



Evaluation of Guar (*Cyamopsis tetragonoloba* L.) genotypes performance under different irrigation water salinity levels: Growth parameters and seed yield



Jhama Das Suthar^{a,b}, Inayatullah Rajpar^a, Girisha K. Ganjegunte^{b,*}, Zia-ul-hassan Shah^a

^a Soil Science, Sindh Agriculture University, Tandojam, Pakistan

^b Soil and Crop Sciences, Texas A&M Agrilife Research, Texas A&M University System, El Paso, TX, USA

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ABSTRACT

Water scarcity and salinity are the major challenges faced by arid regions such as Thar Desert in Pakistan. Developing information on salt tolerance of genotypes and appropriate salinity management practices are necessary to ensure long-term viability of agriculture in these stressed environments. This study evaluated growth and seed yield of 25 different guar genotypes irrigated with waters having varying salinity (control – 0.6, 3, 6 and 9 dS m⁻¹) under field conditions to characterize their salt tolerance. Results indicated salinity levels had significant influence on growth and yield of guar crop. At the highest salinity level of 9 dS m⁻¹, out of 26 genotypes three genotypes (S-6005, S-8885 and 2/1) showed less than 20% reduction in plant height, one genotype (BR 90) had 15% reduction in number of branches and two genotypes (S-6049 and S-5611) produced 70% of the branches compared to control. Seed yields of genotypes ranged from 0.94 to 1.82 Mg ha⁻¹ under control salinity but at 9 dS m⁻¹ it ranged from 0.28 to 0.89 Mg ha⁻¹. BR 99 produced highest seed yield under both control and highest salinity levels. Straw yield ranged from 0.89 to 3.34 Mg ha⁻¹ under control and the range was reduced to 0.57 to 1.4 Mg ha⁻¹ at 9 dS m⁻¹. Sodium concentration increased whereas K concentration and K/Na ratio decreased with increasing salinity levels in both straw and seed samples of all the guar genotypes evaluated in this study. Based on salinity tolerance index (STI) and geometric mean productivity (GMP), out of 25 guar genotypes only four (BR-99, S-5608, 2/1, S-5615 and S-8885) were considered as tolerant. Results of our study indicated that select genotypes of guar can be appropriate for water scarce and salt affected arid regions of the world.

1. Introduction

Thar desert region, covering parts of western Pakistan, characterized by low and uneven distribution of rainfall and intensive cropping is facing serious challenges to long-term viability of agriculture (Asif, 2013). Other than rain, the only significant source for irrigation available in the region is saline groundwater (Khemani et al., 2012; Sial et al., 2003). Soil salinity due to inappropriate irrigation practices and native salts present in soil is another major concern for agriculture in the region (Mustafa et al., 1995). While more attention is given to irrigation induced salinity, which affects about 16% of the total agricultural area in Pakistan, recent investigations suggest that 67% of the cropped area is characterized by ‘transient salinity’, a type of non-groundwater associated salinity (Rengasamy, 2006). Salinity in arid regions puts more pressure on precious freshwater due to additional

irrigation needed to leach salts from root-zone.

In addition to water scarcity and salinity, rapid increase in population has put more pressure on these fragile ecosystems to produce more food and fodder. This has further aggravated the problem by further intensification of cropping system. It is therefore, important to evaluate crops or genotypes that can tolerate water scarcity and salinity but do not require high levels of inputs to produce more food and fodder. In dry regions where, fresh water becomes a scarce commodity, irrigation of moderately salt tolerant crops with brackish water is feasible (Biswas and Biswas, 2014). Therefore, it is necessary to evaluate performance of indigenous crops such as “guar” or Cluster bean (*Cyamopsis tetragonoloba* L.) under limited water and varying salinity levels.

Guar is a multi-purpose legume crop with its uses including vegetable for human consumption, green manure to improve soil fertility, fodder for animals and industrial applications. Guar’s seed is used in

* Corresponding author at: Department of Soil and Crop Sciences, Texas A&M Agrilife Research, Texas A&M University System, 1380 A&M Circle El Paso, TX, USA.

E-mail address: GKGANJEGUNTE@ag.tamu.edu (G.K. Ganjegunte).

¹ URL: <http://elpaso.tamu.edu/ganjegunte/>.

industries to extract product “galatomanan gum (guar gum)” from its endosperm (Mathur, 2011). Guar gum is used in many industries such as textile, paper, explosives, pharmaceutical, cosmetic and hydraulic fracturing and food (Chudzikowski, 1971; Mudgil et al., 2014). Currently, a majority of the guar seed production comes from two countries (India: 80% and Pakistan 15%). It is therefore a great opportunities for rest of the arid and semi-arid regions to produce guar (Pathak, 2015). United State is major importer of guar gum, followed by Germany, Canada and China (Sharma and Gummagolmath, 2012).

Response of guar to salinity varies from genotype to genotype (Ashraf et al., 2002) and in sensitive genotypes salinity mainly affects the total dry matter and seed yield (Francois et al., 1990). This is mainly because of reduction in number of branches, number of pods in cluster or in plant, and number of seeds per plant (Rahul, 2014; Seiler and Stafford, 1985). Reduction in growth and development of guar under salinity are attributed metabolic disorders. For e.g., Tarchoune et al., (2012) reported that increased salinity resulted in decreased chlorophyll content. In contrast, studies on tolerant cultivars of guar have established 8.8 dS m^{-1} as the threshold level for irrigation water salinity (Francois et al., 1990; Teolis et al., 2009). Salinity tolerance indices calculation and grouping is main tool for screening the genotypic variations (Singh et al., 2015). It is important to identify and evaluate tolerant genotypes of guar to suggest cultivars suitable for water scare and saline water irrigation in arid regions. This study evaluated salinity tolerance of 25 genotypes of guar under field conditions using (i) the select growth parameters and yield (ii) salt constituent constituents in plant tissue and (iii) salinity tolerance index (STI) and geometric mean productivity (GMP).

2. Materials and methods

2.1. Site information

This field study was carried out at Research farm of “Pakistan Council of Research on Water Resources (PCRWR)” located in Mithi, Sindh Province, Pakistan ($24^{\circ} 49' 31''\text{N}$, $69^{\circ} 49' 39.1''\text{E}$). Data on climate (temperature, humidity and rainfall) during the study period at research farm is provided in Table 1. Select soil properties of the study site were collected before the study and analyzed for texture, organic carbon, pH and salinity (electrical conductivity or EC_e) using the methods described in Sparks (1996). Table 2 shows the results of select soil samples.

2.2. Experimental design and treatments

Split plot experimental design with salinity as the main plot and genotypes as sub-plots and three replications was used to evaluate the treatment effects. Salinity levels included in this study were decided based on the salinity of the available water sources, rainwater (S0) ($\text{EC} = 0.6 \text{ dS m}^{-1}$) and groundwater (S3) ($\text{EC} = 9 \text{ dS m}^{-1}$). Incidentally, salinity of groundwater also coincided with the reported threshold of gaur. In addition, two blends of rain and groundwater were included to provide growers some options to augment irrigation

Table 1

Cultivation date and mean weather information of experimental area during crop cycle.

Months	Monthly temperature (°C)		Relative humidity (%)		Total rainfall (mm)
	Min.	Max.	Min.	Max.	
August	24.1	34.8	60	88	129
September	20.0	36.6	44	86	00
October	20.5	36.3	36	85	63
November	10.0	34.9	21	80	00

Table 2

Physico-chemical properties of pre-study soil.

Parameters	Value
Sand (%)	75
Silt (%)	13
Clay (%)	12
Texture (%)	Sandy loam
Organic Matter (%)	0.56
EC_e (dS m^{-1})	0.96
pH (1:1)	7.60

supplies by mixing available water sources. For the purpose of this study rainwater (S0) was harvested and groundwater (S3) was pumped from a well at the study site. Two intermediate salinity levels ($\text{S1} = 3 \text{ dS m}^{-1}$ and $\text{S2} = 6 \text{ dS m}^{-1}$) were prepared by mixing 7 parts of S0 with 3 parts of S3 ; and 3.5 parts of S0 with 6.5 parts of S3 , respectively. All irrigation waters used in this study were stored in PVC tanks and grab samples of irrigation waters were collected (3 time at monthly intervals during the study period) to analyze pH, EC, major cations (Na, Mg and Ca), and anions (HCO_3 and Cl) as per the methods described in APHA (2005). Sodium adsorption ratio (SAR) was calculated using the following empirical equation (Ganjegunte et al., 2017). Details of select irrigation water chemical parameters can be found in Suthar et al. (2018) that reported the results of salinity effects on early growth stages of guar. Thus, four salinity levels were evaluated: harvested rainwater as a control (S0 , 0.6 dS m^{-1}), rainwater & groundwater blend as S1 (3.0 dS m^{-1}), rainwater & groundwater blend as S2 (6.0 dS m^{-1}) and saline groundwater as S3 (9.0 dS m^{-1}). Irrigation waters were applied by flooding method to simulate the growing practices in the region.

Study site was fallow before our field experiment and guar was the crop grown two seasons before our study. Most growers in the region follow zero tillage practices. To simulate farmer's practices, study plots were prepared by land leveling without any tilling and seeds were sown using hand drill. Study plots ($4 \text{ m} \times 8 \text{ m}$) were manually delineated by earthen berms. All treatments received the same amounts of fertilizers: 25 kg N ha^{-1} as urea applied in three split applications- 1/3 at first irrigation, 1/3 at flower initiation and 1/3 at pod formation. In addition to N, $60 \text{ kg of P}_2\text{O}_5 \text{ ha}^{-1}$ as single super phosphate and $60 \text{ kg K}_2\text{O ha}^{-1}$ as potassium sulfate at the time of sowing. Seeds of 25 different genotypes given in Table 3 were collected from Guar Research Station (GRS), Bahawalpur and Agriculture Research Station (ARI), Tandojam, Pakistan. Guar seeds of each genotypes were sown on August 5, 2016 through hand drill in prepared plots ($4 \text{ m} \times 8 \text{ m}$) after receiving about 129 mm rainfall. Inter row spacing of 30 cm and intra row spacing of 15 cm was used. Salinity treatments were started after one week when true leaves emerged. Flower initiation occurred 43 to 50 days after sowing and 55–60 days after sowing pods were formed.

2.3. Guar growth parameters, yield and salinity tolerance

Guar plants were harvested on November 18, 2016 (105 days after sowing) at maturity and thrashed manually to separate seeds. Straw

Table 3

Different guar genotypes collected from various sources.

Source	Guar genotypes
Guar Research Station, Bahawalpur (GRS)	2/1, BR-90, BR-99, N-30, S-5607, S-5608, S-5609, S-5611, S-5612, S-5615, S-5876, S-5881, S-5883, S-5932, S-5981, S-5985, S-6003, S-6005, S-6023, S-6049, S-6052, S-6067, S-6128 and S-8885
Agriculture Research Station, Tandojam (ARI)	Thar bean

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