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Studies on physiological amelioration of deleterious effects of drought on *Sorghum bicolor* (I) Moench

By

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The present study was carried out to evaluate physiological treatments of stressed compounds and soil *Mycorrhiza* that will minimize the negative effects of drought on sorghum. Results indicated that drought affected sorghum plants had least height, crude fibre and starch contents, amylase and proteinase, and as well as yields. Drought amelioration was best recorded with *Mycorrhizal* drought amelioration, followed by 15% trehalose drought amelioration.

Key word: Sorghum bicolor**,** *Mycorrhiza*, amelioration, Vegetative growth, proximate.

INTRODUCTION

Sorghum bicolor, commonly called sorghum and also known as *durra*, jowari, or milo, is a grass species cultivated for its grain, which is used for food, both for animals and humans, and for ethanol production. Sorghum originated in northern Africa, and is now cultivated widely in tropical and subtropical regions. *S. bicolor* is typically an annual, but some cultivars are perennial. It grows in clumps that may reach over 4 m high.

The grain is small, ranging from 3 to 4 mm in diameter. Sweet sorghums are sorghum cultivars that are primarily grown for foliage, syrup production, and ethanol; they are taller than those grown for grain. *S. bicolor* is the cultivated species of sorghum; its wild relatives make up the botanical genus *Sorghum*. Sorghum bicolor is a short-day plant which grows best at pH 5-8.5. Many of the new cultivars will also flower in long day, although short day accelerate their flowering.

The leading producers of sorghum bicolor in 2011 were Nigeria (12.6%), India (11.2%), Mexico (11.2%) and the United States (10.0%) (Storade and Boland, 2011). Nonetheless, the major problems limiting sorghum production in Nigeria are low yielding cultivars, frequent drought during the growing season, incidence of striga attacks, damages caused by the pests. In addition, low soil fertility, high temperature and lack of water are recorded to be known to limit the expression of full genetic potential of this plant and thus lead to heavy losses in crop yield.

The major damaging effect of drought is on photosynthesis and thereafter yield, caused mainly by reduction in leaf area, stomatal closure and injury to the photosynthetic apparatus (Osmond et al., 1989; Bjorkmum et al., 1980; Abayomi and Wright, 2000). Drought affected plants are known to produce stressed chemicals, which assist them in lowering to some extent the negative effects of water deficit. These are proline, trehalose and ABA (Diet and Hartung, 1998). In Northern Nigeria, *Sorghum bicolor* is constantly exposed to drought, due mainly to insufficient and irregular rainfall and few irrigation facilities. The present study thus aims at finding out physiological treatments of stressed compounds and soil *Mycorrhiza* that will minimize the negative effects of drought on sorghum.

MATERIALS AND METHODS

Sorghum bicolor, KSV 400 was obtained from IAR, ABU, Zaria. Land for cultivation was ploughed and watered daily for a week. Land was divided into 4 mean plots, A, B, C and D each having some 90 x 60cm beds, NPK

Table 1. Effect of drought and drought ameliorating treatments on vegetative growth and proximate contents of sorghum exposed to water stress at 6 weeks and 10 weeks after sowing.

Drought treatment type and No. of days after drought application	Mean plant height		Crude fibre content (%dry wt)		Starch content (% day weight)	
	6WK	10WK	6WK	10WK	6WK	10WK
Drought control						
6	96.4	117.4	4.6	4.8	60.6	61.7
10	116.6	130.6	5.7	5.8	63.2	64.7
14	130.6	140.5	5.9	6.2	68.5	69.6
15% trehalose drought amelioration						
6	158.6	170.6	7.4	8.4	76.5	77.4
10	175.7	190.7	8.3	9.3	79.6	80.6
14	210.6	215	9.1	10.5	81.6	82.4
15% coconut milk drought amelioration						
6	146.5	165.4	6.8	7.6	75.7	76.2
10	162.6	180.6	7.6	8.7	78.4	79.5
14	196.5	200.7	8.5	9.5	80.5	89.4
Mycorrhizal drought amelioration						
6	160.9	180.7	7.6	7.9	78.6	79.6
10	180.6	200.6	8.7	9.6	81.6	82.5
14	220.1	225.7	9.8	10.7	82.7	83.6
Undroughted control						
6	163.9	198.6	8.6	8.9	80.1	80.8
10	182.2	225.4	9.7	10.7	82.6	83.4
14	225.1	230.6	10.1	11.1	83.6	85.6
LSD (5%)	22.6	23.1	1.0	1.1	8.6	9.0

fertilizer at 100kg N, 50kg P and 100kg K per sq hectare was applied on the land, half at the onset of planting and the other six weeks later. Sorghum seeds for planting were sterilized with 10% bleach.

Seeds were sown inside the beds of the main plots and watered daily. The seedlings in the different beds of the 4 plots were subjected to the following treatments, with the beds being selected at random;

i Droughted control plants obtained when they were denied water totally at the age of six and 10 weeks after sowing. Drought application was for 14 continuous days from the date of drought application.

ii. Droughted stress substances and hormonal treated plants obtained by some of the emerging plants being sprayed foliarly with 15% trehalosec and 15% coconut milk separately at 4 weeks and 8 weeks after sowing. The plants were consequently droughted totally by withholding water from them for 14 days at 6 weeks, and 10 weeks after sowing.

iii. Droughted mycorrhizal treated plants obtained by the soil of some beds having arbovascular mycorrhizal incorporated into them at 2 weeks after sowing. The plants were thereafter totally droughted for 14 days at 6 weeks and 10 weeks after sowing.

iv. Undroughted control plants were emerging plants, watered daily from the beginning of the experiment to the end.

In all the treatments mentioned above, the following determinations were carried out in four replicates at every 6, 10 and 14 days of commencement of each drought application or equivalent time for undroughted plants. The last fully expanded leaves were used for these determinations where applicable.

i. Vegetative growth and proximate plant height, crude fibre and starch contents were determined.

ii. Enzyme activities - These were determined for amylase and proteinase using frozen half-leaf. These were determined at 6 weeks after sowing.

iii. Yields - Fresh weight of seeds per panicle, 1000 seed weight, dry weight of seeds per panicle were determined. These were determined at 14 weeks after sowing.

iv. Climatic factors were observed to be mean temperature of 32 ± 2°C, mean humidity of 50 ± 10%, mean photoperiod of 13 ± lhrs/day and no rainfall.

RESULTS AND DISCUSSION

Droughted sorghum plants were found to have the least plant height, crude fibre and starch contents, amylase and proteinase activities and yields (Tables 1 and 2). Drought amelioration was best achieved with Mycorrhizal drought amelioration, followed by 15% trehalose drought amelioration (Tables1 and 2). Sorghum plants subjected to Mycorrhizal and 15% trehalose drought amelioration compared favourably with undroughted control plants with respect to all the parameters studied. The present results showing that sorghum plants were significantly affected by drought are in agreement with the findings of Abayomi and Wright (2000) on wheat.

Trehalose is one of the stress chemicals produced by droughted plants while mycorrhizal in symbiosis with plant roots enables plants to have a better access to soil

Table 2. Effect of drought and drought ameliorating treatments on enzyme activities and yields of sorghum exposed to water stress at 6 weeks and 10 weeks after sowing.

Drought treatment type and No. of days after drought application	Amylase activity mg maltose/h mg protein	Proteinase activity mg tyrosine/h/ mg protein	Fresh weight of seeds per panicle (g)	1000 seed weight (g)	Dry weight of seeds per panicle (g)
	6wk	6wk	14wk	14wk	14wk
Drought control					
6	1.14	0.56	20.1		4.2
10	1.46	0.67	20.1	30.6	4.3
14	1.67	0.69	18.7		4.4
15% trehalose drought amelioration					
6	2.36	0.89	37.6		10.2
10	3.17	0.98	42.7	96.9	11.6
14	3.36	1.22	51.6		11.8
15% coconut milk drought amelioration					
6	2.18	0.87	36.9		10.1
10	3.02	0.94	41.8	95.4	11.5
14	3.17	1.14	50.7		11.7
Mycorrhizal drought amelioration					
6	2.48	0.96	39.6		11.9
10	3.26	1.02	43.2	97.8	12.1
14	3.54	1.34	53.4		12.5
Undroughted control					
6	2.56	1.06	40.1		11.2
10	3.34	1.28	46.4	110.6	11.8
14	3.76	1.49	55.6		12.6
LSD(5%)	0.42	0.15	6.12	12.01	1.27

water and soil nutrients. This may explain as to why they have had a positive effect on sorghum droughted plants. To our knowledge, this may be the first recorded attempt on the use of mycorrhizal, trehalose and coconut milk in ameliorating the effect of drought on sorghum in savannah habitat. However, further work is warranated.

Conclusion

The use of mycorrhizal and l5% trehalose in ameliorating the negative effects of drought on sorghum in a savannah habitat is strongly recommended.

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