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Study on association of yield and yield attributes with grain yield in sorghum genotypes under post flowering moisture stress conditions

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Abstract
An experiment entitled "Physiological basis of key adaptive traits associated with post flowering drought tolerance in rabi Sorghum" was conducted during *rabi* 2012-13 at research farm of Directorate of Sorghum Research, Rajendranagar, Hyderabad. The experiment was laid out in a split plot design, replicated thrice, with 10 Sorghum genotypes as main treatment (Well Watered (WW) and Water Stress (WS) conditions) and with 10 genotypes are sub treatments CRS 4, CRS 19, CRS 20, PEC 17, CSV 18, M 35-1, Phule chitra, Phule moulee, EP 57 and CRS 1). Among the yield components, panicle length, 1000 grain weight and harvest index (HI) are significantly and positively correlated with grain yield and therefore it can be ascribed that the genotypes, which partitioned more assimilates into economic parts and in which grain filling is high, recorded more grain yield. panicle length, 1000 seed weight, HI and registered higher grain yield (1137 kg ha^{-1}) and maintained its superiority over the other genotypes followed by M 35-1 (1134 kg ha^{-1}) and CSV 18 (1082 kg ha^{-1}). The cultivar CRS 1 recorded significantly least grain yield (824 kg ha^{-1}) and had lowest values for all the above parameters. The overall yield reduction due to moisture stress during the post flowering drought was 10 per cent and it ranged between 8-12 per cent among the genotypes. This indicates that the genotypes used in the present study are relatively drought tolerant. The genotypes CSV 18 and Phule moulee registered least yield reduction (8 per cent) in grain yield due to post flowering drought followed by PEC 17 and M 35-1 which registered 9 per cent yield reduction. However, the overall grain yield of PEC 17 and M 35-1 was more than CSV 18 and Phule moulee even under moisture stress conditions.

Keywords: Triclosan, TCS, determination, detection, sensor

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the world's most important nutritional 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. Sorghum ranks fourth among the world's most important crops after wheat, rice and maize. Its current world production stands at 64.6 million tonnes while in India current production is 7.4 million tonnes. In India, Sorghum is cultivated in both rainy and post rainy (*rabi*) season, mainly as a rain fed crop with about 85% of the production concentrated in Maharashtra, Karnataka and Andhra Pradesh. The national average productivity of Sorghum is very low (880 kg/ha). In India, it is the major dry land crop currently grown in about 7.69 m ha during both *kharif* (3.2 m ha) and *rabi* (4.50 m ha) seasons with a production of 7.73 m t.

The *rabi* Sorghum is normally grown under stored and receding soil moisture conditions with increasing temperature after flowering. Thus, it experiences both soil and atmospheric water deficit (drought). The limited availability of water causes moisture stress which affects various metabolic processes of the plant. The major limitations for Sorghum productivity are the occurrence of various biotic (shoot fly, stem borer, charcoal rot etc) and abiotic (drought, salinity and temperature, etc.) stresses at different crop growth stages.

Delay in the onset and reduced rate of leaf senescence (*i.e*, two distinct component traits of stay-green) offer an effective strategy for increasing grain production, fodder quality and grain crop residues particularly under water limited conditions. Stay-green Sorghum genotypes maintain photosynthetically active leaf area better than genotypes that do not posses this trait under limited soil moisture during grain filling stage. Stay-green has also been viewed as a consequence of balance between N demand by the grain and N supply from the roots during grain filling (Borrell *et al*, 2000) [2].

Material and methods

The present investigation entitled "Physiological basis of key adaptive traits associated with post flowering drought tolerance in *rabi* Sorghum" was conducted during winter (*rabi*) season, 2012-2013 at the research farm of Directorate of Sorghum Research (DSR), Rajendranagar, Hyderabad located at Latitude 17^0 19' N, Longitude 78^0 28' E and at an altitude of 542 m above the Mean Sea Level. At physiological maturity the crop was harvested treatment wise and replication wise from the marked 3 x 1.2 m^2 area and after drying them observations were recorded.

The length of the panicle was measured from the base to the tip of the panicle in a plot for all the treatments and mean length of panicle was reported (cm). The panicles of the tagged plants were separated from the plants and their weight was recorded and the average was reported as the panicle weight /plant (g).

The number of grains in each panicle were counted from each plot and the average was reported as number of grains per panicle. Panicles were threshed completely and grains were separated. The mean of three panicle was expressed as grain weight per plant (g). All the grains from the three tagged plants were collected plot wise. The weight of 1000 grain was recorded treatment wise and expressed in grams.

Harvest index was calculated by using below formula expressed as percentage.

$$\text{Harvest index (\%)} = \frac{\text{Economical yield}}{\text{Total biological yield}} \times 100$$

All the panicles form the net plot (3 x 1.2 m^2) area in all treatments were harvested, sun dried, threshed, cleaned and weight of the grains was recorded (g) and grain yield/ha was computed.

Results and Discussion

The data of both water stress and well watered conditions on yield and yield components viz., panicle length, panicle weight, number of grains per panicle, thousand grain weight, grain weight per panicle, harvest index and grain yield are presented in tables 1&2.

Panicle length (cm)

The data on panicle length presented in table 1 indicated that there was a significant difference among the genotypes at harvest stage. The panicle length was maximum in PEC 17 (18 cm) followed by M 35-1 (17 cm). The lowest panicle length was observed in CRS 1 (13 cm).

There was a significant difference between the treatments, during water stress and well watered conditions. There was decrease in panicle length in all the genotypes due to the moisture stress imposed during post flowering period.

The interaction between genotypes and treatments was significant and among the genotypes PEC 17 recorded highest panicle length in water stress (17 cm) and well watered (18 cm) conditions. The lowest panicle length in water stress (12 cm) and well watered (13 cm) conditions was observed in the genotype CRS1.

Panicle weight (g)

The data on panicle weight presented in table 1 indicated that there was a significant difference among the genotypes at harvest stage. The panicle weight was maximum in PEC 17 (68 g) followed by CSV 18 (66 g). The lowest panicle weight was observed in CRS 1 (34 g).

There was a significant difference between the treatments, during water stress and well watered conditions. There was decrease in panicle weight in all the genotypes due to the moisture stress induced during post flowering period.

The interaction between genotypes and treatments was significant and among the genotypes PEC 17 recorded highest panicle weight in water stress (66 g) and well watered (69 g) conditions. The lowest panicle weight in water stress (33 g) and well watered (36 g) conditions was observed in the genotype CRS1.

Thousand grain weight (g)

The data on thousand grain weight presented in table 1 and figure 1 indicated that there was a significant difference among the genotypes at harvest stage. The thousand grain weight was maximum in PEC 17 (44 g) and was lowest in CRS 1 (23 g). Such variation in thousand grain weight among Sorghum genotypes was earlier reported by Chinnappagoudar *et al.*, (2008) [4].

There was a significant difference between the treatments, during water stress and well watered conditions. There was decrease in thousand grain weight in all the genotypes due to the moisture stress induced during post flowering period.

The interaction between genotypes and treatments was significant and among the genotypes PEC 17 recorded highest thousand grain weight in water stress (43 g) and well watered (45 g) conditions. The lowest thousand grain weight in water stress (22 g) and well watered (23 g) conditions was observed in the genotype CRS1. The thousand seed weight has a positive correlation with grain yield in Sorghum (Kadam *et al*, 2002 and Awari *et al*, 2003) [7, 1].

Grain weight per panicle (g)

The data on grain weight per panicle presented in table 2 & figure 2 indicated that there was a significant difference among the genotypes at harvest stage. The grain weight per panicle was maximum in PEC 17 (61 g). The lowest grain weight per panicle was observed in CRS 1 (37 g).

There was a significant difference between the treatments, during water stress and well watered conditions. There was decrease in grain weight per panicle in all the genotypes due to the moisture stress induced during post flowering period.

The interaction between genotypes and treatments was significant and among the genotypes PEC 17 recorded highest grain weight per panicle in water stress (59 g) and well watered (62 g) conditions. The lowest grain weight per panicle in water stress (35 g) and well watered (38 g) conditions was observed in the genotype CRS1.

Number of grains per panicle

The data on number of grains per panicle presented in table 2 indicated that there was a significant difference among the genotypes at harvest stage. The number of grains per panicle was maximum in PEC 17 (1201). The lowest number of grains per panicle was observed in CRS 1 (965).

There was a significant difference between the treatments, during water stress and well watered conditions. There was decrease in number of grains per panicle in all the genotypes due to the moisture stress induced during post flowering period.

The interaction between genotypes and water stress treatments was also significant and among the genotypes PEC 17 recorded highest number of grain per panicle in water stress (1145) and well watered (1256) conditions. The lowest number of grain per panicle in water stress (937) and well watered (993) conditions were observed in the genotype CRS1. Number of grains per panicle has a positive correlation with grain yield in Sorghum (Kadam *et al*, 2002 and Awari *et al.*, 2003) [7, 1].

A close observation of the data indicated that in drought susceptible genotypes, the grain number per panicle was more affected and the effect of stress appeared to be direct one on this parameter. These finding are in agreement with the results of Nouri *et al*, (2004) [9]. Pawar *et al*, (2005) [11] reported that the number of grains per panicle greatly contributed to the total grain yield.

Grain yield (kg ha^{-1})

The data on grain yield presented in table 2 and depicted in figure 3 indicated that there was a significant difference among the genotypes at harvest stage. The grain yield was maximum in PEC 17 (1137 kg ha^{-1}). The lowest grain yield was observed in CRS 1 (824 kg ha^{-1}). The superior performance of genotypes with respect to grain yield was due to high dry matter production and higher translocation to ear head at physiological maturity (Patil, 2005) [10].

There was a significant difference between the treatments, during water stress and well watered conditions. There was decrease in grain yield in all the genotypes due to the moisture stress induced during post flowering period. Such yield reduction in Sorghum was due to decrease in grain number and grain size when water stress was imposed at anthesis and early grain filling stage (Yadav *et al*, 2003) [15].

The interaction between genotypes and water stress treatments was also significant and among the genotypes PEC 17 recorded highest grain yield in water stress (1082 kg ha^{-1}) and well watered (1192 kg ha^{-1}) conditions. The lowest grain yield in water stress (772 kg ha^{-1}) and well watered (875 kg ha^{-1}) conditions was observed in the genotype CRS1.

Yield stability is an important aspect under drought conditions and reduced grain yields due to water stress during rabi season is a common occurrence and has been well documented (Seetarama *et al.*, 1987) [12]. The degree of yield reduction due to water deficit depends on the timing and severity of stress (Craufurd and Peacock, 1993) [6]. Yield components that are influenced by water deficit depend largely on the timing of stress. Sankarpandian *et al*, (1993) [13] showed that reduction in grain yield was more when stress occurred at flowering and least at vegetative stage and thus opined that Sorghum is able to withstand early drought.

Harvest index

The data on harvest index presented in table 2 and depicated in figure 4 indicated that there was a significant difference among the genotypes at harvest stage. The harvest index was maximum in PEC 17 (36%). The lowest harvest index was observed in CRS 1 (23%). Such variations in HI among the genotypes was earlier reported by Salunke *et al*, 2003 and higher grain yield in Sorghum cultivars RSLG 262 was due to high HI (Kusalkar *et al*, 2003 and Channappagoudar *et al*, 2007) [8, 3].

There was a significant difference between the treatments, during water stress and well wateredconditions. There was decrease in harvest index in all the genotypes due to the moisture stress imposed during post flowering period.

The interaction between genotypes and treatments indicate significant difference. Among the genotypes PEC 17 recorded highest harvest index in water stress (35%) and well watered (37%) conditions. The lowest harvest index in water stress (22%) and well watered (24%) conditions was observed in the genotype CRS1.

Harvest index is the most important factor in determining the grain yield, which indicates the partitioning ability of total dry matter to the developing grains (Channaoppagoudar et al, 2008) [4]. The genotypes 296 B and ICSV 75 with lower HI (10.4-10.5%) resulted in poor yields of 66.1 and 77.3 g m-2, respectively (Chimmad and Kamatar, 2003) [5]. Ludlow (1990) [14] was also of the opinion that higher yield under drought situation was due to larger grains and higher harvest index. The higher harvest index in genotypes PEC 17 could be attributed mainly due to better partitioning of dry matter into economic parts. However, the low yielding genotype, CRS 1 had low harvest index.

Table 1: Panicle length, panicle weight and thousand seed weight of Sorghum genotypes under well watered and water stress conditions.

Genotypes	Panicle length (cm)			Panicle weight (g)			Thousand seed weight (g)		
	WW	WS	Mean	WW	WS	Mean	WW	WS	Mean
CRS 4	17	16	17	36	35	36	30	28	29
CRS 19	15	13	14	66	64	65	38	33	36
CRS 20	14	14	14	54	53	54	32	31	32
PEC 17	18	17	18	69	66	68	45	43	44
CSV 18	17	17	17	66	65	66	43	41	42
M35-1	15	15	15	38	37	38	33	32	33
Phule Chitra	13	13	13	57	55	56	29	27	28
Phule Moulee	15	14	15	39	35	37	42	41	42
EP 57	15	14	15	54	51	53	37	35	36
CRS 1	13	12	13	36	33	34	23	22	23
Mean	15	15	15	52	49	51	35	33	34
CD Genotypes (G)	1.57			6.61			4.25		
Treatments (T)	0.77			4.35			2.15		
G X T	2.44			3.76			6.83		
CV	9.96			16.02			11.46		

Table 2: Grain weight per panicle, no of grains per panicle, grain yield and harvest index of Sorghum genotypes under well watered and water stress conditions.

Genotypes	Grain weight per panicle (g)			No of grains per panicle			Grain yield (kg ha^{-1})			Harvest index (%)		
	WW	WS	Mean	WW	WS	Mean	WW	WS	Mean	WW	WS	Mean
CRS 4	45	37	41	1167	1081	1124	1045	951	998	25	24	25
CRS 19	59	57	58	1208	1121	1165	761	667	714	26	24	25
CRS 20	50	48	49	1194	1065	1130	1005	912	959	29	27	28
PEC 17	62	59	61	1256	1145	1201	1192	1082	1137	37	35	36
CSV 18	58	56	57	1139	1010	1075	1128	1035	1082	30	28	29
M35-1	44	43	44	1048	1018	1033	1190	1078	1134	35	33	34
Phule Chitra	47	44	46	1051	1033	1042	960	845	903	31	29	30
Phule Moulee	52	50	51	1025	952	989	999	919	959	28	26	27
EP 57	47	45	46	1041	1016	1029	915	827	871	25	23	24
CRS 1	38	35	37	993	937	965	875	772	824	24	22	23
Mean	50	47	49	1112	1038	1075	1007	909	958	29	27	28
CD Genotypes (G)	15.34			92.50			115.63			2.15		
Treatments (T)	5.93			39.07			36.91			1.00		
G X T	18.74			23.57			16.74			3.17		
CV	22.54			6.74			7.15			6.69		

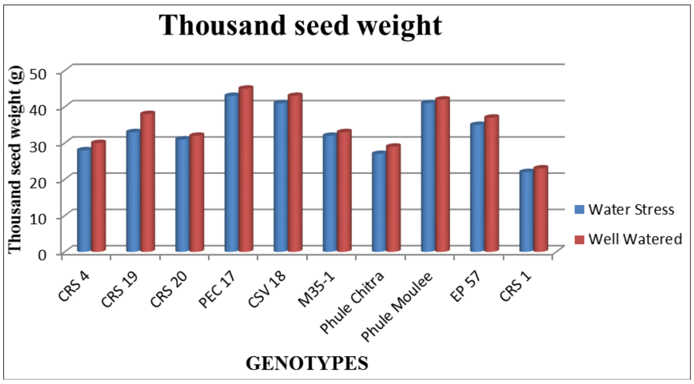

Fig 1: Thousand seed weight of Sorghum genotypes under well watered and water stress conditions.

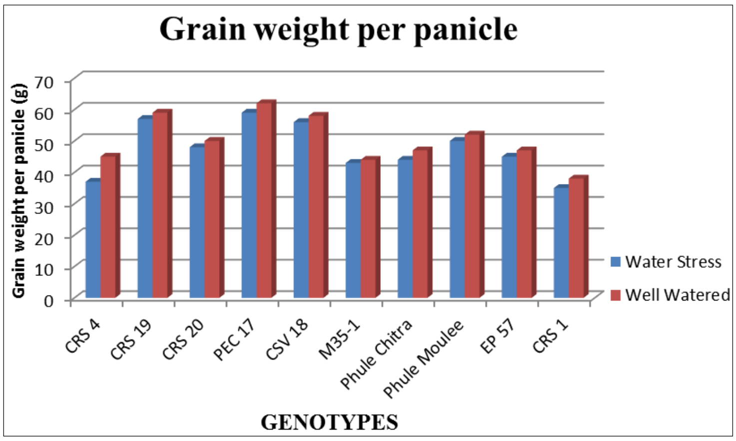

Fig 2: Grain weight per panicle of Sorghum genotypes under well watered and water stress conditions.

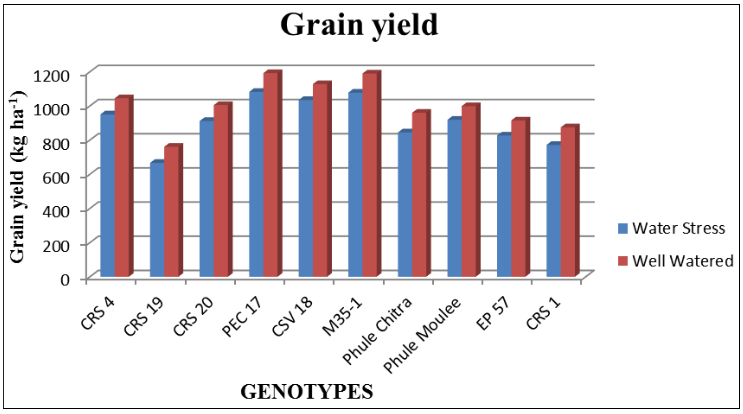

Fig 3: Grain yield of Sorghum genotypes under well watered and water stress conditions.

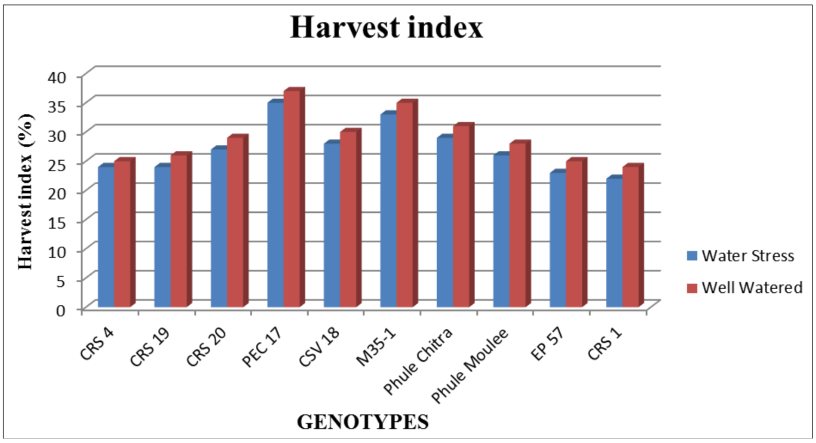

Fig 4: Harvest index of Sorghum genotypes under well watered and water stress conditions.

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