



## Effect of moisture stress on morphological and yield attributes of four sorghum varieties

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### Abstract

Drought adversely affects growth and yield of crops to various extents. Growing of drought tolerant crops is a good option to obtain economical yields from water stress areas for which quick method to screen drought tolerant plants, particularly in early stages of their growth is important. For this reason, a field experiment was conducted to evaluate the genetical potential to drought tolerance of four sorghum varieties viz Hybrid Sorgo, Safal, BD 731, BD 740. The experiment was laid out in a split plot design with three replications. The plants were grown under three drought levels viz. 100% FC (control), 70% FC and 40% FC. Growth and yield of the Sorghum varieties were found to be decreased gradually with gradual increase in drought levels as compared to the control. This reduction was associated with decreased yield components. Water stress also decreased protein and starch content. The variety BD 740 followed by BD 731 showed the better performance in respect of no. of grains panicle<sup>-1</sup>, panicle dry weight, 1000-grain weight, grain yield hill<sup>-1</sup>, protein content and starch content than Hybrid Sorgo and Safal at same water stress condition. Therefore Bangladeshi varieties were found more tolerant than Hybrid Sorgo variety to water stress. Findings of this research will be helpful for the farmers about the beneficial use of resource in terms of managing limited water as well as increasing crop productivity. Finally these research findings would certainly contribute food security in Bangladesh.

**Key words:** Water stress, field capacity, sorghum

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### Introduction

Sorghum (*Sorghum bicolor* L. Moench) is one of the most important cereal crops and also the major staple food crop of millions of people in semi arid tropics (SAT). It is considered as the king of millets and extensively grown in Africa, China, USA, Mexico and India. It is fourth important cereal crops of the world after wheat, rice and maize. The crop is drought tolerant and it is the crop excellence for dry areas. Now-a-days, Sorghum grain is mainly used for human food, fodder, feed and fuel purposes. Moreover, seeds

are used for popcorn and preparing delicious food. This crop has tremendous potentiality to grow under adverse condition by minimum input and care and so its cultivation can be extended in drought prone (Moisture deficit) areas. In Bangladesh this crop is traditionally grown in Jamalpur, Kushtia, Pabna, Rajshahi, Sherpur, Meherpur, Bagerhat and Chittagong Hill Tracts. In the country 3200 metric tons of Sorghum grains are produced annually from about 4000 hectare of land and

average yield is 3.6 metric tons per hectare (BBS, 2012).

Drought is one of the major abiotic stresses in agriculture worldwide, limiting crop productivity (Araus *et al.*, 2002). Generally, drought stress reduces growth (Garg *et al.*, 2004; Samarah *et al.*, 2004) and yield of various crops (Dhillon *et al.*, 1995). Also reduce the nutrient uptake in plants (Baligar *et al.*, 2001). Generally, low water availability results in reduced total nutrient uptake and frequently reduces the levels of mineral nutrients in crop plants (Marschner, 1995; Baligar *et al.*, 2001). It is well evident that drought-stressed plants exhibit various physiological, biochemical and molecular changes to thrive under water limited conditions (Arora *et al.*, 2002).

Drought has long been considered to be a hazard responsible for ups and downs of many civilizations in the world. Drought occurs when rainfall is absent for a prolonged period of time, causing earth to parch, wells to dry, underground water to fall, leading to crop failure. In Bangladesh, drought in the northern districts is very common. The hydrological and climatic conditions of Bangladesh are characterized by too much water in the wet monsoon season and too little water in the dry months, creating a drought environment. The impact of such drought severely affects the economy of Bangladesh. So, it is urgent need to find out possible solutions in order to alleviate the effects of drought for crop production. The wide range of agricultural crops is grown in the Rabi and pre-Kharif seasons which become vulnerable to drought at varying degrees. Genetic improvement for drought tolerance is a long term strategy and hence the selection for drought tolerance has to be either drought escape or drought avoidance or drought tolerance assumes greater importance.

Currently, Bangladesh is facing severe climate change effect, especially in pre Kharif and Rabi season. Temperature is going up; drought condition is persisting with greater intensity. The common crops

are severely affected. Annually, about 2-7 million hectare area is vulnerable to drought. About 28% of the Rabi crops and 19% of the Kharif crops are highly vulnerable to annual drought problem. To face the challenges, one of the strategies to meet climate change effect is to introduce new but tolerant crops. One such crop could be Sorghum. Because it is a very hardy crop which can be grown under rain fed condition with less inputs and it has high yield potential. Superior genetic resources with improved tolerance to drought are required to reduce the risk of loss from water deficit, which requires the identification of easily measurable traits related to drought tolerance.

The study for screening of drought tolerant cultivar is very scanty and the physiological mechanisms that mediate tolerance are poorly understood. So the present study is aimed at evaluating the Sorghum germplasms for drought tolerance based on their morpho-physiological and yield characteristics.

## **Materials and Methods**

A pot experiment was carried out at the net house of the Department of Crop Botany, BAU, Mymensingh. Geographically the experimental area is located at 24°75' N latitude and 90°50' Elongitude at the elevation of 18 m above the sea level.

The seeds of sorghum varieties viz. Safal, BD 731, BD 740 (indigenous) collected from BADC and BARI and Hybrid Sorgo, an exogenous variety, collected from Japan were used as experimental materials. In the experiment, earthen pots of 21cm diameter and 26cm depth were used. Soils were collected from Agronomy farm, BAU, Mymensingh. After pulverizing and drying in the sun, plant propagules and inert materials were removed from the soil. Manure and fertilizers were mixed thoroughly with soil and each pot was filled with 5kg of soil. Five seeds were sown in each pot and plants were thinned to two plants per pot after 10 days of sowing. Urea, TSP, MP and Gypsum were applied @190, 90,90& 50 kg ha<sup>-1</sup> respectively. The weight of 1 hectare soil at the depth of 15 cm was considered 2 x 10<sup>6</sup>

kg soil. According to above rate, fertilizers were calculated as per kg of soil (BINA, 1999).

The two factorial experiments were laid out in a completely randomized design (CRD) with three replications. Total number of pots was 36 (4 × 3 × 3). Treatment combinations were four varieties and three levels of moisture condition. Varieties were V<sub>1</sub>= Hybrid Sorgo, V<sub>2</sub>=Safal, V<sub>3</sub>= BD 731 and V<sub>4</sub>= BD 740 and three levels of moisture stress (Field capacity=FC) were F<sub>1</sub>=100% FC (Control), F<sub>2</sub>=70% FC, F<sub>3</sub>=40% FC. However, there were twelve treatment combinations viz. T<sub>1</sub>= V<sub>1</sub>F<sub>1</sub>, T<sub>2</sub>= V<sub>1</sub>F<sub>2</sub>, T<sub>3</sub>= V<sub>1</sub>F<sub>3</sub>, T<sub>4</sub>= V<sub>2</sub>F<sub>1</sub>, T<sub>5</sub>= V<sub>2</sub>F<sub>2</sub>, T<sub>6</sub>= V<sub>2</sub>F<sub>3</sub>, T<sub>7</sub>= V<sub>3</sub>F<sub>1</sub>, T<sub>8</sub>= V<sub>3</sub>F<sub>2</sub>, T<sub>9</sub>= V<sub>3</sub>F<sub>3</sub>, T<sub>10</sub>= V<sub>4</sub>F<sub>1</sub>, T<sub>11</sub>= V<sub>4</sub>F<sub>2</sub>, T<sub>12</sub>= V<sub>4</sub>F<sub>3</sub>.

Stress was imposed at two days interval started from tillering stage. Weeding and irrigation was done as and when necessary. All the plants of the given varieties were harvested at 120 days after planting when most of the grains became mature (about 95-100% grains were matured). Plant height, panicle length (cm), number of grain panicle<sup>-1</sup>, 1000-grain weight, number of filled grains hill<sup>-1</sup> and number of unfilled grain hill<sup>-1</sup> were recorded. Grain yields were recorded pot wise and weighed carefully. The grains were sun-dried to a moisture content of 14%. Finally grain yields were recorded as kg ha<sup>-1</sup>.

For chemical analysis, the grain samples were dried in an oven at 65 °C for about 72 hours before they were ground in a grinding machine. Then the powdered samples were passed through a 20-mesh sieve and stored in paper bags and finally they were kept in desiccators until analysis. The grain samples were analyzed for determination of protein and starch contents by following standard methods.

Data were analyzed statistically using analysis of variance to examine the treatment effects. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) and ranking was indicated by letters.

## Results

### Growth and yield components

Water stress caused a significant (at 1% level of probability) decrease in plant height, no. of grain panicle<sup>-1</sup>, thousand (1000) grain weight and no. of filled grain hill<sup>-1</sup> of different Sorghum varieties (Table 1) had no significant effect on panicle length and no. of unfilled grain hill<sup>-1</sup> (Table 1). The highest plant height (214.3 cm) and unfilled grain (316.3cm) were observed in BD 731 with 100% FC and 40% FC respectively (Table 1). The highest panicle length (34.00 cm) was observed in Hybrid Sorgo and highest no. grain panicle<sup>-1</sup> (1686), 1000 grain weight (35.28 g) and no. of filled grain (2905) were observed in BD 740 under control condition (Table 1). The lowest plant height (63.67 cm), panicle length (8.667 cm), no. grain panicle<sup>-1</sup> (325.3), 1000-grain weight (9.893g), no. of filled grain (577.7), no. of unfilled grain hill<sup>-1</sup> (54.33) were observed in Safal at 40% FC (Table 1).

### Grain yield

Plants exposed with water stress significantly decreased grain yield of different varieties of Sorghum. The highest grain yield was observed in BD 740 with 100% FC (5.390 ton) and the lowest was observed in Safal at 40% FC (0.8167 ton) (Figure 1).

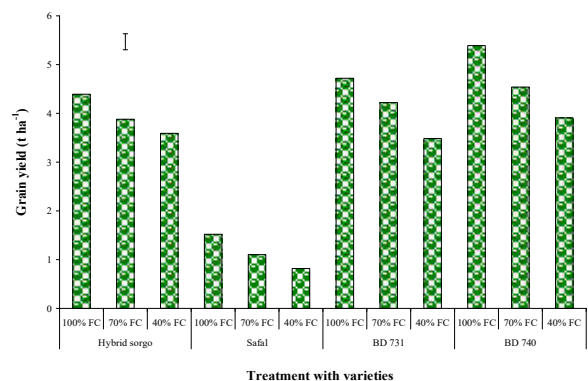


Figure 1. Interaction effect of moisture stress and varieties on grain yield of Sorghum (vertical bar indicates LSD at 1% level of probability)

Table1. Combined effect variety and moisture stress on Sorghum varieties

Variety	Moisture stress	Plant height (cm)	Panicle length (cm)	No. of grains panicle <sup>-1</sup>	Wt. of 1000 grain (g)	No. of filled grain hill <sup>-1</sup>	No. of unfilled grain hill <sup>-1</sup>
Hybrid sorgo (V <sub>1</sub> )	100% FC	192.70b	34.00	1457b	24.49e	2905a	124.0
	70% FC	169.70d	28.33	1320c	18.02g	2628c	173.3
	40% FC	136.00f	23.33	1140d	15.68h	2273.00f	237.0
Safal(V <sub>2</sub> )	100% FC	100.40h	15.33	513.30f	18.67g	1256.00i	54.33
	70% FC	74.67i	11.67	416.7g	10.86i	878.30j	76.67
	40% FC	63.67j	8.667	325.3h	9.89i	577.70k	106.3
BD 731(V <sub>3</sub> )	100% FC	214.30a	29.00	1478b	32.15b	2548d	221.7
	70% FC	153.30e	24.67	1300c	28.41d	2139g	266.7
	40% FC	137.00f	23.33	1024e	21.97f	1837h	316.3
BD 740(V <sub>4</sub> )	100% FC	185.70c	26.00	1686a	35.28a	2744b	73.67
	70% FC	131.30f	23.00	1423b	32.14b	2468e	125.7
	40% FC	119.70g	17.67	1048e	30.18c	2132g	170.3
LSD <sub>0.05</sub>		6.89	2.64	91.41	1.31	63.87	27.48
Level of sig.		**	NS	**	**	*	NS
CV (%)		2.93	7.12	4.96	3.38	1.86	10.06

\*\* = Significant at 1% level of probability, \* = Significant at 5% level of probability, NS = Non significant

### Effect of different moisture stress on chemical composition of Sorghum varieties

#### *Protein content*

The interaction between moisture levels and varieties had significant effect on protein content of Sorghum. Protein content of the Sorghum varieties were gradually decreased by the increasing drought level. The highest protein content (9.96 %) was observed in BD740 with 100%FC .The value was statistically identical to BD 731 at 100% FC(9.96) and Safal at 100% FC (9.88%). And the lowest protein content was observed in Hybrid Sorgo with 40% FC (8.46%) which was statistically identical to Hybrid Sorgo at 70% FC (8.59) (Table 2).

#### *Starch content*

Starch content of the sorghum varieties were gradually decreased by the increasing drought levels. The highest

starch content (71.14 %) was observed in BD731 with 100%FC which was statistically identical with BD 740 at 100% FC whereas The lowest was observed in Hybrid Sorgo with 40% FC (8.46%) which was statistically identical with Safal (59.33) and Hybrid Sorgo (60.83) at 100% FC (Table 2).

### Discussion

In the semi-arid tropics where dryland farming is practiced, drought is a common phenomenon that occurs at different periods during the growing season (Blum, 1988). Drought is a combination of stress effects caused by high temperatures (Prasad et al., 2008) and a lack of water (Campos et al., 2004). Drought can occur at both seedling, pre-flowering and post-flowering stages of development, and has the most adverse effect on yield (Tuinstra et al., 1997; Kebede et al., 2001).

Most of the morphological and physiological characters at seedling stage are affected by water stress in sorghum (Bibi et al. 2010). Drought stress suppressed shoot growth more than root growth (Salih et al. 1999; Younis et al. 2000; Okçu et al. 2005; Bibi et al. 2010). Reduction in seedling growth is the result of restricted cell division and enlargement, as drought stress directly reduces growth by decreasing cell division and elongation (Kramer, 1983).

Table 2. Combined effect of variety and moisture stress on chemical composition of Sorghum

Variety	Moisture stress	Protein (%)	Starch (%)
Hybrid Sorgo (V <sub>1</sub> )	100% FC	9.273 <sup>cd</sup>	68.33 <sup>bc</sup>
	70% FC	8.590 <sup>f</sup>	64.3 <sup>d</sup>
	40% FC	8.460 <sup>f</sup>	60.83 <sup>e</sup>
Safal (V <sub>2</sub> )	100% FC	9.88 <sup>a</sup>	66.67 <sup>c</sup>
	70% FC	9.270 <sup>cd</sup>	64.00 <sup>d</sup>
	40% FC	8.860 <sup>c</sup>	59.33 <sup>e</sup>
BD 731 (V <sub>3</sub> )	100% FC	9.960 <sup>a</sup>	71.14 <sup>a</sup>
	70% FC	9.140 <sup>d</sup>	69.00 <sup>b</sup>
	40% FC	8.860 <sup>c</sup>	63.33 <sup>d</sup>
BD 740 (V <sub>4</sub> )	100% FC	9.960 <sup>a</sup>	70.00 <sup>ab</sup>
	70% FC	9.550 <sup>b</sup>	67.00 <sup>c</sup>
	40% FC	9.410 <sup>bc</sup>	59.0 <sup>c</sup>
LSD <sub>0.05</sub>		0.226	1.86
Level of significance		*	*
CV (%)		1.46	1.69

\*\* = Significant at 1% level of probability,

\* = Significant at 5% level of probability,

NS = Non significant

Water plays a vital role in the growth, yield and nutrient uptake of plant. Insufficient water vigorously affects the germination of seed, cell division, tillering and nutrient uptake of the plants. Nutrients from the soil reach the surface of root by mass flow and diffusion processes. Mass flow and diffusion processes

are positively correlated with moisture content of the soil. Movement of nutrients through the plant body is also associated with soil water content. Application of water without proper planning results not only the wastage of water but also hamper crop growth and yield.

The effect of moisture stress on growth and yield attributes of different varieties was observed. The higher values of growth and yield attributes were observed in normal treatment than drought treatment. The interaction effect of moisture stress on growth and yield attributes of different varieties was statistically significant at 1% level of probability except number filled grains hill<sup>-1</sup>.

An experiment was conducted to study the growth and yield attributes of four sorghum varieties viz. Hybrid Sorgo, Safal, BD 731, BD 740. The plants were grown under normal and drought condition. The different varieties showed variable results on different attributes. Results revealed that different parameters were decreased with the increasing drought stress due to different physiological constraints.

Due to water deficit, stomatal conductance, transpiration, photosynthesis and different physiological process become reduced. For different parameters such as plant height; the effect of varieties: may be arranged as V<sub>3</sub>> V<sub>1</sub>> V<sub>4</sub>> V<sub>2</sub>, for number of filled grains hill<sup>-1</sup>, V<sub>1</sub>>V<sub>4</sub>>V<sub>3</sub>> V<sub>2</sub>, for thousand grain weight, V<sub>4</sub>>V<sub>3</sub>>V<sub>1</sub>>V<sub>2</sub>, no. of grain per panicle, V<sub>4</sub>>V<sub>3</sub>>V<sub>1</sub>>V<sub>2</sub> for grain yield, V<sub>4</sub>>V<sub>3</sub>>V<sub>1</sub>>V<sub>2</sub>, for protein content, V<sub>4</sub>>V<sub>3</sub>>V<sub>2</sub>>V<sub>1</sub>, for starch content V<sub>4</sub>>V<sub>3</sub>>V<sub>1</sub>>V<sub>2</sub>. Considering all the parameters, it may be concluded that V<sub>4</sub> (BD 740) showed better performance considering morpho-physiological attributes in compare to other varieties. The Safal showed to be an inferior variety.

### Conclusion

From the present research work, it could be concluded that the growth, yield contributing characters and chemical compositions of all the varieties were reduced

under increasing drought stress condition. Among the varieties, BD 740 was found comparatively more tolerant under increasing drought stress condition than Hybrid sorgho, BD 731 and Safal. Among the varieties, BD 740 was found comparatively more tolerant under increasing drought stress condition than Hybrid sorgho, BD 731 and Safal. Thus BD 740 variety can be cultivated in the drought prone areas of Bangladesh.

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