The Andhra Agric. J 59(2): 270-275 2012

Studies on Genotypic Variability for Water use Efficiency and Thermo Tolerance in Greengram Genotypes under Imposed Moisture Stress Conditions

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ABSTRACT

A field experiment was conducted at Wet land farm of S.V.Agricultural College Tirupathi to study the genotypic variability for water use efficiency and thermo tolerance in greengram during *rabi* 2010-2011. The results revealed that among the drought tolerant traits used to evaluate greengram genotypes, water use efficiency traits like specific leaf area (SLA), SPAD chlorophyll meter readings (SCMR) and high temperature tolerance traits like chlorophyll fluorescence (Fv/Fm) were significantly reduced under moisture stress conditions compared to irrigated control. However stress at both phenophases showed more or less similar reduction in values of SLA,SCMR and Fv/Fm values .A significant positive correlation between SCMR and WUE and a negative correlation between SCMR and SLA were observed and were already established as good drought tolerant traits .An inverse relationship was observed between the SLA and seed yield and SCMR and seed yield .Among the genotypes tested ,MGG357 recorded moderate WUE traits SCMR ,SLA and moderate temperature tolerance in terms of higher PSII activity .

Key words : Greengram, SCMR, Specific leaf area, Thermo tolerance, Water use efficiency

Drought is complex phenomenon and always coupled with moisture and high temperature stress. Plants responded to drought by initiating a number of developmental, physiological, biochemical and molecular changes. Plants have developed a number of strategies to cope with the physiological traits associated with drought. Several morphological (Chaves *et al* 2003) and physiological (Nageswarao *et al* 1994) and water use efficiency (Latha 2004) and thermo tolerance traits(Sudhakar *et al* 2006) contributing to drought tolerance were reported . However, such traits in greengram genotypes were less explored. Moisture stress at flowering and podding stages is most common in southern zone of Andhra Pradesh and reported to reduce the yield and harvest index significantly .Under such situations , identification of genotypes with higher water use efficiency with thermo tolerance and seed yield is necessary for growing under rainfed conditions .

There are several physiological approaches to screen genotypes under water limited condions. Water use efficiency(WUE) is one such physiological trait ,which is the amount of drymatter produced per unit water transpired .The yield model proposed by Passioura(1986) ,seed yield = WUExTxHI .Among the leaf characters, specific leaf area and SPAD chlorophyll meter reading and chlorophyll florescence are more trustable traits . SLA which is crude but easily measured parameter is suggested as a rapid and in expensive selection criteria for high water use efficiency (Wright *et al* 1994) .Further Rao *et al* (2001) have shown that a hand held portable SPAD chlorophyll meter can be effectively used for rapid assessment of WUE. This would facilitate screening large number of segregating populations with ease. A significant correlation between SLA, SCMR and WUE has provided an option to use these traits as potential technique to quantify the variations in WUE (Bindu Madhavi *et al* 2003 and Sudhakar *et al* 2006).

The potential of a genotype acclimate to moderately high temperature, thereby reducing high temperature injury, is an important factor in determining plant performance in high temperature environment (Babitha *et al* 2006). Although several plant processes are more sensitive to heat, plant adaptations to high temperature essentially require thermo stability of photosynthetic apparatus (Schreiber and Berry ,1977).Direct high temperature injury in crop plants can be measured by chlorophyll fluorescence tests ,which denotes thermo stability of photosynthesis. Hence ,the present investigation was taken up to study the genotypic variability for water use efficiency and thermo tolerance in greengram.

METERIAL AND METHODS

A field experiment was conducted at Wet land farm of S.V.Agricultural College Tirupathi in factorial randomized block design replicated thrice during late *rabi* 2010-11. There are three main treatments ,T_o –adequately irrigated (control) ,T_1 – stress imposed at flowering (30-45DAS) ,T_2 – stress imposed at pod formation and maturity stage (45-60 DAS) and seven sub treatments consists of greengram genotypes (LGG 460, TM 96-2,WGG 37,MGG 347,MGG 348,MGG 357,MGG 360).The crop was sown with a spacing of 30x10cm on 7th of January 2011. Recommended dose of fertilizers were applied .The water stress was imposed at flowering stage (30-45 DAS) and pod formation and maturity stage (45-60DAS). Prophylactic measures were taken for protection of crop from diseases and pests. Destructive analysis of plant samples was done at 10 days interval. For this purpose three plants from each treatment or each plot were dug out along with roots and separated into leaf, stem, root and pod and dried in hot air oven at 80^{0c} for 48hours.Leaf area was measured by LICOR3000 leaf area meter .Specific leaf area can be calculated by leaf area by leaf weight. SPAD chlorophyll meter readings were recorded at 45 DAS and 60 DAS .The third leaf from the apex was selected to record SCMR. Chlorophyll fluorescence was measured at 45 DAS and 60 DAS .The procedure used to measure chlorophyll fluorescence characteristics was similar to that of Smillie and Hetherington (1990).

RESULTS AND DISCUSSIONS

The data on water use efficiency traits like SLA and SCMR are presented in Table 1 and 2 . Significant differences were observed between moisture stress treatments, genotypes and interactions regarding SLA and SCMR values in greengram genotypes. Similar significant differences between genotypes under irrigated as well as moisture stress was reported in chickpea (Hosseni et al 2009).

Due to imposition of moisture stress at flowering stage (30-45DAS) SLA was significantly decreased. The extent of decrease was 5.81% at 45 DAS .Imposition of moisture stress at pod formation and maturity stage (45-60DAS) significantly decreased the SLA by 6.34% at 60DAS. Such decrease in SLA values under water stress conditions was also reported by Latha (2004) in groundnut and Sudhakar *et al* (2006) in blackgram. Water deficit may have influenced leaf thickness by increasing number of chlorenchyma and chloroplast per unit leaf surface area (Nobel 1991).The genotype MGG 357 recorded lowest SLA values followed by WGG37 compared to all other genotypes. Wright *et al* (1994) reported if SLA is lower the leaf thickness would be higher and thus these genotypes recorded high NAR values also. Wright *et al* (1994) reported an inverse relationship between SLA and WUE, thus indicating that genotypes with thick leaves (Low SLA) under moisture stress condions may be water use efficient.

Similar to SLA, significant differences were observed among moisture stress treatments, genotypes and their interaction regarding SCMR values (Table 1). During both stages of moisture stress, mean SCMR values were significantly lower under stress treatments compared to irrigated conditions .Moisture stress at flowering stage decreased SCMR values by 3.5% and 1.48% at 45 DAS and 60 DAS respectively .Similarly moisture stress at pod filling and maturity stage decreased SCMR values by 1.5% and 4.02% at 45DAS and 60 DAS respectively .Reduction in SCMR values attributed to reduction in chlorophyll content under moisture stress conditions (Hong *et al* 1999).Among the genotypes tested, TM96-2 recorded highest mean SCMR (54.4) followed by MGG 347 (51.3) and MGG 360 (52.3) at 60DAS and similar trend was followed at 45 DAS also. The genotype TM96-2 recorded higher SCMR, however, it maintained higher SLA values at 45 and 60DAS .In contrast MGG 357 recorded lower SLA and high SCMR values. Similarly other superior variety in terms of growth attributes WGG 37 recorded lowest SLA with lowest SCMR values.

An inverse relationship (r^2=0.2294) was observed between SLA and SCMR under moisture stress conditions .A significant positive correlation between SCMR and WUE and a negative correlation between SCMR and SLA which were considered as good drought tolerant traits, was already established in groundnut (Nageswara rao *et al* 1993) .Hence, low SLA and high SCMR are the indicators for high WUE and the genotypes MGG 357 had high WUE compared to all other genotypes.

The chlorophyll fluorescence (Fv/Fm) values of greengram genotypes recorded at 45 DAS (mid stress) and 60DAS (end stress) are presented in Table 2. The chlorophyll fluorescence at PSII represented by Fv/Fm values denotes the capability of a genotype for thermo tolerance i.e tolerance to high temperature stress (Babitha *et al* 2006) .Significant differences were observed between moisture stress treatments, genotypes and their interactions regarding Fv/Fm values of greengram.

Table 1. Effect of mid season and end season moisture stress on specific leaf area and SPAD chlorophyll meter reading (SCMR) of greengram genotypes.

Genotypes	SLA(cm^2 g^{-1}) at 45 DAS				SLA(cm^2 g^{-1}) at 60 DAS				SCMR 45 DAS				SCMR 60 DAS			
	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean
LGG 460	133.4	122.4	133.7	129.8	100.1	101.2	94.o	98.43	49.40	47.10	49.60	48.70	49.80	49.70	46.50	48.66
TM 96-2	156.1	125.0	135.5	138.8	75.0	81.0	68.9	74.96	52.10	50.90	51.72	51.57	52.90	51.40	59.80	54.70
WGG 37	111.1	119.0	125.2	118.4	86.6	85.0	86.6	86.06	46.40	45.20	45.80	45.80	47.10	46.80	44.40	46.10
MGG 347	143.4	136.4	147.3	142.4	86.0	95.8	87.2	89.66	52.80	49.80	51.90	51.50	53.10	52.30	48.60	51.33
MGG 348	107.3	128.0	111.6	115.6	92.2	86.7	73.9	84.26	47.20	46.00	47.70	46.96	48.20	48.20	44.60	47.00
MGG 357	112.1	122.9	132.5	122.5	91.2	84.0	81.6	85.76	51.30	49.10	51.60	50.66	51.90	50.70	48.50	50.20
MGG 360	144.0	140.3	144.3	142.9	86.0	89.2	86.1	87.10	51.30	50.20	51.00	50.80	52.30	51.00	47.00	50.10
Mean	129.6	127.7	132.9	-	88.2	88.9	82.61	-	50.07	48.32	49.90	-	50.76	50.01	48.48	-
CD at 5%	T	G	TXG		T	G	TXG		T	G	TXG		T	G	TXG	
	1.44	2.20	3.81		0.300	0.458	0.794		0.52	0.80	1.38		0.34	0.52	0.90	

T_0: Control (Irrigated)
T_1: Moisture stress at flowering
T_2: Moisture stress at pod formation and maturity stage

Table 2. Effect of mid season and end season moisture stress on chlorophyll fluorescence (Fv/Fm) and seed yield of greengram genotypes.

Genotypes	45 DAS				50^{0C}				60 DAS				50^{0C}				Seed yield(Kg ha^{-1})			
	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean	T_0	T_1	T_2	Mean
LGG 460	0.63	0.60	0.64	0.62	0.48	0.41	0.49	0.46	0.64	0.64	0.61	0.63	0.45	0.45	0.41	0.43	839	642	516	665
TM 96-2	0.58	0.56	0.58	0.57	0.39	0.32	0.38	0.36	0.59	0.59	0.53	0.57	0.37	0.35	0.32	0.34	350	538	308	399
WGG 37	0.60	0.58	0.60	0.59	0.46	0.42	0.45	0.44	0.61	0.62	0.60	0.61	0.44	0.45	0.40	0.43	1435	1138	1016	1202
MGG347	0.57	0.56	0.57	0.56	0.43	0.40	0.44	0.42	0.58	0.58	0.57	0.57	0.42	0.41	0.39	0.40	758	728	668	718
MGG348	0.62	0.60	0.61	0.61	0.46	0.41	0.47	0.44	0.63	0.63	0.58	0.61	0.45	0.45	0.45	0.45	872	796	893	854
MGG357	0.61	0.60	0.61	0.60	0.46	0.42	0.45	0.44	0.62	0.63	0.60	0.61	0.44	0.43	0.40	0.42	1290	1196	1218	1235
MGG360	0.58	0.56	0.57	0.57	0.39	0.35	0.38	0.37	0.59	0.57	0.56	0.57	0.37	0.37	0.34	0.36	868	739	876	828
Mean	0.59	0.58	0.59	-	0.43	0.38	0.43	-	0.60	0.60	0.57	-	0.42	0.41	0.38		916	825	785	-
CD at 5%	T	G	TXG		T	G	TXG		T	G	TXG		T	G	TXG		T	G	TXG	
	0.004	0.007	0.01		0.006	0.009	0.02		0.009	0.014	0.03		0.006	0.009	0.02		11	18	31	

T_0: Control (Irrigated)
T_1: Moisture stress at flowering
T_2: Moisture stress at pod formation and maturity stage

The samples collected at 45 DAS from respective treatments ,when exposed to 50^{0c} recorded , decline in Fv/Fm values to the turn of 26% in irrigated treatment ,32.9% in mid stress treatment and 26% in end stress treatment . Higher decreased fluorescence values in mid season stress can be ascertained ,as the leaves were already exposed to moisture stress and hence affected much when compared to high temperature .

Similarly the extent of decline in Fv/Fm values at 60 DAS was 30.9% in irrigated treatments, 32.63% in mid stress treatment and 34.37% in end season stress. Such decrease in Fv/Fm values due to high temperature in greengram genotypes confirms the sensitivity of photosynthetic apparatus to high temperature .Similar results were also reported in groundnut and blackgram (Sudhakar *et al* 2006). Among the genotypes tested, TM 96-2 and MGG 360 genotypes showed to be highly sensitive to high temperature, in terms of higher decline in Fv/Fm values recorded compared to other genotypes. All other genotypes recorded moderate Fv/Fm values when exposed to 50^{oc} .The efficient genotypes in terms of higher growth attributes, high WUE (low SLA, high SCMR) i.e MGG357 also possess higher thermo tolerance stability of chloroplast to high temperature.

Due to imposition of moisture stress at flowering stage and pod formation and maturity stage, mean seed yield was significantly decreased. The extent of decrease was less pronounced at flowering stage (9.92%) compared to pod formation and maturity stage (14.3%) when compared to irrigated control. An inverse relation was observed between SLA and seed yield (r^2=3045) and SCMR and seed yield (r^2=0.2246) .These results are in conformity with the findings in blackgram (Sudhakar *et al* 2006) and in guar (Anupam Chakraborty 2007). From these results it can be conclude that MGG 357 showed higher WUE and thermo tolerance in greengram.

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(Received on 04.08.2011 and revised on 06.09.2011)