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Evaluation of Pearl Millet Ecotypes Under Saline Conditions

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Dedication

This project is dedicated to my mother, father, husband , sisters, brother and friends**.**

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الإقرار

إنا الموقع أدناه مقدم الرسالة التي تحمل عنوان:

Evaluation of pearl millet ecotypes under saline conditions

اقر بان ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل من أو جزء منها لم يقدم من قبل لنيل أية درجة أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification**.**

Student's name:	**اسم الطالب:**
Signature:	**التوقيع:**
Date:	**التاريخ:**

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List of Abbreviations

Abbreviation	Full Name
FW	Fresh Weight
PEG	Polyethylene Glycol
RWC	Relative Water Content
TW	Turgor Weight
DW	Dry Weight
ADF	Acid Detergent Fiber
NDF	Neutral Detergent Fiber

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Abstract

This study was conducted to investigate the effect of differential saline levels on the growth and development of nine Pearl millet accessions (*Pennisetum glaucum*). The experiment was conducted at the research station of the Faculty of Agriculture, An Najah University, Tulkarm, Palestine. The seeds were planted on 4th of April 2016; seeds of the nine accessions were planted in plastic containers filled with sandy soil. Five plants were placed in each container. The plants were irrigated with three salinity levels (fresh water as a control, 75 mM , 150 mM NaCl), with three replicates for each treatment. The results demonstrated that germination percentages, radical and coleoptile length were significantly affected by increasing salinity level. Highest germination percentages at 0 salinity level (control) were observed in accessions IP 6104.

The germination percentage for all accession decreased significantly for 100 mM , 150 mM and 200 mM except IP 6104 accession . in the high level 250 mM the germination percentage decreased significantly, the highest germination percentage IP 19612 accession. the lowest germination

percentage was recorded with Sudan pop III, Sudan pop I, ICMS 7704, MC 94 C2 and ICMV 155 accessions.

Shoot length was found to be significantly reduced when salinity level was increased. However, the average tillers number was not affected by salinity. And significant differences were observed among accessions on shoot length and tillers number .

Chlorophyll content was found to be significantly affected by salinity. were the chlorophyll content decrease when salinity level increase.

No significantly different was conducted between accessions. the nine accessions exhibited statistically different root fresh and dry weight and shoot fresh weight but shoot dry weight not affected significantly . Ash content decrease significantly per salinity treatment and at all accessions Ash content was differ.

Neutral detergent fiber (NDF) content of the different accession was not significantly affected with salinity treatment.

In conclusion, the present study demonstrated the ability of pearl millet to grow under saline condition. As such, indicating that this forage crop has a good potential for planting in areas with high soil salinity. Additionally, cluster analysis show that the MC 94 C2 accession provided the best results in germination and field experimentation.

Chapter One
Introduction

Water shortage is one of the most important limiting factors for crop production in the world (Seghatoleslami et al., 2008). The growth and development of land plants are largely influenced by water availability. Agriculture in Palestine specifically depends mainly on the regional rainfall. as such the availability of forages and cereal crops is highly seasonal.

Palestine is one of the countries with the most limited of renewable water resources due to both natural and political constraints, with avarage 100 cubic meters per capita per annum. This amount is far below the available water levels in other countries in the world. (Jayyousi et al, 2004).

In addition, Palestine suffers from natural water resources that are highly restricted. The existing regulations imposed by the Israeli government on Palestinian water utilization and the denial of access to the ground water aquifers, the Jordan River, have further reduced available water quantities (Bushnaq, 2004). In Palestine the total available water is 291 MCM per year (The World Bank, 2004), among this, agriculture is consuming 150 MCM , which is equivalent to 51.5% of all water usase . Moreover, the irrigated area is only limited to be 8% of the agricultural area in West Bank and 11% in Gaza (PCBS, 2007). In other studies it is estimated that 247,000 dunums out of 708,000 depend on irrigation (The World Bank, 2009).

The livestock sector in Palestine plays a significant economic role and is essential for the food security mainly for the rural population. The high prices of red meat in Palestine has a negative impact on food security of the population. The elevated prices of red meat is mainly due to the high cost of production, therefore, livestock farming is increasingly being limited by the restriction of grazing lands. Legume forage species are valuable source of feed that have been providing significant contributions to agricultural and animal production. The limited water resources restricted the expansion of cultivated forages and other crop. Water scarcity is one of the main problem that restrict the production of forage crops in arid and semi arid regions. Currently the livestock sector in Palestine agriculture is facing a severe dilemma, where the farmers are using the available land resources for vegetables, field crops and trees cultivation, and they import forages for their animal feeding .The forage production sector in Palestinian agriculture is very weak, where it is only forming 4% of the total planted areas in Palestine(PCBS, 2007; Alhaj Hussein et al, 2010), the amount of forages production is less than the required for animal form, however some farmers produce forage crops to reduce the cost of forages (Mansour, 2009). These factors lead to a pressured need to develop the forage production sector and increase the productivity of forages in Palestine.

Pearl millet is a key crop in arid and semiarid regions which needs less water than other crops (Rostamza et al., 2011). Pearl millet is a cereal crop that was domesticated initially in Africa centuries ago (Manning et al., 2011). Landrace open-pollinated cultivars of pearl millet exhibit high levels of vegetative vigor and a very high biomass production. These are necessary adaptive features for the crop to survive stressful conditions (Andrews et al., 1993). Millet is mainly used for feeding.

The Jordan valley is classified as arid area related to low rainfall and high evapo-transpiration (ET) Rainfall varies from less than 100 mm in the central region to more than 600 mm in the mountains. Groundwater is the main source of water for both domestic and agricultural use. Previously water demand and supply were relatively well balanced. However, more recently high water demand has led to over pumping and prolonged lack of rains has reduced the extent of recharge (P.W.A).

Salinization is the process of increaseing salts in soil and water to toxic level for plants. Two types of salinization are identified: one natural and one anthropogenic; so-called ‘secondary salinization’. This paper focuses on secondary salinization. Natural (primary) salinization is essentially restricted to closed (endorheic) drainage basins in semi-arid and arid regions of the world; these regions are also where secondary salinization is most common. The area of semi-arid and arid regions (drylands) is almost one-third of total land area. In these regions, annual rainfall is 25–500 mm.

Over pumping causes elevated salt levels and therefore, increasing salinity (Saleh, 2007). In addition, the limited availability of water resources and the increase in water demands have resulted in an accelerating water shortage in the West Bank. These shortages are negatively affecting the agricultural sector and thus limiting the expansion of agriculture in the West Bank. The lack of water resources has encouraged use of non-ordinary water including saline water, municipal and industrial wastewater (Galavi 2009).

Salinity is currently one of the most severe abiotic factors limiting agricultural production in Palestine. In arid and semiarid lands, the plants are subjected through their life cycle to different stresses, these plants tolerate these stresses in different ways depending on plant species and the type of stress.

Salinity is one of the major factors that limit the geographical distribution of plants and is responsible for significant reductions in the yield and quality of many important crops (Chen et al, 2011). The selection and characterization of salt-resistant species are important to ensure future productivity of the arid agricultural region. Therefore, the ultimate objective of this research is to introduce crops such as pearl millet (*Pennisetum glaucum* (L)) that can tolerate salinity and are valuable as food or animal feed (Kafia et al,2009).

Objectives

The objectives of this study are:

1. To evaluate the effect of different water salinity levels on the germination of millet seeds.

2. To evaluate the effect of different salinity levels on the growth of different millet genotypes.

3. To evaluate the effect of saline water on the nutritional value of the pearl millet.

Chapter Two
Literature Review

Literature Review

The growth and development of land plants is largely influenced by water shortage (El-Sawaf, 2005). Under the current status in Palestine, the water shortage has become more notable , increasing the impact of water scarcity due to the limited resources, and is increasing more and more each day. This is mainly due to the limited resources of water combined with continuous population growth (Alhaj Hussein, 2001).

2.1 Effects of Salinity Stress

Salinity is one of the major abiotic stresses in arid and semi-arid regions (Begum et al, 2013). Nearly 20 to 40% of the world's cultivated areas and half of the world's irrigated land are affected by salinity (Ranganayakulu et al, 2013). Most crops are subjected to growth inhibition under high NaCl conditions (Hussain et al, 2008). Accumulation of salt in the soil solution causes saline stress (De Souza et al, 2016), decreasing the osmotic potential of the soil solutes and thus making it very difficult for roots to extract the required water from its surrounding area (Jamal et al, 2013) . This leads to the limitation of plant growth and productivity (Abdul Qayyum et al., 2016).

Soil salinity creates extremely unfavorable conditions for plant growth and development. Salinity affects cell enlargement as well as photosynthesis, additionally it has negative effects on cell division and cell growth (Esan and Olaiya, 2016).

Salinity stress disturbs the uptake and accumulation of essential nutrients (Greenway and Munns, 1980; Shannon and Grieve, 1999; Zhu, 2001). Generally, Ca_2^+ and K^+ are found decreased in plants under saline conditions (Khan, 1993; Al-Harbi, 1995). In contrast, Ashraf and Rauf (2001) reported that under saline conditions concentrations of Na^+, K^+ and Ca^{++} increased significantly in all the parts of germinated maize seeds subjected to priming with NaCl, KCl, and $CaCl_2 \cdot 2H_2O$, respectively. Alam and Naqvi (1991) observed that plant height and dry matter yield decreased with increase in salinity at 85-days old plants of pearl millet under different salinity levels. Salinity causes an increase in N, P, Ca^{++}, Na^+, Fe^{++} and Mn^{++} and decrease in K^+ contents of the leaves (Hussain et al, 2008)

There are several causes for soil salinity in the West Bank. The main causes are the extreme arid to semi-arid climate in most areas; ineffective irrigation management and practices and the water quality. Soils in the Jordan Valley and adjacent slopes (extremely arid and hyper arid climate areas) exhibit high degrees of salinity. Soil associations in this area have variable degree of salinity such as solon chacks, calcareous and loessial serozems, regosols and alluvial brown soils. Irrigation practices in the irrigated arable land of Jordan Valley have magnified the already existing soil salinity) Dudeen, 2001).

In areas where the depth of ground water is shallow, soil exhibits problems of salinity resulting from the accumulation of salts due to limited leaching capabilities. Even heavy textured (Dudeen et al, 2001) plants have developed different physiological and biochemical mechanisms to adapt or to tolerate stress under these conditions (Ranganayakulu et al, 2013).

When plants are exposed to salt stress metabolism adapts in order to cope with the climate change . Survival under these stressful conditions depends on the plant’s ability to perceive the stimulus, generate and transmit signals and initiate biochemical changes that adjust the metabolism accordingly (Hussain et al, 2010).

The increasing scarcity of water for irrigation is becoming the most important problem for producing forage globally across arid and semi-arid regions. Pearl millet is being proposed as a key crop in these regions as it requires less water than other crops. (Rostamza et al .,2011)

2.2 Pearl Millet

Millets (*Pennisetum spp*.) are small-seeded, annual cereal grasses used for food for humans, feed for domesticated animals, forage, as well as in the creation of industrial or other products in tropical or temperate regions. They are generally short-term, warm-season (summer) crops. Individual millet species or varieties frequently possess some unusual characteristics for adaptation to drought, high temperatures, low soil fertility and diseases or pests; or for making special foods or beverages (Rachie,1975).

Picture 1: pearl millet plant.

Pearl millet is an annual highly tilling C4 plant, which may grow to a height of 1-4 m, depending on the cultivation conditions. Pearl Millet leaves are long, scabrous, rather slender, and may be smooth or have a hairy surface. Inflorescence is a cylindrical spike which varies in length from a few centimeters to over a meter depending on the cultivar. It grows densely packed in groups of spikeslets varying in number from 2 to 5 but generally two. The spikelets are surrounded by involucres of bristles. Each spikelet may contain two flowers or florets, partly protected by glumes. The lower floret is staminate (male) and the upper floret is bisexual (Dakheel, 2015).

Pearl Millet (*Pennisetum glaucum*) has potential to develop as a grain crop in the southeastern United States. Pearl Millet tolerates drought and low fertility conditions well, thus requiring few irrigation and fertilizer inputs, and is not susceptible to pre-harvest aflatoxin contamination. (Raghavender et al.,2007).

Annual rainfall in the areas where this crop is mainly grown ranges from 250 to 700 mm but can be as high as 1500 mm. Pearl Millet is a diploid (2*n*=14 chromosomes) plant with the A genome (Baltensperger, 2002) Under subsistence farming conditions, it gives low grain yield (0.5-0.7 $t \cdot ha^{-1}$) (Rai, 1999).

Drought is the primary constraint in Pearl Millet production in the drier semi-arid and arid regions of south Asia and Africa. The traditional landraces from drier regions are good sources of drought adaptation but often lack high yield under near-optimum growing environments (Yadav, 2010).

Shokohifard et al. (1989) reported that salt stress negatively affected seed germination; either osmotically through reduced water absorption or ionically through accumulation of Na and Cl causing an imbalance in nutrient uptake and a toxic effect. Furthermore, Younis et al. (1991) reported that low moisture content under salt stress caused a cessation of metabolism or inhibition of certain steps in metabolic sequences of germination. Conversely, salt stress increased the intake of toxic ions. Moreover, salinity disturbs plant's hormone balance (Khan and Rizvi, 1994) and reduces utilization of seed reserves (Ahmad and Bano, 1992). Decreasing germination due to increased salinity can be connected to the nature of salinity that reduces imbibition of water due to lowered osmotic potential of the medium and changes (Begum et al. 2013) in metabolic activity (Yupsanis et al., 1994).

Germination and early seedling growth of many plant crops are the most sensitive stages to environmental stresses (Cook, 1997; Jones, 1986). Werner and Finkelstein (1995) demonstrated that elevated salinity slowed down water uptake by seeds, thereby inhibiting germination and root elongation. Significant reduction in seed germination was observed in Canola seeds grown under salinity conditions (Zheng et al., 1998; Puppala et al., 1999).

In another report, four Lentil genotypes were treated with salt stress and it was reported that increasing the NaCl concentration reduced the germination percentage, the growth parameters and the relative water content (Sidari et al., 2007). Pratap and Sharma (2010) reported that germination percentage as well as a variety of seedling growth parameters showed inhibition with an increase in osmotic potentials generated by polyethylene glycol (PEG) 6000 in black gram (*Phaseolus mungo*).

The concentration limits for germination in *Dianthus chinensis* have been reported to be 150 mM for NaCl(He et al., 2009).

Pearl Millet (*Pennisetum glaucoma* (L.) is a cereal crop that has been domesticated in Africa many centuries ago (Manning et al., 2011). It is the sixth most important coarse-grain cereal grown in semi-arid tropical regions of Asia and Africa (Addisie and Yemane ,2011). Landrace open-pollinated cultivars of Pearl Millet exhibit high levels of vegetative vigor and a very high biomass production. These are necessary adaptive features for a crop to survive stressful conditions (Andrews et al., 1993). Pearl Millet can be utilized as an emergency forage that performs well as an economical one-year forage crop option. **(**Ismail, 2012). Millet is mainly used for its feeding value.

The millet crop does not remove salt. Rather, millet is a good crop to grow while leaching is occurring, leaching of accumulated salts from the root zone using good quality irrigation water or rainfall will achieves land reclamation (Primefact, 2006). The effect of NaCl concentration on growth and nutrient content of pearl millet was investigated by using three NaCl concentrations and five pearl millet varietie . It was found that both growth parameters and plant nutrient contents significantly decreased with increasing soil salinization in all varieties. a specific species could therefore possess superior inherent genetic characteristics that could assist in the identification of superior genes for salt tolerance in Pearl Millet for improving its productivity in the region (Yakubu et al., 2010).

Pearl Millet is widely grown as a food crop in subsistence agriculture areas in Africa and on the Indian subcontinent. Pearl Millet has a number of advantages that include tolerance to drought, heat, and leached acid sandy soils with very low clay and organic matter content. Its grain is generally superior to sorghum as human food and at least equals maize in value as a feed grain. Whereas, grain for human consumption, is the main purpose of cultivation in Africa and Asia, the forage, or stover, at harvest is an important secondary product in subsistence agriculture for animal feed, fuel, or construction.(Andrews and Kumar,1992).

Two major approaches to improving and sustaining high agricultural productivity in a saline environment were proposed by Tyagi (2001) involving (i) modifying the environment to suit the available plants; and (ii) modifying the plants to suit the existing environment. Sustained and profitable production of crops on salt-affected soils requires appropriate on-farm management decisions. Growers must know how plants respond to salinity, the relative tolerances of different crops and their sensitivity at different stages of growth (Maas 1993).

An experiment was conducted to identify morphological and physiological traits for salinity tolerance in Tunisian autochthonous ZZ Pearl Millet ecotype (*Pennisetum glaucum* (L.) under local conditions. The ZZ ecotype was cultivated under different levels of salinity and growth parameters and demonstrated that ZZ Pearl Millet ecotype was unable to store large amounts of salt in the leaves, while maintaining high leaf water content without a grave consequent on panicle yield

A study was carried out to assess whether salt tolerance could be improved in pearl millet at the germination stage and vegetative stages. Seeds of two cultivars (C-8206 and 18-BY) were soaked for 8 hours in distilled water, 150 mol·m–3 NaCl , or polyethylene glycol (PEG- 8000, –0.672 MPa), or by subjecting the seeds to chilling (5 °C) or heating (60 °C) for two days. Germination of both treated and non-treated seeds of both cultivars was assessed for 8 days in Hoagland solution amended with 0 or 150 mol·m–3 NaCl. Chilling and PEG,the result was increase in the final germination percentage but not the germination rate of both cultivars under both saline and non-saline conditions. Chilling alleviated the adverse effect of salt stress on IC-8206 in terms of fresh and dry weights of shoots and roots following 42 d in sand culture that received 150 mol NaCl·m–3. Chilling also reduced Cl– accumulation and, that of Na+, and enhanced K+ and Ca2+ accumulation in the shoots and roots of both cultivars under both saline and non-saline substrates. The reverse was true in plants raised from seeds treated with NaCl or PEG (Ashraf et al., 2002). variation in salinity resistance among different varieties (Kafia et al., 2009).

Foxtail Millet (*Setaria italica* (L.) P. Beauv) is an ideal crop for changing climates and stressed environments due to its short duration, high photosynthetic efficiency and good level of resistance to pest and diseases. Foxtail Millet has potential as a crop for salt-affected soils, with its high tolerance to salinity (Krishnamurthyet al., 2014). The genetic bases are linked to some degree. These correlations would be of considerable value in breeding for improved salinity tolerance (Ghulam et al., 2006).

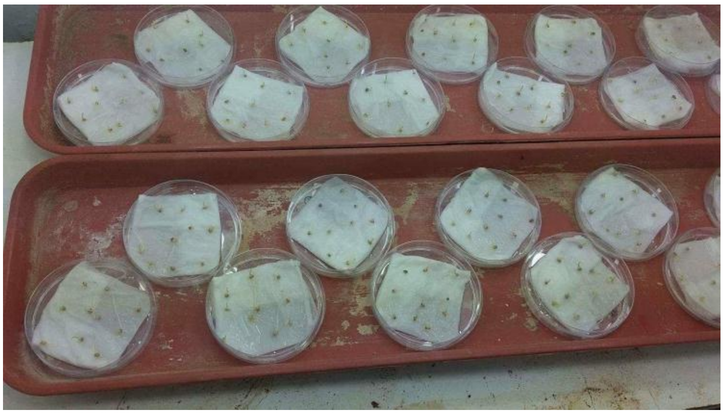
A study of pearl millet used to feed to pigs demonstrates the chemical composition, nutrient digestibility and fat digestibility was much higher in pearl millet than corn. Although nitrogen intake and absorption were higher (P<0·05) for pearl millet, the digestibility of nitrogen was similar for pearl millet and corn. Net protein utilization was lower ($P<0 \cdot 05$) in pearl millet when compared to corn (Adeola and Orban, 1995).

Pearl millet grain could potentially be successfully incorporated into poultry diets. The protein content of pearl millet, although variable, is higher than corn and the essential amino acid profile is more balanced than corn. Pearl millet also has higher oil content than other common cereal grains and is a better source of linolenic acid. Based on the performance of broilers and laying hens fed pearl millet, it appears that pearl millet is equivalent or superior to corn as a grain source for poultry rations **(**Davis et al 2003).

Chapter Three
Materials and Methods

3.1 Germination test

This test was carried out in laboratory condition to study the impact of various NaCl concentrations on germination percent , root and shoot length . Plastic Petri dishes (90 mm diameter, 15 mm height) were used for the test .10seeds for one petri dishes were used at three replicates with complete randomized design (picture 2). used five levels of salinity ,The levels of NaCl were zero (control), 100, 150, 200 and 250 mM level For each accessions . Seed were germinated under laboratory condition on filter paper. The developing seeds were tallied at customary interims . The lengths of root and shoot of the germinated seeds every day, more than 3 mm in length were measured and recorded after 7 days of sowing.



Picture 2: Germination test for pearl millet

3.2 Experiment Description

3.2.1 Field Experiment

The field experiment was carried out in a greenhouse at the Faculty of Agriculture and Veterinary Medicine, An-Najah National University, Tulkarm (Khadoori), Palestine (32.31519º N, 35.02033º W). to study the impact of different salinity water level on the growth performance and yield potential of nine pearl millet accessions .seeds of pearl millet were sown in plastic pots (6x6x7 cm) filled with agricultural sand (picture 3) , three NaCl treatments were used (0.0 (control), 75 and 150 mM NaCl in three complete randomized blocks. 9 accession was represented by .Five seeds per each pot were cultivated with three replicates per each treatment . All treatments were irrigated with tap water .

picture 3: Field Experiment of pearl millet.

3.2.2 Treatments

Seeds of Nine Pearl millet accessions obtained from the Ministry of Agriculture were used in the experiment. (Table 1)

Table (1): Pearl millet *(Pennisetum glaucum* L.*)* accessions used in th experiment .

Accessions cods	Accessions #
IP 3616	1
IP 6104	2
IP 6110	3
IP 19612	4
Sudan pop I	5
Sudan pop III	6
ICMS 7704	7
MC 94 C2	8
ICMV 155	9

Saline irrigation water prepared by using Nacl mixed with tab water ,three salinity levels (zero as control , 75 and 150 Mm Nacl) were used for irrigating the millet seeds for all experiment period .

3.2.3 Irrigation requirement

Irrigation requirement was calculated following the Modified FAO Penman–Montieth equation, using CROPWAT software , depending on the average climatic parameters of Tulkarm area. every three days Plants were irrigated. Plants were fertilized with 6,6,6 NPK at a concentration of 3 ml/L.

3.2.4 Plant observation.

The following measurements were taken from each accession at maturity stage as an average of five plants:

1. Plant height : from ground level to the plant shoot tip.

2. Plant fresh weight.

3. Plant dry weight: plants were placed in oven at 105°C for 24 hours.

4. Root fresh weight.

5. Root dry weight: roots were placed in oven at 105°C for 24 hours.

6. **Leaf chlorophyll measurement (SPAD)**: Chlorophyll meter (picture 4) was used to measure leaf chlorophyll content. The chlorophyll content was measured using three measurements from leaf tip to leaf base and from the flag leaf the averaged was recorded .

Picture 4: chlorophyll meter SPAD-502 Plus.

NDF: (ANKOM Fiber Analyzer (A200 , A2001))(Picture 5) this method determines Neutral Detergent Fiber, which is the residue remaining after digestion in a detergent solution, the fiber residues are predominantly hemicelluloses , celluloses, and liginin.

7. **ADF:** ANKOM Fiber Analyzer (A200 , A2001))(Picture 5) this method determines Acid Detergent Fiber, which is the residue remaining after digestion with H2SO4 and CTAB, the fiber residues are predominantly , celluloses, and liginin.

Picture 5: ANKOM Fiber Analyzer (A200 , A2001).

9 **Ash:** Furnace Carbolite (Picture 6) was used to measure inorganic residue(mineral) remaining after the water and organic matter have been removed by heating in the presence of oxidizing agents.

The difference in weight before and after the test is the percentage of ash content.

Picture 6: Furnace Carbolite

3.4 Data analysis:

Analysis of variance (ANOVA) was conducted using PROC GLM of SAS/STAT software (version 9.0 for Windows) (SAS institute, 2002). Multiple comparisons among pairs of accessions were made using the Duncan test , $P \leq 0.05$.

Similarity among the different accessions were graphically represented using hierarchical cluster analysis with SPSS software.

Chapter Four

Results

4.1 Germination experiment

The germination percentage indicated that a significant interaction between accessions and salinity levels exists. The results are shown in Table 2 Salinity Level and Accessions as a too-w way table .

Table 2: The effect of different salinity levels on seed germination Percentage of nine accessions of pearl millet.

Concentration (Mm)					Accession
250	200	150	100	0	
50.000^{ijk}	80.000^{bcdef}	93.333^{abc}	93.333^{abc}	96.667^{ab}	IP 3616
60.000^{ghij}	86.667^{abcde}	83.333^{abcde}	86.667^{abcde}	100.00^{a}	IP 6104
70.000^{ifgh}	90.000^{abcd}	93.333^{abc}	96.667^{ab}	96.667^{ab}	IP 6110
73.333^{defg}	90.000^{abcd}	96.667^{ab}	100.00^{a}	93.333^{abc}	IP 19612
43.333^{jk}	53.333^{hijk}	76.657^{cdefg}	93.333^{abc}	93.333^{abc}	Sudan pop I
36.667^{k}	80.000^{bcdef}	86.667^{abcde}	86.667^{abcde}	93.333^{abc}	Sudan pop III
40.000^{k}	90.000^{abcd}	93.333^{abc}	96.667^{ab}	96.667^{ab}	ICMS 7704
43.333^{jk}	63.333^{fgki}	50.000^{ijk}	86.667^{abcde}	73.333^{defg}	MC 94 C2
40.000^{k}	73.333^{defg}	93.333^{abc}	100.00^{a}	96.667^{ab}	ICMV 155

Means that do not share a letter are significantly different.

Germination percentage of 9 accessions of pearl millet was reduced significantly by increasing salinity levels , at 0 level (control) the IP 6104 accession, the highest germination percentage 100.00 was recorded and the lowest 73.333 was recorded in the MC 94 C2 accession.

The highest germination percentage at high salinity level 250 mM (250Mm) was Observed in accession IP 19612.

The germination percentage for all accession decreased significantly for 100 mM , 150 mM and 200 mM except IP 6104 . In the high level 250 mM the germination percentage decreased significantly. The lowest germination percentage was recorded with Sudan pop III 36.667 and the highest with 73.333.

The coleoptile length indicated a significant interaction between accessions and salinity levels. The results are shown in Table 2 salinity level and accession in one table as a two way table .

Table (3): The effect of different salinity levels on coleoptile length (cm) of nine accessions of pearl millet.

Concentration (mM)					Accession
250	200	150	100	0	
0.42^{pqrst}	0.64^{opqr}	1.44^{kl}	1.85^{ij}	2.83^{e}	IP 3616
0.46^{pqrst}	0.76^{nop}	1.32^{klm}	2.33^{fgh}	3.61^{cd}	IP 6104
0.50^{pqrst}	0.78^{nop}	1.42^{kl}	2.37^{fg}	3.73^{d}	IP 6110
0.41^{pqrst}	0.75^{nop}	1.22^{klm}	2.05^{ghi}	4.12^{a}	IP 19612
0.17^{t}	0.46^{pqrst}	0.48^{pqrst}	1.55^{jk}	2.53^{ef}	Sudan pop I
0.18^{t}	0.36^{qrst}	076^{nop}	1.30^{klm}	3.37^{d}	Sudan pop III
0.29^{rst}	0.73^{nopq}	1.10^{lmn}	2.29^{fgh}	3.68^{bcd}	ICMS 7704
0.28^{rst}	0.57^{pqrs}	1.30^{klm}	2.15^{ghi}	3.78^{abc}	MC 94 C2
0.19^{st}	051^{pqrst}	0.97^{mno}	1.96^{hi}	4.03^{ab}	ICMV 155

Means that do not share a letter are significantly different

Coleoptile length was affected significantly by salinity level , in that when salinity level increased coleoptile length decreased .Significant differences were recorded between accession in different salinity level .The highest coleoptile length was recorded at 0 salinity level was 4.12 cm at IP 19612 accession and the lowest length recorded was 5 cm at Sudan pop I accession .At 100mM the100mM the IP 6110 accession, the highest length was recorded was 2.37cm but and the lowest length was 1.30cm with in Sudan pop III accession. At 150mM IP 3616 and IP 6110 accessions were recorded at the highest coleoptile length while Sudan pop I accession was recorded at the lowest length. At 200mMthe difference between accessions is not high.

The IP 3616, IP 6104 and IP 6110 accessions obtained the highest Coleoptile length while Sudan pop III accession recorded was the lowest Coleoptile length. At the highest salinity level 250mM the IP 3616 , IP 6110, IP 6104 and IP 19612 accessions obtained the highest coleoptile length.The Sudan pop I and Sudan pop III were obtained the lowest Coleoptile length.

The radicle length indicated a no significant interaction between accessions and salinity levels; the results are shown in Table 4: Salinity level and in table 5 accessions in separate table .

Table (4): The effect of salinity levels on nine accession of pearl millet for radicle length mean (mm).

Accession	radicle length
IP 3616	3.4538[abc]
IP 6104	4.0465[a]
IP 6110	3.6866[ab]
IP 19612	3.3441[abc]
Sudan pop I	2.3864[d]
Sudan pop III	2.7816[cd]
ICMS 7704	2.9765[bcd]
MC 94 C2	3.2650[abc]
ICMV 155	3.7692[ab]

Means that do not share a letter are significantly different

The comparison between the accessions showed that there were significant differences between all nine accessions,the IP 6104 had the highest radical length mean (4.04650 mm) , while the Sudan pop I had the lowest radical length mean (2.38648 mm).

Table (5): the effect of salinity levels on radicle length mean of pearl millet accessions (mm).

Salinity level (mM)	Radicle length
0	8.730[a]
100	3.869[b]
150	2.217[c]
200	1.082[d]
250	0.605[d]

Means that do not share a letter are significantly different

Significant differences were noted on the accession at the five salinity level were radical length decrease when the salinity level increased. The 0 salinity level recorded the highest radical length mean, which was(8.73044 mm). while No significant difference was noted between 200 mM and 250 mM. The lowest radical lengths recorded were (1.08276 mm) and (0.60563 mm) respectively .

4.2 Field experiment

The shoot length mean and tillers numbers mean indicated a no significant interaction between accessions and salinity levels. The results are shown in Table 4: Salinity level and in Table 5: Accessions in separate table.

4.2.1 Vegetative growth

Table (6): The difference between accessions of pearl millet affected by salinity on shoot length mean and tillers numbers mean .

Accession	shoot length	Tillers numbers
IP 3616	76.778 [ab]	3.111 [a]
IP 6104	84.050 [a]	0.305 [d]
IP 6110	83.111 [ab]	0.333 [d]
IP 19612	82.978 [ab]	0.555 [cd]
Sudan pop III	80.978 [ab]	1.555 [abcd]
ICMS 7704	81.867 [ab]	1.333 [bcd]
MC 94 C2	82.044 [ab]	2.666 [ab]
ICMV 155	75.6000 [ab]	2.1111 [abc]

means that do not share a letter are significantly different

Significant difference testing was conducted between accessions. The six accessions were not found to be different. However, the IP6104 and ICMV 155 accessions were different from other accessions. The IP6104 accession reported the highest shoot length and the ICMV 155 accession was recorded the lowest shoot length.

Significant differences were observed between accession. were the The IP 3616 accession recorded the highest tillers numbers while the IP 6104 and IP 6110 recorded the lowest tillers numbers

Table (7): the effect of salinity levels on shoot length mean, tillers number mean of pearl millet accessions.

Salinity level mM	shoot length	Tillers number
0	88.225 [a]	1.333 [a]
75	80.102 [b]	1.9479 [a]
150	74.450 [c]	1.208[a]

Means that do not share a letter are significantly different.

The salinity levels affected on shoot length significantly .the Shoot length decreased with salinity level increase. the 0 salinity level obtained the highest shoot length mean while the 150mM recorded the lowest shoot length mean.

No significant difference was noted when salinity level increased.

The highest tillers number were recorded at 75mM but no significant differences were found between another salinity levels.

4.2.2 Chlorophyll content.

The Chlorophyll content means indicated a no significant interaction between accessions and salinity levels(the results are shown in Table 4: Salinity level and in Table 5: Accessions) in separate table .

Table (8): the different between pearl millet accessions of pearl millet on chlorophyll content mean.

Accession	chlorophyll content
IP 3616	73.660 [a]
IP 6104	42.320 [a]
IP 6110	58.3000 [a]
IP 19612	41.4400 [a]
Sudan pop III	52.8400 [a]
ICMS 7704	47.1067 [a]
MC 94 C2	39.9400 [a]
ICMV 155	47.4067 [a]

Means that do not share a letter are significantly different.

Chlorophyll content was not found to be affected significantly between the accessions.

A all accession except Sudan pop I reached to the flowering stage and as such chlorophyll was measured, but no difference was found between the chlorophyll content means.

Table(9):The effect of different salinity levels on chlorophyll content mean of pearl millet.

Salinity levels (Mm)	chlorophyll content
0	62.036 [a]
75	38.716 [ab]
150	19.412 [b]

Means that do not share a letter are significantly different.

Chlorophyll content reduced significantly when salinity increased The highest chlorophyll contents were noted at 0 salinity level.

4.2.3 Labe measurement

The root and shoot fresh and dry weight mean indicated a no significant interaction between accessions and salinity levels. T the results are shown in Table 4: Salinity level and in Table: 5 Accessions in separate table.

Table (10): the different between nine accessions of pearl millet on root and shoot fresh and dry weight mean affected with salinity treatments.

Accession	Root FW	Shoot FW	Root DW	Shoot DW
IP 3616	125.469[ab]	388.240[a]	54.267[ab]	153.726[a]
IP 6104	68.058[b]	239.072[bc]	15.539[d]	125.782[a]
IP 6110	97.881[ab]	327.389[abc]	44.039[abcd]	125.858[a]
IP 19612	61.213[b]	378.873[a]	24.370[cd]	152.607[a]
Sudan pop I	152.679[a]	423.423[a]	69.821[a]	119.438[a]
Sudan pop III	104.842[ab]	366.121[ab]	37.584[bcd]	162.917[a]
ICMS 7704	131.304[ab]	326.371[abc]	44.755[abc]	122.107[a]
MC 94 C2	96.774[ab]	356.119[abc]	35.713[bcd]	96.228[a]
ICMV 155	75.061[b]	236.926[c]	34.041[bcd]	86.954[a]

Means that do not share a letter are significantly different.

Significant difference analysis t was conducted between accessions for root fresh and dry weight mean and shoot fresh weight mean , But the shoot dry weight mean was not affected significantly.

The highest radical fresh weight was recorded with IP 3616, IP 6110, Sudan pop I, Sudan pop III, ICMS 7704 and MC 94 C2 accessions.

Table (11): The effect of salinity levels on root and shoot fresh and dry weight mean of pearl millet accessions.

Salinity levels mM	Root FW	shoot FW	Root DW	shoot DW
0	262.896[a]	859.679[a]	103.560[a]	302.741[a]
75	27.292[b]	111.884[b]	9.993[b]	54.481[b]
150	14.240[b]	42.615[b]	6.490[b]	24.650[b]

Means that do not share a letter are significantly different

The root and shoot fresh and dry weight mean reduced significantly when salinity level was increased.

The highest root and shoot fresh and dry weight was recorded in 0 salinity level for root and shoot fresh and dry weight .Different ce analysis was conducted at 75 and 150 mM .The differences were not significant between salinity level for root and shoot fresh and dry weight mean.

4.2.4 Chemical analysis

The ADF%, NDF**%**, Ash% mean indicated a no significant interaction between accessions and salinity levels the results are shown in table 4 salinity level and in table 5 accessions in separate table .

Table (12): show the different between nine accession of pearl millet induced salinity effect for ADF% , NDF% , Ash% mean.

Accession	ADF%	NDF%	Ash %
IP 3616	72.179[bc]	88.878[a]	25.341[abc]
IP 6104	79.618[a]	92.350[a]	31.207[ab]
IP 6110	78.803[a]	93.717[a]	25.136[abc]
IP 19612	75.713[abc]	93.174[a]	24.475[abc]
Sudan pop I	75.088[abc]	93.243[a]	20.654[c]
Sudan pop III	73.967[abc]	86.242[a]	24.607[abc]
ICMS 7704	74.186[abc]	87.673[a]	32.318[a]
MC 94 C2	70.219[c]	92.638[a]	24.236[bc]
ICMV 155	76.375[ab]	92.825[a]	25.608[abc]

Means that do not share a letter are significantly different.

Significant difference analysis was conducted between the accessions ,were the IP 6104 and IP 6110 recorded the highest ADF%, the IP 19612 ,Sudan pop I , ICMS 7704 and Sudan pop III were recorded no significant different between it, but have a different from other accessions. the lowest ADF% observed with MC 94 C2.

No significant difference analysis was conducted between the nine accessions with the salinity on NDF%. The high NDF% conducted with IP 6110 accession and the low NDF% conducted with Sudan pop III accession.

The table shows a significant difference between the nine accessions of pearl millet . the ICMV 155 , IP 3616, IP 6110 and Sudan pop III no significant different between them.

the highest Ash% was observed from IP 6104 accession and the lowest is Sudan pop I.

Table (13): the effect of three salinity levels on the pearl millet accessions at ADF%, NDF% and Ash% mean.

Salinity level mM	ADF%	NDF%	Ash%
0	79.948[a]	94.489[a]	33.774[a]
75	73.263[b]	91.136[ab]	27.615[b]
150	72.173[b]	87.956[b]	16.472[c]

Means that do not share a letter are significantly different.

The salinity level was affected significantly in the pearl millet when the ADF% was reduced. When salinity level was increasing, the o salinity level (control) recorded the highest ADF%.

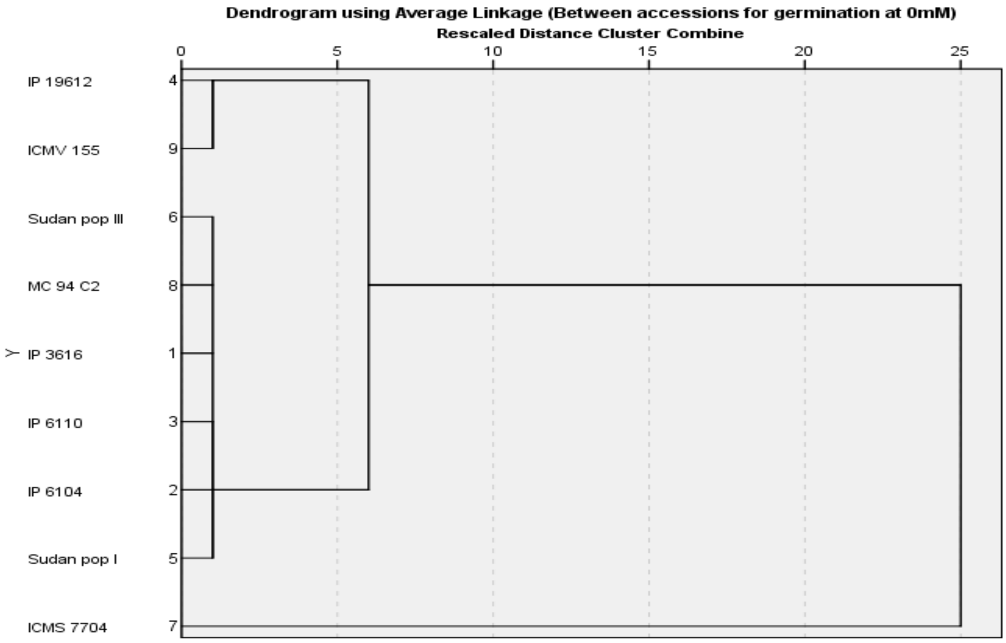
The NDF% reduced significantly when salinity level increased.

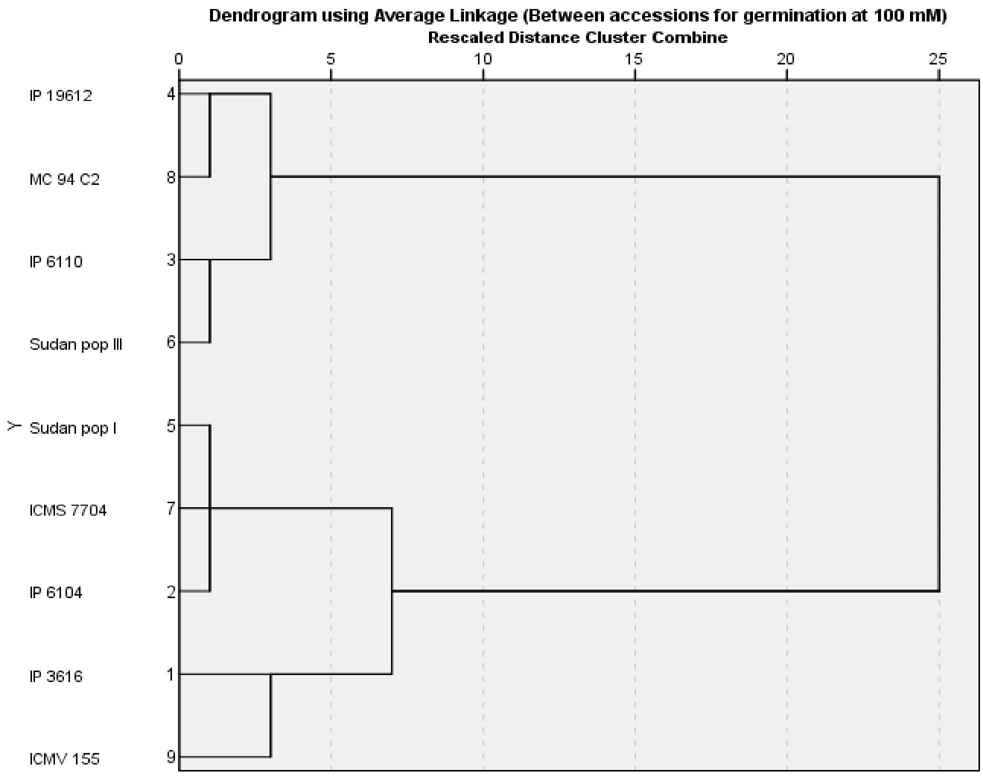
Ash % was significantly affected by salinity treatment.

hen the salinity increased the Ash% increased .

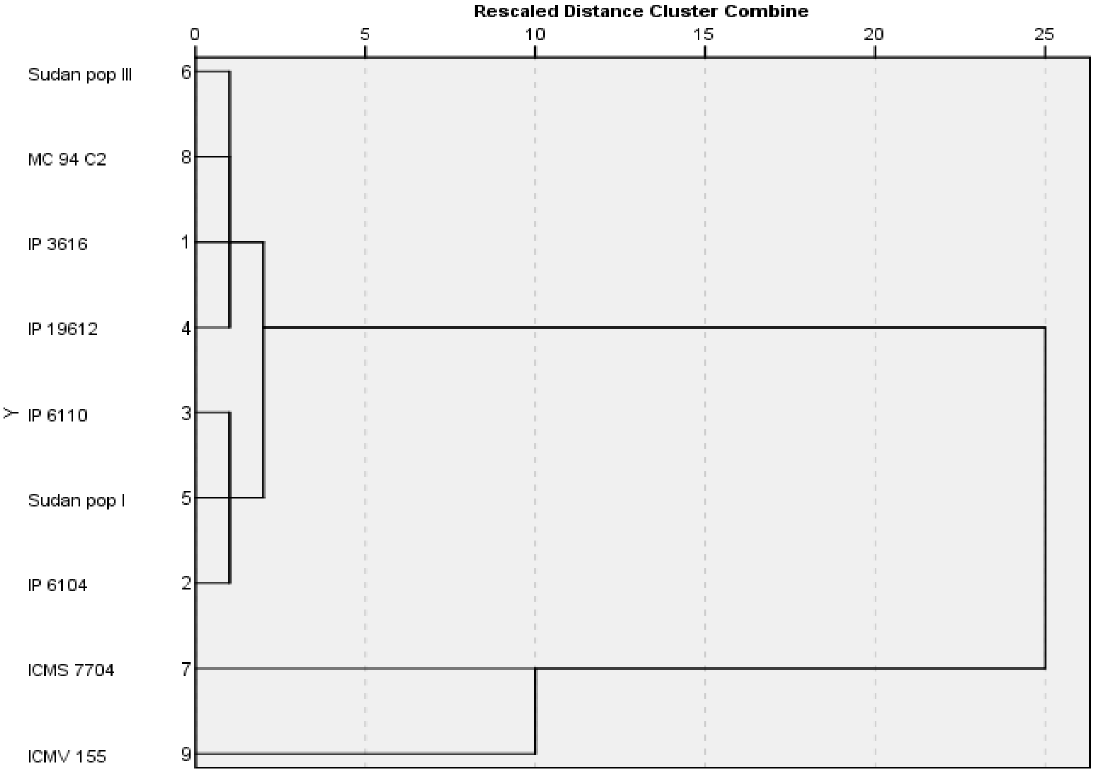
At 0 salinity level the Ash% mean was recorded the lowest percent while 150 Mm recorded the highest .

4.3 Cluster analysis

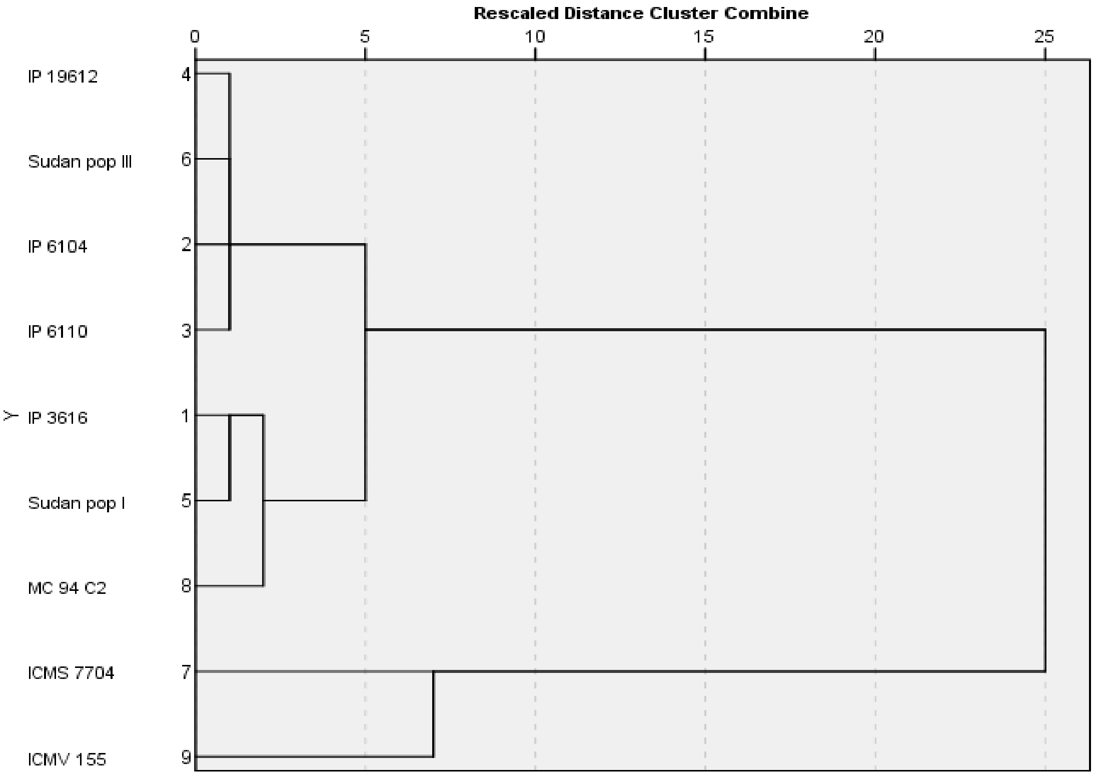


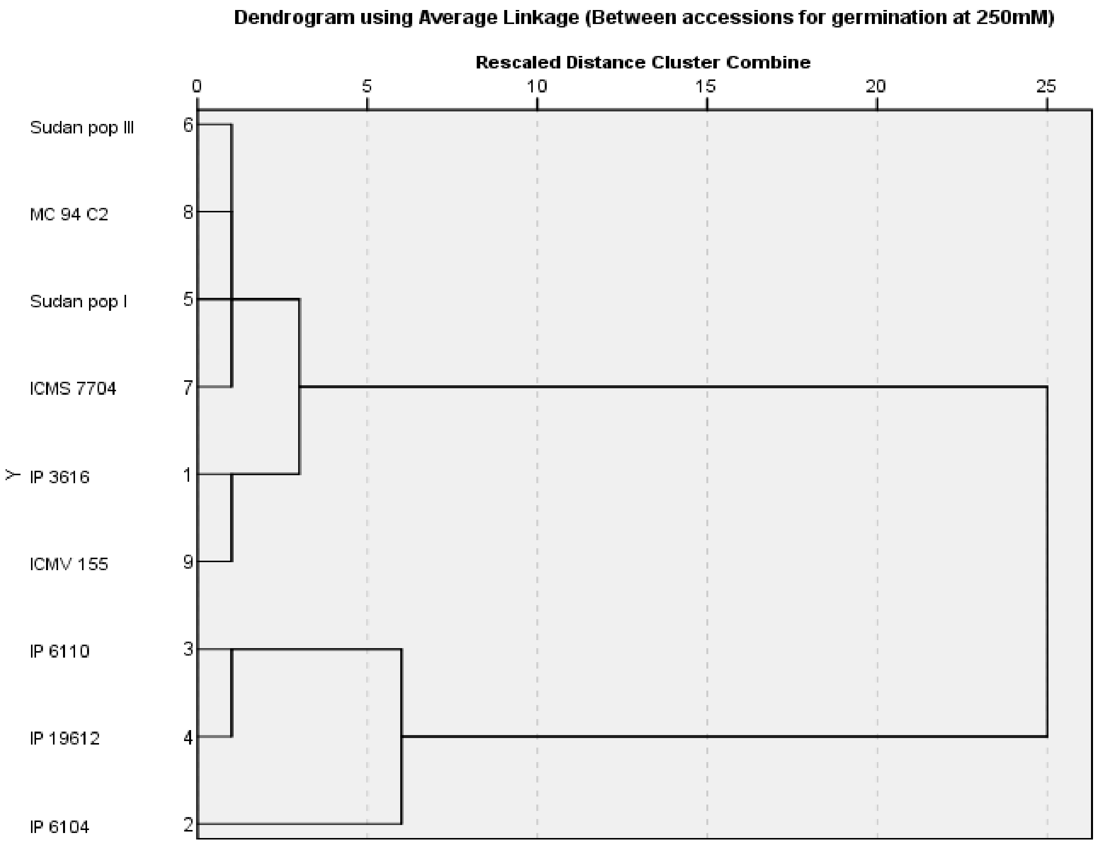


Dendrogram using Average Linkage (Between accessions for germination at 150 mM)



Dendrogram using Average Linkage (Between accessions for germination at 200mM)





A cluster analysis was conducted for different accession on the five salinity levels for germination.

The cluster analysis for zero level showed a variation in all accessions. Accession were divided in two main groups. The first group had two sub-clusters with eight accessions and the second sub-cluster had accession ICMS 77.4.

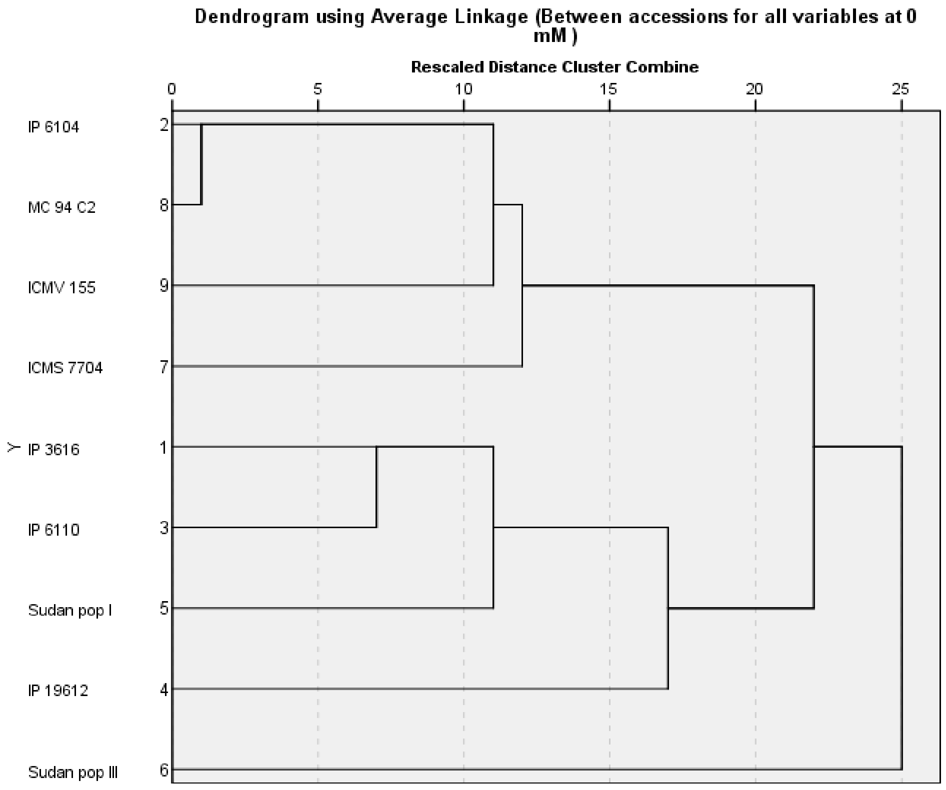
In 100 Mm the accession divided into two groups, and the groups divided into two sub-clusters. The first group consisted of four accessions and the second group consisted of five accessions.

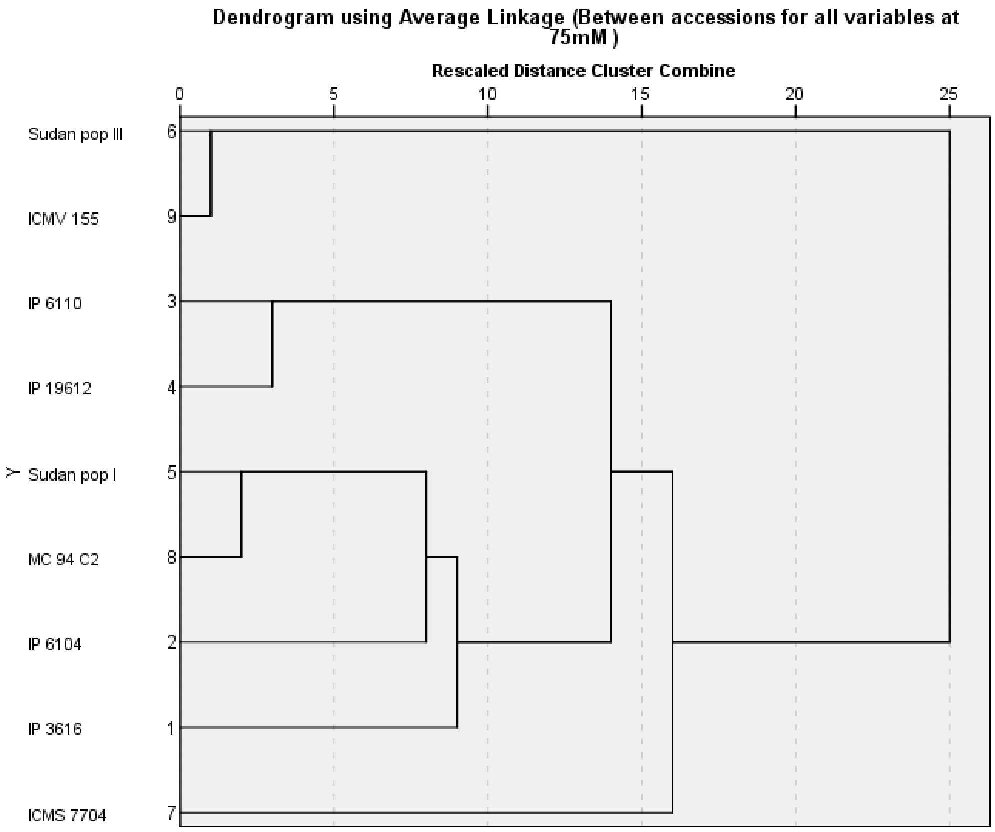
In 150 Mm the accession divided into three groups , first group divided into two sub-clusters with seven accessions and the other groups had one accession each.

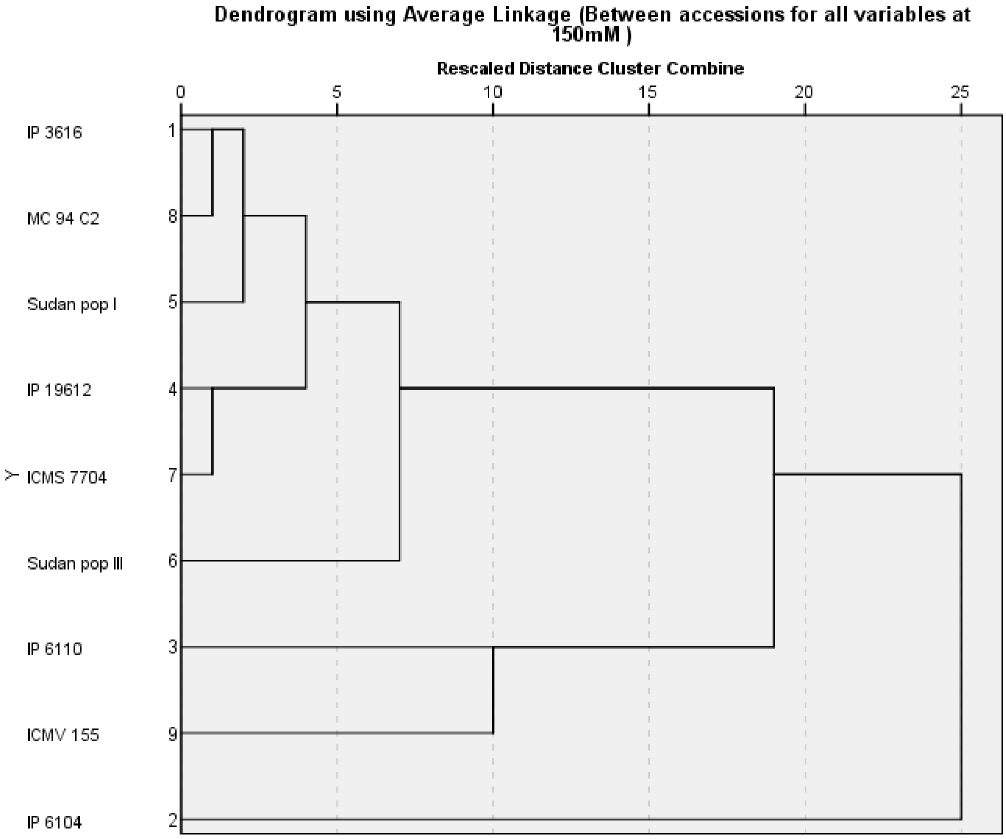
The same test was conducted with 200 Mm. As in the 100 Mm salinity level the accession divided in to two groups, the first group divided to two sub-clusters. The accessions in the first sub-cluster were higher germinated than other, accessions in the second group were of lower germination.

In the 250 mM level of salinity the cluster stayed in two cluster groups. Differences were noted in order to accessions, the first group having a Sudan pop III , MC 94 C2 , Sudan pop I and ICMS 7704 obtained the highest germination accession in a 250 Mm salinity level. The second group containing IP6110, IP 19612 and IP 6104 I accessions, had the lowest germination.

Field experiment







The cluster analysis investigated genetic variation among the different accession for all studied variables (except chlorophyll) at the three salinity levels.

The cluster analysis for means at the zero-level control treatment showed high variation in the studied accessions, with each accession represents single cluster. However, at 75 mM NaCl, the accession was grouped into six clusters, the first three clusters were divided into two sub-clusters each with two accessions.

The accession having the highest tolerance to salinity at 75 mM was grouped in first cluster which includes Sudan pop III and ICMV 155, the second cluster includes IP6110 and IP19612, in the third cluster Sudan pop1 and MC94C2 were included. The other three clusters consisted of single accession in each.

In contrast the cluster analysis for the accession at salinity level 150 mM revealed five main cluster each with a single accession except the first cluster which divided into two sub-clusters with highest salinity tolerance. The first sub-cluster consisted of three accessions IP3616, MC 94C2 and Sudan pop1, while the second sub-cluster included two accessions IP19612 and ICMS 7704.

They were all in five clusters. However, at the high salinity level the accession re-grouped into 4 different cluster where accessions IP3616, MC94C2, Sudan pop1 exhibited the highest tolerance to salinity, followed IP19612, ICMS774. IP6104 was located in single cluster.

The results indicate differential behavior of the accession, mainly due to genetic makeup of the accession. Much potential for improvement for these plants is demonstrated.

Chapter Five

Discussion

Discussion

5.1 Effect of salt treatment on germination

The percentages of germination in the different accessions were significantly influenced by NaCl which is in agreement with the findings stated by other researchers (Gulzar *et al*., 2001); Maouromicale and Licandro (2002) and Chiroma *et al*., 2007). Yakubu et al., 2010, found that NaCl treatment decreased the ultimate germination percentage and germination rate of two varieties of wheat (*Triticum aestivum* L.); and increased the production of abnormal seedlings. Germination of seeds of *Panicum turgidum* has been considerably decreased and decelerated at high NaCl concentration and at 300 and 400 mM the wheat was stop growing. Sugar beet early seedlings growth and the seed germination was also found to inhibited by NaCl treatment. The same result conducted on the sesame seed germination was highly affected and reduced with the salinity raise. (Natarajan and Sozharajan ,2014)

The combined effect of osmotic stress and specific ion toxicity may be

Contributing to the reduction in germination percentage and death of the seedlings (*Yakubu* et al., 2010). During germination, toxic ions can affect specific hormonal or enzymatic action in seeds. Higher levels of salt are also recognized in decreasing the water potential in the medium which prevents water absorption by germinating seeds, also decreasing germination (Poljakaff-Mayber). 1975). Salinity can disorder the normal equilibrium of physiological development in plants, leading to death) Dugje et al.,2010).

In addition**,** salinity affects the plant's capability to absorb water by reducing it, leading to possible growth decreases along with metabolic change such as those arising from water stress. The disorder of the metabolic process causes the phenolic compounds to amplify. Elevated salt levels in root affects the yield and growth of many crops. High salinity may decrease the crop yield by disturbing water and nutritional equilibrium of the plant. Nutrient uptake and water availability of plant roots are partially due to the high toxicity and osmotic potential of Na and Cl ions (Begum et al., 2013).

5.2 Shoot and Root fresh and dry weight

Salinity treatments reduce significantly both root and shoot development in the different accessions excepted shoot dry weight not affected significantly. However, performance of the different accessions in the salinity treatments was not different in all measured variables. The decrease in the growth of the plant in saline conditions is a common phenomenon (Ashraf & Harris, 2004), but such reduction happens inversely in diverse plant organs. For instance, in the current experiment, shoot dry weight was reduced by salt stress more than root dry weight did. Similar results were noted by Jamil, 2007, when rising stress levels, radicle dry weight and plumule dry weight were significantly decreased as salinity concentrate rose.

Increased salt stress decreases the efficiency of assimilation and translocation of many minerals and could lead to inhibition in shoot growth. The decrees in shoot and root growth may be related to the toxic effects of NaCl with the usage of unbalanced nutrient absorption by the seedlings. It also affects the root system's ability to enter ions to the shoot control, which is vital to the survival of plant in the presence of NaCl (Hajibagheri et al., 1989).

It is known that salt stress is caused by high amount of Na+ & Cl. Salt stress has threefold effects that decrease the potential of water and leads to ion inequity and instability in ion toxicity and homeostasis. Saline water leads to early growing inhibition and decreases the productivity of plant. Salt stress has influences on certain main processes like growth, germination and chlorophyll content (Parida and Das, 2005).

(Hajer et al.,2006), The main reason for growth decrease in pearl millet may be dependent on ionic toxicity and water scarcity caused by salinity. According to (Hussain et al., 2010), the plant growth increases could relate to turgor_potential that decreases during water shortage as a result of high salt concentrations in the soil .

5.3 Chlorophyll content

Chlorophyll content reduced with salinity treatments but not significantly affected over the nine accessions. In contrast, other researchers reported an increase in chlorophyll content of salt tolerant plants like pearl millet. Others concluded that salt stress caused a raise in the chlorophyll content. The findings may be due to the fact that chloroplasts in stressed leaves rise. Moreover, chlorophyll content decreasing in salt sensitive plants such as tomato and pea has been previously confirmed. In our experiment, samples were only taken from plants that reached flowering. As only a few plants reached this stage, the samples may not be enough to make a solid conclusion. The reduction in plant growth in our experiment could also be due to lower photosynthesis and thus low chlorophyll content. Chlorophyll content reflects the primary reactions of photosynthesis (RFF) (Javadian et al.,2010).

5.4 Seedling growth

Seeding growth (root and shoot length) was tested in both stressed and control condition after 50 days of planting. The total seedling growth was reduced in all accessions throughout salt stress. Yet, the reduction of seedling growth was similar in all accessions. Marked reduction in plant height is one of the characteristic indicators of salt stress in several plant types, and refers to the osmotic influences of the salt outside the roots that discriminates a salt-susceptible plant from other tolerant ones (Munns et al., 1995). Likewise, this study recorded reduced growth throughout stress circumstances, and reduction in seedling growth degree depended on severity of stress or intensity. The reduced growth under salinity stress has been ascribed either to osmotic or ionic effects; inhibition of cell division and cell elongation process associated with the growth of the seedling and decrease in plastic extensibility of the growing cell walls (Ranganayakulu et al., 2013).

In this research, tiller numbers were decreased with salt treatment in all accessions, however, without significant effect (a reduction in tiller number per plant as water salinity increases). The decreased tillers numbers are evidence of an adaptive device resulting from water stress, which diminishes the transpiration zone and thus helps the plant to endure water stress.)Saleh and Ismail,2012).

5.5 ADF & NDF Content

Significant differences were observed in any accessions when salinity was increased in the current study Different results were recorded by Todd (2006) who studied barley cultivars who found that both ADF and NDF had no significant effect on fiber concentrations.

The high salinity level of irrigation water has been found to generally decrease NDF percentages in ryegrass (Robinson et al., 2004)when the plants were irrigated with saline water. In spite of the non-significant effect of salinity on both ADF and NDF, the level of both fibers was within the acceptable standard for feeding. The maximum cell wall level in forages that will not hinder intake and performance is 700 to 750 mg g -1NDF for mature beef cattle and 150 to 200 mg g -1NDF for growing and finishing cattle.

5.6 Ash Content

When calculating the nutritional value of feed, many measurements were measure the Ash content one of them. Calculate Ash content in forage because estimate energy and calculate non-fiber carbohydrate content, (NFC = 100 − ((NDF-NDFCP) + CP + Fat + Ash)). (Under sander, 2017)

increase Ash content it dilute nutritive value, it lowers forage intake and reduces digestibility. Ash takes the place of forage nutrients on an almost 1-to-1 basis. For each 1 percent ash. (fyksen, 2018) total digestible nutrients decrease 0.98. Percent, and decrease in total digestible nutrients excessive ash contents in forages or in dairy cow diets could be a silent antagonist in the dairy nutrition program performance. (Hoffman, 2015).

Salinity treatment was found to significantly affect Ash content in the current study such that when NaCl concentration increases Ash content decreases.

The same result was demonstrated by Heidari and Jamshid ,2010, in millet plants where salinity increased the amount of Na^+ , K^+ and Mg^{+2} in the leaves in vegetative and reproductive stages.

In contrast increases in NaCl levels led to decreased K concentrations and K/Na ratio of maize plants (Turan et al., 2009).

Chapter Six
Conclusions and Recommendations

6.1 Conclusions

The result of the this research proved that the salinity had affected significantly the germination percentage of the different barley accessions, however with variable effect among the different accessions, in addition, the different accessions exhibited different responses for the measured variables under the tested salinity levels, therefore, there is a potential of screening out salt tolerant accessions among the tested ones.

the present study demonstrated the ability of pearl millet to grow under saline condition. As such, indicating that this forage crop has a good potential for planting in areas with high soil salinity. Additionally, cluster analysis show that the MC 94 C2 accession provided the best results in germination and field experimentation.

6.2 Recommendation

The result of this research showed significant differences among barley accessions under different salinity levels, however the following recommendations could be considered

1. More work should be done with more accessions and local landraces could be included.
2. The plants must reach the production stage for better comparison.

3. It is important to implement trails about the digestibility of these accession and the acceptability of animals for these accession.

4. It is important to examine the effect of salinity levels on the nutritional value of the pearl millet.

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جامعة النجاح الوطنية

كلية الدراسات العليا

تقييم اصناف من الدُخُنْ تحت ظروف الزراعة المالحة

إعداد

إحسان أبو علي

إشراف

د. حسان أبو قاعود

د. منقذ شتيه

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في تخصص إنتاج نباتي، بكلية الدراسات العليا، في جامعة النجاح الوطنية، نابلس– فلسطين.

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الملخص

أجريت هذه الدراسة بهدف دراسة تأثير مستويات مختلفة من الملوحة على نمو وتطور تسعة اصناف من نبات الدخن. نفذت التجربة في محطة البحوث بكلية الزراعة، جامعة النجاح الوطنية- طولكرم- فلسطين. وقد زرعت البذور خلال الموسم 2015، زرعت الاصناف التسعة في اوعية بلاستيكية مليئة بتربة رملية بمعدل خمس بذور لكل وعاء.

تم ري النباتات بثلاثة مستويات من المياه المالحة (المياه العذبة، 75 ملي مول، 150 ملي مول)، مع ثلاث مكررات لكل معاملة. وأظهرت النتائج أن نسب الإنبات، وطول الجذر وطول الساق تأثرت بشكل ملحوظ بزيادة مستوى الملوحة. كانت أعلى نسبة انبات على التركيز المنخفض على الصنفIP 6014.

ان نسبة الانبات لجميع الاصناف قلت بشكل ملحوظ على التراكيز 100مليموز و150 مليموز و200 مليموز ما عدا الصنف IP 6014 .

قلت نسبة الانبات بشكل ملحوظا على التركيز العالي 250 مليموز، حيث كانت اعلى نسبة انبات لدى الصنف,IP 19612 .

واقل نسبة انبات كانت لدى الاصناف Sudan pop III, Sudan pop I ,ICMS 7704 ,MC .94 C2 and ICMV 155.

طول الساق تأثر سلباً مع زيادة تركيز الملوحة. لكنه لم يكن هنالك تأثير للملوحة على عدد الاشطاء، لكنه كان هنالك فروق معنوية بين الاصناف على طول الساق لنبات وعدد الاشطاء.

تأثر محتوى الكلوروفيل بشكل سلبي وملحوظ بالملوحة، لكنه لم يكن هنالك اختلافات ملحوظة بين الاصناف.

اظهرت الأصناف التسعة فروق احصائية ملحوظة لوزن الجذر العادي والجاف ووزن الساق العادي بينما لم يكن هنالك فروق ملحوظة على وزن الساق الجاف. كما لوحظ انخفاض تركيز المعادن في النبات مع زيادة تركيز الملوحة كما كان هنالك فروق واضحة بين الاصناف التسعة؛ لم يلحظ فرق معنوي بين الاصناف التسعة مع تأثير الملوحة NDF%.

في الختام، أشارت الدراسة إلى قدرة الدخن على النمو في ظل حالة ملحية، وبالتالي فإن هذا المحصول العلفي قادر على التعايش مع الاراضي ذات مستويات عالية من الملوحة.