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PSTC FINAL REPORT

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Project Title:
A STUDY OF PHYSIOLOGICAL MECHANISMS ASSOCIATED WITH DROUGHT AND HEAT TOLERANCE IN SORGHUM AND PEARL MILLET GROWN IN THE SAHEL REGION OF MALI

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RESEARCH OBJECTIVES:

The objective was to improve production of dryland sorghum and pearl millet in the semi-arid regions of the world in general, and particularly of the Sahelian Zone of Africa, through a better understanding of the physiological mechanisms and responses of grain sorghum and pearl millet when grown in the natural water and high temperature stress conditions of this region.

The objectives and research of this project coincided well with the research and objectives of the Institute of Rural Economy, Bamako, Mali; the U.S. Department of Agriculture, Agricultural Research Service, Sorghum Physiology Project, Lincoln, Nebraska, and ICRISAT/Mali, USAID Sponsored Program. The research was also supported by INTSORMIL (USAID CRSP) collaborative research on sorghum and millet in Mali by purchase of equipment, other student training, operating expenses and travel funds.

METHODS AND RESULTS:

Abscisic acid (ABA) concentrations are known to increase when most plants are drought stressed. Sorghum seeds were presoaked in dilute solutions (10^{-7} molar) of abscisic acid. Seeds were soaked for 4 hours, air dried, and germinated at a later date. Percent seed germination was assessed after 4-6 days growth. Maximum root length and dry weights were measured. Drought stress was imposed by equilibrating with 50% relative humidity (RH) for 24 to 48 hours. RH was controlled with saturated calcium nitrate. In Mali drought stress was controlled by seeding in concrete pits filled with soil and covered with charcoal to increase soil temperatures, thus creating drought and high temperature stress. The pits were covered in the advent of rain.

In some genotypes, seeds presoaked in ABA had increased germination by as much as 10 to 30% and longer root growth. Some results are shown in Table 1. It was also demonstrated, when germinated seed was exposed to drought stress, that the treatment with ABA increased drought tolerance, as shown in Table 2. This experiment was intended to simulate a situation in the Sahel where seed is planted, it germinates, and drought follows which reduces stand establishment. After 72 hours of desiccation, not one of the control seedlings survived, while 21% of the ABA treated survived. These results may have important applications to stand establishment and drought resistance in the Sahel and other drought prone regions.

Several genotypes were planted in the charcoal pits in Mali and subsequently stressed. The results of one of these experiments is shown in Table 3. In this study, the effects of the ABA seed treatment over all slightly decreased germination. However, there was a noticeable increase in survival under stressful conditions. Particularly noticeable was survival of CSM 219 and Malisor 84-7.

None of the CSM 219 controls survived the drought and high temperature treatment, while 31% of the ABA treated survived. In the case of Malisor 84-7 only 8% of the controls survived, and 53% of the ABA treated survived.

In another experiment, seed from 10 genotypes grown in two different locations in Mali, Bema and Cinzana, were tested for germination and survival under stressful conditions in Mali. The environment at Bema is more stressful than that at Cinzana. The objective was to evaluate whether plants grown from the same seed source, but produced in different environments, subsequently behaved differently when grown under stress at the same location.

The results are shown in Table 4. Location of seed production did not have a great influence on germination, although, over all there was a slight advantage to seed produced at Bema. However, when drought stressed, there was generally a greater survival of seedlings from seed produced at Bema than at Cinzana, with marked differences among genotypes. Particularly CSM 219 and CSM 205 seedlings from seed produced at Bema had greater survival than those from seed produced at Cinzana. Exceptions to the trend were 85-F4-152 and CE 151 which had higher survival when the seed was produced at Cinzana.

It was hypothesized that this response may be due to the synthesis of ABA stored in higher concentrations in seed produced in the more stressful environment.

Experiments were then conducted to analyze the quantities of ABA present in seeds produced from these two different environments.

Graduate student Siriba Dione, from Mali, utilized a monoclonal antibody specific for (+) ABA for the analyses.

Both free ABA and conjugated-ABA content of the seed from the two sources of production were determined. Table 5 gives the results for free ABA in ten sorghum genotypes. Contrary to expectations, there were no significant differences in free ABA among the genotypes or between environments at the 5% level of probability, nor were there any significant environment x genotype interactions. High coefficients of variability apparently were associated with the methodology, since similar variability occurred with known standards. When considered at higher levels of probability, there was a trend toward more free ABA in seed produced at Bema than at Cinzana.

Table 6 shows the results for conjugated-ABA of selected genotypes. When expressed on a dry weight basis, seed produced at Bema had significantly higher conjugated-ABA than that produced at Cinzana when considered over all genotypes. Although, differences between individual genotypes were not significant at the 5% level. Total ABA (free ABA plus conjugated-ABA) was about 2.5 times more over

all genotypes in seed produced at Bema.

It was concluded that seed produced in drought and high temperature stressed areas accumulates higher ABA concentrations, primarily in the conjugated form. It is believed that the conjugated-ABA is converted to free ABA when the seed germinates or during early seedling growth, and is a physiological mechanism for the plant to combat stressful conditions during seedling establishment.

Graduate student Sidi Bekaye Coulibaly conducted growth chamber and greenhouse studies to further evaluate specific responses and characteristics that contribute to high temperature and drought stress resistance of Malian and other sorghums.

In the growth chamber experiments, 4 Malian (CSM 63, Malisor 5 Gadiaba and CSM 228) and one U.S. sorghum (CK60B) were compared. Two growth chambers were used. Plants were established at 28/22 C, (day/night) then one chamber was increased to 36/22 C (day/night). Drought stress was induced by addition of the osmoticum polyethylene glycol 8000 (PEG-8000). Several parameters were then measured.

Table 7 shows the results of photosynthetic rates and total leaf area. Table 8 gives the osmotic potentials of the five sorghums. Table 9 shows differences in proline content, and Table 10 gives the root and shoot dry weights.

Growth at the higher temperature favored greater photosynthesis and growth compared to those grown at the lower day temperature. The Malian local sorghum Gadiaba and CSM 228 tended to maintain their growth when water stressed. All genotypes increased their cellular heat tolerance (membrane stability) when exposed to the higher temperature. The Malian sorghums tended to acquire greater heat tolerance.

Osmotic adjustment (OA) appeared to be an important mechanism for adaptation to water stress. Particularly at the higher temperature, OA increased for the Malian local sorghums CSM 228, Gadiaba, and Malisor 5. Thus, OA is one characteristic that could be selected for improved sorghum production in stressful environments.

The accumulation of proline has been associated with plants exposed to environmental stress, although it is controversial among scientists as to what the physiological role of proline accumulation is in drought resistance.

In this study, there was about a 10 times higher accumulation of proline in stressed plants than non-stressed plants. Although, the higher temperature appeared to metabolically reduce the accumulation. The sorghums Malisor 5 and Gadiaba accumulated the greatest amount of proline when stressed at 36 C and CK 60 and CSM 228 the least amounts.

When comparing root and shoot growth, it was found that Gadiaba had a relatively larger root system than the other sorghums, which is usually favorable for stress resistance. The results indicated that Gadiaba has evolved a stress avoidance mechanism, in addition to high stress tolerance. Gadiaba is grown in the Bema region of Mali.

Impact, Relevance and Technology Transfer:

The results from this project are being used to further investigate, breed, and select for physiological mechanisms in sorghums and pearl millet of Mali for stress resistance and improved productivity.

Two graduate students were associated with the project. One received direct funding from PSTC and the other was funded from a collaborative project. Both students have now returned to Mali, and, as members of the Institute of Rural Economy, are developing research programs in the areas of their training. Dr. Moussa Traore is coordinating further expanded research on these and other aspects of sorghum and pearl millet growth and production in Mali. Equipment purchased from this grant is being fully utilized to continue the research.

Similarly, research in the same area is being continued by the USDA-ARS Sorghum Physiology Project at the University of Nebraska, Lincoln.

Project Activities/Outputs:

1. Training:

   Coulibaly, Sidi Bekaye. 1991. Physiological characteristics of drought resistant sorghums. M.S. Thesis, Agronomy Department, University of Nebraska, Lincoln, NE. 158 pp.

   Dione, Siriba. 1991. Influences of abscisic acid on sorghum growth and stress resistance. M.S. Thesis, Agronomy Department, University of Nebraska, Lincoln, NE. 91 pp.

2. Publications:

   Sullivan, C. Y. and W. R. Jordan. 1987. Physiological effects of high temperatures and drought stress: Screening techniques and scope for genetic improvement. Proc. Int. Symposium, Improving Winter Cereals Under Temperature and Salinity Stresses. Cordoba, Spain, pp. 115-129.

   Traore, M. and C. Y. Sullivan. 1988. Effects of seed production and abscisic acid treatment of sorghum seeds on germination and seedling drought responses. Abstract in PSTC

Conf. on Biotechnology for Health and Agriculture, USAID-Wash. D. C. (June).

Beninati, N. F., M. D. Traore, S. V. R. Shetty, M. Haidara, M. Djourte, and I. Kassambara. 1988. Bilan succint de deux annees de recherche sur le sorgo an Mali. In: Proceedings 3rd Regional Sorghum Workshop, Maroua, Cameroon (1986-87), pp. 121-140.

Traore, M. and C. Y. Sullivan. 1988. The effects of abscisic acid seed treatment on sorghum drought responses. Proc. Int. Plant Physiology Congress, New Delhi, India. Vol. 2, pp. 949-853.

Sullivan, C. Y., Traore, M., W. R. Jordan, and A. Blum. 1988. An overview of heat tolerance. Eds., S. Sinha, et al., Proc. Int. Plant Physiology Congress, New Delhi, India. Vol. 2, pp. 916-922.

Sullivan, C. Y. 1988. Drought research. Contributed to USDA-ARS Information, Beltsville, Condensed in April-June, Quarterly Report of Selected Research Projects, p. 1. (Distributed to periodical and newspaper editors to stir interest in drought research).

Traore, M., C. Y. Sullivan, J. R. Rosowski, and K. W. Lee. 1989. Comparative leaf surface morphology and the glossy characteristic of sorghum, maize, and pearl millet. Annals of Botany 64:447-453.

Traore, Moussa. 1989. The effects of climate change on the production of sorghum and millet in the Sudano-Sahelian Zone of West Africa. In: Pan-Earth Sub-Saharan Africa Workshop Report. Saly, Senegal, Sept. 11-15. p. 45 (Abstract) and A14-22.

Traore, M., C. Y. Sullivan, S. Dione, and B. Coulibaly. 1989. Responses of sorghum to applied abscisic acid. Session IX: Technical Presentations and Abstracts, Int. Sorghum and Millet CRSP Conf., Scottsdale, AZ, p. 157.

Traore, Moussa (et al.). 1987-1990. Annual Reports, Commission Technique des Productions Vivrieres et Oleagineusses, Agrophysiologie. Inst. d' Econ. Rurale, Div. de la Recherche Agronomique, Bamako, Mali.

Sullivan, C. Y., M. Traore, and O. Niangado. 1987-1990. Mechanisms of drought and high temperature resistance in sorghums and pearl millet. INTSORMIL Annual Reports, University of Nebraska, Lincoln, NE.

3. Meetings and Presentations:

Sullivan, C. Y. 1987. Attended meeting and presented paper. Physiological effects of high temperatures and drought stress: Screening techniques and scope for genetic improvement. (Abstract) Int. Symp., Improving Winter Cereals Under Temperature and Salinity Stresses. Cordoba, Spain.

Sullivan, C. Y. 1987 Presentation. Methods of screening for drought resistance in sorghums. Cinzana Agronomic Research Station, Cinzana, Mali (October).

Traore, M. 1987. Strategies of Physiology Research in Intercropping in Mali. Proc. Workshop on Intercropping in Mali, (September).

Traore, M. and C. Y. Sullivan. 1988. Presentation. The effects of abscisic acid seed treatment on sorghum drought responses. Abstracts of Int. Plant Physiology Congress, New Delhi, India.

Sullivan, C. Y., M. Traore, W. R. Jordan, and A. Blum. 1988. Presentation. An overview of heat tolerance. Abstracts of Int. Plant Physiology Congress, New Delhi, India.

Traore, M. 1988 and 1992. Reviewer of ICRISAT programs in India and West Africa.

Traore, M. 1988. Drought Resistance in Sorghum and Millet. Proc. Sorghum and Millet Workshop, Bamako, Mali (March).

Traore, M. 1989. Effects of Climatic Changes on Sorghum and Millet Production in the Sudano-Sahelian Zones of West Africa. Presentation. Pan-Earth Sub-Saharan Africa Workshop, Senegal.

Traore, M. and C. Y. Sullivan. 1989. Participated in planning of Malian Sorghum\Millet Workshop to be held in Bamako, Mali. (Workshop was later canceled).

Traore, M. 1989. Member of the Panel to review ICRISAT Strategic Plan.

Traore, M. 1990. Participated on Review Team of ICRISAT Training Program.

Sullivan, C. Y. 1991. More on accumulation of proline and other metabolites and plant stress. Presentation at 17th Bienn. Grain Sorg. Resh. and Util. Conf., Lubbock, TX.

Attended INTSORMIL Semi-Annual CRSP Conferences. 1987-1990.

Project Productivity:

It is felt that almost all aspects of the proposed project goals were achieved. An insight was gained into some of the important physiological mechanisms of heat and drought tolerance of sorghum grown in Mali, and this has formed the basis for further research.

It is acknowledged that most of the research was conducted on sorghum, although some comparative responses were made with pearl millet. The investigations simply became too great to include millet in all experiments. It is believed that the knowledge, methodology and training gained from the sorghum research is applicable to pearl millet as well.

Future Work:

As indicated under the Impact statement, the research initiated by this project is continuing in Mali and by USDA-ARS at the University of Nebraska.

Table 1. Effects of presoaking sorghum seed in ABA solutions, or water (control) on percent germination and seminal root length.

Sorghum	% Germination*		Root length, cm.*	
	Control	ABA	Control	ABA
103	16	26	3.2	4.5
4210	37	46	3.9	4.2
226	30	32	5.2	4.9
30	14	17	4.2	4.7
121-16	41	42	7.3	7.2
2617	35	37	4.1	4.0
9-3	45	64	3.6	5.1
S-11	45	57	6.0	6.9
146	21	55	5.2	6.8
160	32	37	4.5	4.4
SC 90	69	67	5.3	5.7
SC 283	65	63	6.5	6.3
RS 671	52	65	3.5	5.0

*Values are average of 5 replications of 25 seeds per replication.

Table 2. Effects of presoaking RS671 sorghum seed in ABA solutions or water (control), on recovery from desiccation after different times of germination and growth.

Hours Germinated	Hrs. Dried at 50% R.H.	% Recovery	
		Control	ABA
24	48	45	75
48	48	6	26
72	48	0	21

Table 3. Sorghum varietal responses to ABA seed treatment.

Sorghum	% Germination Cont.	% Germination ABA	% Survival* Cont.	% Survival* ABA
CSM 228	83	95	0	0
CSM 219	85	68	0	36
Tortill	63	48	0	6
M. 84-1	90	80	10	19
M. 84-7	75	69	8	53
Sureno	68	53	8	0
Haggen Dura	79	39	35	50
Vart-15	72	79	0	11

* After high temperature and drought stress in charcoal pits.

Table 4 . Effect of location of seed production on germination and stress resistance.

Sorghum	% Germination		% Survival*	
	Bema	Cinzana	Bema	Cinzana
M. 84-4	46	56	31	31
M. 84-5	70	68	26	25
M. 84-6	58	46	27	14
CSM 219	88	88	43	22
CSM 205	84	86	29	8
CE 90	80	69	38	38
CE 151	60	56	29	34
Bandoka	68	48	62	44
85-F4-43	68	48	19	5
85-F4-152	68	69	27	44

* After high temperature and drought stress in charcoal pits.

Table 5. Free ABA concentrations, including ANOVA and contrast analysis, in seeds of ten sorghum genotypes grown at two locations in Mali.

GENOTYPES	Free-ABA per seed (ng) Env 1‡	Free-ABA per seed (ng) Env 2	Free-ABA per gdw (g) Env 1	Free-ABA per gdw (g) Env 2
CE-151	A 3.82 ab/	A 1.96 b	A 171.75 a	A 82.46 a
CE-90	A 1.98 b	A 4.31 b	A 95.22 a	A 215.52 a
CSM-219	A 2.03 b	A 1.97 b	A 101.75 a	A 94.48 a
CSM-228	A 2.08 b	A 2.08 b	A 160.76 a	A 160.37 a
E35-1	A 2.14 b	A 7.65 a	A 70.46 a	A 260.16 a
GADIABA	A 5.09 a	A 5.14 ab	A 93.46 a	A 88.70 a
MALISOR-5	A 3.27 ab	A 2.93 b	A 157.13 a	A 128.49 a
MALISOR-7	A 3.12 ab	A 3.23 b	A 155.83 a	A 155.12 a
SURENO	A 3.60 ab	A 2.24 b	A 172.80 a	A 108.96 a
S-34	A 4.13 ab	A 4.56 ab	A 152.69 a	A 141.21 a
MEANS	A 3.13	A 3.61	A 133.18	A 143.55

ANOVA

Source	df	F value	Pr	F value	Pr
Environment	1	0.87	>0.20	0.23	>0.20
Genotypes	9	1.74	=0.09	0.55	>0.20
Env × Gen	9	1.63	=0.12	1.47	=0.17
CV (%)		84.00		86.14	

CONTRAST ENV 1 vs ENV 2 (ABA /seed)

Genotypes	df	Pr
CE 151	1	=0.18
CE 90	1	>0.20
CSM 219	1	>0.20
CSM 228	1	>0.20
E 35-1	1	=0.10
GADIABA	1	>0.20
MALISOR-5	1	>0.20
MALISOR-7	1	>0.20
SURENO	1	>0.20
S 34	1	>0.20

‡ Env 1 = Cinzana, Env 2 = Bema; Lower case letters compare genotypes in a column; Capital letters compare env means in a row. / = Values followed by the same letters are not different at Pr ≤ 10%.

Table 6 . Concentration of conjugated-ABA and percent of total (free + conjugated) ABA in seeds of four sorghum genotypes grown at two locations in Mali, including ANOVA and contrasts analysis.

Genotypes	CONJUGATED-ABA per seed				CONJUGATED-ABA per gdw			
	ENV 1‡		ENV 2		ENV 1		ENV 2	
	(ng)	(%)	(ng)	(%)	(ng)	(%)	(ng)	(%)
CSM-219	A 5.89 a	74.4	A 24.43 a	92.50	A 308.8 a	77.90	A 1172.2 a	98.70
CSM-228	A 6.75 a	76.4	A 42.33 a	95.50	A 572.0 a	84.06	A 3293.0 a	96.30
GADIABA	A 33.55 a	86.8	A 6.43 a	55.60	A 603.9 a	87.00	A 171.2 a	82.30
MALISOR-7	A 16.16 a	83.8	A 33.99 a	91.30	A 847.0 a	87.80	A 1673.2 a	93.63
MEANS	A 15.60	80.8	A 26.80	83.77	B 583.0	84.19	A 1577.3	92.73

ANOVA

Source	df	F values	Pr	F value	Pr
Environment	1	2.13	=0.16	4.61	=0.04
Genotypes	3	0.35	>0.20	2.11	=0.13
Env × Gen	3	2.42	=0.09	1.97	=0.15
CV (%)		104		121.24	

CONTRAST ENV 1 vs ENV 2

Genotypes	df	Pr	Pr
CSM-219	1	>0.20	=0.17
CSM-228	1	=0.09	=0.10
MALISOR-7	1	>0.20	>0.20
GADIABA	1	>0.20	>0.20

‡ Env 1 = Cinzana, Env 2 = Bema; Lower case letters compare genotypes in a column; Capital letters compare Env means in a row. / = Values followed by the same letters are not different at Pr ≤0.05.

Table 7. Total leaf area and average rate of photosynthesis of five sorghums grown at two different day temperatures.

Genotype	Average Rate of Photosynthesis		Total Leaf Area		Increase at 36°C	
	28/22°C	36/22°C	28/22°C	36/22°C	Ps[1]	TLA[2]
	— mg CO_2/sec/m² —		——— cm² ———		— % —	
CSM 63	A 0.13 b	A 0.15 b	B 132 b	A 171 c	15	30
Malisor5	A 0.16 ab	A 0.18 ab	B 164 b	A 229 b	13	40
CK60B	A 0.20 a	A 0.25 a	A 110 b	A 138 c	25	25
Gadiaba	B 0.14 b	A 0.21 ab	B 219 a	A 343 a	50	57
CSM 228	B 0.15 ab	A 0.24 ab	A 142 b	A 165 c	60	16
Mean	B 0.15	A 0.21	B 154	A 209	31	36
C.V. (%)	22.9	36.03	27.92	21.55		

[1]Ps = Average rate of photosynthesis
[2]TLA =Total leaf area
Capital letters compare the two temperatures for each genotype.
Lower case letters compare the genotypes within temperature.
Values with the same letter in a column and in a row within a chamber temperature are not significantly different at the 0.05 level.

Table 8. Effects of temperature and water stress on grain sorghum leaf osmotic potential.

Genotype	Osmotic Potential					
	28/22°C			36/22°C		
	Control[1] (MPa)	St[2] (MPa)	OA[3]	Control[1] (MPa)	St[2] (MPa)	OA[3]
CSM 63	B -1.7 b	A -2.7 ab	1.0	B -1.9 a	A -2.4 b	0.5
Malisor 5	B -2.1 ab	A -3.2 a	1.1	B -1.9 a	A -2.8 a	0.9
CK60B	A -1.9 ab	A -2.2 b	0.3	A -1.8 a	A -2.3 b	0.5
Gadiaba	B -2.0 ab	A -2.4 b	0.4	B -1.9 a	A -3.0 a	1.1
CSM 228	A -2.2 a	A -2.4 b	0.2	B -2.1 a	A -3.0 a	0.9
Mean	B -2.0	A -2.6	0.6	B -1.9	A -2.7	
C.V.(%)	14.06	18.30		14.79	11.64	

[1]Control = Non-stressed [2]St = Stressed
[3]OA = Osmotic Adjustment
Capital letters compare the water treatments.
Lower case letters compare the genotypes within water treatments.
Values with the same letter in a column or in a row within a chamber temperature are not significantly different at the 0.05 level.

Table 9. Leaf proline content of water stressed and non-stressed sorghums grown in two different day temperatures.

Genotype	TEMPERATURE (°C)			
	28/22°C Proline		36/22°C Proline	
	Stressed (mg/gdw)	Control[1] (mg/gdw)	Stressed (mg/gdw)	Control[1] (mg/gdw)
CSM 63	A 3.67 a	B 0.24 a	A 2.05 b	B 0.22 bc
Malisor 5	A 2.25 a	B 0.55 a	A 3.49 a	B 0.31 ab
CK60B	A 2.41 a	B 0.23 a	A 0.82 c	B 0.11 c
Gadiaba	A 3.71 a	B 0.56 a	A 2.62 ab	B 0.41 a
CSM 228	A 3.38 a	B 0.13 a	A 0.63 c	B 0.19 bc
Mean	A 3.08	B 0.30	A 1.92	B 0.30
C.V. (%)	74.26	88.61	89.56	52.59

[1]Control = Non-Stressed.
Capital letters compare the water treatments for each genotype and means within water treatment and temperature.
Lower case letters compare the genotypes within water treatment.
Values not followed by the same letter in a column or in a row within a chamber temperature are significantly different at the 0.05 level.

Table 10. Root and shoot dry weights of five sorghums when plants were water stressed and grown at two different day temperatures.

Genotype	TEMPERATURE			
	28/22°C		36/22°C	
	Control[1]	Stressed	Control[1]	Stressed
	RDW[2] g		RDW[2] g	
CSM 63	A 1.7 c	A 3.4 b	A 2.1 c	A 3.0 b
Malisor 5	A 3.2 b	A 3.1 b	A 4.5 b	A 3.9 b
CK60B	A 2.1 bc	A 1.8 b	A 2.6 bc	A 2.2 b
Gadiaba	A 8.3 a	A 7.9 a	A 9.3 a	A 7.6 a
CSM 228	A 2.3 bc	A 4.2 b	A 2.6 b	A 3.1 b
Mean	A 3.5	A 4.1	A 4.2	A 4.0
C.V. (%)	39.97	46.82	36.71	38.83
	SDW[3] g		SDW[3] g	
CSM 63	A 4.6 c	A 5.6 bc	A 7.1 c	A 6.4 bc
Malisor 5	A 8.9 b	A 6.9 b	A 12.7 ab	B 7.8 b
CK60B	A 6.0 bc	A 3.8 c	A 8.0 bc	A 6.0 c
Gadiaba	A 17.9 a	A 11.75 a	A 19.9 a	A 15.3 a
CSM 228	A 8.7 b	A 7.1 ab	A 9.4 ab	A 7.8 b
Mean	A 9.2	A 7.0	A 11.4	A 8.6
C.V. (%)	34.89	32.55	37.03	26.16

[1]Control = Non-stressed [2]RDW = Root dry weight
[3]SDW = Shoot dry weight.
Capital letters compare the two water treatments.
Small letters compare the genotypes within water treatment.
Values with the same letter are not significantly different at the 0.05 level.