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Effects of Salinity on Days to Heading (DTH), Days from Heading to Maturity (DHTM) and Days to Maturity (DTM) of tef [*Eragrostis tef* (Zucc.) Trotter] Accessions and Varieties in Ethiopia

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Abstract: Salinity is a continuing problem in the arid and semi-arid tracts of the world. It could be alleviated using 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 However, the former approach is outdated and very expensive.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. But prior to that there is a need to confirm the presence of genetic based variation for salt tolerance among different species or varieties of a particular crop that can thrive under unreliable agro-ecological situations; tef [*Eragrostis tef* (Zucc) Trotter] is one of such crops. Thus fifteen lowland tef genotypes (10 accessions and 5 varieties) were tested with respect to days to heading, days from heading to maturity and days to maturity at 2, 4, 8 and 16 dS/m salinity levels. Distilled water (0 dS/m) was used as a control. Data analysis was carried out using SAS package. The analyzed data showed significant variation among all the three parameters recorded for accessions and varieties ($p<0.001$) and for treatments ($p<0.01$). Increased salinity level caused delayed Days to Heading (DTH), Days from Heading to Maturity (DHTM) and Days to Maturity (DTM) with a few exceptions. Days to Maturity (DTM) was more salt affected than Days from Heading to Maturity (DHTM) and Days to Heading (DTH). Accessions 212611 and 205217 were the most salt sensitive and salt tolerant genotypes respectively. With respect to the parameters investigated, accessions showed broad intraspecific variation for salt tolerance unlike varieties.

Key words*:* Accessions, *Eragrostis tef*, grain filling, NaCl, salinity, varieties

INTRODUCTION

Salt-affected soils are distributed through out the world and no continent is free from the problem (Brady and Weil, 2002). Salinization of soil is one of the major factors limiting crop production particularly in arid and semi-arid regions of the world (Ahmed, 2009). Globally, a total land area of 831 million hectares is salt affected. African countries like Kenya (8.2 Mha), Nigeria (5.6 Mha), Sudan (4.8 Mha), Tunisia (1.8 Mha), Tanzania (1.7 Mha) and Ghana (0.79 Mha) are salt affected to various degrees (FAO, 2000). Salt stress is known to perturb a multitude of physiological processes (Noreen and Ashraf, 2008). It exerts its undesirable effects through osmotic inhibition and ionic toxicity (Munns *et al*., 2006). Increased salinity caused a significant reduction in germination percentage, germination rate, and root and shoots length and fresh root and shoots weights (Jamil *et al*., 2006).

In Ethiopia salt-affected soils are prevalent in the Rift Valley and the lowlands. The Awash Valley in general and the lower plains in particular are dominated by salt-affected soils (Gebreselssie, 1993). A significant abandonment of banana plantation and a dramatic spread to the adjacent cotton plantation of Melka Sadi Farm was reported (Abeaz, 1995). Moreover, of the 4000 ha irrigated land of the above farm 57% has been salt-affected (Taddese and Bekele, 1996). Similarly, the occurrence of salinity problem in Melka Werer Research Farm was reported (Haider *et al*., 1988). Another study also depicted that of the entire Abaya State Farm, 30% has already been salt-affected (Tsige *et al*., 2000).

This problem is expected to be severe in years to come. Because under the prevailing situation of the country; there is a tendency to introduce and implement large-scale irrigation agriculture so as to increase productivity (Mamo *et al*., 1996). In the absence of efficient ways of irrigation water management, salt-build up is an inevitable problem. To alleviate the problem, we need to look for a solution (Gebre and Georgis, 1988). It can be done either using physical or biological practice (Gupta and Mihas, 1993; Marler and Mickelbart, 1993). Since environmental management (physical approach) is not economically feasible (El-Khashab *et al*., 1997) there

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is a need to concentrate on the biological approach or crop management (Ashraf and McNeilly, 1988; Ashraf *et al*., 2008; Ashraf, 2009). Nevertheless, to proceed with this approach, affirming the presence of genetically based variation for salt-tolerance in a particular crop is a prerequisite (Verma and Yadava, 1986; Marler and Mickelbart, 1993; Mahmood *et al*., 2009).

Thus in doing so, one has to focus on crops that have been cultivated for a long period of time in a country, and are able to provide reliable yield under unreliable agro-climatic conditions and make ranking first against area coverage, demand and market value. Tef [*Eragrostis tef* (Zucc) Trotter] is one of such crops, which has been cultivated in the country as a cereal crop for quite long (Purseglove, 1972). Furthermore, tef can be adapted to a broader range of agro-climatic environments. It can grow in altitudes ranging from sea level to 2800 m above sea level under different moisture, soil, temperature and rainfall regimes. It can tolerate anoxic situations better than maize, wheat and sorghum. It has ease of storage, tolerance to weevils and other pests. The straw is preferred to any other cereal straws and can fetch premium price (Ketema, 1993). According to Hailemelak *et al*. (1965), it contains higher amount of a number of minerals than wheat, barley or grain sorghum. As compared to other cereals, the largest cultivated land area is covered by tef. Moreover, the area used for tef production is increasing from time to time (Tefera and Ketema, 2000). For example, it covered 1,818, 375 (in 2001/02) and 1,989,068 (2003/04) hectares of land which is 28.5 and 28.4% of the area covered respectively by the whole cereals in each production year (CSA, 2004). Generally, tef is a reliable cereal under unreliable climate. That is why, in many areas where recurrent moisture stress occurs, tef production replaces the production of maize and sorghum (Ketema, 1993).

Therefore, this article attempted to screen 15 genotypes (10 accessions and 5 varieties) of tef [*Eragrostis tef* (Zucc.)Trotter] with respect to Days to Heading (DTH), Days from Heading to Maturity (DHTM) and Days to Maturity (DTM).

MATERIALS AND METHODS

This study was conducted from March 2004 to June 2005 at Melkasa Agricultural Research Center (MARC), Ethiopia. The experimental soil was taken from Melkasa Agricultural Research Center (MARC) at a depth of 0-20cm and analyzed profoundly at the National Soil Testing Center (NSTC), Addis Ababa, Ethiopia. It was loam with 2.4% CaCO3, 16.3% total nitrogen, 1.596% organic matter and a pH (1:2.5 soil water ratio) of 9.1. It has adequate phosphorus supply (21.28) and the exchangeable K, Na, Ca and Mg were 3.41, 0.46, 44.31 and 19.97 meq/100 gm soil respectively. Its electrical conductivity, 0.235 dS/m was low. It has a bulk density of l.11 g/cm^3 and 45% of water saturation, and at field capacity it has moisture content of 31.35% while the permanent welting point was 17.31%.

The amount of NaCl to be added per 4 kg dry soil was calculated using the formula:

$$\text{Gram salt per 100 g dry soil} = \frac{0.064\ \text{dS/m} \times \text{water saturation (\%)}}{100\%}$$

(Mamo *et al*., 1996)

Based on this formula 2.314, 4.628, 9.257 and 18.514 g NaCl were dissolved in 250 mL distilled water to get 2, 4, 8 and 16 dS/m salinity levels respectively. The experiment was conducted in a mesh house having a total area of 100 m^2 using plastic pots. The pots were filled with 4 kg dry soil, placed on dishes for collecting leachate (if any) and arranged in a Randomized Complete Block Design (RCBD) with four replications. The mesh house was covered with polyethylene plastic sheet to avoid the entrance of salts and other particles through wind and rain. The average temperature, relative humidity, sunshine, and evaporation of the area were 22.08ºC, 47.33%, 8.45 h/day and 7.48 mm, respectively.

Supplemental nitrogen as ammonium nitrate (NH_4NO_3) was applied to the pots at a rate of 57.14 mg per pot in a solution form so as to ensure that nitrogen is not a limiting factor to the growth of tef. The NaCl treatments were applied in such a way that 50% before seeding and the remaining 50% in two splits 10 and 15 days after seeding. This is to avoid osmotic shock. Twenty tef seeds were seeded per pot and at three leaf stage; they were thinned to 10 per pot. Distilled water was applied as often as necessary. The leachate was collected on the dishes and returned to the pot. In the meantime, Days to Heading (DTH), Days to Maturity (DTM) were recorded and Days from Heading to Maturity (DHTM) was calculated accordingly.

Data analysis: Data analysis was carried out using SAS package (SAS version 8.2, 2001) and SPSS version 12. Since most accessions and varieties were salt sensitive at 16 dS/m, information from this salinity level has not been included in data analysis. Prior to data analysis, Days to Heading (DTH), Days from Heading to Maturity (DHTM) and Days to Maturity (DTM) were log transformed.

RESULTS AND DISCUSSION

Days to Heading (DTH): The analysis of variance (ANOVA) showed significant variation for accessions and varieties ($p<0.001$) and treatments ($p<0.01$). Genotype * treatment interaction effect was found to be

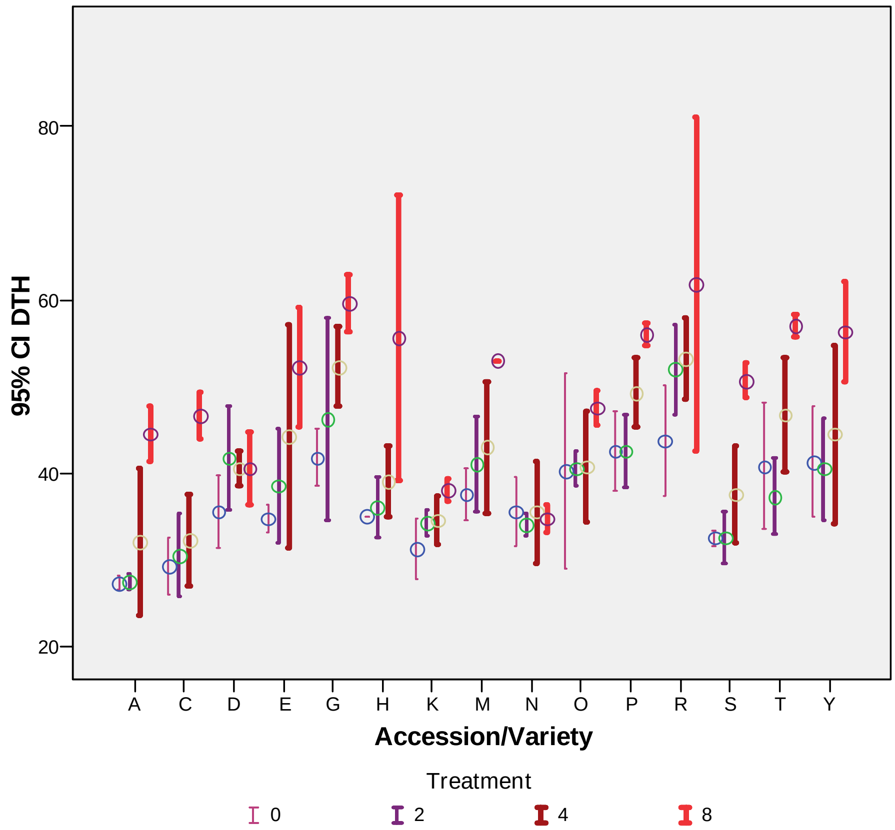

Fig. 1: Effects of salinity on days to heading (DTH) of tef [*Eragrostis tef* (Zucc.) Trotter)] accessions and varieties. A = 231217, C = 212611, E = 229747, G = 236514, H = 236512, M = 55017, N = 237186, O = 237131, R = 212928 and S = 205217; Key to varieties: D = DZ-01-196, K = DZ-Cr-37, P = DZ-01-1281, T = DZ-01-168 and Y = DZ-Cr-358)

insignificant (p>0.05). Days to heading was stimulated at 2 dS/m salinity level in variety DZ-01-1681 as compared to the control. It was affected at all salinity levels but became significant at 8dS/m. Consequently, a delay of 17.9% (7.2 days) - 63% (17.2 days) and 21.4% (6.7days) - 39.7% (16.2 days) in accessions and varieties was recorded respectively in comparison with the control. Similar findings were reported in triticale (Francois *et al*., 1988), sorghum (Azhar and McNeilly, 1989), cucumber (Jones *et al*., 1989), wheat genotypes (Yildirim and Bahar, 2010) and Canola (Bybordi, 2010).

Accessions 231217, 212611, 236512 and 202517 were relatively more delayed unlike the rest genotypes. On the other hand, varieties DZ-01-196 and DZ-Cr-37 and accession 237131 were among the least delayed ones (Fig. 1). With respect to DTH, accessions showed broad intraspecific variation unlike varieties. Unlike all other accessions and varieties, accession 237186 showed hastened heading by 1.9% (0.7 day) at 8 dS/m compared to the control. This is in agreement with reports in bread wheat and durum wheat (Francois *et al*., 1986) and triticale (Francois *et al*., 1988) where inflorescence emerged 10-12 days and 7-10 days earlier on higher salt treatments than on control respectively. Nevertheless, contrary to all the above, Raptan *et al*. (2001) reported that salinity did not affect days to flower in blackgram and mungbean.

Days from Heading to Maturity (DHTM): The analysis of variance (ANOVA) showed significant variation for accessions and varieties (p<0.001) and treatments (p<0.01). Genotype * treatment interaction effect was also found to be significant (p<0.001). Days from heading to maturity (grain filling) is an active stage for assimilates supply. It was not remarkably affected by salinity up to 4 dS/m treatment level but was influenced significantly at 8dS/m. At 8dS/m salinity level, a delay of 10.9% (4.3 days) - 92.4% (28 days) in accessions and 3.9% (1.5 days) - 74.4% (21.2 days) in varieties was recorded as compared to the control. These results comply with recent research report in mungbean (Ahmed, 2009). Nevertheless, in accession 205217 DHTM was speeded up by 5.7% (2 days). This is in agreement with earlier report in wheat (Grieve *et al*., 1992). Generally accession 212611 and

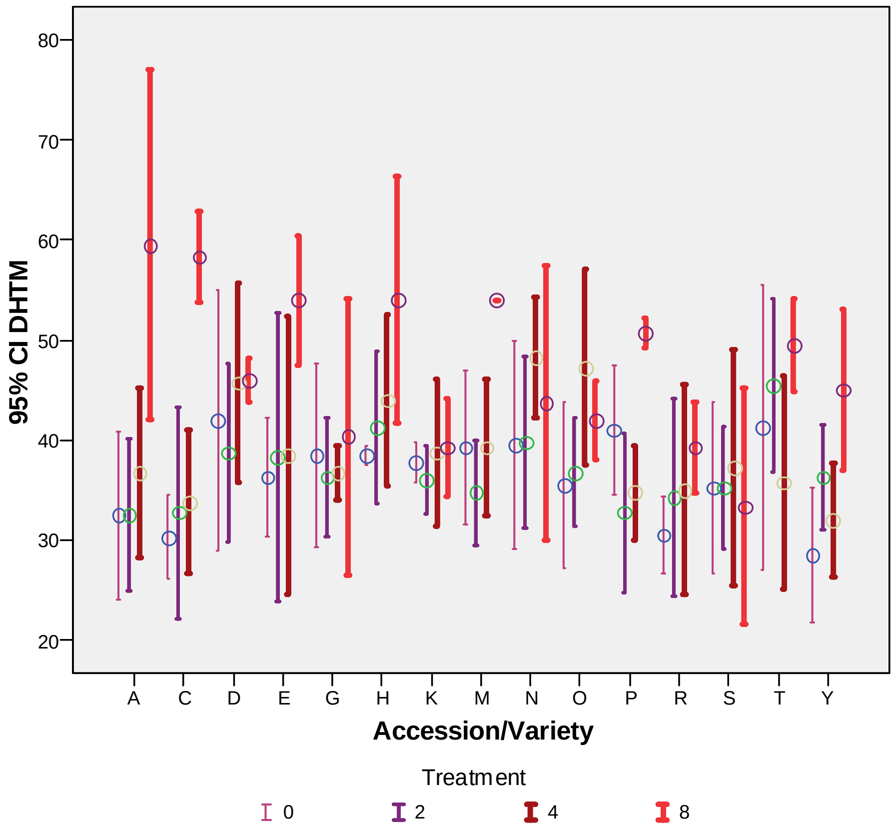

Fig. 2: Effects of salinity on days from heading to maturity (DHTM) of tef [*Eragrostis tef* (Zucc.) Trotter)] accessions and varieties. A = 231217, C = 212611, E = 229747, G = 236514, H = 236512, M = 55017, N = 237186, O = 237131, R = 212928 and S = 205217; Key to varieties: D = DZ-01-196, K = DZ-Cr-37, P = DZ-01-1281, T = DZ-01-168 and Y = DZ-Cr-358)

variety DZ-Cr-358 had more delayed DHTM whereas accessions 205217 and 237186 and varieties DZ-Cr-371 and DZ-01-196 possessed least delayed DHTM. Moreover, accessions 212611 and 205217 were the most salt sensitive and tolerant genotypes respectively (Fig. 2).

Days to Maturity (DTM): The analysis of variance (ANOVA) showed significant variation for accessions and varieties ($p<0.001$) and treatments ($p<0.01$). Genotype * treatment interaction effect was found to be insignificant ($p>0.05$). This character was stimulated at 2 dS/m in variety DZ-01-1281 as compared to the control. Salinity effect was not pronounced at 2 and 4 dS/m but at 8 dS/m treatment level. At 8 dS/m salinity level, a delay of 4.7% (3.5 days) - 76.5% (45.5 days) in accessions and 11.6% (9 days) - 51.9% (36.2 days) in varieties was obtained as compared to the control. It is in conformity with early works in sorghum (Azhar and McNeilly, 1989), mungbean (Ahmed, 2009) and Canola (Bybordi, 2010). Nonetheless, it is in contrast with the reports of Francois *et al*. (1988) in triticale where days to maturity were hastened by 7 days. Accessions 212611, 231217, variety DZ-Cr-358 and accession 229747 were among the most delayed genotypes. On the other hand, accession 237186, varieties DZ-Cr-37 and DZ-01-196 were the least delayed genotypes. Moreover, accessions 212611 and 237186 were the most sensitive and tolerant respectively of all genotypes being considered (Fig. 3). Days to Maturity (DTM) was more strongly affected by salinity stress than both DTH and DHTM at 8dS/m. This may be due to the extended exposure time to stress as well as the associated xylem input that result in the entrance of more salt ions into the plant, which would cause delay in maturity time (Yeo and Flower, 1984).

CONCLUSION

Increased salinity level has caused delayed Days to Maturity (DTM) in all accessions and varieties studied. Even if it also delayed Days to Heading (DTH) and Days from Heading to Maturity (DHTM), there was hastened DTH (accessions 237186) and DHTM (accession 205217). Among the genotypes considered, accessions 212611 and 205217 were the most salt sensitive and salt

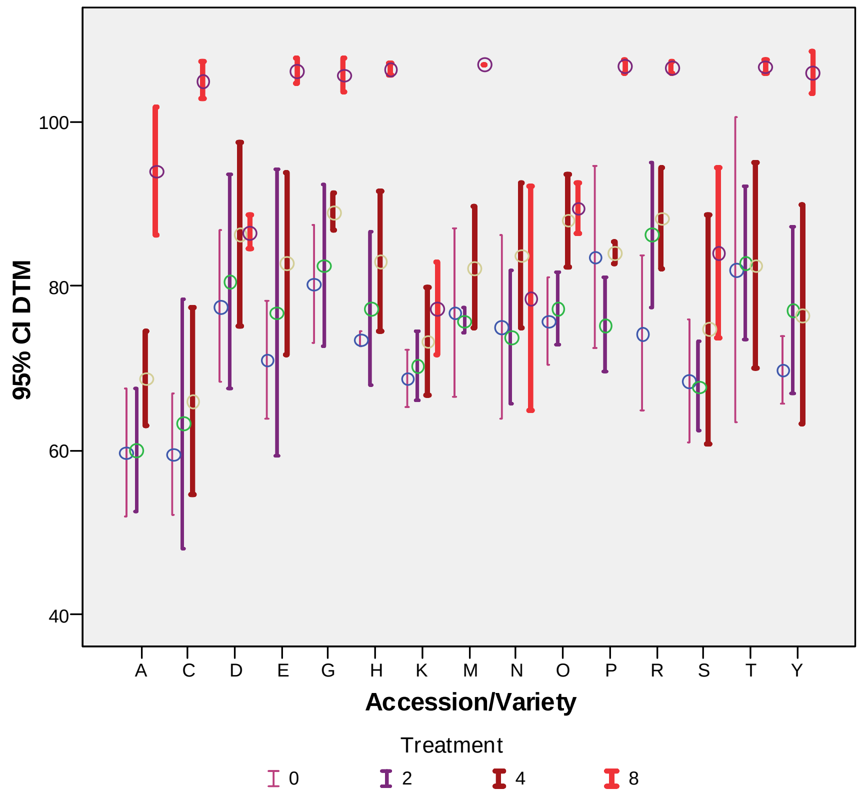

Fig. 3: Effects of salinity on days to maturity (DTM) of tef [*Eragrostis tef* (Zucc.) Trotter)] accessions and varieties. A = 231217, C = 212611, E = 229747, G = 236514, H = 236512, M = 55017, N = 237186, O = 237131, R = 212928 and S = 205217; Key to varieties: D = DZ-01-196, K = DZ-Cr-37, P = DZ-01-1281, T = DZ-01-168 and Y = DZ-Cr-358)

tolerant respectively. With respect to the parameters investigated, accessions showed broad intraspecific variation for salt tolerance unlike varieties. Days to Maturity (DTM) was more salt affected than Days from Heading to Maturity (DHTM) and Days to Heading (DTH).

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