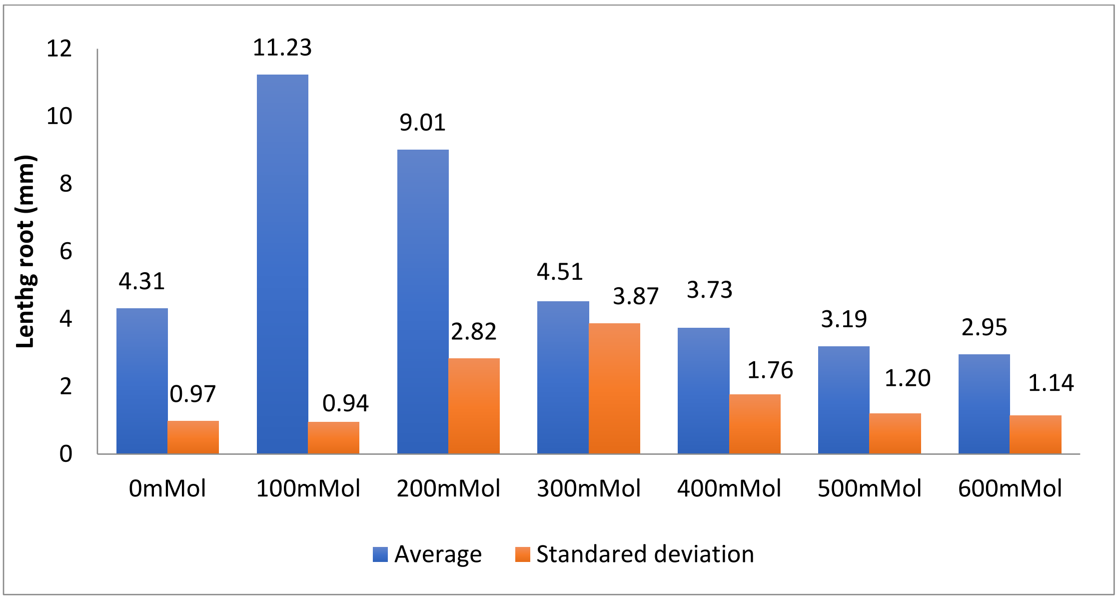


Fig (14): Effects of different NaCl concentrations on root length of *Anabasis articulata.*

1.4.1.2 .For CaSO4

1.4.1.2.1 Shoot length: the results vary for the different treatments compared to the control with a value of 9.25 mm and for the concentrations 100, 200, and 300 mM we note a progressive and sequential increase in the SL of the seedlings estimated at 12.14, 17.62 and 22, 23 mm respectively while for the strong concentrations 400,500 and 600 mM one notices a fluctuation of the length of the rods (14.72, 21.41 and 14.67 mm).

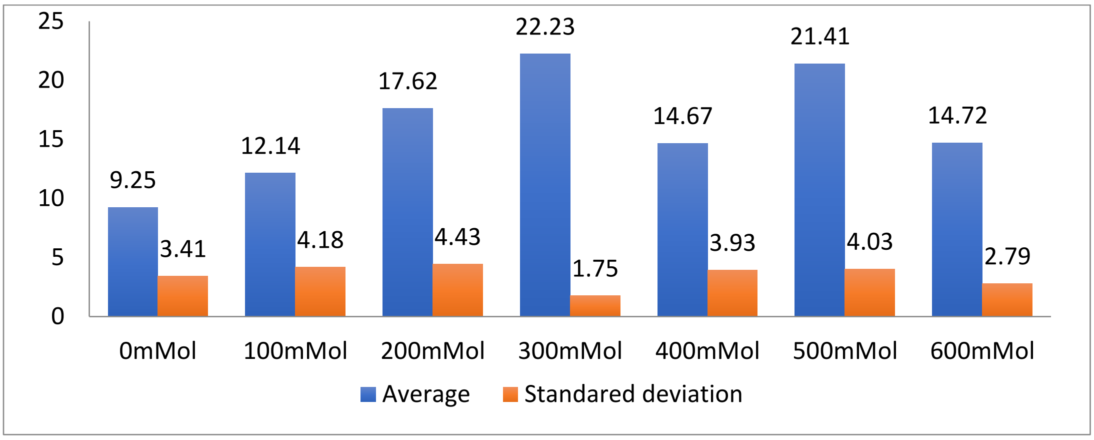


Fig (15): Effects of different CaSO4 concentrations on shoot length of *Anabasis articulata.*

1.4.1.2.2 Root Length: Concerning the root length of the witness is 4.31 mm then one notices increase in the values of RL at the concentrations 100, 200, 300, 400, 500 mM with values of 6.41, 5.6, 8.29, 5.85 and 7.37mM, however; for the last concentration of 600 mM, a close value is recorded with the value of the control rootlets 4.74 mm, this result presented Fig (16).

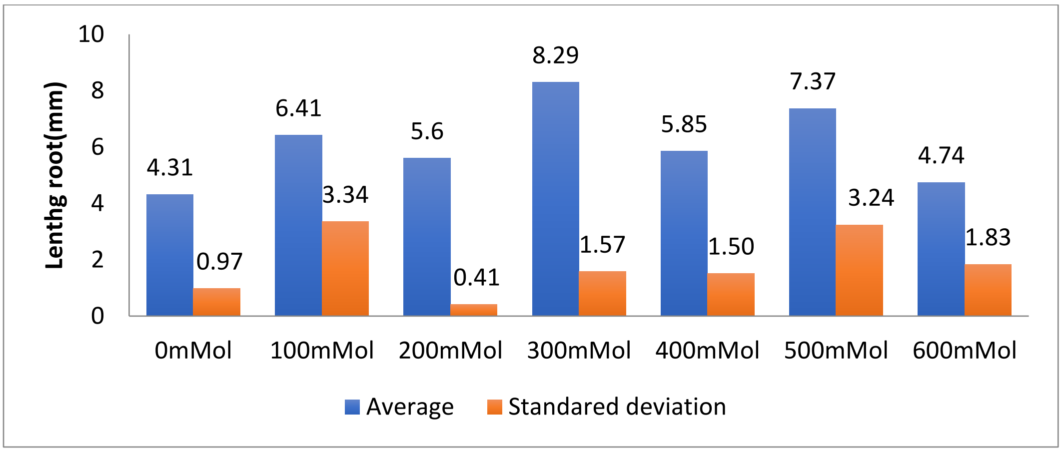


Fig (16): Effects of different CaSO4 concentrations on root length of *Anabasis articulata.*

Root length, root length density and thick roots which are the features of the root, are very vital in development of subsoil parts of plant by taking the existing water. A fertile root system during early seedling stage which is the most sensitive stage provides advantage in accelerating growth. Since the water which is taken by plant In danger of being lost easily as a result it has to be taken from non-deep layers of soil (Shah S,.2014.)

Roots are one of the vulnerable parts of the plant. While under salt stress reduction in root length is being seen, In addition to salt stress not being able to use the existing water negatively affects root and shoot growth of plant. Besides all of these negative effects, roots are also known as surprisingly strong when they directly exposed to salt stress (Shah S,.2014.)

1.4.2 Station El Hajera:

1.4.2.1 For NaCl:

1.4.2.1.1 Shoot length:

This Fig (17) are presented the **effects** of different NaCl concentrations on stem length of *Anabasis articulata.*

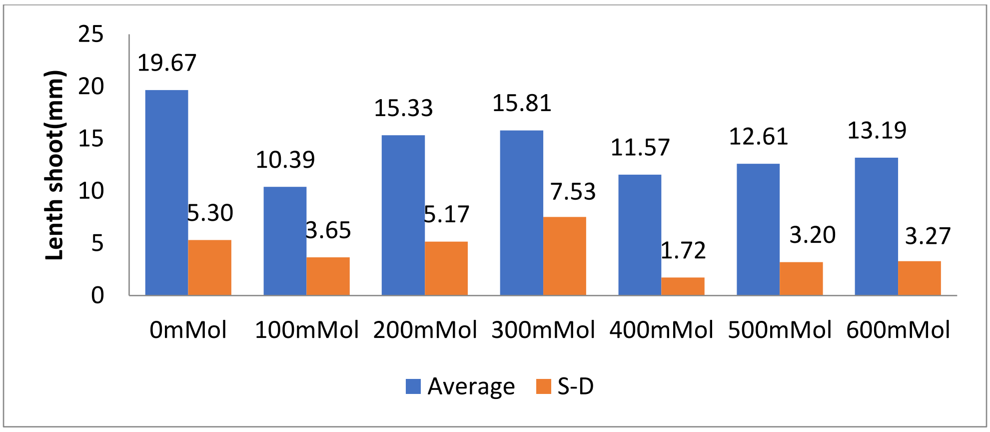


Fig (17): Effects of different NaCl concentrations on shoot length of *Anabasis articulata.*

It is noted that for the control seedlings the length of the stems is estimated at 19.67 mm as for the other concentrations (100, 200 , 300, 400 and 500 mM), a fluctuating increase close to the length of the stems Is recorded with the following values (10.32, 14.39, 11.41, 11.38, 11.72 and 12.37mm)

1.4.2.1.2 Root length

Fig (18) is presented the Effects of different NaCl concentrations on root length of *Anabasis articulata.*

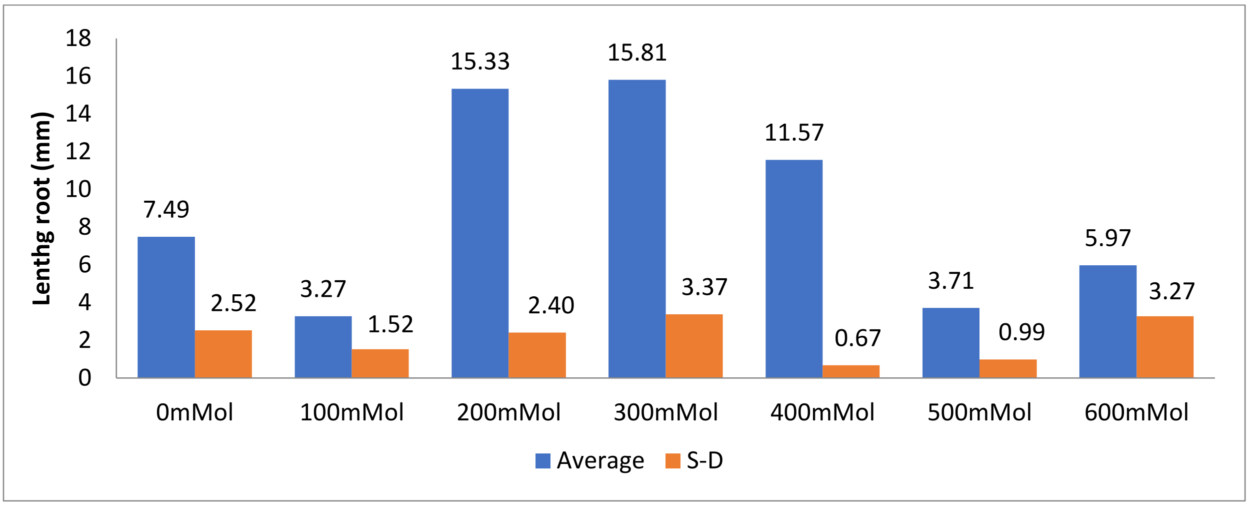


Fig (18): Effects of different NaCl concentrations on root length of *Anabasis articulata.*

For the control batch, the length of the rootlets Is 7.49 mm, It decreases to 2.62 mm for the C1 treatment then increases for the C2 C3 and C4 treatments with the following values 3.82, 4.03, 5.54 mm and for C5 and C6 we recorded these values 4.13 and 5.57 mm.

1.4.2.2 For CaSO4

1.4.2.2.1 Shoot length

The Effects of different NaCl concentrations on shoot length of *Anabasis articulata.* are presented *in* Fig(19).

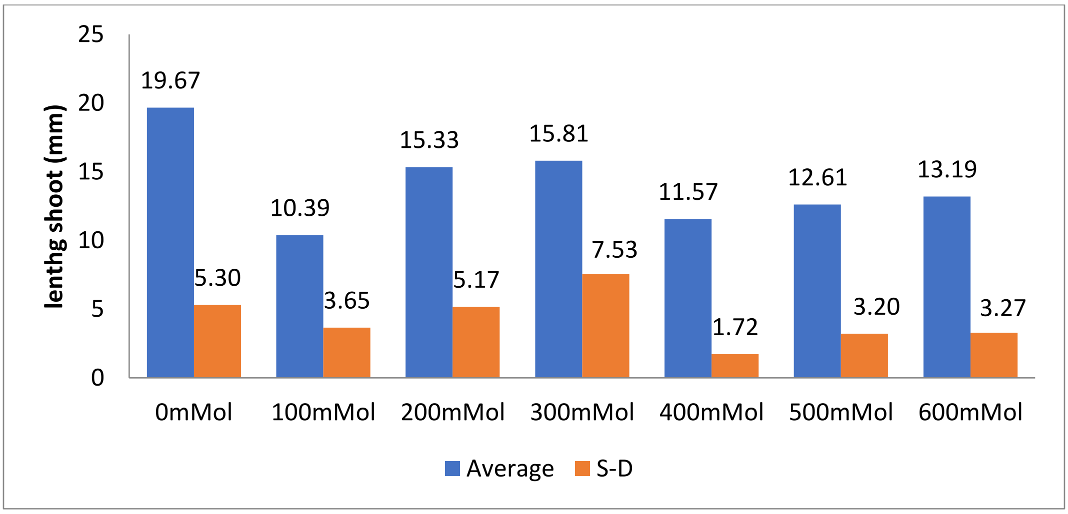


Fig (19): Effects of different NaCl concentrations on shoot length of *Anabasis articulata.*

For the average of control rods a value of 19.67 mm is recorded and for the other treatments the results are fluctuating and lower than the length of the control rods 39, 15.33, 15.81, 11.57, 12.61 and 13.19 mm.

1.4.2.2.2 Root length:

The effects of different NaCl concentrations on root length of *Anabasis articulata* presented in the Fig (20).

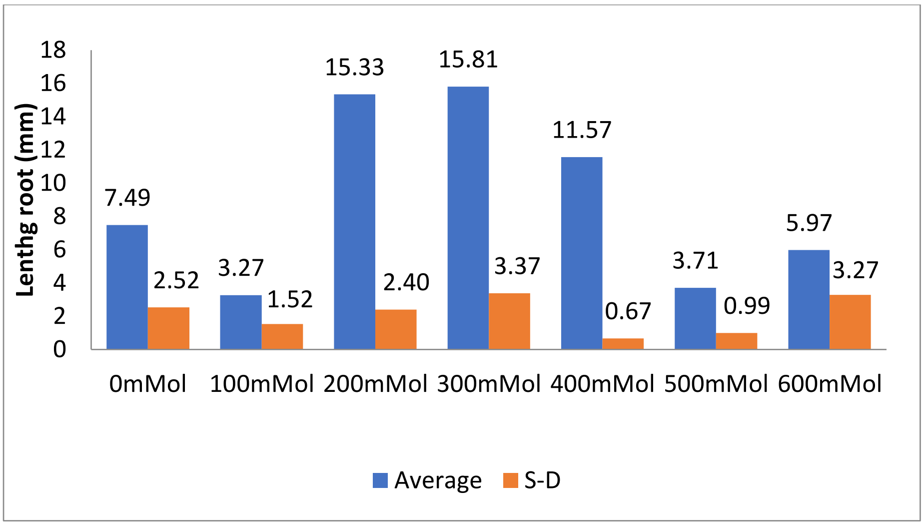


Fig (20): Effects of different NaCl concentrations on root length of *Anabasis articulata.*

We note that the lengths of the rootlets are unstable, we record for the control a value of 7.49 mm, the results Increase in a remarkable way for the treatments C2, C3 and C4 with the following values 15.33, 15.81 and 11.57 mm respectively and the results are lower for the C1, C5 and C6 treatments with the following results 3.27, 3.71 and 5.97mm.

This is a common phenomenon in plants under salinity stress **(Hanson et al., 1994).** Many plants experience a reduction in seedling root and shoot Lengths under saline conditions. This could be due to the harmful effects of NaCl, as Well as a lack of water and nutrient intake [Jantaro et al., 2003]. Furthermore, salt can have a deleterious Impact on cells, tissue, and organ ultra structure **(Hasegawa et al., 2000)** Secondly, salinity, through osmotic and specific ion toxic effects, prevents the preservation of sufficient nutrient levels important for plant growth, reducing root and shoot emergence, and seedling growth **(Ayers, 1985, Botella et al., 2007 Ashrafijou et al., 2010).** Our Findings are in line with the results of **(Shahzad et al., 2019, Jamil et al., 2006)**, where the seedling growth of Sorghum bicolor and *Festuca arundinacea* showed a constant decline with the increase in salinity treatment. Moreover, the exposure of plants to high temperatures can have morphological implications, Such as sunburn on the entire plant's shoot, leaf senescence, and root and shoot growth Inhibition **(Mansour, 2000).**

21

Conclusion

Conclusion:

In conclusion, the results obtained from this study show that the seeds of *A. articulata* are characterized by their ability to germinate rapidly at a satisfactory rate (96%) under non-saline conditions (C0), and the germination behaviour indicates that for the different concentrations of NaCl and $CaSO_4$; the salt stress delays the germination process (kinetics, rate and speed of germination). Thus the salinity has an effect on the length of stems and rootlets. This effect becomes more remarkable with the increase in the saline concentration; on the other hand, a tolerance to saline stress is recorded for a few batches.

Additionally, by the nature of the toxic Salt Ions present in saline solutions, the plant creates resistance and a response to adapt to toxins or any external environmental confrontation.

The effect of Caso4 on the germination and post germination phase is more remarkable than the effect of NaCl salt.

The seeds collected from the Moujbara station show a tolerance to salt stress superior to the response of the seeds collected from the El Hajera station.

To complement this work, advanced research can be conducted to assess physiological and biochemical changes in order to further investigate medicinal extracts that may appear for this species under conditions of high saline concentrations.

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Abstract:

Anabasis articulata is a wild halophyte desert shrub belonging to the Amaranthaceae, mainly distributed in arid and semi-arid bioclimatic stages. The present study aims to investigate the physio-morphological behavior of *Anabasis articulata* seeds facing salt stress at germination and post-germination stage. For these, seeds were germinated under different concentrations of NaCl and CaSo4salts (0, 100, 200,300,400,500and 600mM), physiologically, the highest germination percentages were obtained at 100mM NaCl; however, the increase of solution osmolisete progressively inhibited seed germination. The germination rate decreased with an increase in salinity for most of tested temperatures. Salt stress decreased both the percentage and the rate of germination. By experimental transfer to distilled water, *A.articulata* seeds that were exposed to moderately saline conditions recovered. Morphologically, we recorded a proportional reduction of seedling growth (Root and shoot) with the increase in salinity. The results also show that despite the effect of Depressive of salt, *A. articulata* tolerated salt stress.

Keywords: *Anabasis articulata*, Germination, Salinity, Recovery, Post-germination.

الملخص

العجرم أو ما يسمى باللاتينية *Anabasis articulata* هي شجيرة صحراوية برية ملحية تنتمي لفصيلة Amaranthaceaeتتوزع بشكل أساسي في المناخين الحيويين القاحل وشبه قاحل,تهدف الدراسة الحالية إلى دراسة السلوك الفيزيولوجي والشكل الظاهري لبذور العجرم *Anabasis articulata* التي تواجه الإجهاد الملحي في مرحلة الإنبات ومرحلة ما بعد الإنبات،بالنسبة لهذه البذور فقدتم إنباتها بتراكيز مختلفة {600,500,400,300,200,100} ملي مول, من ملح كلوريد الصوديوم وملح الجبس ،من الناحية الفسيولوجية،تم الحصول على أعلى نسب الإنبات عند (100)ملي مول من كلوريد الصوديوم, ومع ذلك،فإن زيادة في أسموزية المحلول تمنع بشكل تدريجي إنبات البذور. إنخفاظ معدل الإنبات مع زيادة الملوحة لمعظم درجات الحرارة المختبرة . قلل الإجهاد الملحي من نسبة الإنبات ومعدل الإنبات. عن طريق النقل التجريبي إلى الماء المقطر،تم استرجاع بذور العجرم التي تعرضت لظروف ملوحة معتدلة. أما من الناحية الظاهرية سجلنا انخفاضًا نسبيا في نمو (الجذر والساق)الشتلات تناسبا مع زيادة الملوحة كما أظهرت النتائج أيضا أنه على الرغم من تأثير مثبطات الملح،فإن العجرم تتحمل الإجهاد الملح.

Résumé:

Anabasis articulata est un arbuste spontané du désert halophyte appartenant aux Amaranthaceae, principalement distribué dans les étages bioclimatiques arides et semi-arides. La présente étude vise à étudier le comportement physio-morphologique des graines d'Anabasis articulata face au stress salin au stade de la germination et de la post-germination. Pour celles-ci, les graines ont germé sous différentes concentrations de sels NaCl et CaSo4 (0, 100, 200, 300, 400, 500 et 600 mM), Physiologiquement, les pourcentages de germination les plus élevés ont été obtenus à 100 mM NaCl ; cependant, l'augmentation de l'osmose de la solution a progressivement inhibé la germination des graines. Le taux de germination a diminué avec une augmentation de la salinité pour la plupart des températures testées. Le stress salin a diminué à la fois le pourcentage et le taux de germination. Par transfert expérimental dans de l'eau distillée, des graines d'*A. Articulata* exposées à des conditions modérément salines.

Mots clés: Halophyte, *Anabasis articulata,* Germination, Salinité, poste germination, recouvré.