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Genotypes of Sorghum Evaluated Under Two Moisture Conditions

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Abstract: Drought is an adverse factor affecting the sorghum crop production in Mexico. In order to find drought contrasting genotypes tolerant and susceptible for future molecular studies, an experiment was carried out under greenhouse conditions. A complete randomized design was used in a factorial arrangement, to test humidity (A): two moisture levels, irrigated and drought; and genotype (B): 20 genotypes. Results showed significant differences ($P<0.05$) between irrigation and drought conditions (factor A) in fresh stem biomass variable (298 vs 95 g), dry stem weight (111 vs 37 g), fresh root (84 vs 21 g), dry root (57 vs 9 g), and stomatal turgor index (819 vs 630). Among genotypes (factor B), there were significant differences only for stomatal turgor index, where RB-3030 genotype showed the highest values, followed by SBR-31 and Costeño; opposite, genotypes that expressed the lowest values were G-Star 7609 and Nus 421. With the above results, sorghum genotypes with higher values of stomatal turgor index can be useful to differentiate among genotypes and could be employed for differential genetic tags development on future molecular analysis.

Keywords: Genotype, irrigation, drought, sorghum.

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is the fifth most important cereal crop in the world. Mexico is the fourth world producer with approximately 6 million grain tons per year. Northern Tamaulipas is the Mexican region of largest area productivity with more than 450 thousand hectares under rainfall conditions, being the main socioeconomic source on the rural areas[1]. Drought conditions in Tamaulipas are present cyclically and have been more intense on the last 10 years; this situation makes evident the necessity of attend the problematic of drought in sorghum. Different studies have been conducted in order to identify sources of resistance to drought tolerance in sorghum[2-5]. Nevertheless, selection of sorghum germplasm with drought tolerance can be complicated due to the instability on evaluations between environments and interactions, and between phenological stages of the plants, and environments[6]. Two general responses have been recognized when sorghum is subjected to drought stress, depending on the time of onset: pre-flowering and post-flowering responses.

Pre-flowering drought stress occurs when plants are under significant moisture stress prior flowering, close to panicle differentiation and until flowering[7]. Stay-green, or delayed foliar senescence, is a mechanism of post-flowering drought stress tolerance and is characterized by the ability to resist premature stalk and leaf death. Both types of drought tolerance mechanisms have been the subject of QTL molecular mapping studies but more emphasis has been placed on stay-green[8-11], however there are few studies showing a clear relationship between stay-green and yield under drought stress. Several other methods have been adopted to determine drought stress in sorghum but the most current variables used are biomass, grain yield, stomatal turgor index, productivity, green leaf area, etc., all variables depends of the genetic and environmental conditions variations. On this sense, the utilization of all these variables could help to determine drought tolerance or susceptibility on genotypes under controlled conditions[12]. Even though the sorghum genome has been sequenced, genes involved on this phenomenon are still unknown. Genetic molecular studies can assist on the research of genes involved to drought tolerance, but first, it is important to locate contrasting genotypes (tolerant and susceptible) for developing specific molecular markers linked to drought tolerance.

The aim of this work was to evaluate several sorghum genotypes under two controlled moisture conditions, in order to identify contrasting genotypes that could be used on future genetic evaluations.

METHODS

There were 20 sorghum genotypes evaluated under controlled conditions on greenhouse at National Institute for Forestry, Agriculture and Livestock Research (INIFAP), Campo Experimental Río Bravo, Tamaulipas (25 m 25 ° 57 'LN, 98 ° 01' LO), during the 2013 spring-summer period; these genotypes come from INIFAP sorghum collection and commercial seed companies. Soil properties on plant pot were 0.95% organic matter, pH 7.9 (soil-water, 1:1), electrical conductivity 2.8 dS m^{-1}, 23.8 N-NO_3, 21.6 P (Weak-Bray), 606 K, in mg kg^{-1} of soil, and loam sandy clay. The soil was putted into 10 kg plastic black bags and the sowing date was July 30. The sorghum plants were maintained regularly with uniform amount of water into each pot. Two humidity conditions were used, irrigation and drought. A complete randomized design was used using four replications, in a factorial arrangement with two factors, A (humidity) and B (genotype). At 70 days after planting (post-flowering), the genotypes were subjected to drought conditions. Soil moisture was evaluated using the Delmhorst soil moisture measuring system on which the Permanent Wilting Point (PWP) was determined. During the drought period, three chlorophyll sampling dates (July 8, 14 and 21) were taken on the center flag leaf, using the Minolta SPAD-meter 502®. The assessed variables were fresh and dried biomass of sorghum stem and root, and stomatal turgor index, according with Borell *et al.*[13] and Gan *et al.*[14], respectively. The data obtained from measurements were statistically analyzed by analysis of variance. The significance probability among treatments and interactions was performed with Tukey ($p<0.05$) mean comparison.

RESULTS

Moisture conditions in soil marked significant differentiations related to fresh and dry biomass of stem and root variables, as well as the stomatal turgor index. Between irrigation and drought soil conditions (factor A), it was observed significant values ($P<0.05$) for irrigation, compared with fresh stem biomass variable (298 vs 95 g), dried stem (111 vs 37 g), fresh root (84 vs 21 g), dried root (57 vs 9 g), and stomatal turgor index (819 vs 630) on the evaluated sorghum genotypes. These results are agreed with those reported by many authors that have measured biomass on sorghum and other cereals[2, 13, 15, 16]. Several studies provide evidence of an association between a high rate of physiological changes as stomatal turgor, osmotic adjustment and sustained biomass yield under water limited conditions. Among genotypes (factor B), it was only observed statistical significance for stomatal turgor index, further which not existed interactions between humidity and genotype (**Table 1),** this indicated that factors are independents. However some sorghum genotypes have the "stay green" characteristic that may influence the variable chlorophyll index, it was generally observed through readings taken since the beginning of the dry season, an obvious answer where the stressed plants were decreased progressive chlorophyll values. By contrast, plants irrigated maintained or slightly increased SPAD values that can be linked to the addition of nitrogen in plants **(Figure 1).**

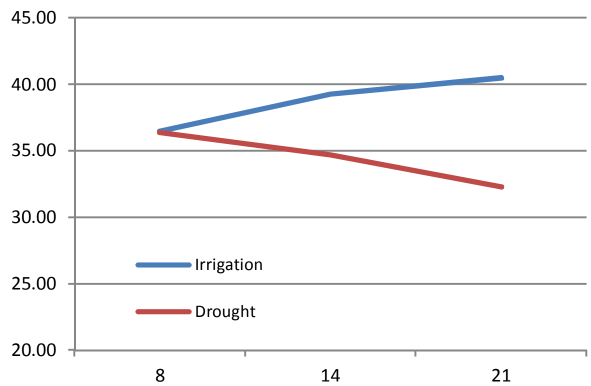
Table 1: Plant features of 20 sorghum genotypes under two moisture conditions.

	Biomass weight (g)				Stomatal turgor
Humidity	Fresh/stem	Dry/stem	Fresh/root	Dry/root	index
Irrigation	0.298a	0.111a	0.084a	0.057a	819a
Drought	0.095b	0.037b	0.021b	0.009b	730b
	***	*	**	***	***
Tukey(0.5)	0.062	0.0536	0.0549	0.0279	35.2
Average	0.180	0.052	0.061	0.0140	774

***Significance, *** High Significance**

For stomatal turgor index (**Table 2**), it was observed significant differences among genotypes; the RB-3030 was the genotype with highest values, followed by SBR-31 and Costeño; opposite, genotypes that expressed the lowest values were G-Star 7609 and Nus 421. In earlier studies[18] the stomatal turgor index variable allowed to differentiate tomato genotypes under salt stress conditions. In some drought-adapted crop plants, typically sorghum, older leaves are selectively killed under stress, while the remaining young leaves retain turgor, stomatal turgor index, and assimilation as a result of high osmotic adjustments in the young leaves [2]. Stomatal turgor indicates that some sorghum genotypes have the genetic capacity to resist drought stress. With the above it deduces that sorghum genotypes with higher values could be predicted like possible tolerant to drought. Differentiation among genotypes, indicate that those individuals could be employed for differential genetic tags development on future molecular studies.

SPAD Index



Chloropyll reading dates

Figure 1. Chlorophyll index readings (SPAD) in sorghum genotypes under irrigation and drought condition, obtained from the beginning of drought treatment.

Table 2: Stomatal turgor index value in sorghum genotypes assessed at two moisture conditions.

Genotype	Stomatal turgor index
RB-3030	906.5 A
SBR-31	858.3 ABC
Costeño	844.1 ABC
RB-Patrón	822.2 ABC
P-83G19	800.1 ABC
SBR-21	783.8 ABC
P-82G63	783.5 ABC
Anzu 4475	779.7 ABC
SBA-25	778.3 ABC
SBA-12	745.7 ABC
NK 180	739.9 ABC
Exp 1	719.1 ABC
Cipres	716.2 ABC
NK K73J6	707.1 ABC
A-Plomo	697.5 ABC
DK-32	693.1 ABC
G-Star 7601	681.7 BC
SBA-22	679.4 BC
G-Star 7609	632.1 C
Nus 421	630.0 C
	***
Tukey(0.05)=	264

*** **High Significance**

CONCLUSIONS

The irrigation values of variables exceeded to those of drought. Also, the obtained values on drought and irrigation conditions, for stomatal turgor index variable, allowed to have contrasting responses among sorghum genotypes. The biggest difference on stomatal turgor index was for RB-3030, while minor differences were for G-Star 7609 and Nus 421.

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