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Effect of Salinity on Yield and Yield Related traits of some Accessions of Ethiopian Lentil (Lens culinaris M.) under Greenhouse Conditions

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Abstract: To evaluate the effect of salinity on yield and yield related traits of Ethiopian lentil, greenhouse experiment, were conducted. Seeds of 12 Lentil accessions were grown at greenhouse (Pot) conditions with different levels of salinity (0, 2, 4, and 8 dSm^{-1} NaCl) for 12 weeks. The experimental design was randomized complete block design in factorial combination with three replications. Data analysis was carried out using SAS software. Plant height, number of branch, number of leaves seed yield and total biological yield were evaluated. The two way ANOVA for varieties revealed statistically significant variation among lentil accession, NaCl level and their interactions ($p<0.001$) with respect to the entire parameters.It was found that salt stress significantly decreases, Plant height, Number of branches per plant, Number of Leaves per plant, Number of pods per plant, Total biological yield per plant, and Seed yield per plant of lentil accessions. The degree of decrement varied with accessions and salinity levels. All accessions were sensitive to high salinity level and did not produce sufficient seed yield and total biological yield. Accessions Lent12, Lent1 and Lent2 were better salt tolerant than the other accessions up to 4 dS/m salinity level. As the result, it is recommended to be used as a genetic resource for the development of lentil accession and other very salt sensitive crop with improved germination and seed yield under saline condition.

Key words: Accession, Effect, Lentil, NaCl, seed Yield

Introduction

Salinity is one of the most serious factors limiting the productivity of agricultural crops, with adverse effects on germination, plant vigor and crop yield [19], particularly in arid and semi-arid regions of the world [2] because of the lack of sufficient amount of rainfall leads to leaching the accumulated salt. Salinity affects many irrigated areas mainly due to the use of brackish (underground) water.Salt-affected soils are distributed throughout the world and no continent is free from the problem [1 and 6]. In Ethiopia, salt-affected soils are prevalent in the Rift Valley and the lowlands[14]. There are various detrimental effectsof salt stress in crop plants responsible for severedecrease in the growth and yield of plants. Osmoticstress (drought problem), ion imbalance, particularlywith Ca, K, and the direct toxic effects of ions on themetabolic process are the most important and widelystudied physiological impairments caused by salt stress [18, 11]. High salt concentrationin root affects the growth and yield of manyimportant crops [13]. The salinity may reduce the crop yield byupsetting water and nutritional balance of plant [23]. Exploration of variation for salt tolerance at inter-specific and intra-specific levels is a pre-requisite for improving the trait through a breeding program [5]. Variation for salinity tolerance in different crops had assessed at a specific growth stage rather than at different growth stages. This causes a problem in assessing the overall degree of salt tolerance of a crop, particularly because degree of salt tolerance varies with the developmental stage. In such crops, the plausible way is to assess degree of salt tolerance at each growth stage [21].Since grain legumes especially lentil are salt sensitive, farmers do not consider growing them in a saline environment, though; there is a considerable difference in salt tolerance among crops/accessions [4]. Screening of large number of available Lentil accessions is important to find a relative salt tolerant accession. Therefore, the general objective of this study was to evaluate the genetic variability for salinity tolerance among some Lentilaccessions whereas the specific objective was to evaluate the effect of salt yield and yield related traits of Lentil accessions and to identify salt tolerant Lentil accession.

MATERIAL AND METHODS

Description of the Study Area

The study was conducted at Haramaya University Greenhouse stations Rarre. It is situated in the semi-arid tropical belt of eastern Ethiopia[2]. The texture, pH and Electric Conductivity (EC) of the soil type used in the experiment (0-20 cm of depth) were analyzed before the experiment.

Plant Material

Seeds of twelve Lentil accessions were obtained from the EthiopianInstitute of Biodiversity (EIB) those were collected from different parts of Ethiopia.

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Accession Number	Accession Code	Region/ State/	Zone	Woreda/ District	Latitude	Longitude	Altitude
9235	Lent1	Oromiya	MisrakHarerge	Meta	09-16-21-N	41-33-45-E	2535
36004	Lent2	Amara	Semen Shewa	Ankober	09-39-00-N	39-41-00-E	3180
36006	Lent3	Oromiya	MisrakShewa	Gimbichu	08-57-00-N	39-05-00-E	2370
36019	Lent4	Oromiya	MirabShewa	AlemGena	08-48-00-N	38-20-00-E	2150
36025	Lent5	Gumuz	Metekel	Wenbera	Unknown	Unknown	1580
36032	Lent6	Oromiya	Bale	Ginir	Unknown	Unknown	1520
36064	Lent7	SNNP	Bench Maji	Dirashe	Unknown	Unknown	Unknown
36093	Lent8	Oromiya	MirabHarerge	Chiro	09-04-00-N	40-41-00-E	2000
36094	Lent9	Oromiya	MirabHarerge	Chiro	09-02-00-N	40-44-00-E	1870
36095	Lent10	Somali	Shinile	Afdem	Unknown	Unknown	1800
36113	Lent11	Oromiya	MisrakHarerge	Deder	Unknown	Unknown	Unknown
36120	Lent12	Oromiya	MirabWellega	Gawo Dale	Unknown	Unknown	1870

Table1. Description of lentil accessions that were used in the experiment

Treatments and Experimental Design
The study was conducted under greenhouse condition and it was focused on yield and yield related traitof lentil accessions under salt stress condition. Four different NaCl solutions with salinity levels of 0, 2, 4, and 8 dS/m [3, and 17] were prepared by dissolving 0, 1.28, 2.56 and 5.12 gm. of NaCl in one liter of water respectively. 12 accession of Lentil. The experiment was laid as Randomized Completed Block Design (RCBD) in a factorial arrangement and replicated three times[8].

Experiment procedure: the experiment was conducted from December to April 2013 using plastic pots of 19 cm diameter at the base and 20 cm at the top and 18 cm height in a greenhouse at Haramaya University Rarre Research Station following the modified procedures used by [2]. The experimental soil was taken from Rarre, Haramaya University's Research field. The soil was sandy clay loam (3% of silt, 29.2% of clay, and 67.8% of sand) and had pH of 6.8 and EC 0.56 dSm^{-1}. The soil was filled into 144 pots. Then twelve surface sterilized uniform seeds of each Lentil accessions were sown in the plastic pots at uniform depth and distance. Pots were arranged in RCBD replicated three times, and irrigated with equal 100 ml of NaCl solutions of 2, 4, and 8 dSm^{-1}, and tap water as control. The EC of the tap water was measured by EC meter and it was 1.47 deci Siemen per meter (dS/m) during the experiment period. Treatment application with the same amount of salt solution continued every other day and germination count started count started after 6th days sowing and continued until the 14th day.

Data Collected

Plant height (cm): The perpendicular distance from the ground level to the tip of the longest branch had measured on five randomly selected plants from each accessions and the average value was recorded[9].
Number of branches per plant: The number of branches emerging directly from the main stem counted at the time of maturity on five randomly selected plantsfrom each accessions and the average was recorded[10].
Number of Leaves per plant: Total number of leaves on five randomly selected plants from each accession was counted at maturity and the average has been recorded[10].
Number of pods per plant: Total numbers of seeds bearing pods on five randomly selected plants from each accession were counted andthe average recorded[11].
Total biological yield per plant(g): The completely matured plants were uprooted carefully along with roots and were dried completely. The weight of five randomly selected dried plant along with pods from each accession recorded as biological yield in grams [10].
Seed yield per plant (g): The weight of seeds of five randomly taken plants from each accession from each pot measured in gram[11].
Data Analysis: The data were subjected to analysis of variance using SAS (version 9.1.) software and the means were separate using the Least Significant Difference (LSD) test at 5% significance level.

RESULTS AND DISCUSSIONS

Influence of salinity on plant height of lentil of accession: Two-way analysis of variance (ANOVA) for plant height data revealed that highly significant variation exist among accessions , salinity and their interaction ($p<0.001$) (Table 2).The salinity level used in the experiment exerted adverse effect on growth of plant and consequently reduced plant height, but accessions responded differentlyand the mean value of plant height varied between 39.17 to 50.17 cm at control, 22.63 to 41.7 cm at 2 dsm^{-1} , 15.67 to 29.67 at 4 dsm^{-1} 0.00 at 8 dsm^{-1}. At 2 and 4 dsm^{-1} salinity level, accession Lent12, Lent1 and Lent2 achieved the longest plant height than the rest of the accessions that were tested (fig 1). In contrast to this, salinity adversely reduced growth of accession Lent5, Lent11 and Lent4.Thus; those accessions achieved the shortest plant height (fig 1). Furthermore, at 8 dSm^{-1} salinity level,all accessions were unable to survive on higher salinity level and failed to produce sufficient plant height(fig 1) to carry their leaves and provided photosynthetic support to the plant and this lead to shortage of food of those accessions and finally the death of the entire plant.This is because of Lentil was very sensitive to salinity and un able to produce sufficient plant height. According to [4] salinity hampered plant height growth of lentil and at high salinity level lentil was failed to produce adequate amount of plant height (reduced photosynthetic activity).The result indicated that salinity stress significantly reduced plant height(fig 1)and this was in full agreement with that of [10] in lentil and [15] in rice reported decreased plant height as NaCl salinity level become increase. Decreased plant height may be due to inhibition of cell division or cell enlargement by salinity stress.

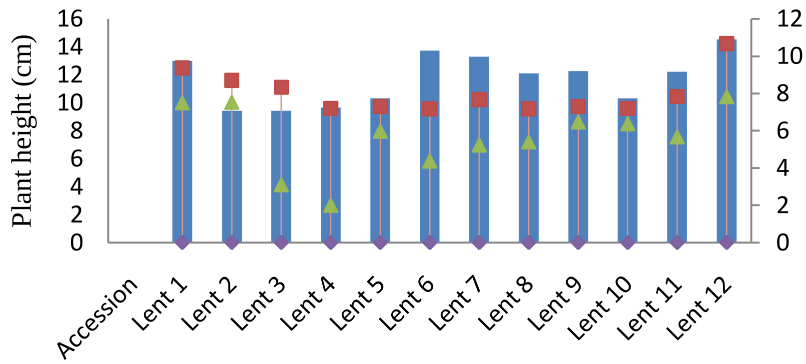

fig 1. Effect of salinity on plant height of lentil accessions

control 2 4 8

Table2. Summary of analysis of variance of yield and yield related traits of Lentil accession as affected by NaCl levels

Mean squares					
Parameter	NaCl (N) (df= 3)	Accession(A) (df= 11)	N x A (df= 33)	Error (df= 94)	CV (%)
PH	12303.56**	98.28**	39.78**	6.71651	2.60
NBP	875.47**	11.78**	5.55**	0.445474	10.48
NLP	20245.94**	141.09**	55.08*	1.01513	3.07
NPP	3770.61***	52.15**	27.23**	1.02661	8.85
SY	77.23**	0.24**	0.15*	0.0148121	6.35
TBY	171.12**	0.53**	0.11**	0.0108176	3.40

*and ** = significantly different at 1% and 0.1% level of probability, respectively; PH=plant hieght; NBP=number of branch per plant; NLP=number of leaves plant^{-1}; NNP=number of pod plant^{-1}; TBY=Total biological yield, SY=seed yield

Influence of salinity on number of branch per plant

Two way analysis of ANOVA for primary branch data revealed that there were highly significant variation for branch number among accession, salinity level and their interaction (p<0.001) (Table 2).At 2 and 4 dSm^{-1}salinity level, some accession produced the maximum number of branch whereas,the minimum number of branch were recorded in other accessions. For instance, the highest branch number observed in accession Lent12, Lent1 and Lent2 than other accessions that were tested (fig 2) while, the lowest branch number recorded in accession Lent10 and Lent4 (fig 2). Furthermore, at 8 dSm^{-1}salinity levels,all accessions were botched to produce adequate number of branch at maturity level (fig 2) because of high salinity concentration which hampered the growth of branch on the individual plant and hindered photosynthetic activity of the plant as result the plant exposed to deficiency of important mineral and food to survive and the plant become die.The result showed that increasing of salinity levels cause significant reduction in branch number (fig2). Similar result was reported by [10 and 2] who found that decrement of branch number of lentil under salinity level. This might be due to salinity inhibits the formation of new branch and facilitating the aging of old branch at various degrees in those accessions.

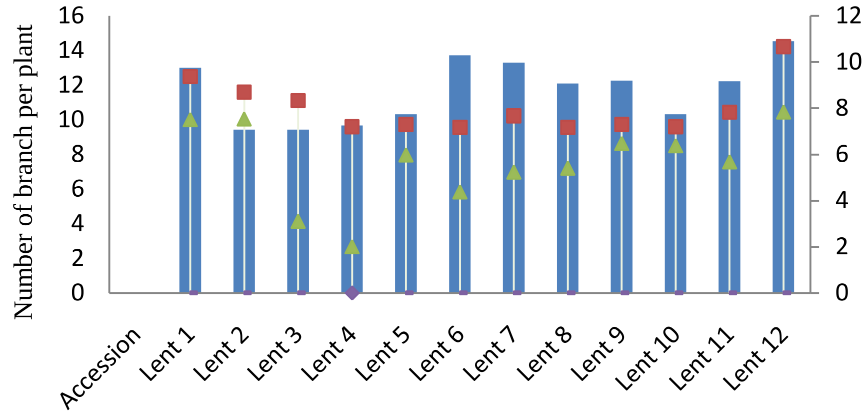

fig2. Effect of salinity on formation of branch of lentil accessions

Influence of salinity on number of leaves per plant Two-way analysis of ANOVA found that there were highly significant among accession, salinity level and their interaction (p<0.001) (Table2) with respect to number of leaves.At 2 and 4 dSm^{-1} salinity level, the highest leaf number was recorded at accession Lent1, Lent12, Lent2 (fig 3) whereas accession Lent3 and Lent8achieved the lowest leaf numbers than the other accessions that were tested (fig 3). Additionally at 8 dSm^{-1} salinity level,salinity extorted adverse effect and all accessions unable to achieved adequate amount of photosynthetic leaves (fig 3). Thus, as consequence, all accession were become died before the maturity stage. The mean number of leaves ranged from 27.67 to 63.33 at control, 18 to 32 at 2 dSm^{-1}, 4.5 to 29.57 at $4dSm^{-1}$ and 0.00 at 8 dSm^{-1}NaCl salinity level. The result showed that increasing NaCl concentration reduced in leaf number in all the accessions (fig 3). The result was full agreement with studies by [16 and 7] in mungbeanreported that higher concentrations of NaCl resulted in reduction in number of leaves.This might be due to accumulation of more cations, mainly Na^{+}, or anions particularly Cl in the leaves that need energy for plant to manage them. Elevated $Ca2^{+}$ concentration in the root medium result higher leaf $Ca2^{+}$ concentration, and higher growth speed, especially in young leaves.

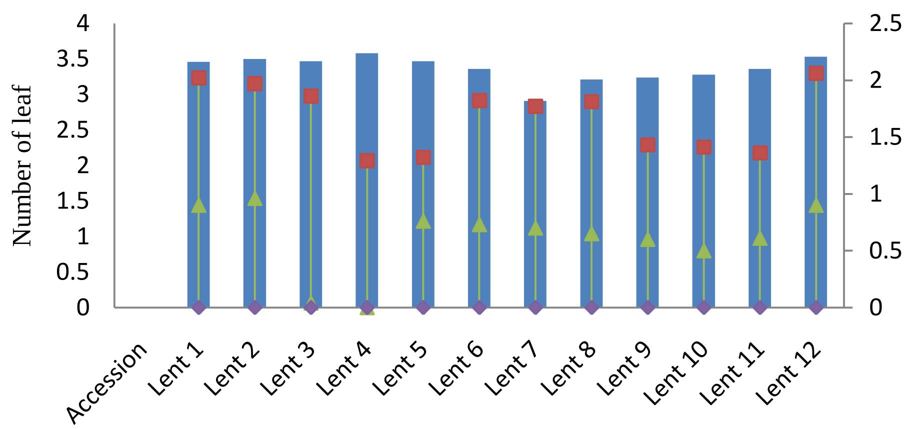

fig 3. Leaf of lentil accessions as influenced by salinity

control 2 4 8

Effect of salinity on pod number of lentil accessions Analysis of variance of the data for pod number showed that NaC1 treatment had a significantly adverse effect formation of pod number (p<0.001)(Table2) and their interaction were also significant. Different accessions responded differently to NaC1 treatment. Pod number per plant, as one of the main yield components, significantly affected by adding NaCl and the mean value of pod number ranged from 16.6 to 30.00 at control, 4.85 to 17.67 at 2 dSm^{-1}, and 2.53 to 11.67 at 4 $dSm^{-1}$and 0.00 at 8 dSm^{-1}salinity levels.At 2 and 4 dSm^{-1} salinity level, the maximum pod number was recorded in accession Lent12, Lent1 and accession Lent2 than the rest accessions that were tested (fig 4)whereas, salinity inhibited significantly the formation and growth of pod in accession Lent4.Thus, this accession had the minimum number of pod (fig 4). Furthermore, at 8 dSm^{-1} salinity level, salinity adversely inhibited the formation and growth of pod in all accession in similar way and those accessions failed to achieve sufficient pod number(fig 4). Because of salinity hinder the formation and development of branch ,leaf and even plant of each accessions at its high concentration all accession were un able to produced their food through photosynthesis activity and also salinity hinder the plant them to absorb nutrient and mineral through its adverse effect consequently, those accession failed to produced adequate pod number.The findings of the study elucidate that increment of salinity level in the growth media cause significant reduction in pod number (fig 4). Similar result were reported by [10 and 22] reported that increasing salinity decreased number of filled pods in lentil. Decreased pod number under salinity might be due to less translocation of assimilates towards reproductive organ and salinity affect many metabolic activities such as, photosynthesis of the plant.

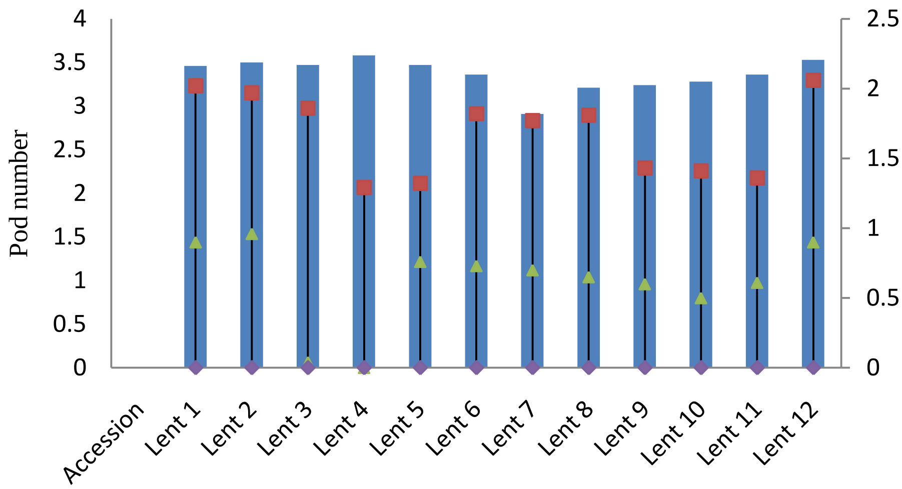

fig 4. Effect of salinity on formation of pod of lentil accessions

control 2 4 8

Effect of salinity on Total Biological Yield of lentil accessions (g) Statistical analysis of total biological yield showed that there were significant variation among accession, salinity level and their interaction ($p < 0.001$) (table2) for production of total biological yield.Accessions were responded differently to entire salinity level and their value of Total biological yield range from 3.77 to 4.64 g at control, 1.39 to 3.15 g. at 2 dSm^{-1}, and 0.78 to 1.79 g at 4 $dSm^{-1}$and 0.00 g at 8 dSm^{-1} of salinity level. At 2 and 4 dSm^{-1}salinity level, salinity reduced the overall growth of accession Lent12, Lent1 and Lent2but the degree of reduction was lesser in those accession as result the maximum value of total biological yield were recorded in those accession (fig5), whereas salinity highly reduced the overall growth of accession Lent4(fig 5) as consequence, this accession achieved the lowest biological yield than the other accession. Moreover, salinity totally inhibited the overall growth of all accession drastically and accessions could not achieved sufficient amount of total biological yield at 8 dsm^{-1}. This result revealed that increment of salinity cause decrement of total biological yield and at higher salinity level, salinity prevented the plant from production of sufficient biological yield (fig 5). The result was in line with [24 and 11]reported that increasing level of salinity decreased the plant height, leaf area, leaf dry weight, total biomass production and finally the grain yield of lentil genotypes.This might be because of high level of salinity may decrease biomass production because it causes a lowering of plant water potentials, specific ion toxicities, or ionic imbalance. Salinity affects both water absorption and biochemical processes resulting in reduction of plant growth [22].

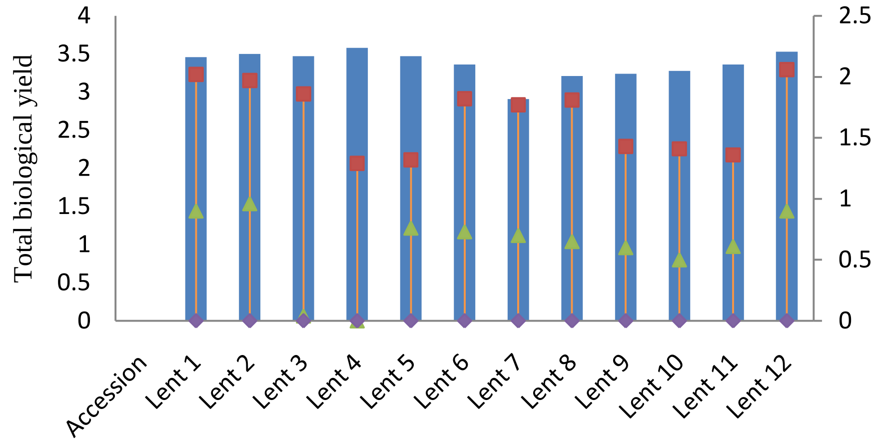

fig 5. Effect of salinity on total biological yield of lentil accessions

control 2 4 8

Effect of salinity on seed yield of lentil accessions Analysis of variance for seed yield of lentilaccession revealed that seed yield production of lentil accession significantly influenced by NaC1 treatment and accession responded differently for different salinity level and also their interaction were highly significant($p<0.001$) (Table,2).Accessions responded differently to different salinity level andtheir seed yield varied between 2.91 to 3.53 g at control, 1.29 to 2.06 g at 2 dSm^{-1}, 0.00 to 0.90 g at 4 dSm^{-1} and 0.00 g at 8 dSm^{-1} salinity levels. At 2 and 4 dSm^{-1} accession Lent12, Lent1 and Lent2 performed well and produced the highest value of seed yield than the other accessions that were tested (fig 6) whereas, accession Lent4 performed poorly and as result this accession was achieved the minimum value of seed yield compared to the control. While salinity inhibited the overall growth of accession Lent4 than the other accession and this accession achieved the lowest yield (fig 6). Furthermore, at 8 dSm^{-1}salinity level, salinity adversely hampered the growth and productivity of all accession and accessions responded in similar fashion and unable to attained adequate amount of seed because of high salinity level (fig 6). The findings of the study elucidate that increment of salinity level in the growth media cause significant reduced in seed yield (fig 6). Similar results were reported by [10 and 17]in lentil and [12] in soybean reported that decrement in the seed yield of lentil as consequence of increasing salinity. This may be due to salinity adversely reduced in leaves per plant, chlorophyll content and leaf water content and high leaf temperature which result in decrement of grain yield of plants [20].

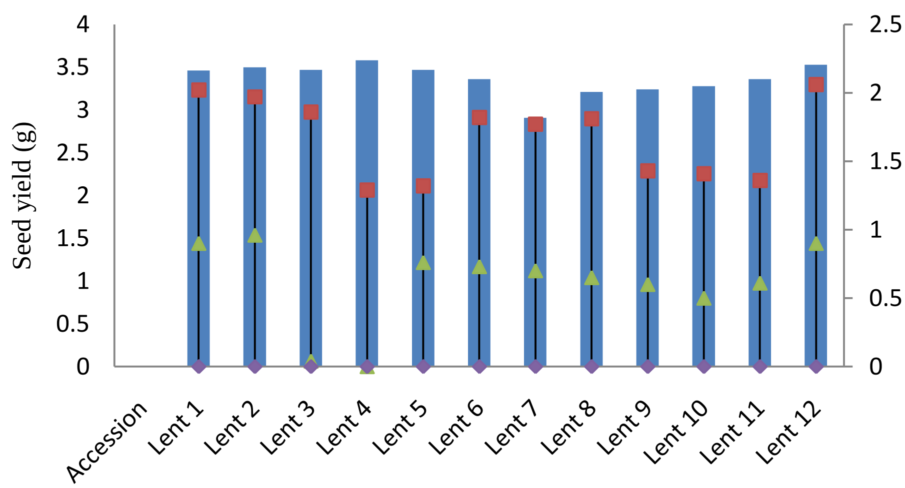

fig 6. Effect of salinity on seed yield of lentil accessions

control 2 4 8

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Conclusion

Salinity is a continuing problem in the arid and semi-arid tracts of the world. It could be alleviate during irrigation management and/or crop management. However, the former approach is outdated and very expensive. Nevertheless, the latter is economical as well as efficient and it enables to produce salt tolerant crop lines. However, prior to that there is a need to confirm the presence of genetically based variation for salt tolerance among different species or varieties of a particular crop at different growth stages. The presence of genetic variation offers a basic tool for evaluating effect of salinity on lentil accessions and to overcome the presence of large number of variation for relatively salt tolerant lentil accession and it will appreciated to find accession with gene tolerant to salinity. Screening of salinity tolerance under field condition involves many environmental factors that affect genetic and phenotypic expression of accessions. Hence, controlled environment,greenhousescreening method indicate to be an ideal method to screen large amount of accessions with less efforts and accurately. Thus, the correct and clear expression of Lentil accessions for salt tolerant can be evaluated by this method using different NaCl level. The findings of this work confirmed that response of lentil accession to salinity show significant variation as their expose to different salinity level. The result explain that most out that all of yield and yield related traits considered were significantly decreased with higher levels of salinity. Out of twelve lentil accession, accession Lent12, Lent2 and Lent1 performed well under salt stress conditions in most of the parameter greenhouse experiment as result those accession were recommended to be sown in saline condition

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