



Evaluation of Wheat Varieties/Lines for Salt Tolerance at Different Growth Stages

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ABSTRACT

Plant scientist, to overcome soil salinity have adopted various strategies, one of the important strategy is to exploit genetic variability of the available germplasm to identify a tolerant genotype that may sustain a reasonable yield on salt affected soils. In this experiment, forty six wheat varieties were screened for salt tolerance on germination, seedling and production stage at laboratory, lath house and field growth stages at different salt levels, respectively. Treatments included at laboratory were control and sodium chloride (NaCl) at various EC levels (10, 20 and 30 ds/m) and at lath house the treatments were control, 10 and 20 dS/m salt concentrations prepared from NaCl. Results indicate that the wheat varieties, Botitho #29, Tay # 14, Shorima # 14, Meda-wolabu # 35, K 6290 (bulk), ETBW-5879, Hidassie and ETBW - 6095 were relatively tolerant at germination and seedling stage in most of the growth parameters studied. Generally when the level of salt increase, most of wheat growth and yield parameters were decreased. In further screening under saline soil plant height, spike length, seed number/spike, root length and grain yield were showed significant difference among tested wheat varieties. ETBW-7879 and HIDASIE were the varieties that gave highest grain yield, while K-6290 and MEDE-WELABU varieties were appeared inferior other than tested wheat varieties grain yield.

INTRODUCTION

The continuous salinization of arable land is a threat to global food security. Over 800 Mha of land are affected by salinity, which equates to more than 6% of the world's total land area (FAO 2010) and affects more than 20% of present-day agriculture (Mickelbart et al. 2015). Soil salinity and sodicity assessment of the Middle Awash specifically Amibara Irrigation Project showed that

substantial parts of farm areas affected by salinity problem (Frew et al., 2015; Ashenafi and Bobe, 2016; Melese et al., 2016). As a result in the area declining crop production is the most common problem and some part of Amibara Irrigation Project totally out of crop production due to soil salinity. Wheat (*Triticum aestivum* L.) is one of most important crop plants worldwide with annual production of about 736 million metric tons (FAO, 2015), but suffers significant grain yield losses due to

soil salinity. There are several strategies to increase wheat production in the salt-affected areas (such as leaching and drainage), the cultivation of tolerant genotypes is recognized as the most effective way to overcome this limitations (Ashraf *et al.*, 2006). The prerequisite is identification of wheat genotypes with proven wide adaptation under saline conditions. High concentration of complex inorganic salts present in the growing medium, retard the growth in most of the crop plants depending on the nature of the salts present, the growth stages and the salt tolerance or avoidable mechanism of the plant tissues (Ashraf *et al.*, 2002). Most of the crops tolerate salinity to a threshold level and above, where yield decreases as the salinity increases (Khan *et al.*, 2006; Beakal *et al.*, 2016). Characters such as germination, survival and seedling growth or biomass accumulation, have been the most commonly used criteria for identifying salinity tolerance in plants (Khan *et al.*, 2006).

The present study was carried out with the major objective of providing information on the extent and basis of genetic variation for salinity tolerance in wheat varieties at germination, seedling and field stage.

MATERIALS AND METHOD

Description of the study area

The study was conducted from 2014 to 2018 at Amibara District, Werer agricultural research center, located at 9°20'31" N latitude and 40°10'11" E longitude and the elevation is at about 740 masl. Screening for salt tolerance was conducted at three growth stages; germination, seedling and reproductive at laboratory, lath house and saline soil field condition, respectively. The trial was performed through exposing all wheat varieties to salt stress condition while selecting relatively tolerant at each growth stage and advancing to next growth stage. Since large number of genotypes, screening for salinity tolerance in the field is difficult, due to spatial heterogeneity of soil physico-chemical properties, and difficulty for management in the field.

Experimental procedures

Germination Test

At germination stage a total of forty six (46) wheat varieties collected from Melkasa Agricultural Research Center were tested. Germination stage screening was conducted through subjecting each wheat varieties to different level of salt concentrations; control (distil water), 10, 20 and 30 dS/m. Saline solutions were prepared from NaCl. The experimental design was complete randomized design (CRD) with three replications. Ten seeds of each varieties were placed in petri dish then salt concentrations were applied. Seeds that produce full radical were considered as germinated. First germination count was made at 5th day after treatment application

and counting was also done at 7th and 10th days to take into account late germinated seeds. From recorded data germination percentage, germination mean time and germination stress tolerance index of seeds were computed accordingly.

Mean germination time (MGT) which was calculated according to the equation of Ellis and Roberts (1981):

$$MGT = \Sigma Dn / \Sigma n;$$

Where: n = number of seeds which were germinated on day D,

D = number of days counted from the beginning of germination.

Germination Index (GI) which was calculated as described by the Association of Official Seed Analysts (AOSA, 1983) as:

$$GI = \Sigma (Gt / Tt);$$

where GI = [Number of germinated seeds in first count/ Days of first count] +...+ [Number of germinated seeds in final count/Day of final count].

Seedling stage screening

Seedling stage screening was conducted under lath house condition with selected varieties under germination stage. Bulk surface soil (non-saline and alkaline in reaction) was collected and packed into pot. Three salinity levels (control, 10 and 20 dS/m) of saline solutions were prepared from NaCl. Treatments were arranged in CRD with three replications. Ten seeds of each selected varieties were sowed on pot. Accordingly saline solutions were added to each pot maintaining to field capacity. Subsequent irrigations were made to a field capacity at five days interval. Drained solutions collected from each were added again to the respective experimental pots. Emerged seedlings were counted at 5, 7 and 10 days after planting and expressed as germination percentage, mean germination time and germination stress index. Shoot and root length, and shoot and root dry matter were also recorded.

Field Experiments

Screening for salt tolerance and evaluation for yield performance at field condition was carried out at Werer Agricultural Research Center experimental site. Before sowing, soil was taken at surface depth (0-30 cm) from the experimental site, air dried and sieved through a 2 mm screen. The soil was analyzed in the laboratory for some physical and chemical characteristics by standard methods. Laboratory result showed that the soil of the study had an ECe of 12-14 ds/m. The treatments were laid out in RCBD with three replications on a plot size of 3 m x 3 m.

Statistical Analysis

Analysis of variance (ANOVA) on collected parameters were carried out using SAS version 9.4 statistical software program (SAS, 2016). Significant difference among treatment means were assessed using the least significant difference (LSD) at 0.05 level of probability (Gomez and Gomez, 1984).

RESULT AND DISCUSSION

Germination stage screening

Germination percentage of all 46 wheat varieties decreased gradually with increasing salinity levels of the media (Figure 1). Variation in seed germination was

recorded in all the tested wheat varieties. Mean germination percentage of most varieties were above 85% at 0 ds/m (control) while it decreases at 10 ds/m and 20 ds/m salt levels. When the salt stress further increased to 30 ds/m in most wheat varieties, the germination percentage were below 50% (Figure 1d). This might be that, inorganic salt concentration in the media hinder and delay wheat germination. The same result reported by Khan et al., (2007) and Blabani et al., (2013), wheat germination decreased with increasing salinity levels of the media. Based on the result nine relatively tolerant genotypes (Gambo (v1), Botitho (v2), Tay (v3), Shorima (v4), Meda-wolabu (v5), K-6290 (v6), ETBW – 5879 (v7), Hidassie (v8) and ETBW – 6095 (v9)) with higher germination percentage were selected and advanced to seedling stage screening.

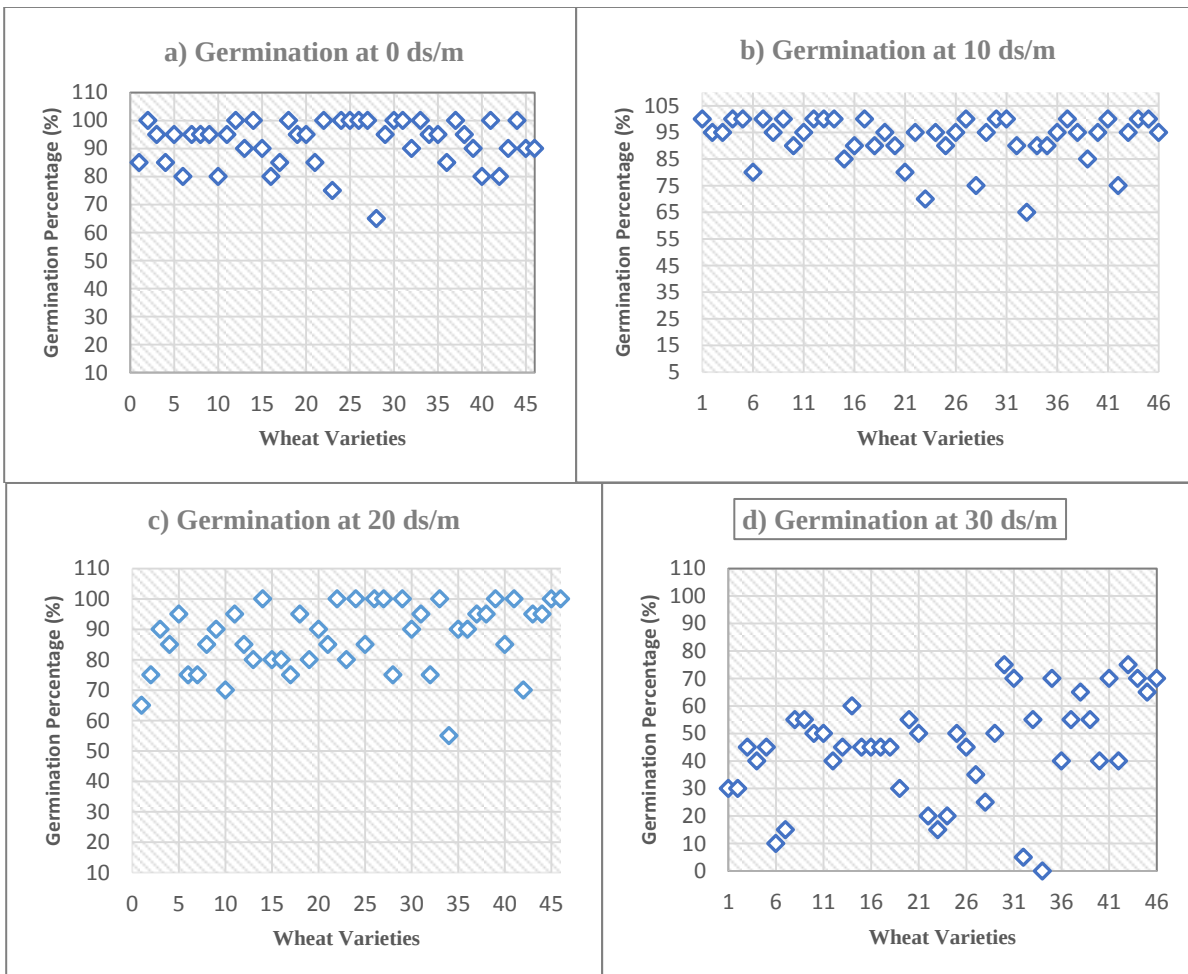


Figure 1. Effect of different level of salt concentration on germination percentage of wheat varieties

Seedling stage screening

Nine selected and promoted wheat varieties during germination stage screening were further evaluated for yield and yield component parameters on pot experiment. The relations of various seedling growth parameters to seed yield and yield component of crops are important for the development of salt tolerant cultivar for production under saline conditions. Among the tested parameters; GP, MGT and GI index were not showed any statistical difference among each varieties. However, when the concentration of salinity increased these parameters were decreased and under similar salinity level there was numerical difference for

germination. The highest GP was recorded from Hidase and ETBW-5879 equally gave 96.67% at 10 dS/m and Mede-Welabu (90%) at 20 dS/m. While the lowest GP was recorded by Tay#14 (36.67) variety at 20 ds/m (Graph 2a). The probable reason might be their embryo was damaged due to the presence of Na⁺/Cl⁻ ions. Physiologically absolute ratio of K⁺/Na⁺ in the tissue is important. Decrease and delay in germination in saline medium has also been reported by Rahman *et al.* (2000). Biabani *et al.* (2013) reported highly significant differences among cultivar in view of germination rate, germination index, germination mean time and germination rate index.

Table 1: Effect of different salt level on wheat germination index at lath house.

Salinity level (DS/m)	Germination index									LSD (0.05)	CV (%)
	V 1	V 2	V 3	V 4	V 5	V 6	V 7	V 8	V 9		
0	4.36	4.43	4.30	4.23	4.00	4.23	4.28	4.08	4.08	NS	4.66
10	2.88	2.48	2.96	2.81	3.47	3.14	3.09	3.04	2.96	NS	11.48
20	2.10	1.99	0.83	1.50	2.49	1.73	1.45	1.55	1.09	NS	44.2
Mean	3.11	2.97	2.70	2.85	3.32	3.03	2.94	2.89	2.71		

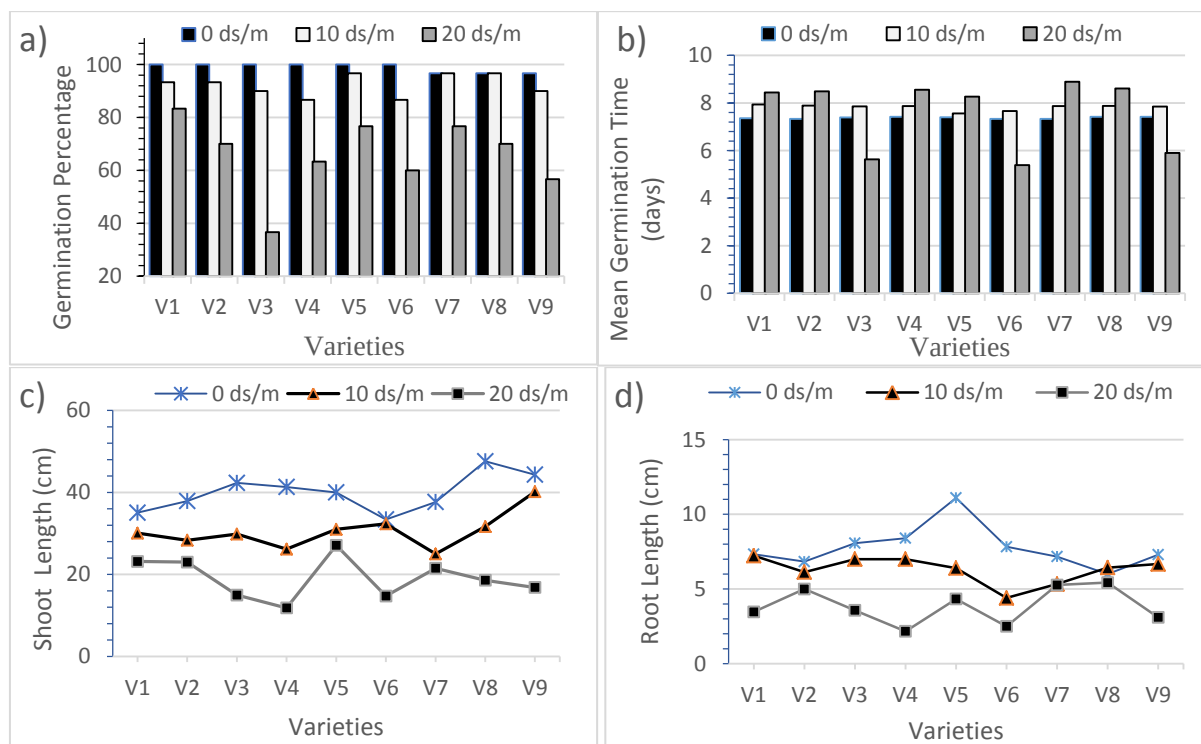


Figure 2 (continues below).

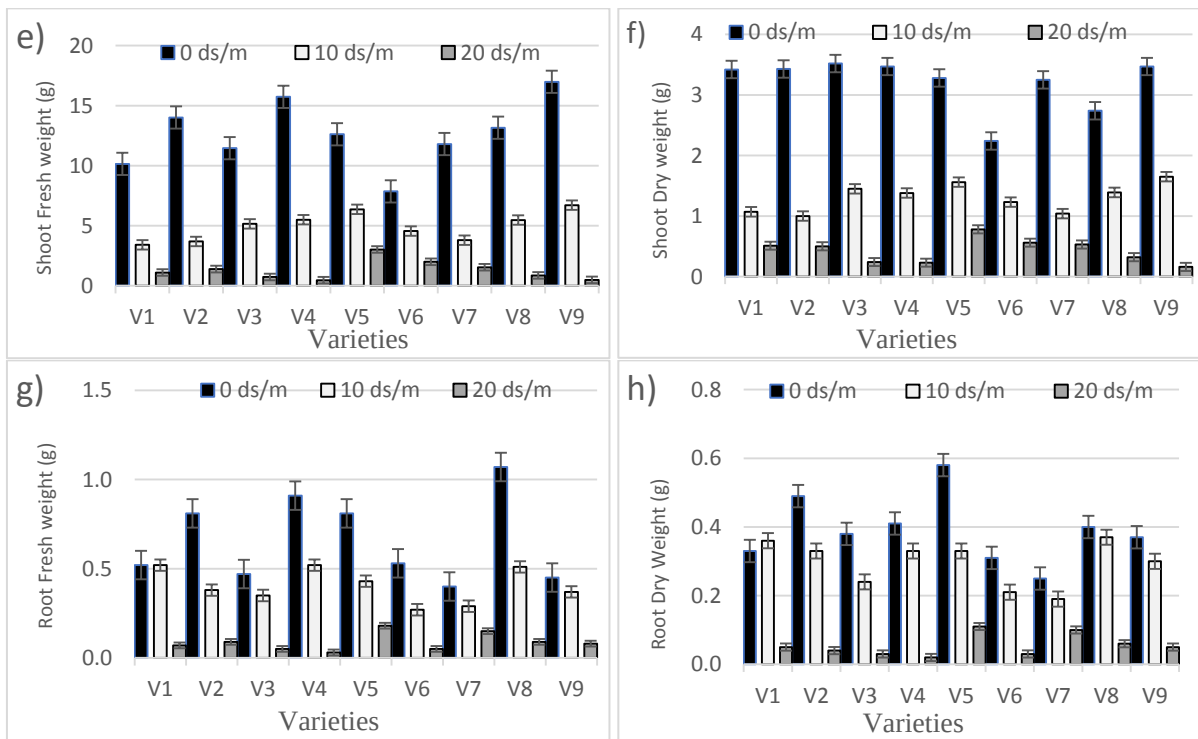


Figure 2 : variation among wheat varieties (a) germination percentage, (b) mean germination time, (c) shoot length, (d) Root length, (e) shoot fresh weight, (f) shoot dry weight, (g) Root fresh weight and (h) root dry weight.

Shoot and Root fresh and dray weight

There is no significant difference in shoot and root fresh and dray weight among tested wheat varieties. However, increase in NaCl concentrations decreased the shoot and root length and biomass of all the wheat cultivars. But, the intensity of stress varied with the cultivars. The same salt effect on wheat cultivar reported by Rahman et al., (2008). At 10 dS/m ETWB- 6095 (6.71g) and MEDE-WELABU (6.36g) variety showed the highest shoot fresh weight and when the salinity concentration increase further to 20 dS/m the highest shoot fresh weight recorded from MEDE-WELABU (3.02g). Concerning shoot dry matter, when the stress of salt increase shoot dry matter decrease, the highest recorded from MEDE-WELABU (0.78g) under 20 dS/m.

At 10 dS/m Shorima #14 and Gambo (0.52g) equally showed the highest root fresh weight, while the lowest

was recorded from K-6290 (0.27g). When the salinity concentration increase further to 20 dS/m the highest root fresh weight recorded from Mede-Welabu (0.18 g). When the stress of salt increase root dry matter decrease, the highest recorded from Mede-Welabu (0.11g) under 20 dS/m and the lowest obtained from Shorima #14 (0.2 g). Due to increase in salinity, shoot and root emergence was delayed, as a result of which biomass accumulation was severely affected consequently; fresh and dry weights were reduced. Increasing NaCl concentration adversely affected shoot dry weight and root dry weight of wheat genotypes (Akbarimoghaddam et al., 2011). The same result reported by Khan et al., (2007). Most parameters were statistically not significant as a result, all nine varieties were advanced to production stage screening for further screening under salt affected soil condition.

Production stage screening

Table 2: Response of wheat varieties for yield and yield component parameters under saline soil field condition.

Wheat Varieties	Plant Height (cm)	Tiller number (#)	Spike Length (cm)	Spikelet Number /spike (#)	Root Length (cm)	Grain Yield (Kg/ha)
Gambo	80.57 ^a	8.11	9.74 ^a	41.07 ^{ab}	14.23 ^a	3529.6 ^{ab}
Botitho #29	72.71 ^{bc}	8.56	8.62 ^{cd}	35.11 ^c	10.76 ^d	3252.3 ^{bc}
Tay # 14	78.41 ^{ab}	7.87	9.32 ^{ab}	42.67 ^a	12.78 ^b	3338.3 ^{abc}
Shorima # 14	70.04 ^c	8.91	8.60 ^d	37.04 ^{bc}	11.79 ^{bcd}	3322.6 ^{abc}
Meda-wolabu # 35	72.40 ^{bc}	8.84	9.65 ^a	25.56 ^d	11.36 ^{cd}	2642.5 ^c
K 6290 (bulk)	82.77 ^a	8.58	7.53 ^e	32.31 ^c	12.03 ^{bcd}	2788.5 ^c
ETBW - 5879	67.00 ^c	8.69	7.95 ^e	33.40 ^c	12.52 ^{bc}	3998.1 ^a
Hidassie	68.77 ^c	9.27	8.71 ^{bcd}	37.07 ^{bc}	12.42 ^{bc}	3685.3 ^{ab}
ETBW - 6095	67.42 ^c	7.67	9.23 ^{abc}	35.00 ^c	11.79 ^{bcd}	3355.6 ^{abc}
LSD(0.05)	7.15	NS	0.63	5.19	1.37	726.52
CV (%)	10.36	19.5	7.65	15.51	11.95	23.24

Plant height and Root Length

The analysis of variance showed that plant height and root length of wheat were significantly ($P < 0.05$) influenced due to genetically difference. The highest plant height observed from K-6290 variety (82.77 cm) followed by Gambo (80.57 cm), while the lowest plant height was obtained from ETBW-5879 (67.00 cm) and ETBW-6095 (67.42 cm). The highest root length was observed from Gambo variety (14.23 cm) followed by Tay # 14 (12.78 cm), while the shortest root length was obtained from Botitho # 29 (10.76 cm) and Mede-Welabu (11.36 cm). Under saline conditions, depletion of O₂ deprives the plants of its primary energy source and accumulation of internal ethylene causes the inhibition of root elongation (Ashraf et al., 2005) by reducing root growth, which consequently reduce root fresh and dry biomass (Khan et al., 2007).

Tiller Number

Tillering is one of the most important agronomic traits because tiller number per plant determines spike number, a key component of grain yield. Regarding number of tillers per plant analysis of variance (ANOVA) showed that there was no significant difference among tested wheat varieties in tiller production at maturity at lath house.

Spike length

The analysis results revealed that there was variation among tested varieties for spike length. Gambo variety showed significantly higher spike length (9.74) than the other wheat varieties, while K 6290 variety showed lower spike length (7.53) than other nine wheat varieties. Soil salinity directly affects plant growth through osmotic

stress and ionic toxicity caused by Na⁺, Cl⁻ and SO₄²⁻ and thus reduce spike length. Rajpar et al., (2006) reported soil salinity clearly affect spike length of wheat. Asgari et al., (2011) after screening four wheat varieties under four salinity levels, reported plant height, spike length, seed number per spike, root length and grain yield difference among tested wheat varieties due to salt effect.

Number of spikelet per Spike

Number of seed per spike showed significant difference among tested varieties. The results presented in Table 2 show that Tay #14 (42.67) gave higher seed number per spike, while the lower seed number per spike was obtained from Mede-Welabu (25.56). This experiment revealed that, production of shorter plants with small and empty spikes might have affected the grain and straw yield in saline soil treatments, however, genetic difference to respond for such stress varies among wheat varieties. The same result reported by Asgari et al., (2011).

Grain Yield

The result indicates that there was statistically significant variation between tested wheat varieties for most measured parameters. ETBW-7879 and HIDASIE gave highest grain yield, while K-6290 and MEDE-WELABU varieties grain yield were appeared inferior other than tested wheat varieties. Clear different response to saline stress condition observed among tested materials suggests that existence of genetic variability among tested materials. The same result reported by Turki et al., 2012 salinity induced variations in grain yield and quality were larger among sensitive genotypes than salt tolerant ones. These results suggested that breeding

and the use of salt-tolerant wheat cultivars might be the most promising strategies for harvesting higher grain yield of best quality under saline conditions.

CONCLUSION

The results obtained from this experiment showed that soil salinity had clear effect on wheat crop at different growth stage. It was observed that increasing soil salinity progressively decreased germination percentage, plant height, spike length, number of spikelet per spike and grain yield. Due to genetic variability of tested wheat varieties Botitho #29, Tay # 14, Shorima # 14, Meda-wolabu # 35, K 6290, ETBW – 5879, Hidassie and ETBW- 6095 were relatively showed high germination percentage. In further screening under saline soil; plant height, spike length, seed number/spike, root length and grain yield were showed significant difference among tested wheat varieties. ETBW-7879 and HIDASIE were the varieties that gave highest grain yield, while K-6290 and MEDE-WELABU varieties were appeared to be inferior in grain yield other than tested wheat varieties.

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