Comparison of Three Varieties of Sorghum Grain Yield Response to Salinity Under Drip Irrigation System

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1.Introduction

Fresh water resources in arid and semi-arid regions are becoming increasingly scarce, therefore farmers are resorting to unconventional water sources, particularly those high in salinity or saline water. Irrigated agriculture using saline water in arid and semi-arid region may lead to salt build-up in soil and reduction in yield and soil resource sustainability, if proper management practices are not followed. The management practices may include appropriate irrigation system, scheduling and water input, and crops/varieties. However, insufficient information is available on the impact of saline water irrigation when the aforementioned practices are integrated, particularly in developing countries. The salinizition of soils and water places a substantial constraint on crop productivity in the arid and semi-arid regions (Royo, et el., (2000). Ayers and Westcot (1985) defines salinity problem as a condition whereby the salt in soil solution within the crop root-zone accumulates in concentrations that will have an impact on crop yield. This definition indirectly implies there is tolerance limit characteristic of crop/variety. Several salinity yield response functions had been proposed during last two decades, because the functional sensitivity may vary with crops/varieties and the irrigation management practices imposed. Very few attempts have been made to conduct variety-functional sensitivity analysis for sorghum grown sandy soil, which are characterized by low water content and under drip irrigation system (DIS). Sorghum is one of the most important crops that have been commonly grown in semi-arid environment, particularly in developing countries of Africa for human consumption and as feed and fodder. The objective of this study was to assess different salinity response models to discriminate sorghum varietal response to saline water irrigation using DIS.

2. Materials and methods

The experiment was conducted at the Arid Land Research Center, Tottori University (Tottori, Japan), from April to August 2005 in a plastic greenhouse. Three sorghum varieties (*bicolor (L)*, *BK 16*, and *EC 90*) were tested in a triplicated randomized complete block experiment. The experimental plots received 180 kg N ha^{-1}, 45 kg P_2O_5 ha^{-1} and 80 kg K_2O ha^{-1}just before sorghum seeding. The irrigation treatments consisted of 4 levels of salinity of the irrigated water; 5.70 (S1), 7.32 (S2), 9.40 (S3) and 12.50 (S4) dS m^{-1} and the control with quality water of 0.11 dS m^{-1}. Sorghum was irrigated daily at rates equivalent to daily open-pan evaporation using a DIS. The total irrigation input during the growing season was 770 mm. Soil water content (θ_v) and electrical conductivity (EC) measurements were carried out daily using Time Domain Reflectometry (TDR). After crop maturity grain yield from each plot was determined. Soil samples for laboratory determination of θ_v and EC were taken at after crop harvest 5 cm away from the emitters on the lateral line of DIS at 0-10, 10-20, 20-30, and 40-50 cm depth increments. Five models were used to assess sorghum grain yield response to salinity. The models are: Yr = Exp (a EC - b $(EC)^2$),

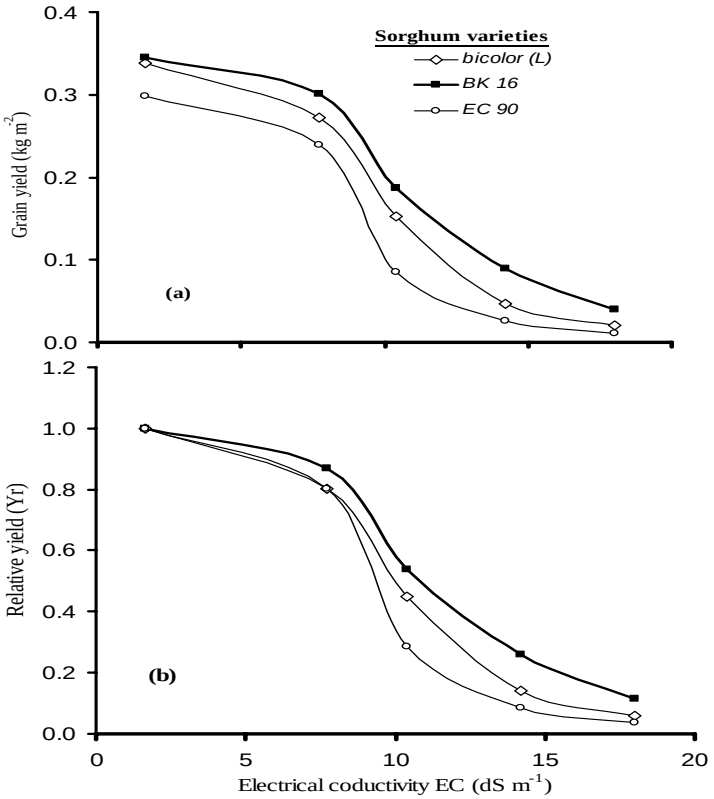

Fig. 1 Sorghum grain yield and relative yield under drip irrigation system

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[Eq.1], Yr = 1- Exp(a Exp(b EC)), Eq.[2], [$Yr = 1/(1+(EC/C_{50})^{p})$], Eq. [3], [$Y = Ym/(1+(EC/C_{50})^{3})$], [Eq.4], and $Y = Ym/(1+(EC/C_{50})^{p})$], Eq.[5]. Where Y is grain yield, Yr is relative yield, Ym is maximum yield under non-saline irrigation water, C_{50} is salinity where crop equals 50% of the non-saline yield, and a, b, and p are fitting parameters. The non-linear regression analysis functions and sum square were conducted using the SAS/Statg (199x) software package.

3. Result and discussions

The results show that sorghum grain yield decreased with increasing salinity of the irrigated water, similar to what others have reported (Maas and Grattan, 1999). The data shown in Fig.1 indicate that grain yield and the relative yield (Yr) of the three varieties responded in curvilinear fashion to salinity levels. The highest yield obtained under quality irrigation water for the varieties EC 90, bicolor (L), and BK 16 was 0.30, 0.35, and 0.35 Kg m^{-2}, respectively and is considered as the control for each variety. The lowest yield observed under highest salinity was 0.01, 0.02, and 0.04 kg m^{-2} for EC 90, bicolor (L), and BK 16 respectively. The data indicate the variety BK 16 showed most tolerance to salinity. Relative yield data shown in Fig. 1(b) indicates visual discrimination of varietal response to salinity is difficult. The data were fitted to 5 models to mathematically discriminate the responses. Equation 5 was fitted data well than others equations. The root mean square error (RMSE) for EC 90, bicolor, and BK 16 are 1.0×10^{-4}, 1×10^{-5}, and 3×10^{-5} respectively. The coefficients for the parameters of model indicate the varieties are discriminated by significant differences for average of steepness (s), salinity threshold (Ct), salinity tolerance index (ST-index), and the salinity at which 50 % crop yield reduction (C_{50}) in the control. In term of C_t, C_{50}, and ST-index the BK 16 outperformed the other varieties, indicating its' highest degree of tolerance to salinity stress (Table 1).

Table1. Nonlinear parameter discount parameter and salinity tolerance index (ST-index)

Sorghum varieties	s	C_{50} (dS m^{-1})	Ct (dS m^{-1})	ST-index
bicolor (L)	0.16±0.003	10.02±0.09	6.88±0.06	11.62±0.10
BK 16	0.14±0.007	11.14±0.13	8.00±0.23	12.70±0.37
EC 90	0.21±0.011	9.25±0.23	6.11±0.15	11.19±0.28

s is absolute value of the nonlinear steepness parameter, **C_{50}** is salinity where crop equals 50% of the non-saline yield, **Ct** is threshold salinity parameter, and **ST-index** is salinity tolerance index.

4. Conclusion

The sensitivity of three sorghum varieties to salinity induced grain yield reductions were assessed using 5 salinity response models. The results indicated mirror image S-shape yield response curves, and the selected 5 models fitted the functional relation well. The varietal response to salinity induced sorghum grain yield can be discriminated by the coefficients of the parameters of the models. The coefficients for parameters salinity threshold (Ct), salinity tolerance index (ST-index), and the salinity at which 50 % crop yield reduction (C_{50}) would occur in non-saline water indicated the variety BK 16 was the most tolerant to salinity stress and EC 90 was the least tolerant. The results indicate the salinity response models provide comparative quantitative assessment of varietal response to salinity taking into consideration several salinity associated yield parameters.

Referemces

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