Int.J.Curr.Microbiol.App.Sci (2019) *8*(2): 1601-1612

International Journal of Current Microbiology and Applied Sciences
***ISSN: 2319-7706* Volume 8 Number 02 (2019)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2019.802.188

Study on Association of Bio-physiological Parameters with Grain Yield in Sorghum Genotypes under Post Flowering Moisture Stress Conditions

D. Devkumar[1*], V. Padma[2], H.S. Talwar[3] and Farzana Jabeen[4]

[1]Department of Crop Physiology, College of Agriculture, Prof. Jayashankar Telangana State Agricultural University (PTSAU), Rajendranagar, Hyderabad-30, India
[2]Department of Crop Physiology, Lam form Guntur, India
[3] Department of Plant Physiology, Indian institute of Millet Research (IIMR), Rajendranagar, Hyderabad -30, India
[4]Department of Genetics and Plant Breeding, College of Agriculture, Prof. Jayashankar Telangana State Agricultural University (PTSAU), Rajendranagar, Hyderabad-30, India
**Corresponding author*

Keywords

SPAD Clorophyll Meter Reading (SCMR), Photosynthetic rate, Transpiration rate, Stomatal resistance, Grain yield, Sorghum genotypes

Article Info

Accepted:
10 January 2019
Available Online:
10 February 2019

A B S T R A C T

A field experiment 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 and water stress 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). Photosynthetic rate and stomatal resistance at 15 and 30 DAF were positively and significantly correlated with grain yield while the transpiration rate at 15 and 30 DAF exhibited negative correlation with grain yield. SPAD chlorophyll meter reading (15 and 30 DAF) and chlorophyll content at 30 DAF had positively significant correlation with grain yield.

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 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.

Materials and Methods

The treatments comprised to screen the promising germplasm, advanced breeding lines and landraces to identify the new sources and traits associated with post flowering drought tolerance in sorghum. The crop was sown under well watered and water stress condition to examine the potential of Sorghum genotypes to adapt to the post flowering drought. Well Watered and Water Stress (two main treatments) conditions and 10 Sorghum genotypes *viz;* CRS 4, CRS 19, CRS 20, PEC 17, CSV 18, M 35-1, Phule chitra, Phule moulee, EP 57 and CRS 1. The experiment was laid out in split plot design and replicated thrice. The SPAD-502 (Soil Plant Analytical Development) meter was used for measuring the relative chlorophyll content of leaves. The readings were taken from top third fully expanded leaf. Mean of five values from five hills was obtained. The photosynthetic rate, transpiration rate and stomatal resistance were measured in the 3rd fully expanded leaf from the top by using Infra Red Gas Analyzer (Model TPS-1). The data on were analyzed statistically by applying the technique of split plot design taken from (Panse and Sukhatme, 1978).

The spacing maintained was 60 cm between rows and 15 cm between plants. A basal dose of 20 kg ha^{-1} N and 20 kg ha^{-1} P_2O_5 was applied before final ploughing. The seed were hand sown and the field was irrigated to saturate the soil profile with water to ensure uniform germination. The crop was thinned to two plants per hill after 10 days of emergence and then to one plant per hill after about a week. Around 20 days after emergence, an additional 20 kg ha^{-1} N as urea was applied and irrigated.

Results and Discussion

SPAD Chlorophyll Meter Reading (SCMR)

The data on SPAD reading revealed significant differences among the genotypes both at 15 and 30 DAF and the maximum SPAD readings was recorded at 15 DAF by all the genotypes compared to 30 DAF are presented in table 1 and figure 1.

At 15 DAF, the genotype PEC 17 (51) had the maximum SPAD reading and the lowest SPAD reading was CRS 1 (38). At 30 DAF the maximum SPAD readings was recorded in PEC 17 (37). The lowest SPAD reading at this stage was recorded in the genotype CRS 1 (24). Significant differences were also observed between the treatments, during well watered and water stress conditions. The SPAD readings decreased in all the genotypes due to the moisture stress imposed during post flowering period. The SPAD chlorophyll meter readings had significant and positive correlation with grain yield both at 15 DAF (r = 0.80) and 30 DAF (r = 0.50).

So, SCMR can be used to evaluate the performance of Sorghum genotypes under

post flowering drought condition. In general, higher SCMR means greater nitrogen and chlorophyll and thus these values can be taken as an index for evaluation of Sorghum genotypes for drought tolerance. The results observed in the present study are in conformity with the results of Xu *et al.*, (2000) Rao *et al.*, (2003) (Talwar *et al.*, 2011) and Sudhakar *et al.*, (2006).

Photosynthetic rate (μ mol CO_2 m^{-2} s^{-1})

The data on photosynthetic rate revealed significant differences among the genotypes both at 15 and 30 DAF and the maximum photosynthetic rate was recorded at 15 DAF by all the genotypes compared to 30 DAF (Table 2 and Fig. 2).

At 15 DAF, the genotype PEC 17 (36.5 μmol CO^2 m^2 s^{-1}) had the maximum photosynthetic rate followed by M 35-1 (35.5 μmol CO^2 m^2 s^{-1}) and CSV 18 (32.5 μmol CO^2 m^2 s^{-1}), and the lowest photosynthetic rate was in CRS 1 (25.5 μmol CO^2 m^2 s^{-1}). At 30 DAF the maximum photosynthetic rate was recorded in PEC 17 (26.5 μmol CO^2 m^2 s^{-1}) followed by M 35-1 (25.5 μmol CO^2 m^2 s^{-1}).

The lowest photosynthetic rate at this stage was recorded by the same genotype CRS 1 (16.5 μmol CO^2 m^2 s^{-1}). Such variation in photosynthetic rate among genotypes was also reported by Watling *et al.*, (2003), Rao *et al.*, (2001), Pawar *et al.*, (2005) and Channappagoudar *et al.*, (2008). There was significant difference between the treatments, during well watered and water stress. The photosynthetic rate decreased in all the genotypes due to the moisture stress impose during post flowering period. The photosynthetic rate was positively and significantly correlated with grain yield at 15DAF (r = 0.71) and 30 DAF (r = 0.57).

Transpiration rate (μ mol H_2O m^2 s^{-1})

The data on transpiration rate revealed significant differences among the genotypes at 15 and 30 DAF and the maximum transpiration rate was recorded at 15 DAF compared to 30 DAF (Table 3 and Fig. 3).

At 15 DAF, maximum transpiration rate was recorded in CRS 1 (4.28 μ mol H_2O m^2 s^{-1}) followed by CRS 20 (4.17 μ mol H_2O m^2 s^{-1}). The lowest transpiration rate at this stage was recorded in the genotype PEC 17 (2.43 μ mol H_2O m^2 s^{-1}) and M 35-1 (2.69 μ mol H_2O m^2 s^{-1}). Similarly, at 30 DAF, the maximum transpiration rate was recorded in CRS 1 (2.70 μ mol H_2O m^2 s^{-1}) followed by CRS 20 (2.58 μ mol H_2O m^2 s^{-1}). The lowest transpiration rate was recorded in PEC 17 (0.87 μ mol H_2O m^2 s^{-1}) and M 35-1 (0.96 μ mol H_2O m^2 s^{-1}). Similarly, the genotypic variations in transpiration rate were also reported by several workers (Dhopte *et al.*, 1987 and Yadav *et al.*, 1991). Significant differences were also observed between the treatments, during well watered and water stress conditions. There was increase in transpiration rate in all the genotypes due to the moisture stress induced during post flowering period. Higher transpiration efficiency was desirable for higher grain yield and biomass productivity under post anthesis drought stress situations was earlier reported by Rao *et al.*, 2001. The transpiration rate was negatively and significantly correlated with grain yield both at 15 DAF (r=-0.54) and 30 DAF (r = 0.56) (Table 5).

Under receding soil moisture situation, maintenance of low transpiration rate is an important factor for yield stability. The lower transpiration rate as a trait can be incorporated into the hybrids for better yields under receding soil moisture situation (Ashok Surveshi *et al.*, 2011).

Table.1 SPAD readings at 15 DAF and 30 DAF of Sorghum genotypes under well watered and water stress conditions

Genotypes	SPAD – 15DAF			SPAD – 30DAF		
	WW	WS	Mean	WW	WS	Mean
CRS 4	50	45	48	32	28	30
CRS 19	44	40	42	33	30	32
CRS 20	48	43	46	27	25	26
PEC 17	52	49	51	38	35	37
CSV 18	46	45	46	32	32	32
M35-1	49	45	47	34	31	33
Phule Chitra	45	43	44	32	29	31
Phule Moulee	45	41	43	37	34	36
EP 57	46	42	44	33	31	32
CRS 1	39	37	38	24	23	24
Mean	46	43	45	32	30	31
CD Genotypes (G)	4.63			4.23		
Treatments (T)	2.25			2.23		
G X T	7.12			7.06		
CV	9.33			13.37		

WW-Well Watered, WS- Water Stress.

Table.2 Photosynthetic rate (µ mol CO^2 m^2 s^{-1}) at 15 DAF and 30 DAF of Sorghum genotypes under well watered and water stress conditions

Genotypes	Photosynthetic rate - 15DAF			Photosynthetic rate - 30DAF		
	WW	WS	Mean	WW	WS	Mean
CRS 4	31	30	30.5	20	19	19.5
CRS 19	30	27	28.5	20	20	20.0
CRS 20	27	26	26.5	18	17	17.5
PEC 17	37	36	36.5	27	26	26.5
CSV 18	33	32	32.5	21	20	20.5
M35-1	36	35	35.5	26	25	25.5
Phule Chitra	27	26	26.5	18	16	17.0
Phule Moulee	28	26	27.0	19	17	18.0
EP 57	33	31	32.0	22	20	21.0
CRS 1	26	25	25.5	17	16	16.0
Mean	31	30	30.5	21	20	20.5
CD Genotypes (G)	2.22			1.67		
Treatments (T)	0.84			0.84		
G X T	2.66			2.66		
CV	7.77			3.26		

WW-Well Watered, WS- Water Stress.

Table.3 Transpiration rate (µ mol H_2O m^2 s^{-1}) at 15 DAF and 30 DAF of Sorghum genotypes under well watered and water stress conditions

Genotypes	Transpiration rate -15DAF			Transpiration rate -30DAF		
	WW	WS	Mean	WW	WS	Mean
CRS 4	3.40	3.73	3.56	2.27	2.42	2.35
CRS 19	3.20	3.34	3.27	2.07	2.11	2.09
CRS 20	4.15	4.18	4.17	2.53	2.63	2.58
PEC 17	2.32	2.53	2.43	0.84	0.89	0.87
CSV 18	2.93	3.10	3.02	1.14	1.17	1.16
M35-1	2.54	2.84	2.69	0.91	1.00	0.96
Phule Chitra	3.57	3.74	3.66	2.33	2.40	2.37
Phule Moulee	4.01	4.06	4.04	2.64	2.72	2.68
EP 57	3.05	3.12	3.09	1.19	1.24	1.22
CRS 1	4.23	4.33	4.28	2.65	2.74	2.70
Mean	3.34	3.50	3.42	1.86	1.93	1.90
CD Genotypes (G)	0.14			0.08		
Treatments (T)	0.06			0.06		
G X T	0.19			0.19		
CV	3.26			6.08		

WW-Well Watered, WS- Water Stress

Table.4 Stomata resistance (s.cm^{-1}) at 15 DAF and 30 DAF of Sorghum genotypes under well watered and water stress conditions

Genotypes	Stomatal resistance -15DAF			Stomatal resistance -30DAF		
	WW	WS	Mean	WW	WS	Mean
CRS 4	45	44	44.5	29	28	28.5
CRS 19	42	41	41.5	26	25	25.5
CRS 20	35	34	34.5	23	22	22.5
PEC 17	54	53	53.5	37	36	36.5
CSV 18	47	46	46.5	31	30	30.5
M35-1	52	51	51.5	33	33	33.0
Phule Chitra	43	42	42.5	26	25	25.5
Phule Moulee	38	37	37.5	28	27	27.5
EP 57	50	49	49.5	31	30	30.5
CRS 1	36	34	34.5	25	24	24.5
Mean	44	43	43.5	29	28	28.5
CD Genotypes (G)	1.10			1.38		
Treatments (T)	0.63			0.61		
G X T	2.00			1.95		
CV	2.69			4.03		

Table.5 Correlation Coefficient among fifteen yield and yield related attributes in 10 genotypes of Sorghum

Characters	PH	GLAR10	GLAR 20	GLAR 30	GLAR 40	PSR 15	PSR 30	TRAS 15	TRAS 30	STOM 15	STOM 30	SPAD 15
PH	1.00000	0.74955	0.56558	0.74505	0.76535	0.45749	0.31157	-0.52112	-0.38139	0.46524	0.40532	0.72213
GLAR 10		1.00000	0.76666	0.75924	0.81673	0.66750	0.57251	-0.68575	-0.62819	0.60310	0.56893	0.79546
GLAR 20			1.00000	0.78614	0.78170	0.47241	0.48748	-0.59095	-0.55425	0.46550	0.34905	0.52267
GLAR 30				1.00000	0.92397	0.37803	0.36612	-0.50432	-0.35114	0.36082	0.25450	0.56451
GLAR 40					1.00000	0.44195	0.39801	-0.53670	-0.41178	0.41128	0.36596	0.69483
PSR 15						1.00000	0.93217	-0.93434	-0.92832	0.93381	0.94319	0.73645
PSR 30							1.00000	-0.90752	-0.87254	0.86114	0.88265	0.61612
TRAS 15								1.00000	0.94382	-0.95700	-0.88733	-0.64545
TRAS 30									1.00000	-0.92537	-0.87505	-0.55245
STOM 15										1.00000	0.92285	0.64516
STOM 30											1.00000	0.65296
SPAD 15												1.00000

Charecters	SPAD 30	Chlorophyll content	N conent	K conent	Panicle length	Panicle weight	1000 seed wt	GWP	No Grains per panicle	HI	GY
PH	0.48181	0.40671	0.21529	0.23607	0.49609	0.53381	0.34717	0.49170	0.69721	0.59234	0.50869
GLAR 10	0.60293	0.61462	0.54715	0.47557	0.53517	0.43580	0.50709	0.53641	0.64479	0.67829	0.66093
GLAR 20	0.40050	0.48520	0.43800	0.34156	0.25355	0.68761	0.44809	0.59485	0.62873	0.55128	0.27237
GLAR 30	0.43024	0.32470	0.25703	0.26102	0.27778	0.60753	0.34445	0.57896	0.74304	0.56010	0.30798
GLAR 40	0.58200	0.44763	0.30556	0.31126	0.39531	0.61981	0.50042	0.66013	0.67872	0.68520	0.47684
PSR 15	0.63724	0.94841	0.90911	0.86078	0.78182	0.29867	0.56543	0.38855	0.40838	0.67004	0.71594
PSR 30	0.57334	0.89585	0.90141	0.91585	0.64511	0.30617	0.51505	0.42145	0.41373	0.69083	0.57892
TRAS 15	-0.67680	-0.91599	-0.83443	-0.78232	-0.67073	-0.49802	-0.57436	-0.51755	-0.44591	-0.65210	-0.53955
TRAS 30	-0.54711	-0.92177	-0.86935	-0.72392	-0.62204	-0.45570	-0.55184	-0.42222	-0.27355	-0.60292	-0.56452
STOM 15	0.64676	0.92555	0.79782	0.77433	0.65443	0.33882	0.47695	0.32245	0.31607	0.59949	0.56848
STOM 30	0.72119	0.96940	0.86006	0.87122	0.74686	0.22516	0.61112	0.37231	0.27032	0.66100	0.69925
SPAD 15	0.63797	0.67609	0.55359	0.59953	0.78576	0.30853	0.50596	0.43915	0.68566	0.71577	0.80475
SPAD 30	1.00000	0.73445	0.55918	0.60357	0.62288	0.32374	0.82722	0.65336	0.35218	0.57278	0.50430
Chloro		1.00000	0.90815	0.86886	0.74944	0.37629	0.69990	0.48934	0.33893	0.65170	0.65086
N content			1.00000	0.91038	0.71761	0.30344	0.63435	0.45291	0.38183	0.45255	0.51861
K content				1.00000	0.67531	0.15494	0.52818	0.36415	0.42784	0.51902	0.51316
Panicle length					1.00000	0.34468	0.68815	0.53798	0.55946	0.48976	0.72169
Pl wt						1.00000	0.54386	0.82000	0.59558	0.35277	0.03855
1000 seed wt							1.00000	0.84791	0.38413	0.46841	0.44820
GWP								1.00000	0.63354	0.45358	0.22574
No of grains per panicle									1.00000	0.39835	0.28708
HI										1.00000	0.78341
GY											1.00000

Fig.1 SPAD readings at 15 DAF and 30 DAF of Sorghum genotypes under well watered and water stress conditions

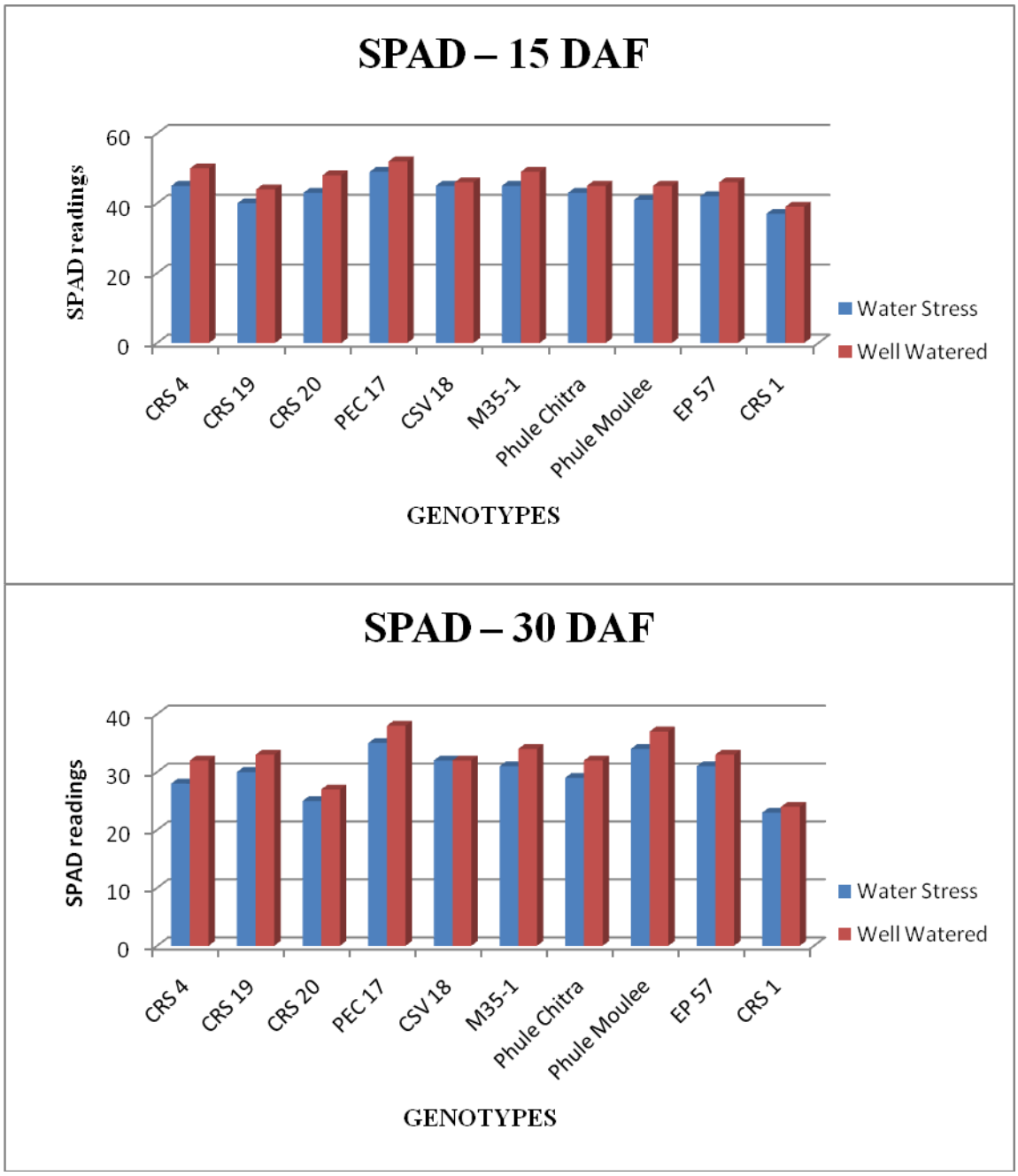


Fig.2 Photosynthetic rate (µmol CO^2 m^2 s^{-1}) at 15 DAF and 30 DAF of Sorghum genotypes under well watered and water stress conditions

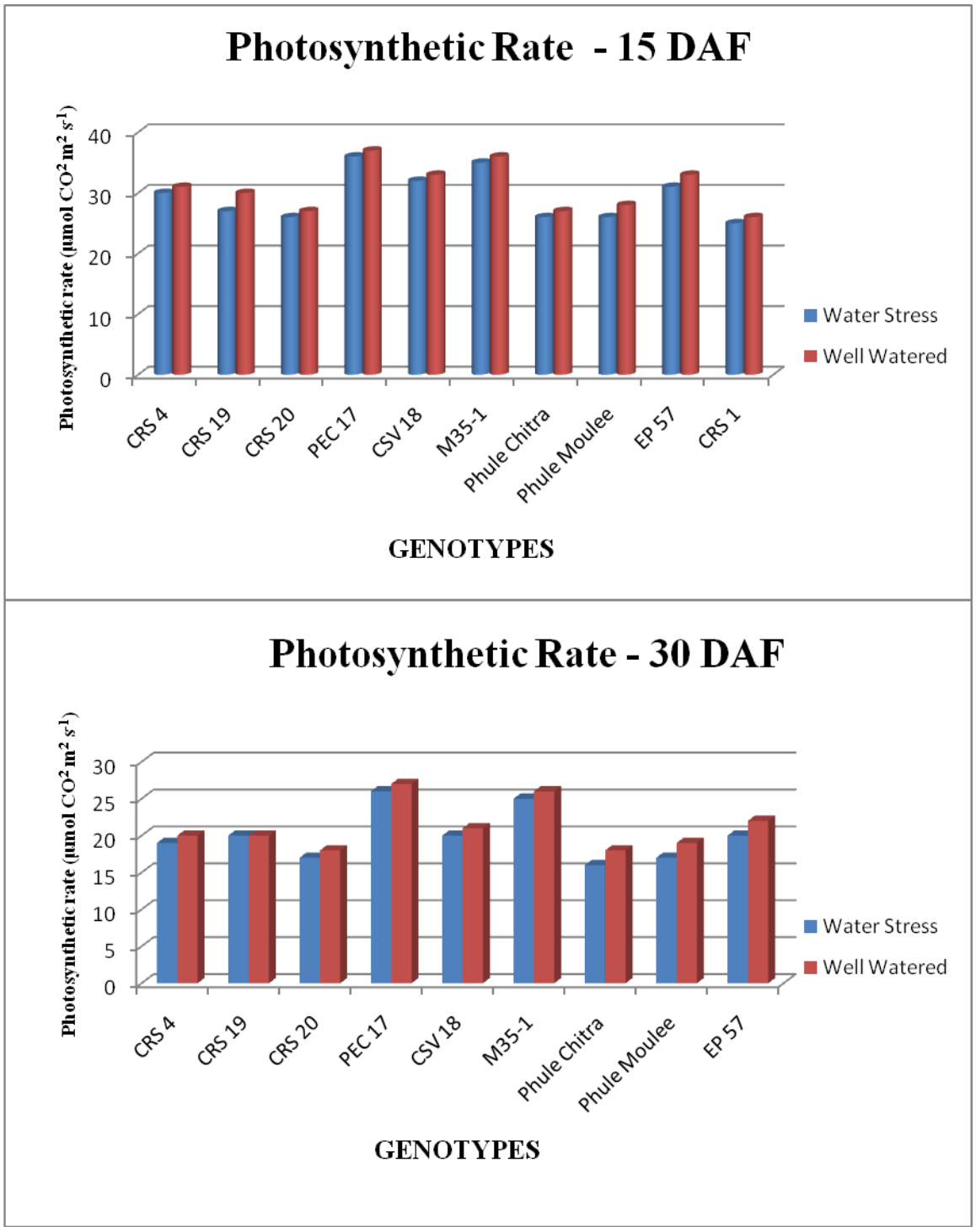


Fig.3 Transpiration rate (µ mol H_2O m^2 s^{-1}) at 15 DAF and 30 DAF of Sorghum genotypes as under well watered and water stress conditions

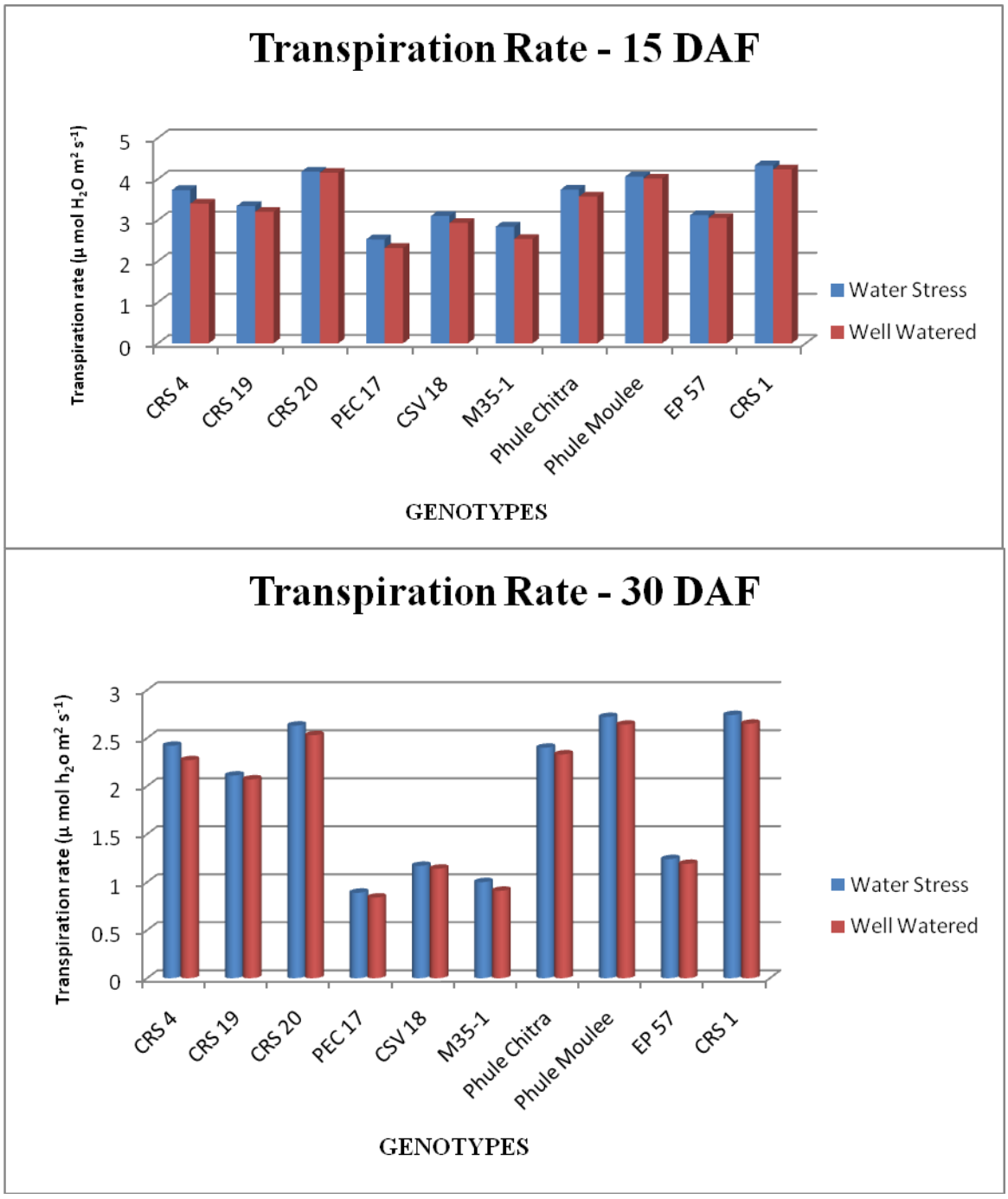
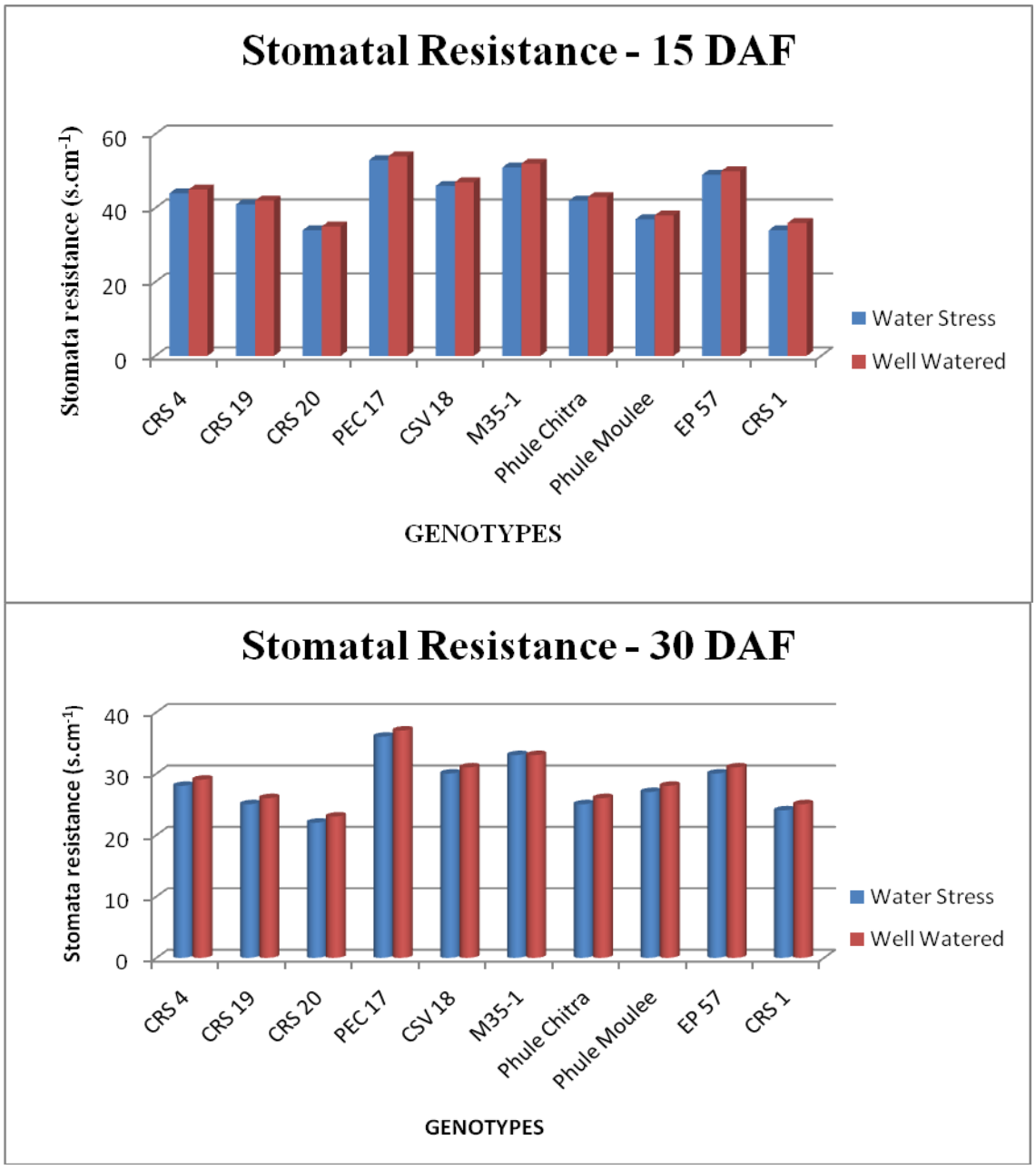


Fig.4 Stomata resistance (s.cm^{-1}) at 15 DAF and 30 DAF of Sorghum genotypes under well watered and water stress conditions



Stomatal resistance (s.cm^{-1})

The data on stomatal resistance revealed significant differences among the genotypes both at 15 and 30 DAF and the maximum stomatal resistance was recorded at 15 DAF by all the genotypes compared to 30 DAF (Table 4, Fig. 4).

At 15 DAF, the genotype PEC 17 had the maximum stomatal resistance followed by M 35-1 and EP 57. The lowest stomatal resistance was observed in CRS 1. At 30 DAF also the maximum stomatal resistance was recorded by PEC 17 followed by M 35-1 and EP 57. The lowest stomatal resistance at this stage was recorded in the genotype CRS 1.

The interaction between genotypes and stress treatments was significant and among the genotypes PEC 17 recorded highest stomatal resistance at 15 DAF in well watered (54 $s.cm^{-1}$) and water stress (53 s.cm-1) conditions. The lowest stomatal resistance in well watered (38 $s.cm^{-1}$) and water stress (37 $s.cm^{-1}$) conditions was observed in the genotype CRS 1. Similar trend was observed at 30 DAF with highest stomatal resistance in PEC 17 in well watered (37 $s.cm^{-1}$) and water stress (36 $s.cm^{-1}$) conditions. The lowest stomatal resistance in well watered (25 $s.cm^{-1}$) and water stress (24 $s.cm^{-1}$) conditions was observed in the genotype CRS 1.

It was observed in our study that the transpiration rate decreased from 15 DAF to 30 DAF in all the genotypes. In general, the genotypes which had maximum transpiration rate had low stomatal diffusive resistance. At 30 DAF, the maximum transpiration rate was observed in CRS 1 which also had the minimum stomatal diffusive resistance. While at 15 and 30 DAF, the genotypes PEC 17 also had low transpiration rate and considerably more stomatal diffusive resistance. This clearly indicates that these genotypes were able to maintain low leaf temperature which is a desirable character. These results are in accordance with the findings of Rao *et al.*, (2001) and Pawar *et al.*, (2005).

References

Ashok Surwenshi, V.P., Chimmad, R.L., Ravikumar. 2007. Comparative Studies of Hybrids and Parents for Physiological Parameters and Yield in Sorghum Karnataka Journal of Agricultural Sciences. 20 (1): 25 - 28.

Channappagoudar, B.B., Biradar, N.R., Bharamagoudar, T.D and Rokhade, J. 2008. Morpho-physiological Traits of Sorghum Parental Lines Determining Grain Yield and Biomass Karnataka Journal of Agricultural Sciences. 21(2): 168-170.

Dhopte, A.M., Raghangadale, S.L and Jamadar, S.L. 1987. Physiological evaluation of forty exotic and wild sorghum lines in relation to stomatal factors involved in drought resistance. Annals of Plant Physiology, 1: 143 – 150.

Pawar, K.N., Biradar, B.D., Shamarao Jahagirdar, M.R and Ravikumar. 2005. Identification of Germplasm sources for adaptation under receding soil moisture situations in *rabi* Sorghum Agriculture Science Digest 25 (1): 56 – 58.

Rao, S.S., Seetharama, N., Kiran Kumar, K.A and Vanderlip, R.L. 2001. Characterization of sorghum growth stages NRCS Bulletin Series NO. 14. National Research Centre for Sorghum Rajendranagar. Hyderabad AP. pp: 1-15.

Rao, S.S., More, P.R., Solunke, V.D., kusalkar, D.V., Jirali, D.I., Pawar, K.N., Channappagoudar, B.B., Chimmad, V.P., Prabhakar and Rana, B.S. 2003. Physiological approaches for improving drought tolerance in *rabi* Sorghum. Proceedings of National Seminar on 'Role of Plant Physiology for Sustaining Quality and Quantity of Food Production in relation to Environment'. held at University of Agricultural Sciences. Dharwad. 26-32.

Sudhakar, P., Latha, P., Babitha, M., Prasanthi, L., Reddy, P.V. 2006. Physiological traits contributing to grain yields under drought in black gram and green gram Indian Journal of Plant Physiology.11 (4): 391-396.

Talwar, H.S., Prabhakar, M., Elangovan, Aruna, K., Rao, S.S., Mishra, J and Patil, V.J. 2011. Strategies to Improve Post flowering Drought Tolerance in *Rabi* Sorghum for Predicted Climate Change Scenario. Crop Improvement.37

(2): 93-98.

Watling, J.R., Press, M.C. and Quick, W.P. 2003. Elevated CO_2 induces biochemical and ultra structural changes in leaves of the C_4 cereal Sorghum. Plant Physiology. 123(3): 1143-1152.

Xu, W., Rosenow, D.T and Nguyen, H.T. 2000. Stay green trait in grain sorghum: relationship between visual rating and leaf chlorophyll concentration. PlantBreeding. 119(4): 365-367.

Yadav, S., Jyothi Lakshmi, N., Maheshwari, M. and Venkateswarlu, B. 1991. Influence of water deficit at vegetative, anthesis and grain fillings stages on water relation and grain yield in sorghum. Indian Journal of Plant Physiology. 10(1): 20-24.

How to cite this article:

Devkumar, D., V. Padma, H.S. Talwar and Farzana Jabeen. 2019. Study on Association of Bio-physiological Parameters with Grain Yield in Sorghum Genotypes under Post Flowering Moisture Stress Conditions. *Int.J.Curr.Microbiol.App.Sci.* 8(02): 1601-1612.
doi: https://doi.org/10.20546/ijcmas.2019.802.188