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PHYSIOLOGICAL TRAITS CONTRIBUTING TO GRAIN YIELDS UNDER DROUGHT IN BLACK GRAM AND GREEN GRAM

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SUMMARY

Ten genotypes each of black gram and green gram were evaluated for traits contributing to water use efficiency in a field experiment conduced during *Rabi,* 2004-05. Under terminal moisture stress conditions there was a significant reduction of SCMR (SPAD chlorophyll meter reading) and SLA (specific leaf area) both in black gram and green gram genotypes. Black gram genotypes PBG 107, LBG 20 and MBG 207, and green gram genotypes MGG 336 and MGG 351 showed higher SCMR and lower SLA under stress. Significant inverse relationship ($r=0.73$, $P<0.05$) was observed between SLA and SCMR in black gram genotypes while no correlation was observed in green gram genotypes. Significant positive relationships were observed between seed yield and SCMR both in black gram and green gram under moisture stress, indicating that SCMR could be used as a screening tool for grain yield under drought conditions.

***Key words:* Black gram, green gram, moisture stress, specific leaf area, SPAD chlorophyll meter reading.**

INTRODUCTION

Green gram [(*Vigna radiata* (L.) Wilczek)] and black gram [(*Vigna mungo* (L.) Hepper)] are mostly grown in rice fallows in Andhra Pradesh utilizing *in situ* moisture. The low productivity of these pulses is attributed to the terminal moisture stress often encountered due to cultivation under limited moisture conditions. Moisture stress at flowering and pod filling stage reduce pod yield and harvest index significantly. Identification of donor parents with higher water use efficiency is necessary for breeding drought tolerant cultivars. Work on physiological traits like specific leaf area and SCMR which give an indication of the water use efficiency, has not been attempted earlier in pulses. Hence, the present study was taken up on black gram and green gram to examine genotypic variation for traits contributing to water use efficiency (SLA and SCMR); to identify donor parents for these traits and also to estimate losses in yield due to end-of-season moisture stress.

There are several physiological approaches to sustain the productivity under water-limited conditions. Water use efficiency (WUE) is one such physiological trait, which is the amount of dry matter produced per unit amount of water transpired. The yield model proposed by Passioura (1986), seed yield = WUE × T × HI, where WUE is the water use efficiency, T is transpiration and HI is the harvest index of the crop, substantiates the importance of WUE in crop improvement. Several workers have confirmed the relationship of water use efficiency with carbon isotope discrimination (CID) in both field and pot studies (Farquhar *et al.* 1982, Wright *et al.* 1994, Rao *et al.* 1995, Craufurd *et al.* 1999, Ashok *et al.* 1999). As measurement of CID requires the use of expensive equipment, SLA, which is a crude but easily measurable

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parameters, is suggested as a rapid and inexpensive selection criterion for high water use efficiency (Wright *et al.* 1994, Rao and Wright 1994). Further Rao *et al.* (2001) have recently shown that a hand-held portable SPAD chlorophyll meter can be used effectively following necessary protocols for rapid assessment of SLA and specific leaf nitrogen (SLN), the surrogate measures of water use efficiency. This would facilitate screening of large number of segregating populations with ease. A significant positive correlation between SCMR and WUE has provided an option to use SPAD chlorophyll meter reading (SCMR) as a potential technique to quantify variations in WUE (Bindhu Madhava *et al.* 2003).

MATERIALS AND METHODS

Ten genotypes of green gram, viz. MGG351, MGG336, LGG487, LGG498, LGG502, LGG450, LGG460, LGG492, LGG494 and LGG521 of similar duration (85-90 days) and ten genotypes of black gram (LBG20, LBG623, MBG201, MBG207, MBG211, MBG212, MBG213, MBG214, PBG32 and PBG107) of similar duration (80-85 days) were sown on 11.01.2005 in a replicated trial with factorial randomized block design. Experiments were conducted during *rabi* 2004-2005 in the dry land farm of Regional Agricultural Research Station, Tirupati, Andhra Pradesh. Each genotype was planted in 10 rows of 5 m length with 30 cm row spacing and 10 cm intra row spacing. The experiment was replicated thrice with irrigation regimes as main treatments and genotypes as sub treatments. Prophylactic measures were taken for protecting the crop from diseases and pests. Moisture stress was imposed on both the crops at the time of flowering, i.e. 40 days after sowing (DAS) till harvest in black gram (80 days) and green gram (75 days). Due to terminal moisture stress, crop maturity of all genotypes was reduced by 10 days. Data on specific leaf area and SPAD (Soil Plant Analytical Development) chlorophyll meter reading (SCMR) was recorded on third leaf from the apex 30 days after imposing stress (DAIS). Specific leaf area was calculated from the measured values of leaf area (using leaf area meter LI-COR Model-3100) and leaf dry weight. SCMR was measured using Minolta SPAD-502 chlorophyll meter. Data on seed yield attributes were recorded after harvest. Weather data during the experiment period (11.01.05 to 28.03.05) was given in Table 1. The data reveals that after imposing moisture stress (20.02.05), there was no rainfall till harvest, i.e. 28.03.05. Soil moisture data shows that after stress imposition, soil moisture gradually reduced from 7.04% to 1.04% in green gram and 6.83% to 1.22% in black gram (Table 2) confirming the depletion of soil moisture.

RESULTS AND DISCUSSION

Genotypes differed significantly for SCMR both in black gram and green gram (Table 1). There was a significant reduction of SCMR under stress both in black gram and green gram compared to irrigated treatment. Reduction in SCMR is attributed to reduction in chlorophyll content under moisture stress (Hong *et al.* 1999). At 30 DAIS, black gram genotypes PBG 107, LBG 20, MBG 623 and MBG 214 recorded higher SCMR values (41.6-44.4), indicating maintenance of higher chlorophyll content in the leaves. Green gram genotypes LGG 521, MGG 336, LGG 498 and MGG 351 had higher SCMR values under stress. Published work on the relationship of SCMR with water use efficiency in black gram and green gram is scanty. A significant positive relationship between WUE and SCMR was observed in groundnut (Bindu Madhava *et al.* 2003), suggesting that a quick determination of SCMR could reflect intrinsic mesophyll efficiency.

There was a significant reduction in SLA under moisture stress compared to irrigated conditions at 30 DAIS in black gram and green gram (Table 2). Genotypic differences in black gram and green gram were significant for SLA. There was greater genotypic variation for SLA than for SCMR between genotypes of both black gram and green gram. Reddy *et al.* (2000) reported that in groundnut SLA was higher under adequately irrigated compared to simulated drought treatment. Water deficit may have influenced leaf thickness by increasing number of chlorenchyma cells and chloroplasts per unit leaf surface area (Nobel 1991). At 30 DAIS, black gram genotypes LBG 20, MBG 211, MBG 207 and PBG 107 maintained lower SLA values (124.4-145.0 cm^2g^{-1}) under stress. Green gram

Table 1. Weather data during crop growth period

Standard week	Maximum Temperature	Minimum temperature (°C)	Evaporation (mm) (°C)	Rainfall (mm)
Jan 1-7	29.31	17.24	4.84	0.0
Jan 8-14	30.02	14.57	4.28	0.0
Jan 15-21	30.34	15.57	4.35	0.0
Jan 22-28	31.28	20.54	4.58	0.0
Jan 29-Feb 4	30.07	20.57	3.80	5.6
Feb 5-11	31.07	16.91	6.21	0.0
Feb 12-18	36.31	16.67	6.31	0.0
Feb 19-25	34.84	19.44	7.01	0.0
Feb 26-Mar 4	35.34	19.17	7.80	0.0
Mar 5-11	29.92	22.90	6.80	0.0
Mar 12-18	22.57	7.00	0.0	
Mar 19-25	57.51	23.38	7.90	0.0
Mar 26-Aprl 1	38.30	25.98	7.80	0.0

Table 2. Mean soil moisture per cent during the crop growth period

Days after imposition of stress	Green gram	Black gram
Beginning of stress 0	7.04	6.83
10	4.26	3.30
20	1.66	1.49
30	1.28	1.22
40	-	1.02

genotypes MGG 336, LGG 460, MGG 351 and LGG 502 showed lower SLA under stress. An inverse relationship between SLA and WUE is normally observed (Wright *et al.* 1994), thus indicating that genotypes with thick leaves under moisture stress conditions may be water use efficient.

Relationship between SLA and SCMR : A significant inverse relationship (r=0.85 P<0.05) was observed between SLA and SCMR in black gram genotypes (Fig. 1). Similar relationship between SLA and SCMR has earlier been reported in groundnut (Anonymous 1996, Rao *et al.* 2001). Genotypes with lower SLA (thicker leaves) are known to have more of photosynthetic machinery, i.e. more chlorophyll content (Rao and Wright 1994). Positive relationship between leaf chlorophyll content and SLN, SLN and SCMR (Rao *et al.* 2001, Bindu Madhava *et al.* 2003) provide an indirect evidence for existence of an inverse relationship

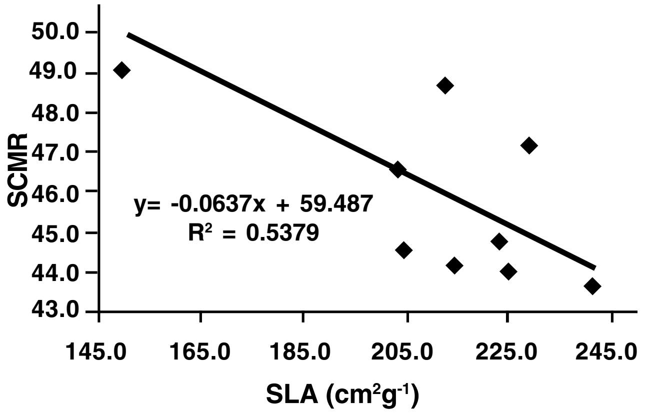

Fig. 1. Relationship between SLA and SCMR in black gram genotypes

Table 3. SPAD chlorophyll meter reading (SCMR) of black gram and green gram genotypes at 30 days afer imposing moisture stress (DAIS)

Genotype		Black gram		Genotype		Green gram	
	Irrigated	Stress	Mean		Irrigated	Stress	Mean
LBG 20	46.3	44.1	45.2	MGG 351	46.1	45.6	45.9
LBG 623	45.6	42.1	43.9	MGG 336	49.2	48.1	48.7
MBG 201	49.0	39.8	44.4	LGG 487	46.4	42.3	44.4
MBG 207	47.0	43.0	45.0	LGG 498	49.1	46.2	47.7
MBG 211	43.3	40.4	41.9	LGG 502	48.1	44.4	46.3
MBG 212	44.3	40.4	42.4	LGG 450	46.5	44.8	45.7
MBG 213	45.6	38.2	41.9	LGG 460	49.4	44.6	47.0
MBG 214	42.1	41.6	41.9	LGG 492	47.7	44.7	46.2
PBG 32	42.7	34.1	38.4	LGG 494	44.2	44.9	44.6
PBG 107	45.4	44.4	44.9	LGG 521	52.9	49.2	51.1
Mean	45.1	40.6		Mean	47.9	45.5	
		SEm	**CD at 5%**		**SEm**	**CD at 5%**	
Irrigation treatment		038	1.09		0.43	1.23	
Genotype		0.85	2.24		0.96	2.74	
Irri. treat. x genotype		1.21	3.45		1.35	3.87	

Table 4. Specific leaf area (SLA) of black gram and green gram genotypes at 30 days after imposing moisture sress (DAIS)

Genotype		Black gram		Genotype		Green gram	
	Irrigated	Stress	Mean		Irrigated	Stress	Mean
LBG 20	160.2	124.4	142.3	MGG 351	175.2	131.1	153.2
LBG 623	163.9	156.6	160.3	MGG 336	144.4	118.6	131.5
MBG 201	155.9	152.8	154.4	LGG 487	154.7	143.0	148.9
MBG 207	147.8	135.7	141.8	LGG 498	143.6	143.9	143.8
MBG 211	171.6	130.7	151.2	LGG 502	138.3	137.1	137.7
MBG 212	179.0	176.5	177.8	LGG 450	159.8	142.9	151.4
MBG 213	181.0	163.9	172.5	LGG 460	133.4	199.9	126.7
MBG 214	185.9	150.0	168.0	LGG 492	157.0	143.1	150.1
PBG 32	173.6	168.6	171.1	LGG 494	155.7	148.0	151.9
PBG 107	145.7	145.0	145.4	LGG 521	175.2	162.5	168.9
Mean	166.5	150.4		Mean	153.7	139.0	
		SEm	**CD at5%**	**SEm**	**CD at 5%**		
Irrigation treatment		2.29	6.56	2.04	5.84		
Genotype		5.12	14.66	4.56	13.06		
Irr. treat. x genotype		7.24	20.74	6.45	18.48		

Table 5. Seed yield (kg ha^{-1}) of black gram and green genotypes at harvest

Genotype	Black gram			Genotype	Green gram		
	Irrigated	Stress	Mean		Irrigated	Stress	Mean
LBG 20	1455	845	1150	MGG 351	1334	1226	1280
LBG 623	1444	588	1016	MGG 336	1205	945	1075
MBG 201	1123	263	693	LGG 487	1243	943	1093
MBG 207	1215	512	864	LGG 498	146	921	1194
MBG 211	1582	226	904	LGG 502	1182	704	943
MBG 212	1733	393	1063	LGG 450	1504	506	1005
MBG 213	1526	445	986	LGG 460	929	860	895
MBG 214	1795	809	1302	LGG 492	1249	744	997
PBG 32	1289	470	880	LGG 494	1356	992	1147
PBG 107	1085	917		LGG 521	1207	1211	1209
Mean	1425	547		Mean	1268	905	
		SEm	CD at 5%	SEm	CD at 5%		
Irrigation treatment		35.6	101.9	36.5	104.4		
Genotype		79.6	227.8	81.5	233.4		
Irri. treat. x genotype		112.5	322.2	115.3	330.1		

between SLA and SCMR SLN might thus be the cause of linkage between SCMR and SLA (Radio *et al.* 2001). Surprisingly no such significant correlation was observed between SLA and SCMR in green gram genotypes.

Seed yield: There was a significant reduction in seed yield under stress when compared to irrigated conditions both in black gram (62%) and green gram (29%) genotypes (Table 3). The possible decrease in stomatal conductance and leaf area resulting in loss of dry matter accumulation partly explains the decrease in yield and yield components under water stress (Ramana Rao 1994). Black gram gram genotypes PBG 107, LBG 20 and MBG 214, greengram genotypes MGG 351, LGG 521, MGG 336 and LGG 498 showed higher seed yields even under stress. Incidentally these genotypes also showed higher SCMR values under stress, thus providing evidence for the existence of a positive relationship between SCMR and seed yield under moisture stress, in black gram and green gram.

Relationship between seed yield and SCMR : A significant positive relationship was observed between seed yield and SCMR both in black gram (Fig. 2a) (r=0.68

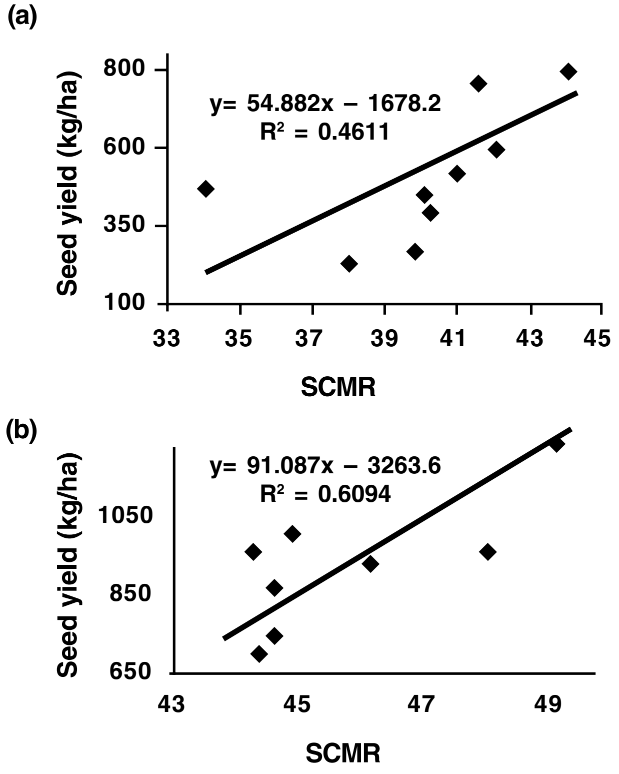

Fig. 2. Relationship between seed yield and SCMR in black gram (a) and green gram (b)

$P<0.05$) and green gram (Fig.2b) ($r=0.78$ $P<0.05$). Similar positive correlation between SCMR and seed yield has earlier been reported in groundnut (Rao *et al.* 2001), cereals (Argenta *et al.* 2001) and maize (Costa *et al.* 2001). SCMR is known to be related to leaf N content in several crops (Uzik and Zofajova 2000, Veeraputhiran *et al.* 2001 and Schepers *et al.* 1992). Leaf N content has a direct relationship with the amount of ribulose 1, 5 biphosphate carboxylase, which accounts for 37% of the soluble proteins (Rao *et al.* 1995) and thus with the photosynthesis. Rao *et al.* (1995) reported that most of the variation in the water use efficiency and carbon isotope discrimination in groundnut was associated with the variation in Rubisco. Higher SCMR seems to be an indication of the genotype's capacity for higher carbon assimilation and in turn seed yields even under moisture-limited situations.

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