Effect of different levels of salinity on growth, yield and seed quality of barley (*Hordeum vulgare*)

By

Omaima Mohamed Abdel Gadir

B. Sc. (Agricultural Science) Honours

University of Gezira

June, 1993

A thesis submitted in partial fulfillment of the requirements for the degree of master of science in Agriculture (Seed Technology)

Supervisor: ***Dr. Mustafa M. A. Elballa***

Faculty of Agriculture

University of Khartoum

February, 2003

تأثير معدلات مختلفة من الملوحة على النمو؛ الإنتاج وجودة البذور لمحصول الشعير

إعداد

اميمة محمد عبد القادر

بكالوريوس العلوم الزراعية مع درجة الشرف

جامعة الجزيرة يونيو 1993م

أطروحة قدمت لمقابلة متطلبات درجة الماجستير فى الزراعة

(تقانة بذور)

المشرف

د. مصطفى محمد على البلة

كلية الزراعة-جامعة الخرطوم

فبراير 2003م

DeDICATION

To my mother, sprit of my father,

my sisters, brothers

and their families

Omaima

ACKNOWLEDGE MENT

I would like to express my deep and sincere thanks to Dr. Mustafa M.A El Bella for his guidance and valuable advice during the planning and execution of this research. I am also greatly indebted to Dr. Faisal E. Ahmed (Department of Agronomy, University of Khartoum) for his valuable advice, suggestions and help throughout the course of the study.

My sincere appreciation is also extended to all colleagues in the National Seed Administration, the Arab Sudanese Seed Company and Agriculture Research Corporation (Hudeiba and Shambat Stations) for their advice, support and help. Thanks must also be accorded to Mr. Mohamed Makkawi (ICARDA, Seed Unit).

I am very grateful to my family for their blessing and encouragement during my study.

I gratefully acknowledge the financial support of Sudan Government and Seed Administration for nomination. Thanks are due to all members and colleagues of the Department of Horticulture, Faculty of Agriculture University of Khartoum.

ABSTRACT

Two pot experiments and laboratory tests were conducted during two seasons (1999/2000 and 2000/2001) to investigate the effect of different levels of salinity on barley seed yield and seed quality.

The two pot experiments were carried out at Shambat, Faculty of Agriculture University of Khartoum while the laboratory tests were carried at the Seed Administration Lab, Federal Ministry of Agriculture and Forestry, Khartoum.

Local barley cultivar was used in 1999/2000, while in 2000/2001 four introduced cultivars were used along with the local cultivar. Seeds were planted at 5 levels of soil salinity in 1999/2000 (0, 2, 4, 6 and 8 mmohs/cm) and 4 levels (0, 4,6 and 8 mmohs/cm) in 2000/2001.

The results revealed significant effect of salinity on seedling emergence, all growth and yield parameters and seed quality.

Salinity increased seedling emergence percentage and reduced days to 50% heading. Significant increase in number of spikelets/spike, number of seeds/spike and seed yield/pot was found in the first season. No significant effect was obtained on number of tillers / plant, number of spike/plant and 100 seed weight. In the second season significant increase in number of tillers/plant, number of spikes/plant and 100 seed weight

was obtained in response to salinity. Significant reduction was found in number of spikelets/spike, number of seeds/spike and seed yield/pot.

Seed quality evaluations revealed that salinity resulted in an increase in seedling shoot and root lengths but reduced seedling growth rate, seedling dry weight and speed of germination in the first season. No significant effect was found on standard germination percentage. In the second season, standard germination percentage, seedling shoot length and speed of germination were increased by salinity. Seedling root length was reduced by salinity and no significant effect was found on seedling dry weight and growth rate.

Salinity level of 6 mmohs/cm resulted in a significant increase in growth and yield parameters as well as seed quality.

The local cultivar was found to be more tolerant to salinity than the introduced cultivars as reflected in growth parameters and seed quality.

The interaction effects between salinity levels and cultivars were significant in some tests of growth, yield and quality parameters.

ملخص البحث

أجر ى البحث في موسمى 2000/1999م و 2001/2000م بكل من شمبات كلية الزراعة –جامعة الخرطوم و معمل فحص واختبار التقاوى الخرطوم / إ دارة التقاوى /وزارة الزراعة والغابات لمعرفة تأثير معدلات مختلفة من الملوحة على النمو , الإنتاج وجودة البذور لمحصول الشعير.

لقد تضمن البحث زراعة بذور الشعير فى الأصص و بعض الاختبارات المعملية مثل: الإنبات تحت الظروف المثالية ،وزن المائة حبة ،الوزن الجاف للبادرة،معدل نمو البادرة، طول السويق ،طول الجذر ومعدل سرعة الإنبات.

أجريت التجارب على الصنف المحلى لمحصول الشعير في موسم 2000/1999م وأضيفت أربعة أصناف من الشعير للصنف المحلى في موسم 2001/2000م. تمت زراعة البذور في خمس درجات من الملوحة في الموسم 2000/1999م (0، 2، 4، 6، 8 ملموز/سم) واربعة درجات في موسم 2001/2000م (0، 4، 6، 8 ملموز/سم).

أوضحت النتائج بأن هنالك تأثير معنوى للملوحة على نسبة الإنبات وكل مقاييس النمو انتاج وجودة البذور.

توصلت الدراسة إلى أن الزيادة في درجة الملوحة تؤدى إلى زيادة في نسبة الإنبات وتقلل من عدد الأيام للحصول على نسبة 50% أزهار للموسمين.

زاد عدد السنيبلات ، عدد البذور بالسنبلة وإنتاجية البذور بالنسبة للاص بينما لا يوجد تأثير معنوى على عدد الخلف والسنابل للنبات ووزن المائة حبة في الموسم 1999-2000م.

تلاحظ وجود تأثير معنوى على عدد الخلف والسنابل في النبات ووزن المائة حبة حيث أنها تزيد مع زيادة درجة الملوحة، بينما يقل عدد السنيبلات وعدد البذور في السنبلة وكذلك إنتاج البذور بالاص فى 2001/2000م.

أثرت الملوحة على جودة البذور وقوة إنباتها تأثير معنوى حيث أدت زيادة الملوحة في الموسم 99-2000م إلى زيادة في طول ساق وجذور البادرات وقللت من معدل سرعة الإنبات والوزن الجاف للبادرات ومعدل نموها. وقد تلاحظ عدم وجود تأثير معنوى فى نسبة الإنبات تحت الظروف المثالية.

أدت الزيادة في درجة الملوحة إلى زيادة نسبة الإنبات تحت الظروف المثالية، طول ساق البادرات و معدل سرعة الإنبات وتسببت في قصر جذور البادرات ، بينما لم يكن هنالك أى تأثير معنوى للملوحة على معدل نمو البادرات ووزنها الجاف فى 2001/2000م درجة الملوحة 6 ملموز/سم أدت إلى نتائج ايجابية في كل مقاييس النمو ،إنتاج البذور وجودة البذور وقوة إنباتها.

الصنف المحلى لمحصول الشعير أكثر مقاومة للملوحة مقارنة بالأصناف الأخرى و الذى انعكس في مقاييس النمو واختبارات جودة البذور.

التداخل بين الملوحة والأصناف كان له تأثير معنوى على بعض مقاييس النمو والإنتاجية وبعض اختبارات جودة البذور.

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1- INTRODUCTION

Improved crop production is concerned with the successful application of the fundamental sciences of botany in its many phases.

Every one is interested in the factors that influence the food supply of the world especially the amount of land suitable for agricultural production. Various climatic, soil and economic factors limit agricultural production over large parts of the earth's surface and result in concentrating production in limited areas.

Crops are grouped or classified on the basis of their botanical characteristics or of their utility, or both. By these criteria field crops are commonly grouped into cereals, pulses or grain legumes, fiber crops, oil crops, root crops and rubber. The most important food crops are cereals and feed grains.

Cereals as a group are the most widely adapted crop species. They are a high-energy food that is easily stored and transported. A cereal is generally defined as a grass grown for its small edible seeds. Wheat, rice, barley, rye and sorghum are the major cereals.

Rice, wheat and rye form the basis of the daily diet of many millions of people, while other cereals such as maize or barley are also extensively used for livestock production.

Wheat and barley which constitute the world's most important cereal crops. Moreover barley is the world's fourth most important cereal crop after wheat, rice and corn. These two cereals contribute about 41%of the world production of important cereal crops (Fageria, *et al*. 1997).

Barley (*Hordeum vulgare* L.) is an annual grass adapted to an arid climate and was domesticated in the Near East (Almekinder, 1999). It is adapted to a wide range of conditions in the cool temperate zone. It is grown extensively in Europe, the Near East, in some parts of Asia, North America, Australia and New Zealand.

The use of barley malt in brewing is well known. Several of the cereal grains may be used for malt, but barley, wheat and rye are unique in the production of α-amylose and β-amylose enzymes, which hydrolyze starch to dextrin's and fermentable sugars. Grain protein content is the one of the most important malt quality traits in barley.

Barley grows well on a fairly wide range of soils. It is best suited to soils that have a high moisture holding capacity, well drained, light to medium in texture and neutral to slightly basic pH (7-8) (Chapman and Carter, 1976). It has the

highest salt tolerance of all cereal crops (Mass and Hofman, 1977) and can be grown in soils which are too saline for bread and durum wheat. Many wild species of the genus *Hordeum* can also be found in saline habitats and can provide a source for salinity tolerance.

Soil salinity and sodicity are becoming major problems of crop production. A number of crops were found to be seriously damaged by salinity and sodicity as a result of agriculture expansion to so-called high terrace soils which are mostly salt affected (Ayoub, 1976).

Excessive soil salinity reduces the yield of many crop. This may range from a slight loss to complete crop failure, depending on the crop and severity of the salinity problem. Proper plant selection is one way to moderate yield reductions caused by excessive soil salinity. Choosing a suitable salt-tolerant crop can minimize crop loss caused by salinity.

The future expansion of agriculture in most parts of the Sudan will be directed to the high terrace and marginal soils with high salinity. However excessive reclamation program is required for the success of these expansions. Barley which is reported a salt tolerant crop and can be used for reclamation. The objectives of this study are to investigate the effect of different levels of salinity on growth, yield and seed quality as well as salinity tolerance of barley cultivar.

2- LITERATURE REVIEW

2.1 General:

2.1.1 Barley origin and distribution:

Vavilov back in 1926 proposed three centers of origin for barley in west Asia and north Africa. The Near East center of agricultural origin corresponds geographically to a region known as the Fertile Crescent, an arc that extends from Palestine through Syria and southern Turkey into Iraq and western Iran.

Wheat and barley together with domesticated sheep and goats, formed the basis of farming systems which evolved in the fertile crescent around 7000BC and then spread quickly as a Neolithic agriculture package to other parts of west Asia, the Nile valley and the Balkans (ICARDA and IDGRI, 1996).

Barley is probably the most ancient cultivated grain. All cultivated barley apparently belongs to one species *Hordium sativum*. However, there are very large number of subspecies and still greater number of varieties. Two main groups are recognized: the distichum group or two–row barley and the polystichum, *Hordium. vulgare* group, the six-row and four–row barley.

There has been disagreement over the origins of cultivated barley, particularly over whether six-row and two – row barley arose separately or from a common two- row or six–row stock. The present balance of evidence points to a single origin, from ancestors arc from Egypt through Turkey, Iraq, Iran and Afghanistan, from there numerous forms of both two row and six–row barley developed and were carried into the horn of Africa and into Indus valley and hence to China (Parry and Parry, 1989). Cultivated barley, *Hordcum vulgare*, probably evolved from a wild ancestor in the Near East, although suggestions have been made that it was originated in Tibet (Champman and Carter, 1976).

2.1.2 Barley production in the world:

In many countries of the Middle East and North Africa, barley constitutes the major part of the total cereal production. In 1986, barley accounted for 9% of the world cereal production. The major producers are Western Europe (30%), USSR (28%), USA and Canada (16%) and Turkey (4%) (Parry and Parry, 1989). The other large producers of barley include South Korea, Iran, India and Ethiopia.

In Canada, barley is currently the second most important cereal crop, while in the United States, it is of lesser importance, but must still be considered a major field crop, (Chapman and Carter, 1976).

In West Asia and North Africa, barley is the second most widely grown cereal crop (Joumaa and Matar, 1985), while in Africa , barley production accounts for a small proportion (9%) of the present world out put. Barley is Iraq's second most important field crop in terms of cultivated area, volume and value of output (Kamil, 1989).

In Tunisia, it is second to wheat in both area and production but is more important than wheat in some of the southern governorates where rainfall is lower. The main rain-fed barley area of Egypt is the North West coast extending from Alexandria to the Libyan border, a region about 500 Km long and 5-70 Km wide (Elenin, 1989).

In Sudan barley is grown in the northern region in small areas (Nouri and Ahmed, 1982).

2.1.3 Chemical composition and crop utilization:

Barley grains contain approximately, 13% water, 12% protein, 2% fat, 68% carbohydrate, 3.5% fiber and 1.5% Ash (Purseglove, 1972).

In the distant past, barley was largely used directly for human consumption, but once wheat was firmly established as a major source of flour, most of the production was used for malting or livestock feeding (Brian, 1971).

Until the fifteenth century, barley was ground for flour used in baking bread and it is a major source of food today for large number of people living in the cooler, semi-arid areas of the world where the other cereals are less well adapted (Chapman and Carter, 1976).

In Europe and North America about a third of barley crop is used for malting. Approximately 80% of the malt is used in beer, 4% distilled alcoholic products and 6% in malt syrups, malt milk concentrates, breakfast food and coffee substitutes (Leonard and Martin, 1968). A further third of barley grown in Europe and North America is used directly on the farms where it is produced as feed for pigs.

In Japan, about of half the crop is used directly as human food, generally as pearled barley cooked with rice. In China, barley often ground into flower with either broad beans or lentils, where as in Tibet, it is traditionally roasted or parched, ground and mixed with Yak milk to form dough which is eaten directly.

2.1.4 Malting barley:

The malting process is essentially the conversion of the starch to sugar in the grain, by inducing germination (Brian, 1971).

Producing malting barley requires special management efforts. Grains must be uniform, high quality, plump free from broken and skinned kernels and bright in color. For safe storage, grain should contain no more than 13% moisture and low percentage of protein ranging from 11.5–13.0% for six-row cultivars and 10-12% for two–row cultivars. The germination percentage of the grain must be high and the rate of germination is uniform.

2.1.5 Barley seed production:

Barley seed production is best done on heavier soils with good water–holding capacity and good surface drainage. Contamination with weeds or other crops should be avoided. Fields that have been used in the previous season for other small grains should not be used to avoid seed contamination and diseases.

Barley is basically a self-fertilized plant but a significant degree of cross-fertilization may occur, especially under stress conditions e.g. drought, thus greater distance between seed field may be advisable (Almekinder and Louwaars, 1999).

2.2 Salinity:-

Salinity is the total concentration of water soulble salts in water and soil. Soil salinity can be measured as a concentration, but in most agricultural situations it is measured as the electrical conductivity of a saturated soil paste (Ece) or a (1:5) (Ece 1:5) water extract in units of deci siemens per meter (ds/M) at 25 ˚C (Rogers, 1997).

Soil salinity and sodicity are becoming major problems of crop production. A number of crops were found to be seriously damaged by salinity and sodicity as a result of agricultural expansion into the so-called high terrace soils which are mostly salt affected (Ayoub, 1976).

2.2.1 Effect of salinity on plant growth:-

Rogers (1997) demonstrated the effect of salinity on plants in three ways. Initially, salts make it more difficult for plants to withdraw water from the soil, (even if the soil appears quite moist), in effect, the plant suffers from a form of drought which can result in retarded growth and reduced yield. Secondly, some salts, such as Na and CL can be directly toxic to plants. Plants take up salts with the water, and often those salts can damage the plant internally, affecting the plants physiological processes and often resulting in reduced growth, leaf burn and even plant death. Thirdly, high amounts of ions such as Na and Cl may affect the availability of other ions e.g K, Mg, N or P, which are extremely important for plant growth.

2.2.1.1Germination and seedling emergence:-

Salinization of the soil is a serious problem in arid and semiarid regions, for species to become established in saline environments, adaptation of the species to salinity in the germination stage is crucial, (Ungar, 1983, 1991). Seed germination is a major factor limiting the establishment of plants under saline conditions. Salinity can effect the germination of seeds either by creating an osmotic potential which prevent water uptake or by toxic effects of sodium and chloride ions

on the germinating seed, (Bewely and Black, 1982, Poljakoff *et al*., 1994). Although plants are generally most sensitive during germination (Mayer and Poljakoff, 1989; Catalan *et al*., 1994), white clover (Roger *et al*., 1995) and rice (Pearson *et al*., 1966) were reported to be more sensitive to salinity during the young seedling stage than during germination. Ayoub (1976) found no differences in germination of Senna (*Cassia autifolia*) up to salinity 6.0mmhos /cm, but 50% reduction in germination occurred at salinity levels of about 10, 17 and 22 mmohs/cm. Lentil (baladi cultivar) seed germination was satisfactory up-to salinity of about 5 mmohs/cm, but beyond that it decreased gradually and 50% reduction in germination occurred at salinity above 20 mmhos/cm (Ayoub, 1976).

Sowing sterilized seed of *Phaseolus aurcus* in solution of NaCl, KCl, Na_2SO_4 and K_2SO_4 at salinity level of 5 or 10 mmohs/cm in petri-dishes and sand soil resulted in decreased germination (Sheoran and Garg, 1980). Islam (1980) found that Semmes cultivar of soybean gave 100% germination at 0,100 and 200 ppm NaCl and then decreased, while other two cultivars (Lee 74 and improved pelican) gave 90% germination at 100 and 200 ppm Nacl, then decreased at levels 300 ppm NaCl, lowest at 400 and 500 ppm NaCl but rose to 100 and 98.7% at the higher levels (700-800 ppm NaCl).

Increasing salinity levels (0-15.5 mmohs/cm) using different salts decreased the germination percentage of some groundnut cultivars, but increased the germination of Gaug 10 and Gan gapurs cultivars at the lower salinity levels of $CaCl_2$,$MgSO_4$ and $Na2SO_4$ (Nautyal *et al*., 1990). Jing *et al.* (1990) found that the germination percentage of sensitive wheat cultivars decreased with increasing NaCl levels and fell to about 30 and 22% at 400 mM NaCl in the resistant cultivars. Increasing NaCl concentration between 60 to 200 mmhos/cm significantly decreased germination of white clover (*Trifolium repens* L) (Rogers *et al.,* 1995). However, germination of sorghum seeds was not affected by salinity (Amthor, 1984).

Seedling emergence of white clover was significantly more sensitive to NaCl than the germination (Rogers *et al.*, 1995). The higher the degree of salinity, the more prolonged was the emergence period in barley cultivar (Davydova, 1990). However the emergence of *Pinus banksiana* seedlings was least affected by salinity and at certain concentration it was appeared to be stimulated by the presence of salt (Croser *et al.,* 2001).

2.2.1.2 Seedling shoot: root ratio:-

Generally plants are more sensitive to salinity during their vegetative than their reproductive stage (Botella, 1993). Francois *et al.* (1986) and Mass and Poss (1989) reported similar results. Munns and Termaat (1986) stated that root growth

was less affected than shoot growth by increasing salinity, so that shoot: root ratio generally increased. A more recent review paper by Lauchli and Epstein (1990) concurs. The depressing effect of salinity on root growth of soybean and maize was generally less severe than its effect on the growth of the aerial components (stem, leaves and fruits) (Shalhevet *et al*, 1995). High increase in salt levels of Na2 So4 caused corresponding reduction in seedling height and root length of *Picea mariana*, *Picea gluca* and *Pinus banksiana* (Croser, *et al.,* 2001). Also the shoot: root ratio of (pirooz) a cultivar of chickpea was consistently reduced at all sampling stages by increasing salinity (Gholipoor *et al.,* 2000). Shoots are generally more inhibited in growth than roots and at low salinity levels root growth may not decrease at all (Rogers, 1997). Islam (1980) found that seedling shoot length of a soybean cultivar was little affected when germinated at 0,100 and 200 PPmNaCl concentration, where as 0-90 mM NaCl caused seedlings of different sorghum cultivars to be stunted (Amthor, 1984).

2.2.1.3 Seedling fresh and dry weight:-

Rogers (1995) demonstrated that individual seedling dry weight of grasses decreased significantly at concentrations greater than 10 mmohs /cm Nacl. Salinity induced significant reduction in shoot dry weight of rice plants harvested before panicle initiation. (Zeng–Lingtle *et al.,* 2001). Croser (2001) found that an increase in salt levels caused a reduction in

seedling dry weight of *Picea mariana, Picea glauca* and *Pinus banksiana*. Also an increase in soil salinity to and beyond 3.0 mmohs/cm resulted in a sharp decrease in shoot dry weight of lentil seedling (Ayoub, 1976).

2.2.1.4 Heading and flowering:-

Salinity generally accelerates flower initiation in contrast to most plant species (Francois, 1982; Francois and Bernstein, 1964; Francois *et al.,* 1986), however, the time of flower initiation of four sunflower hybrids cultivars among salinity treatment was unaffected (Francois, 1996). On the other hand, Katerji *et al.,* (2001) found that flowering of the drought tolerant variety of chickpea was accelerated by salinity.

2.2.1.5 Plant height:-

Plant height of wheat (treated with irrigation water with 4 Sodium adsorption ratio "SAR" levels) decreased with increasing SAR levels. (Majumdar, and Balai, 2000), whereas salinity (16 ds/m) reduced plant height of onion (*Allium cepa)* (Yadao *et al.,* 1998). Also Francois, (1996) found that all hybrids cultivars of sunflower in high salt plots were about 50% shorter than the control plants. A similar reduction in height was reported by Hang and Evans (1985) and Unger (1983) for water stressed sunflower.

2.2.1.6 Number of leaves/plant:-

Generally a reduction in plant growth evident by a reduction in plant height or in the number of leaves or shoots is the plants first response to salinity (Rogers, 1997). Both water stress (Oasterhusis and Cart Weright, 1983) and salinity stress (Grieve and Francois, 1992, Mass and Grieve, 1990) during the early vegetative stage of growth have been shown to decrease leaf number in wheat. However, leaf primordium initiation of spring wheat was more sensitive to changes in salinity, and the final main stem leaf number was controlled by the new applied salinity rather than the original stress level (Grieve *et al.,* 2001). Yadao *et al.* (1998) demonstrated that the highest salinity level (16 ds/m) reduced the number of leaves/ plant of onion.

2.2.1.7 Number of tillers /plant:-

Tillering of plants was essentially salt-resistant. The number of tillers/ plant of wheat were not significantly affected by salt treatment (Botella *et al.*, 1993). Although some workers have reported inhibition of the number of tillers by salinity (Silberbush and Lips, (1991) , others have reported no reduction in tiller number / plant (Franlois *et al.,* 1988, in response to salinity. Increasing salinity levels decreased the total number of tillers set per plant in wheat (Kirby, 1988). However,

changes in salinity level did not inhibit tiller bud initiation, but affected the timing of tiller emergence of spring wheat (Grieve *at al.,* 2001).

2.2.1.8 Number of spikes / plant:-

When salinity was applied 19 days after sowing (beginning of the vegetative stage) the number of spikes / plant of wheat were not significantly affected by salt treatment (Botella *et al.,* 1993). However, others (Francois *et al.*, 1988) have reported significant reduction in the number of spikes/ plant of triticle as affected by salinity. On the other hand, Ayoub (1976) found that any increase in soil salinity beyond 3.0 mmohs/cm had a drastic effect on the number of pods per plant of lentil.

2.2.1.9 Spike length:-

Water salinity (Ec_{iw} 12 ds/m) significantly decreased ear length of *Blonde psyllium (Plantago ovata forsk*) (Laxman *et al.,* 2000). Abdullah *et al.* (2001) reported significant decrease in panicle length of rice at salinity 50 mM NaCl. Similar results were reported by Sajjad (1984), Heenan *et al.* (1988) and Khatum *et al.* (1995).

2.2.1.10 Spike weight:-

When rice plants were stressed by water between 3-leaf and panicle initiation stages, a significant reduction in seed weight /panicle was pronounced. (Zeng Lingtle *et al.*, 2001). Also Zeng Lingtle *et al.* (2000) reported highly significant effects of salinity on seed weight/panicle of rice plant. Where as 50 mM NaCl caused significant decrease in panicle weight of rice (Abdullah *et al.,* 2001).

2.2.1.11 Number of spikelets/spike:-

Continuous salinity through out the growing season significantly reduced all growth and yield components. Kirby (1988) found that salinity imposed prior to terminal spikelet differentiation reduced the number of spikelets/spike in wheat. However, Grieve *et al.* (2001) demonstrated that the spikelet primordium initiation was less sensitive to changes in salinity and when salinity was changed at double ridge stage, the final spikelet number of spring wheat was controlled by the original salinity level. Zeng Lingtle, *et al.* (2000) observed highly significant linear responses of spikelet number per panicle of rice plant to salinity. Also Sajjad (1984), Heenan *et al. (*1988), and Khatum *et al.* (1995) found significant reduction in number of spikelets/panicle in rice in response to salinity.

2.2.1.12 Number of seeds/spike:-

The effects of salinity at 50 mM NaCl on floral characteristics, yield components and biochemical and physiological attributes of the sensitive rice variety IR-28, showed significant decreases in filled seeds /panicle (Abdullah *et al.,* 2001). On the other hand, water salinity Ece_{iw} 12dsm significantly decreased the number of grains/ear of *Blonde pscyllium (Plantago ovataforsk)* (Laxman *et al.,* 2000). Also Sajjad (1984), Heenan *et al.* (1988) and Khatum *et al.* (1995) found that the number of filled spikelets of rice was significantly reduced by salinity, where as the number of grains /spike in wheat was not significantly affected by Nacl salt treatment (Botella *et al.,* 1993).

2.2.1.13 Seed weight:-

Total seed weight/plant and 1000 seed weight of rice were significantly reduced in response to salinity at 50 mM NaCl (Abdullah *et al.,* 2001). Water salinity (Ece_{iw} 12ds/m) significantly decreased 1000 grain weight of *Blonde psyllium (Plantago ovata forsk)* (Laxman *et al.,* 2000). Also 1000 grain weight of *Setaria italica* L, was decreased from 3.15–1.9g with increasing salinity from 1.0-16ds/m (Thimmaiah, 1989).

2.2.1.14 Seed yield:-

Grain yield of wheat was decreased with increased SAR levels (Majumdar and Balai, 2000). Also grain yield of rice (Zeng Lingtle *et al.,* 2000) and *Setaria itatica* L. (Thimmaiah *et al.,* 1989) was decreased with increasing salinity. However, bulb yield of some onion cultivars were not affected adversely up to salinity level of 4 ds/m, where as high salinity (16ds/m) reduced bulb yield about 40-50% compared to the control (Yadao *et al.*, 1998).

Increasing levels of salinity above 4.8 ds/m, significantly reduced seed yield of sunflower hybrids (Francois, 1996). Where as increase in soil salinity to and beyond 3.0 mmohs/cm resulted in a sharp decrease in grain yield of lentils in green house experiment (Ayoub, 1976), while under field conditions, the grain yield was maximum at the lowest salt level and was 50% at 3.9 mmohs/cm and at salinity greater than 5 mmohs/cm, seed yield was very low. When salinity was applied 19 days after sowing (at the beginning of the vegetative stage), wheat grain yield was reduced (Botela *et al.,* 1993). Zeng Lingtle *et al.* (2000) reported significant effect of salinity on rice grain yield. However a positive response of corn to added chlorine (Cl_2) was observed where the Cl_2 treatment averaged more grain yield than the check yield (Heckman, 1995).

2.2.1.15 Plant dry matter:-

Dry biomass production of wheat was reduced when salinity was applied 19 days after sowing (Botella *et al.,* 1993). On the other hand, Majumdar (2000) reported reduction in straw yield of wheat crop with increasing SAR levels, while water stress alone reduced the dry matter production of bean (Adiku *et al.*, 2001). Also increasing salt concentration after 20 days from sowing decreased shoot dry weight of wheat cultivar. (Roy and Srivastava, 2001).

2.3 Seed Quality:-

The use of high quality seeds for planting is a major requirement for high and reliable yield of crops. High quality seed is the seed that has the ability to establish a full stand of vigorous and uniform seedlings which will grow into productive mature plant (Delouche, 1969).

Seed must be physically and genetically pure, free from impurities (seeds of other species, noxious weeds and inert matter), highly germinable and vigorous, of uniform size, free from seedborne diseases and with low moisture content (Thomson, 1979). Seed germination and vigor are the main seed physiological quality attributes, which are affected during seed deterioration. They are measured to provide an indication of the future performance of a seed lot. In most cases,

performance relates to the ability of seeds to germinate and produce a seedling that will emerge from the soil and develop into a healthy vigorous plant (Egli and Tekrony, 1995).

Many researchers have reported significant correlation coefficient between laboratory measure of quality (standard germination and numerous measures of seed vigor) and field emergence (Edje and Burris, 1971; Tekrony and Egli, 1977; Yaklick and Kulik, 1979 , Yaklick *et al.,* 1979; Clark *et al.,* 1980; Kulik and Yaklick, 1982 and Johnson and Wax, 1987;)

2.4 Germination as index of quality:-

Germination test is the most widely accepted measure of seed quality. It is defined as "the emergence and development from the seed embryo of those essential structures , for the kind of seed being tested, which indicate the ability to develop into normal plant under favorable conditions in the soil" (Anon, 1985). The standard germination test is the simplest test used as index of quality, in which external conditions are controlled to facilitate fast and uniform germination of a seed. It was developed and described by the International Seed Testing Association (ISTA) and used as an indicator of field emergence under optimum conditions, where field conditions are often very far from optimal.

Some authors have concluded that the standard laboratory germination test appears reliable for the predication of plant establishment in the field (Kraak *et al.*, 1984; Durrant *et al.,* 1985). However, a number of studies have shown the correlation between field emergence and laboratory vigor assays such as cold test (Herzog, 1980; Kraak *et al.,* 1984) and accelerated ageing test (Kraak *et al.*, 1984) but not with the standard germination (Akerson and Widner, 1980). Happ *et al,* in 1993 regarded the ISTA standard germination test as a vigor measure. Moreover Baalbaki and Copeland (1987) demonstrated the failure of germination test to predict field performance of bean and wheat seeds.

2.5 Seed vigor as index of quality:-

The two important characteristics of seeds that fundamentally affect their germination are viability and vigor. Seed vigor as an important quality attribute has gained significance because standard germination does not reflect the field emergence potential of a seedlot under varied environmental conditions. The International Seed Testing Association (ISTA) has defined vigor as the sum total of those properties of the seed which determine the potential level of activity and performance of the seed or seedlot during germination (Perry, 1978). The Association of Official Seed Analyst's vigor committee, defined seed vigor as "These seed properties which determine the potential for rapid uniform emergence and

development of normal seedling under a wide range of field conditions (McDonald, 1980). Seed vigor is also defined as the ability of a seed or seedlot to germinate quickly and with subsequent uniform seedling development under a wide range of environment (Anfinrud and Schneiter, 1984).

Seed vigor directly affects the performance of seed planted to regenerate the crop. Low vigor can reduce the yield if plant population come below a critical level (Tekrony and Egli, 1991).

2.5. 1 Factor affecting seed vigor:

Many genetic and environmental factors as well as crop management practices during seed production influence the vigor of seed. Among these factors are variety, weather conditions during seed development and maturation, mechanical damage during harvest or processing, inadequate drying and unsuitable storage conditions. The effects of those factors may not be reflected in the standard germination test results although they may affect the vigor of the seeds (OSU seed laboratory, 2001). The quality and quantity of seed produced depend on various factors such as soil, climate, cultural practices especially those which are more important are the timely involved from sowing to harvest of seed (Verma and Chaurasia, 1994).

Early harvest may result in poor germination and vigor. Like wise, delayed harvest may lead to low germination and vigor (Mugnisijah and Nakamura, 1984) due to adverse weather conditions s00uch as rain fall, drought and frost (Austin, 1972, Agrawal; 1980, Delouche, 1980; Tekrony *et al.,* 1980). The high temperature and relative humidity along with frequent rainfall during the period of seed development, and heavy rainfall just prior to harvesting reduced seed viability and vigor (Gurusamy, 1999). The time of storage, type of seed stored and storage environment (temperature, relative humidity and oxygen levels) also affect seed vigor. It is concluded that under mediterranean conditions and in the absence of humidity control, long term (>1-2 years) storage of aubergine seed should be carried out at ambient (25 $\pm$ 5˚C) rather than at low (5 $\pm$ 2˚C) temperature (Passam *et al.*, 1999)

2.5.2 Seed vigor Testing:

Vigor measures can be used for predicting the potential field performance of seedling as compared to the germination test, which is the most widespread method used to provide an index of quality for seed trade (Barla–Szabo and Dolinka, 1988; Hampton and Coolbear, 1990). Vigor testing is important for seed production because it better predicts field performance and it is a more sensitive indicator of seed quality than germination (Younis *et al.*, 1990). Several attempts

have been made to develop physiological and biochemical tests to determine seed vigor, yet there is not as yet a reliable test to evaluate it in all the different species (Gladys and Johnston, 1995).

For a seed vigor test to be useful it should be rapid, simple, inexpensive, reproducible and easy to perform on a large number of samples, the results should be meaningful and related to field performance (McDonald, 1980). Many vigor tests have been suggested; however, only few ones were attained accepted by analysts and seed testing organizations (AOSA, 1983, Berry, (1981). McDonald (1975) divided vigor tests into three categories:

1/ Physical tests measuring seed characteristics such as size, weight and density.

2/ Physiological tests utilizing parameters of germination or growth.

3/Biochemical tests measuring chemical reactions involved in cellular maintenance.

2.5.2.1 Physical Tests: -

Physical tests are quick, inexpensive and need not for well trained personal and sophisticated equipment's. Because of its simplicity, physical tests can easily be used to determine seed vigor. Physical tests include tests that measure seed size, weight, density, volume, and color and water imbibitions.

2.5.2.1.1 Seed size:-

Uniformity in size is one of the desirable properties of seed quality and in many cases seed size is positively associated with vigor (Paul and Rama Swamy, 1979). Pandita and Ramdhawa, (1992) found that vigor index values were higher for large seeds, followed by medium and small in radish. However Rajendra *et al.* (1990) observed the superiority of smaller seeds in soybean varieties over the large seeds with regard to vigor and emergence potential.

2.5.2.1.2 Seed weight:-

Seed weight is an important physical indicator of seed quality. A positive correlation between thousand seed weight and seed vigor was observed in wheat grains (Bona *et al.,* 1988).

2.5.2.2 Physiological Test:-

Physiological tests which are used to evaluate parameter of germination and growth can be divided into two main categories:

1/ Tests to evaluate seedlings under normal conditions.

2/Tests to evaluate seedlings growth under stress conditions.

2.5.2.2.1 Seedling evaluation:

Seedling evaluation tests are used to monitor some aspects of seedling growth. These including;

i) Seedling growth rate ii) speed of germination iii) seedling shoot and root length iv) seedling dry weight and v) seedling vigor classification.

2.5.2.2.1.1 Seedling growth rate:

It has long been known that germination rate is positively correlated with rapid field emergence and seedling development in many species. Seedling growth rate was found to be excellent in estimating seedling vigor. Vigorous seeds are able to synthesize new materials and rapidly transfer these new products to the emerging embryonic axis, resulting in increased dry weight accumulation (Copeland and McDonald, 1985). Younis *et al.* (1990) found that there is a dramatic decrease in seedling growth rate in two rice cultivars after aging and the reduction in seedling growth rate was more pronounced in the low vigor lot.

2.5.2.2.1.2 Speed of germination:

Speed of germination is one of the oldest parameters suggested as a vigor indicator (Gladys *et al.*, 1995), and as an important aspect of seed vigor. Many methods for determining germination rate have been employed (Nichols and Heydecker, 1968, Tucker and Wright, 1965, Timson, 1965). Belcher and Miller (1974) used the number of days a lot requires to reach 90% germination as an index of seed germination. The speed of germination test has been suggested as a vigor test because vigorous seeds have been shown to germinate rapidly. This test is rapid, required no specialized equipments, inexpensive and does not require additional technological training; however variations in temperature or moisture in the test chambers and substrata may affect test results.

Burris *et al.* (1969) and Kumar *et al.* (1988) showed that speed of germination is significantly correlated with seed vigor in soybean and green gram, however a weak correlation was reported between speed of germination and vigor during storage (BaalBaki, 1989). Artificial aging in wheat decreased speed of germination indicating that speed of germination could possibly used as a vigor test (Ram and Wiesner, 1988).

Maguire (1962) demonstrated that seedlots having the same speed of germination often differ in field emergence and growth, this result would indicate that speed of germination is not a good vigor test, but Shenoy *et al.* (1990) showed that speed of germination contributes more towards predicting field emergence than other vigor tests.

2.5.2.2.1.3 Seedling shoot and root length:

Several researchers have used shoot and root length as a vigor test. Germ (1949) first suggested measuring plumule growth as a vigor test for cereals and sugar beet, and the method was developed by Perry (1977) for barley and wheat. It has been used also by Woodstock (1969) for corn and suggested for soybeans by Burris and Fehr (1971). A measurement of lettuce root growth has been used successfully by Smith *et al* (1973). Based on their results, Gladys and Johnston (1995) believed that short laboratory tests based on radical emergence could differentiate seed vigor in lentil, bean and chick pea. Kim *et al.* (1987) concluded that hypocotyl length provide a good estimate of seed quality in soybean. Alizaga *et al.* (1987) also observed that the hypocotyl length declined with decrease in seed vigor. On the other hand, seedling root length accurately predicted seedling emergence in wheat (Steiner *et al.*, 1989).

2.5.2.2.1.4 Seedling dry weight:

Seedling dry weight is a test that further evaluates normal seedling after standard germination. Seedling dry weight excluding the cotyledons or endosperm was successfully used to assess seed vigor. Sinha *et al.* (1988) and Steiner *et al.* (1989) showed that seedling dry weight is one of the best single vigor tests to predict seedling emergence of wheat and cowpea. Edje and Burris (1970) mentioned that total seedling dry weight of soybean was not correlated with vigor. More over, Kittock and Law (1968) showed that there was no relation between changes in seedling dry matter and seed vigor in wheat.

2.5.3 Effect of salinity on seed vigor and germination:

Data on the effect of salinity on seed vigor is so limited. Germination and seedling vigor of *Setaria italica* L. seeds produced from plants grown under various levels of salinity were not significantly different (Thimmaiah *et al.*, 1989). However, salt treatments inhibited both germination and seedling vigor of sorghum (Prisco *et al.,* 1987). The maximum germination rate of *Lepidium sativum* L. (a medicinal plant) seeds when germinated in petri dishes was attained at lowest concentration of 50 mM NaCl, and decreased as salinity was increased from 100-200mMNaCl. The maximum plumule

and radical length (3.7 and 5.1 cm, respectively) and growth rate were obtained in the control and were found to decline significantly with increasing salinity (El-Darier and Yousef, 2000). Ghaulam and Fares (2001) found that germination percentage, rate of germination and the relative germination percentage of sugar beet (*Beta vulgaris* L.) seeds were inhibited by sodium chloride treatments. Also increasing salinity from 0-8 mmhs/cm caused reduction in germination and early seedling growth of sesame (*Sesamum indicum)* seed when germinated in petri-dishes (Ragiba, 2000). However, Maldeniya and Thenabadu (1977) found that germination was never completely suppressed by $(NH_4)_2$ SO_4 even at 0.08 M concentration. Increasing concentration of urea suppressed germination and caused a degeneration of seedling vigor, where as increasing the concentration of NaCl had no adverse effect on rice germination. On the other hand, Campos and Assuneao (1990) showed significant effect of salinity on germination, the number of abnormal plants and un germinated seeds of rice. Hosseini *et al.* (2002) found that germination of soybean (*Glycine max* L) decreased at NaCl concentrations of 330 mmoh/cm (81 % germination) and 420 mmoh/cm NaCl (only 40% of seeds germinated), while at 500 mmoh/cm NaCl there was no germination and seedling growth rate decreased drastically with increasing salinity.

3 - MATERIALS AND METHODS

Two pot experiments and laboratory tests were conducted in 1999/2000 and 2000/2001 to evaluate the effect of salinity on germination, seedling emergence, seedling growth and seed vigor of five barley cultivars. The two pot experiments were carried out at Shambat (latitude 15˚ 40′ N, longitude 32˚ 32′ E) and altitude 28 m above sea level, with heavy clay soil (more than 50% clay content and alkaline, pH 8.5). Monthly mean, maximum and minimum temperature, relative humidity, and total rainfall were recorded for the two seasons (Appendix 1). The two laboratory tests were carried out at the Seed Administration Lab (Federal Ministry of Agriculture and Forestry, Khartoum).

3.1 Seed source

The Department of Agronomy Faculty of Agriculture, University of Khartoum provided seed sample of barley (local cultivar) in the first season, while ICARDA Seed Unit provided seed sample of four cultivars in the second season (table 3.1).

3.2 Pot experiments:

The soil used in all pot experiments in the two seasons was Shambat soil. To determine the effect of salinity on barley seed vigor, artificial salinization was used by using different weight of calcium chloride (0, 4, 8, 12 and 16 g in the first season and 0, 8, 12 and 16 g in the second season). The specified weight of the salt was added to one

Table 3.1 Barley cultivars

NO.	**cultivars**	**Abbreviation**
1	Local	V1
2	Line 22-7 H 33/1 PA 265	V2
3	Ca / Mr/I PA 265	V3
4	Lignee 527// Bahtim /DL 71/3/Apil/ CM67//	V4

	MZq//4/Rhn-03/5/cm67	
5	Mari / Aths'2 // Avt /Attiki/3/Aths/Lignee 686/4/Arar//Hr /Nopal	V5

litter of water and the Ece of each solution was measured. The soil in each pot was irrigated by the salt solution as mentioned above according to saturation point of the soil and the Ece was measured before planting. Table (3.2) shows the different levels of salinity used in the two seasons.

The pots used were 15 and 12 inch in diameter for first and second season respectively.

3.2 Pot experiments:

The experimental design used was completely randomized design with four replicates in the two seasons. 150 seeds were planted in each pot in the first season, while 60 seeds were used in the second season. Nitrogen fertilizer was added after one month at the rate of 1g urea per pot.

3.2.2 Parameters studied:

To evaluate the effect of salinity on barley seed germination, seedling growth and seed vigor, the following parameters were measured in the two seasons:

3.2.2.1 Growth parameters:

3.2.2.1.1 Seedling emergence percentage

To determine the effect of salinity on barley seed germination, seedling emergence percentage was assessed. After 15 days from emergence, the number of emerging seedlings was counted in each pot

Table 3.2 Soil salinity levels in mmohs/cm

Treatments	First Season (1999/2000)	**Second Season (2000/2001)**
S_1	0.66	0.75

S_2	2.0-2.3	4.0
S_3	3.9-4.2	6.0
S_4	6.0-6.3	8.0
S_5	8.0	-

and the seedling emergence percentage was calculated by dividing the total number of seedlings emerged at that time by the total number of seeds used. Seedling emergence percentage was calculated at first emergence, 7days, 10 days and 15days after first emergence.

3.2.2.1.2 Seedling fresh weight:

Seedling fresh weight was evaluated by taking a random sample of ten seedlings in the first season and 5 seedlings in the second season 30 days after emergence. Average seedling fresh weight was calculated in mg by dividing the total seedling fresh weight by the number of seedlings used.

3.2.2.1.3 Seedling dry weight:

Seedling dry weight was evaluated after the seedling fresh weight was determined. Seedlings of each sample were dried at 75c for 24 hrs and the seedling dry weight was measured. The average seedling dry weight was calculated in mg.

3.2.2.1.4 Seedling shoot: root ratio:

Shoot length was determined by cutting the seedlings from their endosperm and the shoot length was measured from the point of attachment to the endosperm to the tip of the seedling. The average shoot length was calculated in cm by

dividing the total shoot length by the number of the seedlings used. Similarly the root length was measured from the point of attachment to the endosperm to the tip of the root. The average root length was calculated in cm. Shoot : root ratio was calculated by dividing the mean shoot length by the mean root length.

3.2.2.1.5 Number of leaves per plant:

At harvest, the number of leaves of the main plant was counted, and the average number of leaves was calculated.

3.2.2.1.6 Number of tillers per plant:

The number of tillers per plant was counted and the average number was calculated at harvest time.

3.2.2.1.7 Plant height:

At harvest, the height of plant was measured from the base of the main stem to the tip of the last leaf.

3.2.2.2 Days to 50% heading

At flowering stage, the number of days from planting to 50% heading of the total number of plants was counted for each pot.

3.2.2.3 Yield parameters

3.2.2.3.1 Number of spikes per plant

The number of spikes per plant was counted at harvest and the average number was calculated by dividing the total number of spikes by the number of plants used.

3.2.2.3.2 Spike length

The length of the spike of the main plant was measured from the base of the spike to the tip of the awns and the average length was calculated in cm for the two seasons.

3.2.2.3.3 Spike weight

After the length of the main spike was determined, the spike was weighed and the average spike weight was calculated in g.

3.2.2.3.4 Number of spikelets / spike

The number of spikelets of the main spike was counted and the average number was calculated.

3.2.2.3.5 Number of seeds per spike

After the number of spikelets per spike was counted, the spikelets were threshed, the number of seeds was counted, and the average number of seeds was calculated.

3.2.2.3.6 Total seed yield per pot

To determine the total seed yield per each pot, the spikes were collected, threshed and the total number of seeds of each pot was weighed in g.

3.2.2.3.7 Plant dry weight

In determining the plant dry weight, the plants were cut just above the soil surface, weighed and the average dry weight was calculated in g.

3.3 Laboratory tests

After harvest, seeds were collected from each pot separately, stored before it was used for vigor test determination.

To evaluate the effect of salinity on seed vigor, different laboratory vigor tests were studied. The vigor tests were carried out for the two seasons (1999/2001) at Seed Administration Lab, Khartoum, Sudan and included 100 seed weight, standard germination , speed of germination , seedling dry weight, growth rate and seedling shoot and root length.

3.3.1 Hundred seed weight

To examine the effect of salinity on seed weight and its association with seed vigor, hundred seed weight was assessed. Seed weight was determined by using hundred seeds (hand count) replicated four times and the average seed weight was calculated.

3.3.2 Standard germination test

The germination test was carried out to determine the effect of salinity on the standard germination and its relationship with seed vigor. Twenty-five seeds, replicated four times were used for the two seasons.

In the first season, seeds were planted in petri-dishes with two filter papers at the bottom of the dish, a third paper was placed over the seeds. The three papers were moistened with tap water and $CaCl_2$ solution with Ece 6mmohs /cm . The seeds were kept in the dark in the germination room at 20 $\pm$1˚C for ten days according to ISTA rules. At the end of the

incubation period, the number of normal seedlings was recorded. In the second season double towels (20x34 cm) were laid on a table and the seeds were placed in the mid of the towel, 1.5 cm apart to avoid contact of seedlings during germination. After planting, a third paper towel moistened with tap water and $CaCl_2$ solution with Ece of 6mmohs/cm was placed over the seeds and the towels were rolled, placed in polyethylene bags to preserve moisture and set upright in the germination room and allowed to germinate in the dark at 20 $\pm$ 1˚C for ten days. At the end of the period the towels were removed and the number of the normal seedlings was recorded.

3.3.3 Speed of germination

Speed of germination test was carried out with four replicates of twenty-five seeds each. In the first season, seeds were planted as mentioned in the standard germination test, while in the second season seeds were placed on paper towels 1.5 cm apart to prevent contact during germination and sown as mentioned in the standard germination test. After planting, the petri-dishes and the paper towels were kept in the dark for 10 days in the first season and 12 days in the second season (no further increase in the number of seeds germinated after 10 days in first season and 12 days in second season). Daily counts of normal seedlings were recorded. Vigor index was calculated by multiplying the number of seeds germinated on a

specific day by the reciprocal of the day on which the seedlings germinated (Maguire, 1962). The sum computed indicates the vigor index

$$X = \frac{\text{number of normal seedlings}}{\text{Days of the first count}} + \ldots + \frac{\text{Number of normal seedlings}}{\text{Days of the final count}}$$

3.3.4 Seedling Dry weight

Seedling dry weight was assessed after the final count in the standard germination test (10 days). Seedlings were cut free from their endosperm, twenty five seedlings were replicated four times and were dried in an oven at 80 $\pm$ I˚C for 24 hrs. The dried seedlings were weighed to the nearest milligram and the average seedling dry weight was calculated.

3.3.5 Seedling growth rate

Seedling growth rate test evaluates the growth of seedling in the standard germination test. Seedling growth rate was calculated after the seedling dry weight test had been determined.

Seedling growth rate was computed using total dry weight of normal seedlings weighed to the nearest milligram and divided by the number of normal seedlings (Fiala, 1987) using the following formula:

$$\text{Seedling growth rate} = \frac{\mathbf{Y}}{x-(a+b)} \text{ mg/normal seedlings}$$

Y= Normal seedling dry weight (mg)

x = No. of seeds germinated

a = No. of abnormal seedlings

b = No. of dead seeds

x- (a + b) = No. of normal seedlings

3.3.6 Seedling shoot and root length

In the first season, 25 seeds replicated four times were planted in petri-dishes and covered with a filter paper moistened with tap water and $CaCl_2$ solution with Ece 6mmhos/cm as mentioned in the standard germination test.

In the second season, 25 seeds replicated four times were placed on double towels and covered by a third one moistened with tap water and $CaCl_2$ with Ece 6mmohs/cm as mentioned in the standard germination test. The petri-dishes and paper towels were incubated in the dark at 20 $\pm$ I ˚C for 10 days in the two seasons. After the period of incubation, shoot and root length of the normal seedlings were measured, shoot length was measured from the point of the attachment to the endosperm to the tip of the seedling. The average shoot length was calculated by dividing the total shoot length by the number of normal seedlings measured. Similarly the root length was measured from the point of the attachment to the endosperm to the tip of the root. The average root length was computed by dividing the total root length by the total number of normal seedlings measured (Fiala, 1987).

4 - RESULTS

4.1 Experiment I, season 1999/2000

4.1.1 Pot experiment

4.1.1.1Effect of salinity on vegetative growth parameters:

4.1.1.1.1 Seedling emergence:

The mean emergence percentage ranged between 71.8% and 87.5%. Salinity significantly affected seedling emergence. S_1 (control) showed the lowest emergence percentage, while S_5 (8 mmohs/cm), S_4 (6 mmohs/cm), S_3 (4 mmohs/cm) and S_2 (2 mmohs/cm) showed the highest emergence percentage (table 4.1).

4.1.1.1.2 Seedling fresh and dry weight:

The different levels of salinity had no significant effect on the seedling fresh weight. The mean fresh weight ranged between 960 and 1195 mg. (table 4.1).

Mean seedling dry weight ranged from 210.0 to 277.5 mg. Salinity had no significant effect on seedling dry weight (table 4.2).

4.1.1.1.3 Seedling shoot: root ratio:

Seedling shoot: root ratio when determined after 30 days was not significantly affected by salinity. The mean shoot: root ratio ranged from 18.7 to 22.0. (table 4.2).

Table (4.1) Effect of Salinity on seedling emergence %, seedling fresh and dry weight (mg) (1999/2000)

Salinity levels (mmohs/cm)	Seedling emergence (%)	Seedling fresh weight(mg)	Seedlings dry weight(mg)

S_1 (control)	71.8	960	277.5
S_2	82.8	1015	210.0
S_3	84.5	1190	275.0
S_4	82.0	1195	250.0
S_5	87.5	1040	230.0
SE±	1.8	74.7	13.3
LSD	5.4	-	-

4.1.1.1.4 Plant height:-

Mean plant height ranged between 41.7 and 46.1 cm. The different levels of salinity highly significantly affected plant height. Salinity $S_{4,}$ $S_{3\ and}$ S_2 (6, 4, and 2 mmohs/cm) had the highest plant height where as S_1 (control) and salinity S_5 (8 mmohs/cm) showed the lowest plant height (Table 4.2).

4.1.1.1.5 Number of leaves/ plant:

Salinity at all levels studied had no significant effect on the number of leaves per plant (Table 4.2).

4.1.1.1.6 Number of tillers / plant:-

The number of tillers per plant was not significantly affected by the different levels of salinity (Table 4.3).

4.1.1.1.7 Plant dry weight:

Salinity had no significant effect on plant dry weight. The mean plant dry weight ranged from 1.2 to 1.4 g (table 4.3) .

4.1.1.2 Effect of salinity on heading:

Number of days to 50% heading was highly significantly affected by salinity. The mean number of days to 50% heading ranged between 48 and 55 days. Plants at S_5 and S_4 (8 and 6 mmohs/cm) took fewer days to reach 50% heading followed by those at S_3 (4 mmohs/cm), however, plants at S_1 (control) and S_2 (2 mmohs/cm) took longer time to reach 50% heading. (Table 4.3).

Table (4.2) Effect of salinity on seedling shoot: root ratio, plant height and no. of leaves/ plant (1999/2000)

Salinity levels mmoh/cm	**Shoot: root ratio**	**Plant height (cm)**	**No. of leaves/ plant**
S_1 (control)	4.7	41.7	6.4
S_2	4.9	44.4	6.3
S_3	5.1	45.4	6.3

S_4	5.5	46.1	6.3
S_5	4.7	41.7	6.3
SE $\pm$	0.24	0.8	0.1
LSD	-	2.6	-

Table (4.3) Effect of salinity on number of tillers/plant, plant dry weight (g) and number of days to 50% heading (1999/2000)

Salinity levels (mmohs/cm)	**No. of tillers/plant**	**Plant dry weight(g)**	**Days to 50% heading**
S_1 (control)	0.5	1.2	55
S_2	0.5	1.3	55
S_3	0.5	1.2	50
S_4	0.3	1.4	48
S_5	0.5	1.2	40
SE $\pm$	0.08	0.09	0.7

LSD	-	-	2.1

4.1.1.3 Effect of salinity on yield parameters:

4.1.1.3.1 Number of spikes/plant and spike weight:

Salinity had no significant effect on the number of spikes per plant and spike weight (table 4.4).

4.1.1.3.2 Spike length:

Spike length was highly significantly affected by salinity levels. The mean spike length ranged from 10.9 to 14.2 cm. Salinity at S_4 (6 mmohs/cm) showed the highest spike length, followed by S_3 (4 mmohs/cm), S_2 (2 mmohs/cm) and S_5 (8 mmohs/cm) , while S_1 (control) showed the shortest spike (Table 4.4).

4.1.1.3.3 Number of spikelets/spike:

Salinity highly significantly affected the number of spikelets. Mean number of spikelets ranged between 11 and 17. Salinity S_4 (6 mmohs/cm) showed the highest number of spikelets, followed by salinity S_2 (2 mmohs/cm) , S_3 (4 mmohs/cm) and S_5 (8 mmohs/cm), while S_1 (control) had the lowest number of spikelets (Table 4.5).

4.1.1.3.4 Number of seeds/spike:

The number of seeds per spike ranged from 6 to 12 seeds. Salinity highly significantly affected the number of seeds per spike. Salinity at S_4 (6 mmohs/cm) resulted in the highest number of seeds, followed by

Table (4.4) Effect of salinity number of spikes/plant, spike length (cm) and spike weight (g) (1999/2000)

Salinity levels (mmoh/cm)	**No. of spikes/ plant**	**Spike length (cm)**	**Spike weight (g)**
S_1 (control)	1	10.9	0.3
S_2	1	12.8	0.3
S_3	1	13.6	0.3
S_4	1	14.2	0.4
S_5	1	12.3	0.2
SE $\pm$	0.07	0.3	0.05
LSD	-	1.0	-

Table (4.5) Effect of salinity on number of spikelets/ spike, number of seeds/ spike, seed yield / pot and 100 seed weight (1999/2000)

Salinity levels (mmohs/cm)	No. of spike lets / spike	No. of seeds/ spike	Seed yield / pot (g)	100 seed wt. (g)

S_1 (control)	11	6	2.4	2.9
S_2	14	7	4.7	2.9
S_3	14	8	7.2	3.1
S_4	17	12	10.4	2.9
S_5	12	7	7.2	2.9
SE±	0.8	0.7	0.7	0.9
LSD	2.5	2.2	2.04	-

salinity at S_3(4 mmohs/cm), S_2 and S_5(2 and 8 mmohs/cm), while S_1 (control) had the lowest number of seeds (Table 4.5).

4.1.1.3.5 Seed yield /pot:-

Seed yield was highly significantly affected by salinity. The mean seed yield ranged between 2.4 and 10.4 g. Salinity at S_4 (6 mmohs/cm) produced the highest seed yield, followed by both S_5 and S_3 (8 and 4 mmohs/cm), S_2 (2 mmohs/cm), while S_1 (control) produced the lowest seed yield (Table 4.5).

4.1.2 Laboratory Tests:

4.1.2.1 Effect of salinity levels on seed quality:

Standard germination, seedling shoot length, seedling growth rate, speed of germination, seedling root length and seedling dry weight were evaluated on the produced seeds of barley "local cultivar".

4.1.2.1.1 Hundred seed weight:-

Mean 100 seed weight ranged from 2.9 to 3.1g. Salinity had no significant effect on seed weight. (table 4.5).

4.1.2.1.2 Standard germination percentage:

The mean germination percentage ranged between 96 and 100%. Germination percentage was not significantly affected by salinity

(table 4.6)

4.1.2.1.3 Seedling shoot length

Salinity levels highly significantly affected seedling shoot length. The mean shoot length ranged between 6.5 and 9.0 cm. Seeds from salinity S_5, S_4 and S_2 (8, 6 and 2 mmohs/cm) showed the longest shoot, followed by seed from S_3 (4mmohs/cm), whereas seeds from S_1 (control) showed the shortest shoot length (Table 4.6).

4.1.2.1.4 Seedling growth rate:-

Mean seedling growth rate ranged from 9.2 to 12.0 mg/normal seedling. Salinity had no significant effect on seedling growth rate (Table 4.6).

4.1.2.1.5 Seedling root length:-

Mean seedling root length ranged between 5.9 and 7.6 cm. Salinity highly significantly affected root length. Seeds from salinity S_3, S_4 and S_5 (4, 6 and 8 mmohs/cm) showed the longest root, while seeds from salinity S_2 (2mmohs/cm) and S_1 (control) showed the shortest root (Table 4.7).

4.1.2.1.6 Seedling dry weight:-

` Salinity showed a highly significant effect on seedling dry weight. The mean dry weight ranged between 13.5 to 20.0 mg. Seeds from S_1 (control) produced the highest seedling dry weight, while seeds from salinity S_2, S_3, S4 and S_5 (2, 4, 6 and 8 mmohs/cm) showed the lowest seedling dry weight (Table 4.7).

Table (4.6) Standard germination (%), seedling shoot length (cm) ` and seedling growth rate (in 2000)

Salinity levels (mmoh/cm)	Standard germination	Seedling shoot length	Seedling growth rate (mg/normal

	(%)	**(cm)**	**seedling**
S_1 (control)	100	6.5	12.0
S_2	96	8.1	9.9
S_3	98	7.7	9.2
S_4	98	8.2	9.9
S_5	99	9.0	9.3
SE $\pm$	12.1	0.2	0.5
LSD	-	1.4	-

Table (4.7) Seedling root length (cm), seedling dry weight (g) and speed of germination (1999/ 2000)

Salinity levels (mmoh/cm)	**Seedling root length (cm)**	**Seedling dry weight (mg)**	**Speed of germination**
S_1 (control)	5.9	20.0	6.1
S_2	6.4	15.8	5.7
S_3	7.4	14.9	5.3
S_4	7.6	15.0	5.6
S_5	7.4	13.5	5.6

SE ±	0.1	0.7	0.01
LSD	0.1	2.7	0.4

4.1.2.1.7 Speed of germination:-

Salinity had a highly significant effect on the speed of germination. The mean speed of germination ranged between 5.3 and 6.1. Seeds from S_1 (control) showed the highest speed of germination, while seeds from salinity S_2, S_3, S_4 and S5 (2, 4, 6 and 8 mmohs/cm) showed the lowest speed of germination (table 4.7).

4.1.2.2 Stress experiment:

Seeds produced from the different salinity levels were germinated at salinity 6 mmohs/cm, the effect of salinity on the vigor of the produced seeds was as follows:

4.1.2.2.1 Effect of salinity on standard germination:-

The mean germination percentage ranged between 84 and 98%. Salinity highly significantly affected germination percentage. Seeds from salinity S_2 (2mmohs/cm) and S_3 (4mmohs/cm) showed the highest germination percentage, followed by seeds from salinity S_5 (8mmohs/cm), where as seeds from S_1 (control) and S_4 (6mmohs/cm) showed the lowest germination percentage (table 4.8).

4.1.2.2.2 Effect of salinity on seedling shoot length:

Mean shoot length ranged from 3.2 to 4.1cm. Salinity had a significant effect on shoot length. Seeds from salinity S_4 (6mmohs/cm) showed the highest shoot length, followed by seeds from S_2 (2mmohs/cm) and S_1 (control), where as seeds from salinity S_3 and S_5 (4 and 8mmohs/cm) showed the lowest shoot length (table 4.8).

Table (4.8) Effect of salinity on standard germination (%), seedling shoot length (cm) and seedling growth rate (mg/ normal / seedling) at 6 mmohs/ cm (1999/ 2000)

Salinity levels (mmoh/cm)	**Standard germination (%)**	**Seedling shoot length (cm)**	**Seedling growth rate (mg/normal seedling)**
S_1 (control) X S_3	**86**	3.8	11.9
S_2 X S_3	98	3.6	9.4
S_3 X S_3	97	3.4	11.7
S_4 X S_3	84	4.1	14.3

S_5 X S_3	92	3.2	10.8
SE $\pm$	3.0	0.2	1.2
LSD	9.2	0.6	-

4.1.2.2.3 Effect of salinity on seedling growth rate:

Salinity had no significant effect on seedling growth rate. Mean growth rate ranged between 9.4 and 14.3 mg/ normal seedling (table 4.8).

4.1.2.2.4 Effect of Salinity on seedling root length:-

Salinity showed a highly significant effect on root length. Mean root length ranged between 2.0 and 2.4 cm. Seeds from S_1 (control) showed the longest root length, followed by seeds from salinity S_3 (4mmohs/cm), seeds from S_4 (6mmohs/cm), whereas seeds from S_2 (2mmohs/cm) and S_5 (8mmohs/cm) showed the shortest root (table 4.9).

4.1.2.2.5 Effect of salinity on seedling dry weight:-

Mean dry weight ranged from 15.0 to 20.0 mg. Salinity had no significant effect on seedling dry weight (table 4.9).

4.1.2.2.6 Effect of salinity on speed of germination:

Mean speed of germination ranged between 3.3 and 3.9. Salinity highly significantly affected speed of germination. Seeds produced from S_1, S_2, S_3 and S_5 (control, 2,4 and 8 mmohs/cm) showed the highest speed of germination while seeds from salinity S_4 (6mmohs/cm) showed the lowest speed of germination (table 4.9).

Table (4.9) Effect of salinity on seedling root length (cm), seedling dry weight (mg) and speed of germination at 6 mmohs/cm (1999/ 2000)

Salinity levels (mmoh/cm)	**Seedling root length (Cm)**	**Seedling dry weight (mg)**	**Speed of germination**
S_1 (control) X S_3	2.5	16.7	3.6
S_2 X S_3	2.1	14.9	3.8
S_3 X S_3	2.3	18.3	3.9
S_4 X S_3	2.2	20.0	3.3
S_5 X S_3	2.0	16.7	3.7
SE$\pm$	0.07	1.6	0.9

LSD	0.2	-	0.24

4.2 Experiment 2 Season 2000/2001

4.2.1. Pot Experiment:

In 2000/2001 all the growth and yield parameters which had been measured in experiment one were measured in the second season with five cultivars of barley (table 3.1).

4.2.1.1Effectof salinity and cultivar on growth parameters:

4.2.1.1.1 Seedling emergence %

Seedling emergence was significantly affected by salinity. The mean emergence percentage ranged between 86.2 and 89.5%. Salinity S_2 and S_3 (4 and 6 mmohs/cm) showed the highest emergence percentage, followed by salinity S_4 (8 mmohs/cm), while S_1 (control) showed the lowest emergence percentage (table 4.10).

Emergence percentage among cultivars was highly significant. V_1 (the local cultivar) showed the highest emergence percentage at the first emergence, emergence after 7,10 and 15 days, followed by V_4, V_3, V_5 and V_2 (table 4.10).

The interaction between salinity and cultivar was significantly affected seedling emergence (Fig.4.1).

4.2.1.1.2 Seedling fresh and dry weight

Seedling fresh weight highly significantly affected by salinity. Seedling from salinity S_4 (8 mmohs/cm) showed the highest fresh weight,

Table (4.10) Effect of salinity and cultivar on seedling emergence %, Seedling fresh and dry weight (mg) (2000/2001)

Treatments	Emergence (%)	Seedling fresh weight (mg)	Seedling dry weight (mg)
Salinity levels			
S_1 (control)	86	630.0	150.0
S_2	90	470.0	112.0
S_3	89	400.0	120.0
S_4	88	880.0	161.0
SE+	0.7	24.7	8.5
LSD	2.0	69.8	24.2

Cultivars			
V_1	95	700.0	181.3
V_2	81	425.0	107.5
V_3	87	937.5	177.5
V_4	91	450.0	108.8
V_5	85	462.5	103.8
SE±	0.8	27.6	9.5
LSD	2.3	78.0	27.0

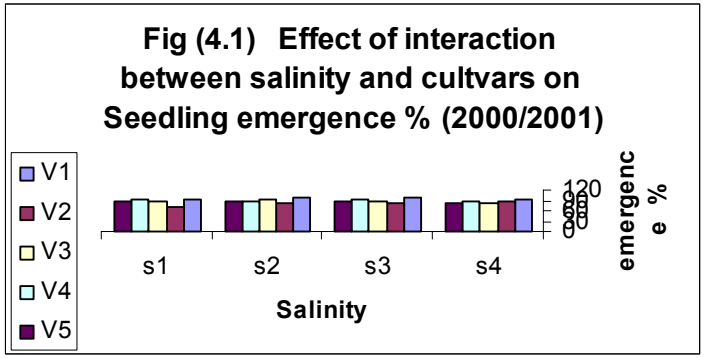


Fig (4.1) Effect of interaction between salinity and cultvars on Seedling emergence % (2000/2001)
V1
V2
V3
V4
V5
120
s1
s2
s3
s4
Salinity
emergence %

followed by S_1 (control), S_2 (4mmohs/cm) however S_3(6 mmohs/cm) showed the lowest seedling fresh weight (table 4.10).

Seedling fresh weight among cultivar was highly significantly affected by salinity.V_3 showed the highest seedling fresh weight, followed by the local cultivar (V_1), where as V_5, V_4 and V_2 showed the lowest seedling fresh weight (table 4.10).

The interaction between salinity and cultivars highly significantly affected seedling fresh weight (fig 4.2).

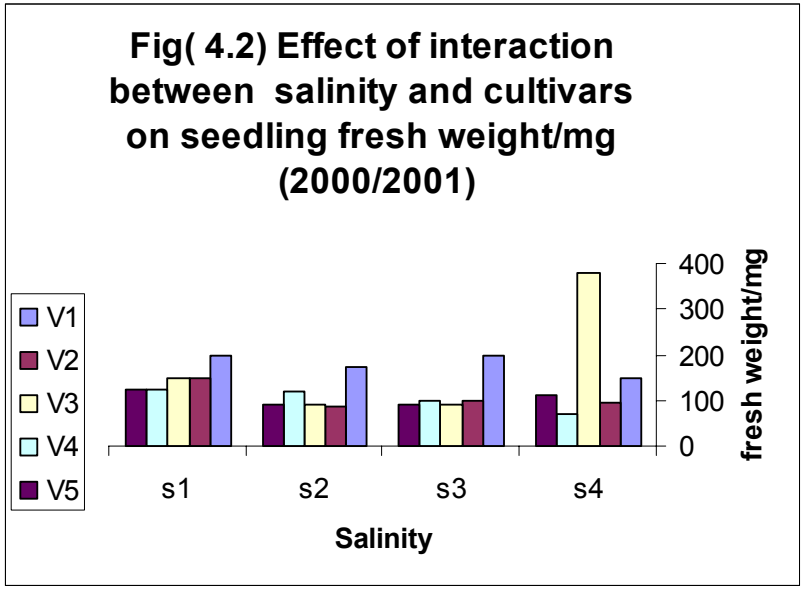
Seedling dry weight when determined was highly significantly affected by salinity. Mean seedling dry weight ranged from 112 to 161 mg. Salinity at S_4 (8 mmohs/cm) and S_1 (control) showed the highest dry weight, while salinity S_2 and S_3 (4 and 6 mmohs/cm) showed the lowest dry weight (table 4.10).

Seedling dry weight among cultivars was highly significantly different. The local cultivar (V_1) and V_3 showed the highest dry weight while V_2, V_4 and V_5 showed the lowest dry weight (table 4.10).

The interaction between salinity and cultivar significantly affected seedling dry weight (fig 4.3).

4.2.1.1.3 Shoot: root ratio:

Seedling shoot: root ratio when determined after 30 days was found to be decreased in response to salinity. The mean ratio ranged between 2.1 and 2.5 (table 4.11). Mean shoot: root ratio among cultivars


Fig(4.2) Effect of interaction between salinity and cultivars on seedling fresh weight/mg (2000/2001)
V1
V2
V3
V4
V5
s1
s2
s3
s4
Salinity
400
300
200
100
0
fresh weight/mg

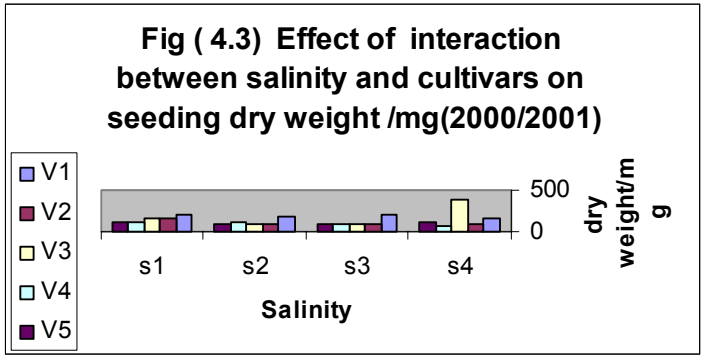


Fig (4.3) Effect of interaction between salinity and cultivars on seeding dry weight /mg(2000/2001)
V1
V2
V3
V4
V5
500
0
dry weight/mg
s1
s2
s3
s4
Salinity

was significantly affected by salinity. The local cultivar (V_1) showed the highest ratio, followed by V3, V4 and V5 which were not significant from each other, while V2 showed the lowest ratio (table 4.11).

The interaction between salinity and cultivar was significantly affected shoot: root ratio (fig. 4.4).

4.2.1.1.4 Number of leaves / plant:

Salinity had a highly significant effect on the number of leaves per plant. The mean number of leaves ranged between 5.1 and 5.3. Salinity S_2 (4 mmohs/cm) and S_1 (control) produced the highest number of leaves, while salinity S_3 and S_4 (6 and8 mmohs/cm) produced the lowest number of leaves (table 4.11). Number of leaves per plant was highly significantly affected by cultivars. The mean number of leaves ranged between 5.0 and 5.4 .V_2 and V_4 had the highest number of leaves, followed by the local cultivar (V_1), V_3, while V_5 produced the lowest number of leaves per plant (table 4.11). The interaction between salinity and cultivar showed a highly significant effect on number of leaves per plant (fig. 4.5).

4.2.1.1.5 Plant height:

Salinity showed a highly significant effect on plant height. The mean plant height ranged between 38.6 and 44.3 cm. The highest plant height was shown by S_1 (control), followed by salinity S_3 (6 mmohs/cm) ,

Table (4.11) Effect of salinity and cultivar on seedling shoot: root ratio, No. of leaves/plant and plant height (cm) (2000/2001)

Treatments	Shoot :root ratio	Number of leaves/plant	Plant height
Salinity levels			
S1 (control)	2.5	5.3	44.3
S2	2.2	5.3	39.6
S3	2.1	5.1	41.5
S4	2.0	5.1	38.6
SE±	0.07	0.04	0.5
LSD	0.2	0.1	1.4
Cultivars			
V1	3.1	5.2	41.6
V2	1.7	5.3	41.1
V3	2.1	5.1	40.6
V4	2.2	5.4	41.9
V5	2.0	5.0	39.7
SE±	0.14	0.04	0.6

LSD	0.2	0.1	1.6

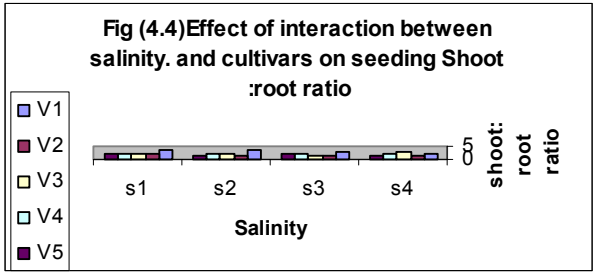


Fig (4.4)Effect of interaction between salinity. and cultivars on seeding Shoot :root ratio
V1
V2
V3
V4
V5
s1
s2
s3
s4
Salinity
shoot: root ratio

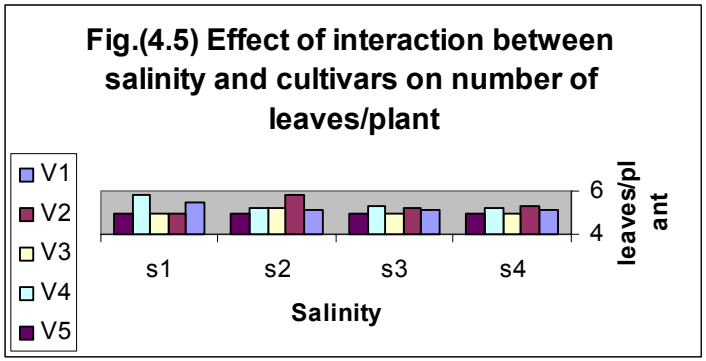


Fig.(4.5) Effect of interaction between salinity and cultivars on number of leaves/plant
V1
V2
V3
V4
V5
6
4
leaves/plant
s1
s2
s3
s4
Salinity

where as salinity $S_{2\ and}$ S_4 (4 and 8 mmohs/cm) produced the shortest plants (table 4.11).

Plants height among cultivars was significantly different. The mean height ranged between 39.7 and 41.9 cm. The local cultivar (V_1) and V_4 had the highest plant height, followed by both V_2 and V_3 while V_5 had the shortest plants (table 4.11). The interaction between salinity and cultivars had significant effect on plant height (fig. 4.6).

4.2.1.1.6 Plant dry weight:

Mean plant dry weight ranged between 2.7 and 4.9 g. Salinity had a highly significant effect on plant dry weight. Salinity S_3 (6 mmohs/cm) showed the highest dry weight, followed by salinity S_4 (8 mmohs/cm), S_2 (4 mmohs/cm), while S_1 (control) showed the lowest plant dry weight (table 4.12).

Plant dry weight among the cultivars was highly significantly different. The mean dry weight ranged between 1.6 and 4.3 g. The local cultivar (V_1) had the lowest plant dry weight, while the other four cultivars were not significant and showed the highest plant dry weight (table 4.12). The interaction between salinity and cultivars was highly significant (fig. 4.7).

4.2.1.2 Effect of salinity and cultivar on number of days to 50% heading:-

Plant heading was highly significantly affected by salinity. The

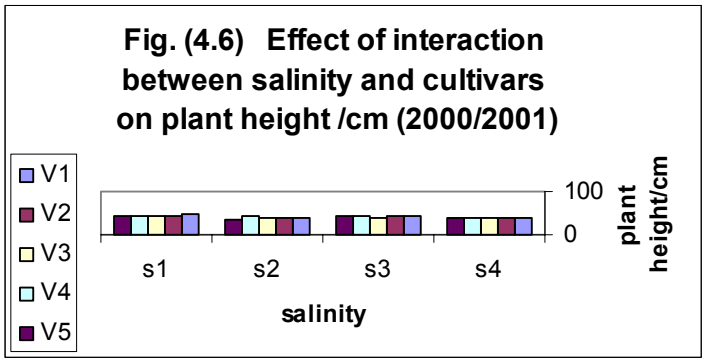


Fig. (4.6) Effect of interaction between salinity and cultivars on plant height /cm (2000/2001)
V1
V2
V3
V4
V5
100
0
plant height/cm
s1
s2
s3
s4
salinity

Table (4.12) Effect of salinity and cultivar on number of days to 50% heading, number of tillers/plant, number of pikes/plant and plant dry weight (2000/2001)

Treatments	No. of days to 50% heading	Number of tillers/plant	Number of spikes/plant	Plant dry weight (g)

Salinity levels				
S_1 (control)	72	1.9	2.0	2.7
S_2	69	3.3	2.7	3.2
S_3	69	4.5	3.5	4.9
S_4	70	3.8	2.9	3.6
SE±	0.6	0.2	0.1	0.2
LSD	1.6	0.7	0.3	0.5
Cultivars				
V_1	54	2.1	2	1.6
V_2	102	3.5	2	4.0
V_3	68	4.2	4	4.2
V_4	71	3.8	4	4.3
V_5	57	3.3	4	3.7
SE±	0.6	0.3	0.1	0.2
LSD	1.8	0.8	0.4	0.6

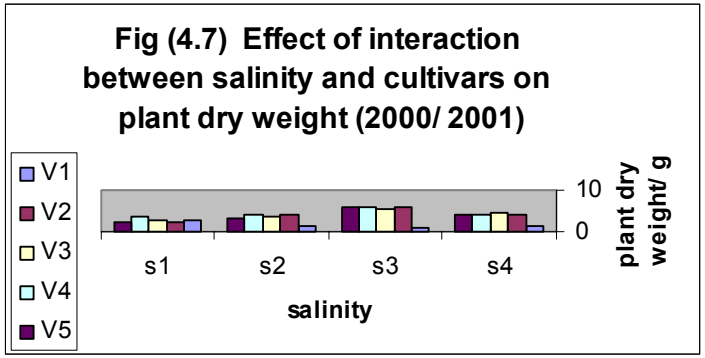


Fig (4.7) Effect of interaction between salinity and cultivars on plant dry weight (2000/ 2001)
V1
V2
V3
V4
V5
10
0
plant dry weight/ g
s1
s2
s3
s4
salinity

mean number of days to 50% heading ranged between 69 and 72 days.

Salinity S_2, S_3, and S_4 (4, 6 and 8 mmohs/cm) reduced days to 50% heading, compared to S_1 (control) (table 4.12).

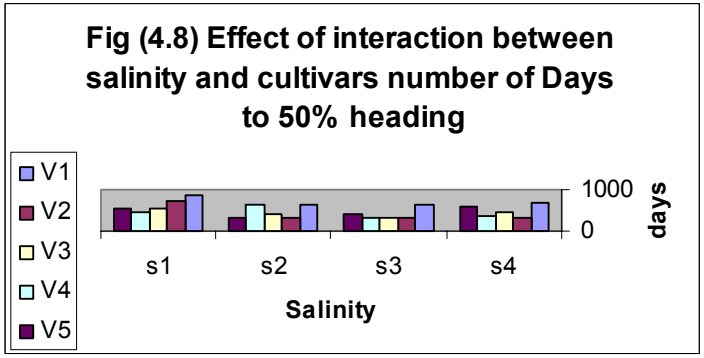
Cultivars were highly significantly different in number of days to 50% heading. Mean number of days among cultivars ranged between 54 and 102 days. The local cultivar (V_1) had the lowest number of days to 50% heading, followed by V_5, V_3, V_4, while V_2 was the latest to reach 50 % heading (table 4.12). The interaction between salinity and cultivars showed significant effect on the number of days to 50% heading (fig. 4.8).

4.2.1.3 Effect of salinity and cultivar on yield parameters:

4.2.1.3.1 Number of tillers/ plant:

Number of tillers per plant was highly significantly affected by salinity. The mean number of tillers ranged between 2 and 5. Salinity S_3 (6 mmohs/cm) resulted in the highest number of tillers, followed by salinity S_4 and S_2 (8 and 4 mmohs/cm), while S_1 (control) had the lowest number of tillers per plant (table 4.12). Cultivars were highly significantly different in number of tillers. The mean number of tillers

ranged between 2.1 and 4.2. The highest number of tillers was produced by V_3, V_4 and V_2, followed by V_5, while the local cultiver (V_1) had the



lowest number of tillers (table 4.12). The interaction between salinity and cultivar on the number of tillers per plant was not significant.

4.2.1.3.2 Number of spikes/plant:

The mean number of spikes ranged between 2 and 4. The number of spikes/plant was highly significantly affected by salinity. Salinity S_3 (6 mmohs/cm) resulted in the highest number of spikes, followed by salinity S_2 and S_4 (4 and 8 mmohs/cm), while S_1 (control) resulted in the lowest number of spikes (table 4.12).

Number of spikes among cultivars was highly significantly different. The mean number of spikes ranged between 2 and 4. The highest number of spikes was produced by V_4, V_3 and V_5, while the local cultivar (V_1) and V_2 had the lowest number (table 4.12). The interaction between salinity and cultivar on number of spikes/plant was highly significant (fig. 4.9).

4.2.1.3.3 Spike length:

Salinity had a highly significant effect on spike length. The mean length ranged between 13.1 and 15.1 cm. Salinity S_3 (6 mmohs/cm) and S_1 (control) resulted in the longest spikes; where as salinity S_4 and S2 (8 and 4 mmohs/cm) had the shortest spikes (table 4.13). Spike length among cultivars was highly significantly different. The mean length ranged between 13.0 and 14.9 cm. V_5, V_4, V_3 and V_2 showed the longest

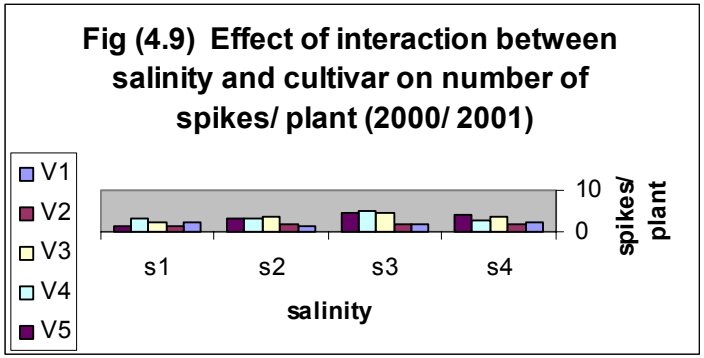


Fig (4.9) Effect of interaction between salinity and cultivar on number of spikes/ plant (2000/ 2001)

Table (4.13) Effect of salinity and cultivar on spike length (cm), spike weight (g) and number of spikelets/spike (2000/2001)

Treatments	Spike length (cm)	Spike weight (gm)	Number of spikelets/spike
Salinity levels			
S_1 (control)	14.9	0.5	23.7
S_2	13.7	0.3	21.4
S_3	15.1	0.5	24.5
S_4	13.7	0.4	21.9
SE±	0.2	0.02	0.6
LSD	0.7	0.6	1.8
Cultivars			

V_1	13.0	0.3	17
V_2	14.6	0.2	25
V_3	14.4	0.4	24
V_4	14.8	0.4	25
V_5	14.9	0.5	24
SE$\pm$	0.3	0.03	0.7
LSD	0.7	0.7	1.9

spikes, where as the local cultivar (V_1) showed the shortest spikes (table 4.13). The interaction between salinity and cultivar was not significant.

4.2.1.3.4 Spike weight:

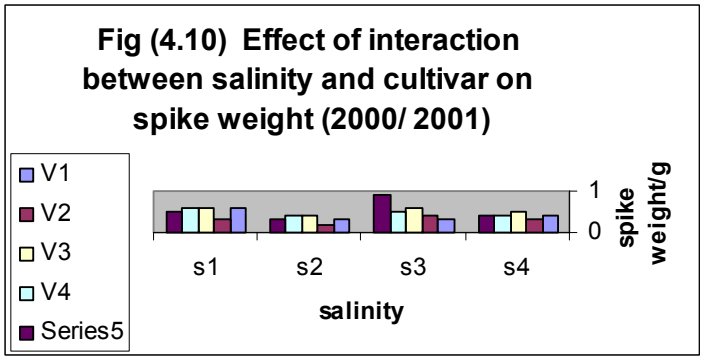
Mean weight of spike ranged between 0.3 and 0.5g. Spike weight was highly significantly affected by salinity level. Salinity S_3 (6 mmohs/cm) and S_1 (control) produced the highest weight, while salinity S_2 and S_4 (4 and 8 mmohs/cm) resulted in the lowest spike weight (table 4.13).

Spike weight among cultivars was highly significantly different. Mean spike weight ranged between 0.2 and 0.5g. V_5 had the heaviest spikes, followed by V_3 and V_4, local cultivar (V_1), while V_2 showed the lightest spikes (table 4.13). The interaction between salinity and cultivars was highly significant (fig.4.10).

4.2.1.3.5 Number of spikelets /spike:

Mean number of spike lets per spike ranged between 21 and 25. Salinity had a highly significant effect on number of spike lets. Salinity S_3 (6 mmohs/cm) and S_1 (control) showed the highest number of spikelets, where as salinity S_2 and S_4 (4 and 8 mmohs/cm) showed the lowest number of spikes lets (table 4.13). The mean number of spikelets among cultivars

ranged between 17 and 25. Cultivars were highly significantly different in number of spikelets. The local cultivar (V_1) showed the lowest number of spike lets, where as the differences among



the other four cultivars were not significant but showed the highest number of spike lets (table 4.13). The interaction between salinity and cultivars was highly significant. (fig. 4.11).

4.2.1.3.6 Number of seeds /spike:

Salinity showed highly significant effect on the number of seeds per spike. Mean number of seeds ranged between 15 and 19. S_1 (control) had the highest number of seeds, while salinity S_2, S_3 and S_4) (4, 6 and 8 mmohs/cm) had the lowest number of seeds per spike (table 4.14). The number of seeds among cultivars was highly significantly different. The mean number of seeds ranged between 12 and 19. V_5 produced the highest number of seeds, followed by V_4 and V_3, while the local cultivar (V_1) produced the lowest number of seeds (table 4.14). V_2 was excluded from these parameters due to its failure to set seeds. The interaction between salinity and cultivars was highly significant (fig. 4.12).

4.2.1.3.7 Seed yield /pot:

Mean seed yield ranged between 2.4 and 6.3g. Salinity had a

highly significant effect on seed yield. S_1 (control) produced the highest

seed yield, followed by salinity S_3 (6 mmohs/cm) where as salinity S_2 and S_4 (4 and 8 mmohs /cm) produced the lowest seed yield (table 4.14).

Seed yield among cultivars was highly significantly different. V_3 had the highest seed yield, followed by the local cultivar (V_1), V_5, while

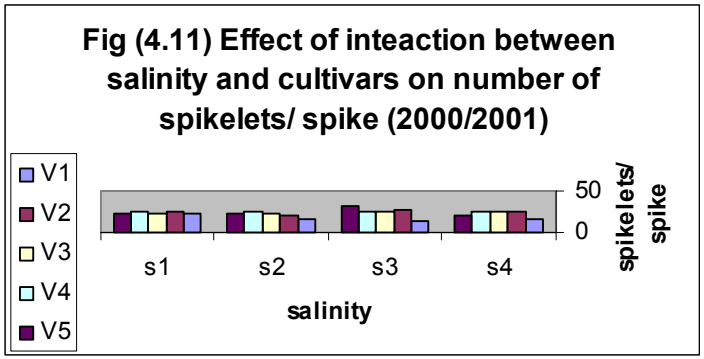


Fig (4.11) Effect of inteaction between salinity and cultivars on number of spikelets/ spike (2000/2001)
V1
V2
V3
V4
V5
50
0
spikelets/ spike
s1
s2
s3
s4
salinity

Table (4.14) Effect of salinity and cultivar on number of seeds/spike, seed yield/pot (g) and 100 seed weight (g) (2000/2001)

Treatments	Number of seeds/spike	Seed yield/pot (g)	100 seed weight (g)

Salinity levels			
S_1 (control)	19.3	6.3	2.3
S_2	15.8	2.4	2.6
S_3	16.0	4.6	2.8
S_4	15.0	2.6	2.6
SE±	0.5	0.3	0.1
LSD	1.4	0.9	0.2
Cultivars			
V_1	12	4.2	2.9
V_3	17	5.1	2.4
V_4	17	2.9	2.5
V_5	19	3.9	2.5

SE±	0.5	0.3	0.1
LSD	1.4	0.9	0.2

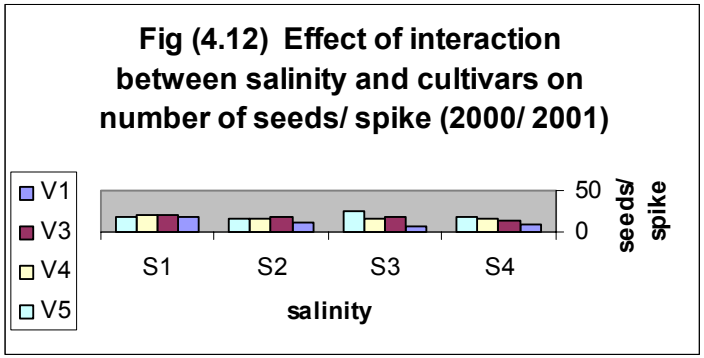


Fig (4.12) Effect of interaction between salinity and cultivars on number of seeds/ spike (2000/ 2001)

V_4 produced the lowest seed yield (table 4.14). The interaction between salinity and cultivar was highly significant (fig 4.13).

4.2.2.1 Effect of salinity and cultivars on seed quality:

4.2.2.1.1 100 seed weight:

Mean 100 seed weight ranged between 2.3 and 2.8g. Salinity had a highly significant effect on seed weight. Salinity S_3 (6 mmohs/cm) produced the heaviest seeds, followed by salinity S_2 and S_4 (4 and 8 mmohs/cm), where as S_1 (control) produced the lightest seeds (table 4.14). Seed weight among cultivars was highly significantly different. Mean seed weight ranged between 2.4 and 2.9g. The local cultivar (V_1) had the heaviest seed; where as the other three cultivars produced the lightest seed (table 4.14). The interaction between salinity and cultivar was highly significant (fig 4.14).

4.2.2.1.2 Standard germination %:

Mean standard germination for seeds grown in different level of salinity ranged between 79 and 86 %. Salinity had significant effect on standard germination. Seeds from salinity S_4 (8 mmohs/cm) showed the highest germination

percentage, followed by seeds from salinity S_2 and S_3 (4 and 6 mmohs/cm), while seeds from S_1 (control) showed the lowest germination percentage (table 4.15). Standard germination among cultivars was not significantly different. The mean standard germination ranged between 81 and 84 % (table 4.15).

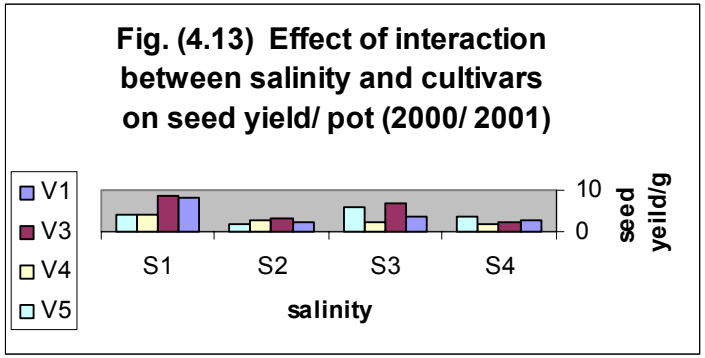


Fig. (4.13) Effect of interaction between salinity and cultivars on seed yield/ pot (2000/ 2001)
V1
V3
V4
V5
10
0
seed yeild/g
S1
S2
S3
S4
salinity

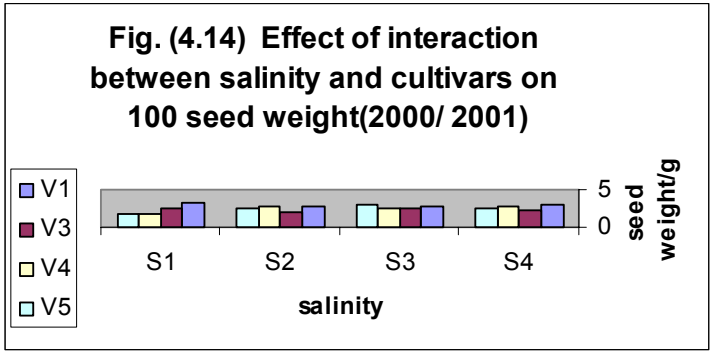


Fig. (4.14) Effect of interaction between salinity and cultivars on 100 seed weight(2000/ 2001)
V1
V3
V4
V5
S1
S2
S3
S4
salinity
5
0
seed weight/g

Table (4.15) Effect of salinity and cultivar on seed quality (standard germination %, seedling root length (cm) and seedling dry weight (mg) in 2000/2001

Treatments	Standard germination %	Seedling root length (cm)	Seedling dry weight (mg)
Salinity level			
S_1 (control)	79	13.6	16.9
S_2	83	12.6	15.6
S_3	81	12.1	19.4
S_4	86	13.2	17.5
SE$\pm$	1.9	0.3	1.5
LSD	5.3	0.7	-
Cultivars			
V_1	84	14.2	16.9
V_3	81	12.9	18.1

V_4	83	12.2	18.1
V_5	81	12.1	16.2
SE±	1.9	0.3	2.9
LSD	-	0.7	-

The interaction between salinity and cultivar had no significant effect on standard germination.

4.2.2.1.3 Seedling root length:-

Seedling root length was highly significantly affected by salinity levels. Mean root length ranged between 12.1 and 13.6 cm. Seeds from S_1 (control) had the longest roots, followed by seeds from salinity S_4, (8 mmohs/cm), S_2 (4 mmohs/cm), while seeds from salinity S_3 (6 mmohs/cm) produced the shortest root (table 4.15). Seedling root length among cultivars was highly significantly different. Mean root length ranged between 12.1 and 14.2 cm. Local cultivar (V_1) had

the longest roots, where as V_3, V_4 and V_5 showed the shortest roots (table 4.15). The interaction between salinity and cultivar was not significant.

4.2.2.1.4 Seedling dry weight:-

Mean seedling dry weight ranged between 15.6 and 19.4 mg. Salinity had no significant effect on seedling dry weight (table 4.15). Seedling dry weight among cultivars was not significantly different. Mean dry weight ranged between 16.2 and 18.1mg. (table 4.15). The interaction between salinity and cultivar was not significant.

4.2.2.1.5 Seedling shoot length:-

Mean shoot length ranged between 15.9 and 17.6 cm. Salinity had a highly significant effect on seedling shoot length. Seeds from salinity $S_3$and S_4 (6 and 8 mmohs/cm) produced the longest shoot, while seeds from S_1 and S_2 (control and 4 mmohs/cm) produced the shortest shoot (table 4.16). Seedling shoot length among cultivars was highly significantly different. Mean shoot length ranged between 15.6 and 18.4 cm. The local cultivar (V_1) produced the longest shoot, followed by V_4 and V_5, while V_3 produced the shortest shoot (table 4.15). The interaction between salinity and cultivars was highly significant (fig 4.15).

4.2.2.1.6 Seedling growth rate:-

Salinity and cultivars had no significant effect on seedling growth rate (table 4.16). The interaction between salinity and cultivars was highly significant (fig 4.16).

4.2.2.1.7 Speed of germination:

Mean speed of germination ranged between 5.7 and 6.0. Salinity had a highly significant effect on speed of germination. Seeds from salinity S_2 and S_4 (4 and 8 mmohs/cm) had the highest speed of germination, while seeds from S_1 and S_3 (control and salinity 6 mmohs/cm) had the lowest speed of germination (table 4.16). Speed of germination among cultivars was highly significantly different. Mean speed of germination ranged between 5.7 and 6.1. The local cultivar (V_1) had the highest speed compared to other cultivars (table 4.16). The interaction between salinity and cultivar was significant (fig 4.17).

Table (4.16) Effect of salinity and cultivar on seed quality (seedling shoot length (cm), seedling growth rate (mg/normal seedling) and speed of germination) in 2000/2001

Treatments	Seedling shoot length (cm)	Seedling growth rate (mg/normal seedling)	Speed of germination
Salinity level			
S_1 (control)	15.9	15.9	5.7
S_2	15.9	14.9	6.0
S_3	17.6	15.6	5.8
S_4	17.3	17.2	5.9
SE+	0.2	0.7	0.07
LSD	0.5	-	0.2

Cultivars			
V_1	18.4	16.0	6.1
V_3	15.6	16.1	5.7
V_4	16.4	16.3	5.9
V_5	16.4	15.2	5.7
SE+	0.2	0.7	0.07
LSD	0.5	-	-

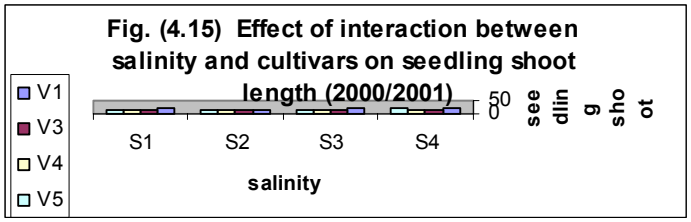


Fig. (4.15) Effect of interaction between salinity and cultivars on seedling shoot length (2000/2001)
V1
V3
V4
V5
50
0
seedling shoot
S1
S2
S3
S4
salinity

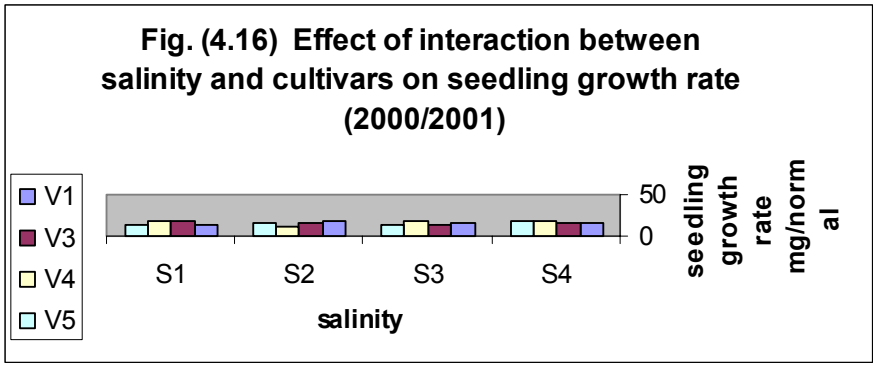


Fig. (4.16) Effect of interaction between salinity and cultivars on seedling growth rate (2000/2001)
V1
V3
V4
V5
50
0
S1
S2
S3
S4
salinity
seedling growth rate mg/normal

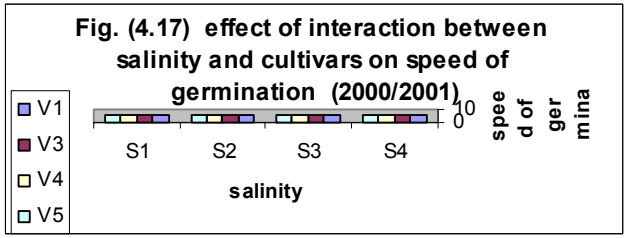


Fig. (4.17) effect of interaction between salinity and cultivars on speed of germination (2000/2001)
V1
V3
V4
V5
10
0
S1
S2
S3
S4
salinity
spee d of ger mina

4.2.2.2 Stress experiment:

4.2.2.2.1 Effect of salinity and cultivar on standard germination:

Salinity had no significant effect on germination percentage. Mean standard germination percentage ranged between 98 and 99% (table 4.17). Cultivars were significantly different in germination percentage. The local cultivar (V_1) showed

the highest germination percentage, followed by V4, where as V3 and V_5 showed the lowest germination percentage (table 4.17). The interaction between salinity and cultivar was highly significant (fig 4.18).

4.2.2.2.2 Effect of salinity and cultivar on seedling shoot length:

Mean shoot length ranged between 17.3 and 18.7cm. Salinity had a highly significant effect on shoot length. Seeds produced from S_1 (control) showed the longest shoot, followed by seeds from S_4 (8 mmohs/cm), S_3 (6 mmoh/cm), while seeds from S_2 (4 mmohs/cm) showed the shortest shoot (table 4.17). Cultivars were highly significantly different in shoot length. The mean shoot length ranged between 16.5 and 18.9 cm. The local cultivar (V_1) produced the longest shoots, followed by V_4, however V_3 and V_5 produced the shortest shoots (table

4.17). The interaction between salinity and cultivar showed a highly significant effect on seedling shoot length (fig 4.19).

Table (4.17) Effect of salinity and cultivar on standard germination %, seedling shoot length (cm) and speed of germination at 6 mmoh/ cm (2000/ 2001)

Treatments	Standard germination %	Seedling shoot length (cm)	Speed of germination
Salinity levels			
S_1 (control) X S_3	98	18.7	5.7
S_2 X S_3	99	16.7	5.7
S X S_3	98	17.3	5.6
S_4 X S_3	99	18.0	6.1
SE±	1.5	0.2	0.06
LSD	-	0.6	0.2
Cultivars			
V_1 X S_3	99.5	18.9	5.8

V_3 X S_3	98.0	16.5	5.9
V_4 X S_3	98.4	18.2	5.9
V_5 X S_3	97.5	17.1	5.6
SE±	1.5	0.2	0.06
LSD	4.3	0.6	0.2

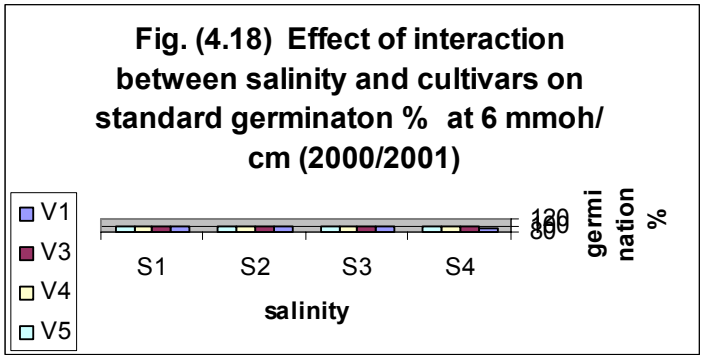
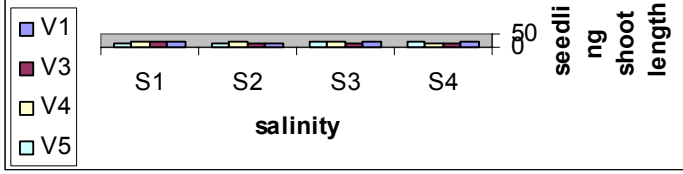


Fig. (4.19) Effect of interaction between salinity and cultivars on seedling shoot length at 6 mmoh/ cm (2000/2001)



4.2.2.2.3 Effect of salinity on speed of germination:

Salinity had a highly significant effect on speed of germination. Mean speed of germination ranged between 5.7 and 6.1. Seeds produced from salinity S_4 (8 mmohs/cm) showed the highest speed of germination, followed by seeds from salinity S_2, S_3 and S_1 (4, 6 mmohs/cm and the control) (table 4.17).

Speed of germination among cultivars was highly significantly different. The mean speed of germination ranged between 5.6and 5.9. The local cultivar (V_1), V3 and V_4 showed the highest speed of germination, where as V_5 showed the lowest speed of germination (table 4.17). The interaction between salinity and cultivar had a highly significant effect on speed of germination (fig 4.20).

4.2.2.2.4 Effect of salinity and cultivar on seedling root length:

Mean length ranged between 9.4 and 9.6 cm. Salinity had no significant effect on root length (table 4.18). Seedling root length among cultivars was significantly different. Local cultivar (V_1) and (V_4) showed the longest roots, followed by (V_3), while (V_5) showed the shortest roots (table 4.18). The interaction between salinity and cultivar was highly significant (fig 4.21).

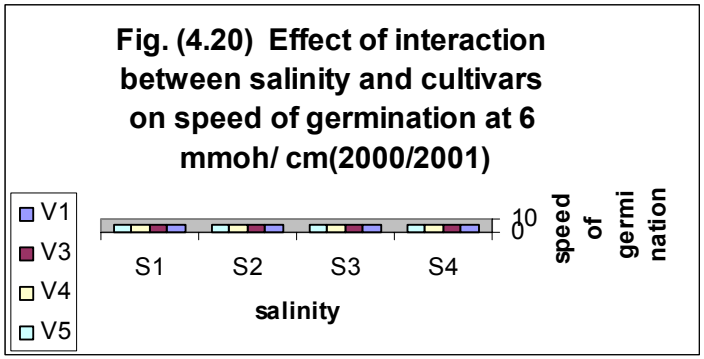


Fig. (4.20) Effect of interaction between salinity and cultivars on speed of germination at 6 mmoh/ cm(2000/2001)
V1
V3
V4
V5
10
0
S1
S2
S3
S4
salinity
speed of germi nation

Table (4.18) Effect of salinity and cultivar on seedling root length (gm), seedling dry weight (mg) and seedling growth rate mg/normal seedling) at 6 mmoh/ cm(2000/ 2001)

Treatments	Seedling root length (gm)	Seedling dry weight (mg)	Seedling growth rate (mg/normal seedling)
Salinity levels			
S_1 (control) X S_3	9.6	20.0	18.3
S_2 X S_3	9.5	19.4	19.6
S_3 X S_3	9.4	18.8	17.0
S_4 X S_3	9.4	16.3	17.1
SE±	0.13	1.0	0.6
LSD	-	2.9	1.7
Cultivars			
V_1 X S_3	9.8	21.3	20.4

V_3 X S_3	9.6	19.4	19.7
V_4 X S_3	9.7	16.9	15.4
V_5 X S_3	9.2	16.9	16.5
SE±	0.13	1.0	0.06
LSD	0.38	2.9	1.7

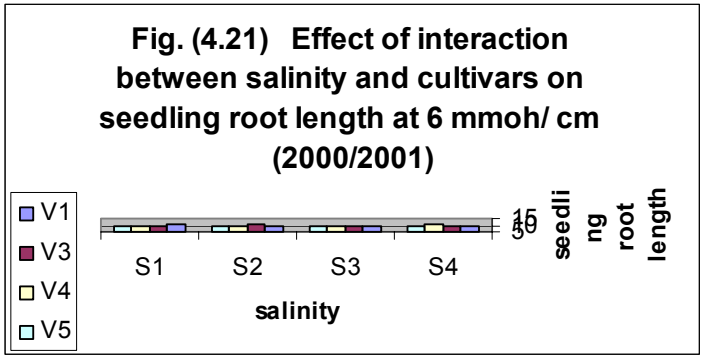


Fig. (4.21) Effect of interaction between salinity and cultivars on seedling root length at 6 mmoh/ cm (2000/2001)

4.2.2.2.5 Effect of salinity and cultivar on seedling growth rate:

Salinity had significant effect on seedling growth rate. Mean growth rate ranged between 17.0 and 19.6 mg/normal seedling. Seeds from salinity S_2 (4 mmohs/cm) showed the highest seedling growth rate, followed by seeds from S_1 (control), while seeds from salinity S_3 (6 mmohs/cm) and S_4 (8 mmohs/cm$_4$) showed the lowest growth rate (table 4.18). Seedling growth rate among cultivars was highly significantly different. The local cultivar (V_1) and (V_3) showed the highest growth rate, where (V_4) and (V_5) showed the lowest growth rate (table 4.18). The interaction between salinity and cultivar was highly significant (fig 4.22).

4.2.2.2.6 Effect of salinity on seedling dry weight:

Salinity had a significant effect on seedling dry weight. Mean dry weight ranged between 16.3 and 20.0 mg. Seeds from S1 (control) and salinity S_2 (4 mmohs/cm) showed the highest dry weight, followed by seeds from salinity S_3 (6 mmohs/cm), where as seeds from S_4 (8 mmohs/cm) showed the lowest dry weight (table 4.18). Cultivars were highly

significantly different in seedling dry weight. Mean dry weight ranged between 16.9 and 21.3 mg. The highest dry weight was shown by the local cultivar (V_1), followed by (V_3), while (V_4) and (V_5) showed the lowest dry weight (table 4.18). The interaction between salinity and cultivar showed a highly significant effect on seedling dry weight (fig 4.23).

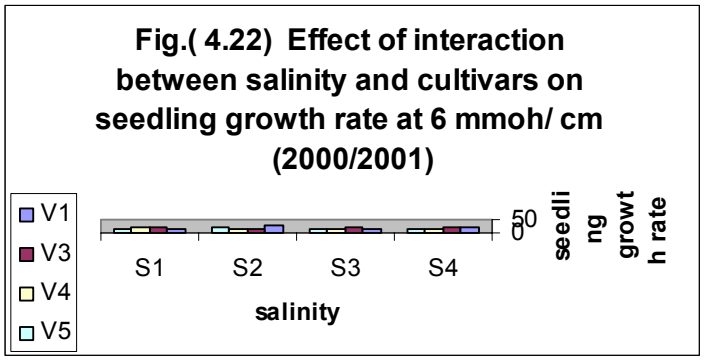


Fig.(4.22) Effect of interaction between salinity and cultivars on seedling growth rate at 6 mmoh/ cm (2000/2001)

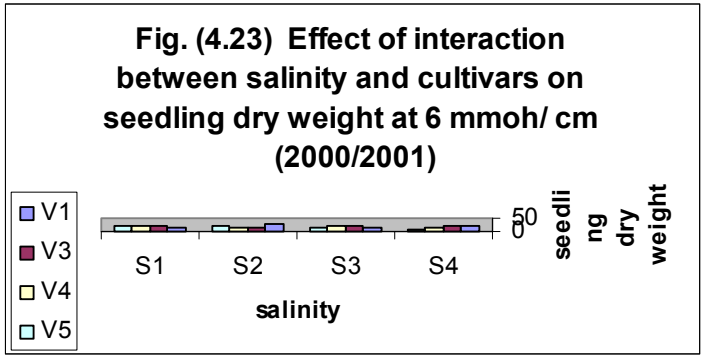


Fig. (4.23) Effect of interaction between salinity and cultivars on seedling dry weight at 6 mmoh/ cm (2000/2001)
V1
V3
V4
V5
50
0
seedling dry weight
S1
S2
S3
S4
salinity

5- DISCUSSION

Salinization of the soil is a serious problem in arid and semiarid regions, for species to become established in saline environments; adaptation of the species to salinity in the germination stage is crucial (Ugar, 1985, 1991).

Stimulation of seedling emergence with increasing salinity levels is not surprising in light of similar results reported by Croser *et al*, (2001) and Amthor (1984). This is simply due to the presence of salt which favor water uptake which stimulated seedling emergence.

Salinity has been shown different effect on plant growth. Plants are more sensitive to salinity during their vegetative than reproductive stage.

Soil salinity resulted in a significant decrease in seedling shoot, length, number of leaves/plant and plant height.

The studies of Munns and Termaat (1986), Lauchli and Epstein (1990), Shaihevet *et al.* (1995) and Gholi poor, *etal*. (2000) showed the reduction of shoot length in response to salinity. Also Oasterhusis and Wright (1983), Grieve and Francois (1992), Mass and Grieve (1990) and Rogers (1997) demonstrated the reduction in number of leaves/plant as an effect of salinity, while Yadov *et al.*(1998) , Hang and Evans(1985) and Unger (1983) reported the reduction in plant height in response to salinity.

Increasing in soil salinity when resulted in increasing seedling fresh and dry weight, number of tillers/plant and plant dry weight this could be due to the presence of Ca ions which is known in increasing photosynthesis resulting in increasing tillers of plant which are reported to be salt resistant (Botella, *etal*, 1993 and Francois, *et al.*, 1988).

Generally the time of initiation of heading was accelerated by salinity from low to high level. This is in support of the finding of Francois (1982), Francois and Bernstan (1964), Francois, *et al.* (1986) and Katerji *et al.* (2001).

The effect of salinity on number of spikes/plant, spiklets/ spike, number of seeds/spike and seed yield has been reviewed by many investigators, Kirby (1988), Sajjad, (1984), Heenan *et al.*, (1988), Khartoum, *et al.* (1995), Zeng *et al.* (2000), Thimmaiah *et al.* (1981), Francois (1995), Ayoub (1976) and Abdullah *et al.* (2001), they all showed significant reduction in the above parameters. In this study results obtained are in agreement with those mentioned above.

In this study seed vigor tests were carried on the produced seeds, better results of standard germination %, seedling shoot and root length, hundred seed weight, seedling dry weight and speed of germination were obtained in the seeds from treated soil than the control. This is may be due to the Ca ions which reported to increase seed calcium concentration by

increasing photosynthesis and translocation of carbohydrates to the growing embryo. Some researcher reported an increase in the total germination count in response to addition of Ca on cotton plant (Sawan *et al.,* 1999).

Also this high concentration of Ca ions in the seed was reported to protect the germinating seeds against the surrounding salinity when seeds were germinated at salinity 6 mmohs/cm and better results of standard germination and speed of germination were obtained with treated soil (Hosseini, *et al.,* 2002).

Seeding shoot and root length, seedling dry weight and seedling growth rate of the seeds when germinated at 6 mmoh/ cm were found to be reduced by salinity. This will be due to the toxic effects of surrounding salinity to the germinating seeds (EL-Darier and Yousif, 2000).

The greatest values of seedling emergence, seedling fresh and dry weight, seedling shoot length plant height, few days to 50% heading, seed yield, hundred seed weight, standard germination percentage, seedling root and shoot length, speed of germination and all seed quality tests under stress conditions were obtained with the local cultivar which appeared to be more tolerant to salinity than the introduced cultivars.

CONCLUSION

The effect of different levels of salinity on seed germination, growth, seed yield and seed vigor was studied in barley. From this study we concluded that:

1/ Salinity in the form of Ca Cl2 enhanced germination, seedling emergence, seedling growth and seed yield.

2/ Salinity accelerated heading initiation.

3/Salinity improved barley seed vigor.

4/More improvement of seed vigor was noticed when seeds were tested at salinity 6 mmoh/cm.

5/Plants grown on soils with medium salinity level (6 mmoh/cm) gave seeds of better emergence, seedling growth and seed yield compared to the others levels.

6/The local cultivar showed better salinity tolerance than the introduced ones in with regard to the parameters tested.

7/Barley may be a psteutral crop for high terraces and marginal lands.

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Appendix (1) Mean monthly meteorological data Shambat

month	Mean max.	Mean min.	R.H.
	1999		
Oct.	36.5	24.3	38
Nov.	35.8	20.8	26
Dec.	32.7	17.3	34
	2000		
Jan.	31	14.2	30
Feb.	31.6	16.5	25
Mar.	30	18.0	21
Oct.	37.4	23.0	30
Nov.	34.9	18.5	27
Dec.	30.5	14.4	29
	2001		
Jan.	29.7	13.5	26
Feb.	31.9	16.2	23
Mar.	37.3	18.7	16

Appendix (2) Analysis of variance for Effect of salinity on seedling emergence, seedling fresh and dry weight and shoot : root ratio (1999/2000)

Source of variation	D.F	Mean square			
		Emergence%	Seeding fresh weight	Seeding dry weight	Shoot : root ratio
Salinity (s)	4	64.92 *	45550.00 NS	3370.00 N.S	0.45 N.S
Error	12	12.45	22336.67	1190.00	0.27
Total	19				
C.V%		5.6	13.8	13.9	10.5

ppendix (3) Analysis of variance for effect of salinity on plant height, number of leaves and tillers /plant and plant dry weight 999/2000)

Source of variation	D.F	Mean square			
		Plant height	Number of leaves/plant	Number of tellers/plant	Plant dry weight
Salinity (s)	4	16.89 **	0.01 N.S	0.04 N.S	0.03 N.S
Error	12	2.82	0.04	0.02	0.03
Total	19				
C.V%		3.8	3.2	34.6	13.9

Appendix (4) Analysis of variance for effect of salinity on number of days to 50% heading, number of spikes/plant, spike length and spike weight (1999/2000)

Source of variation	D.F	Mean square			
		Number of days to 50% heading	Number of spikes/plant	Spike length	Spike weight
Salinity (s)	4	52.18 **	0.4/ N.S	0.04 N.S	0.03 N.S
Error	12	1.88	0.22	0.02	0.03
Total	19				
C.V%		2.7	12.3	5.1	30.2

Appendix (5) Analysis of variance for effect of salinity on number of spikelets/spike, number of seeds/spike, seed yield/ pot and 100 seed weight (1999/2000)

Source of variation	D.F	Mean square			
		No. of spikelets/plant	No. of seed/spike	Seed yield /pot	Seed weight
Salinity (s)	4	15.92 **	28.21 **	36.37 **	0.03 N.S
Error	12	2.65	2.09	1.76	0.04
Total	19				
C.V%		12.0	17.9	20.8	6.6

Appendix (6) Analysis of variance for effect of salinity on seed quality (standard germination %, seedling shoot length and seedling growth rate (1999/2000)

Source of variation	D.F	**Mean square**		
		Standard germination	**Seedling shoot length**	**Seedling growth rate**
Salinity	4	53.23 N.S	3.45 **	5.33 N.S
Error	12	48.21	0.86	2.05
Total	19			
C.V%		8.1	11.7	14.2

Appendix (7) Analysis of variance for effect of salinity on seed quality (seedling root length, seedling dry weight and speed of germination (1999/2000)

Source of variation	**D.F**	**Mean square**		
		Seedling root length	**Seedling dry weight**	**Speed germination**
Salinity	4	2.28 **	24.59 **	0.37 **
Error	12	0.38	2.97	0.05
Total	19			
C.V%		7.1	`10.9	3.9

Appendix (8) Analysis of variance for effect of salinity on standard germination %, seedling shoot length and seedling growth rate at 6 mmoh/ cm (1999/2000)

Source of variation	D.F	Mean square		
		Standard germination	**Seedling shoot length**	**Seedling growth rate**
Salinity	4	188.57 **	0.47 **	12.99 N.S
Error	12	36.98	0.13	6.00
Total	19			
C.V%		8.2	10.0	21.0

Appendix (9) Analysis of variance for effect of salinity on seedling root length, seedling dry weight and speed of germination (1999/2000)

Source variation	D.F	Mean square		
		Seedling root length	**Seedling dry weight**	**Speed of germination**
Salinity (s)	4	0.12 **a	15.59 N.S	0.17 **
Error	12	0.02	10.47	0.03
Total	19			
C.V%		6.1	18.7	4.9

Appendix (10) Analysis of variance for effect of salinity and cultivar on seedling emergence , seedling fresh and dry weight and seedling shoot to root ratio (2000/2001)

Source of variation	D.F	Mean square			
		Emergence%	Seedling fresh weight	Seedling dry weight	Shoot : root ratio
Salinity (s)	3	31.18*	907333.33**	907333.33**	0.86 **
Cultivar (v)	4	377.84**	783250.00**	783250.00**	4.5 **
SXV	1	39.48**	919416.67**	919416.67**	0.84 **
Error	60	10.40	12166.67	12166.67	0.09
Total	79				
C.V%		4.6	18.5	28.1	13.37

Appendix (11) Analysis of variance for effect of salinity and cultivar on number of days to 50% heading, plant height, number of leaves, tillers and spike/plant (2000/2001)

Source of variation	D.F	Mean square				
		Number of days to 5% heading	Plant height	Number of leaves / plant	Number of tillers/plant	Number of spikes/plant
Salinity (s)	3	44.85 **	125.23 **	0.14 **	25.26 **	7.32 **
Cultivar (v)	4	5730.08 **	12.53 *	0.37 **	9.88**	12.49 **
SXV	12	69.70 **	15.71 **	0.19 **	2.12 N.S	1.93 **
Error	60	6.43	5.05	0.03	1.17	0.28
Total	79					
C.V%		3.6	5.5	3.1	31.6	19.3

Appendix (12) Analysis of variance for effect of salinity and cultivar on number of spikelets/spike, spike length, spike weight and plant dry weight (2000/2001)

Source of variation	D.F	Mean square			
		Number of spikelets/spike	Spike length	Spike weight	Plant dry weight
Salinity (s)	3	43.44 **	11.60 **	0.22 **	18.5 **
Cultivar (v)	4	179.89 **	9.61 **	0.15 **	19.8 **
SXV	12	38.01 **	1.27 N.S	0.05 **	3.91 **
Error	60	7.67	1.07	0.02	0.62
Total	79				
C.V%		17.2	12.1	29.0	21.9

*significant, * * highly significant and N.S not significant

Appendix (13) Analysis of variance foe effect of salinity and cultivar on number of seeds/spike, seed yield/pot and 100 seed weight (2000/2001)

Source of variation	D.F	Mean square		
		Number of seeds/spike	Seed yield /pot	100 seed weight
Salinity (s)	3	56.62 **	54.40 **	0.59 **
Cultivar (v)	3	173.19 **	13.19 **	0.79 **
SXV	9	38.76 **	9.09 **	0.65 **
Error	48	3.99	1.64	0.05
Total	63			
C.V%		12.1	31.9	9.0

*significant, * * highly significant and N.S not significant

Appendix (14) Analysis of variance for effect of salinity and cultivar on seed quality standard germination, seedling root and shoot length) (2000/2001)

Source of variation	D.F	Mean square		
		Standard germination	**Seedling root length**	**Seedling shoot length**
Salinity (s)	3	182.04 *	6.93 **	11.96 **
Cultivar (v)	3	33.64 N.S	13.41 **	23.64 **
SXV	9	39.61 N.S	1.15 N.S	2.33 **
Error	48	56.05	1.05	0.56
Total	63			
C.V%		9.1	7.9	4.5

*significant, * * highly significant and N.S not significant

Appendix (15) Analysis of variance of effect of salinity and cultivar on seed quality (speed of germination, seedling dry weight and seedling growth rate) (2000/2001)

Source of variation	D.F	Mean square		
		Speed of germination	Seedling dry weight	Seedling growth rate
Salinity (s)	3	0.47 **	39.06 N.S	14.33 N.S
Cultivar (v)	3	0.62 **	14.06 N.S	4.63 N.S
SXV	9	0.18 *8	29.34 N.S	32.75 *8
Error	48	0.07	33.85	7.86
Total	63			
C.V%		4.7	`4.7	17.6

*significant, * * highly significant and N.S not significant

Appendix (16) Analysis of variance for effect of salinity and cultivar on standard germination, seedling root length and seedling shoot length at 6 mmoh/cm (2000/2001)

Source of variation	D.F	Mean square		
		Standard germination	Seedling root length	Seedling shoot length
Salinity (s)	3	71.71 N.S	0.38 N.S	11.02 **
Cultivar (v)	3	105.46 *	0.83 A	18.84 **
SXV	9	138.21 **	0.81 **	8.44 **
Error	48	37.04	0.28	0.71
Total	63			
C.V%		7.3	5.6	4.8

*significant, * * highly significant and N.S not significant

Appendix (17) Analysis of variance for effect of salinity and cultivar on speed of germination, seedling dry weight and seedling growth rate at 6 mmoh/ cm (2000/2001)

Source of variation	D.F	Mean square		
		Speed of germination	Seedling dry weight	Seedling growth rate
Salinity (s)	3	0.45 **	43.23 *	24.36 **
Cultivar (v)	3	0.36 **	72.40 **	93.02 **
SXV	9	0.38 **	94.62 **	8.77 **
Error	48	0.06	16.15	6.01
Total	63			
C.V%		4.3	21.6	13.6

*significant, * * highly significant and N.S not significant