Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7139

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **7 (1):** 520-530 (2019)

Research Article

Influence of Moisture Stress on Mungbean Genotypes for Morpho-Physiological Traits

Y. Yohan*, P. Sudhakar. V. Umamahesh, D. Mohan Reddy and V. Sumathi

Department of Crop Physiology, S.V. Agricultural College, Tirupati

*Corresponding Author E-mail: yohanpg30@gmail.com

Received: 14.12.2018 | Revised: 23.01.2019 | Accepted: 30.01.2019

ABSTRACT

A field experiment was conducted on twelve Mungbean (Vigna radiata L.) genotypes under water stress condition at S.V agricultural college, Tirupati. A wide diversity among the genotypes in their physio-morphological characters was recorded. Genotypes varied from genotypes TBG-104, KU-12-13 plant height was slightly affected during moisture stress condition in both the years and maintained higher nodule number in irrigated control as well as moisture condition. TBG-104, KU-12-13, KU-12-37, LBG-623 recorded significantly higher leaf area, drymatter partioning under both irrigated as well as stress conditions, which denotes the ability of these genotypes in sustaining the photosynthesising area and accumulation of photosynthates in stem. Whereas NDU-12-300 recorded lowest total dry matter during rabi 2015-16 and rabi 2016-17.

Key words: *Mungbean, Rabi, Crop, Diseases*

INTRODUCTION

Drought stress is characterized by reduction of water content, diminished leaf water potential and turgor loss, closure of stomata and decrease in growth. Severe water stress may result in the arrest of photosynthesis, disturbance of metabolism and finally the death of plant. Water stress inhibits cell enlargement more than cell drought stress coupled with high temperature is associated with reduced water availability and cellular dehydration alters the cellular metabolism coupled with osmotic adjustment[20]. However, production of blackgram is adversely affected by drought that reduce yield[11]. Soil moisture stress is a major hazard for successful crop production through out the world. It reduces the productivity by delay or prevention of crop establishment, destruction of established crop, predisposition of crop to insects and diseases, alteration of physiological and biochemical metabolism in plant and quality of grain. However, species and genotypes vary in their capacity to tolerate water stress.

MATERIALS AND METHODS

The experiment was laid out in a split plot design with two main treatments, twelve sub treatments and replicated thrice.

Cite this article: Yohan, Y., Sudhakar, P., Umamahesh, V., Mohan Reddy, D. and Sumathi, V., Influence of Moisture Stress on Mungbean Genotypes for Morpho-Physiological Traits, *Int. J. Pure App. Biosci.* **7(1):** 520-530 (2019). doi: http://dx.doi.org/10.18782/2320-7051.7139

Main Treatments: 2: i) Irrigated (control) ii) Impose moisture stress at 60-80 DAS, Sub Treatments (12 Genotypes) KU -12-55, LBG-623, LBG-680, NDU-12-300, LBG-685, KU-12-14, LBG-645, KU-12-37, TBG-104, KU-12-33, LBG-752 and LBG-20. Following parameters are recorded every 15 days interval in both *rabi* 2015-16 and *rabi* 2016-17.

Plant height (cm)

Plant height was measured from the base of the plant to the tip of the leaf and expressed in cm.

Number of nodules

Nodules for three plants were counted at the every 15 days interval. The average of three plants was worked out.

Leaf area (cm^2 $plant^{-1}$)

After separation of leaves from the plant, leaf area was estimated using leaf area meter (LICOR model LI 3000) and expressed as cm^2 $plant^{-1}$.

Dry matter partioning (g $plant^{-1}$)

The dry weights of oven dried stems, leaves, roots and pods were recorded and expressed as g $plant^{-1}$.

RESULTS AND DISCUSSION

The plant height(cm) of twelve blackgram genotypes as influenced by irrigated and imposed moisture stress conditions during *rabi* 2015-16 and *rabi* 2016-17. Plant height had a continuous increase till crop reached maturity. The increase was exponential up to 45 DAS thereafter it has increased with decreasing trend during both the seasons. Significant differences were observed among moisture stress treatments and genotypes, throughout the crop growth except 15 and 30 DAS of *rabi* 2015-16. However, during *rabi* 2016-17 differences were significant through crop growth. Interactions effects were not significant in both seasons testing Similar significant differences between genotypes under irrigated as well as moisture stress conditions were also reported in chickpea[19], and in greengram[4].

Moisture stress condition during flower initiation stage to pod filling stage i.e 40 to 60 DAS decreased mean plant height significantly compared to irrigated condition in both the years. The extent of decrease was 13.3 and 14.1 percent at 45 DAS 16.0 and 19.1 per cent at 60 DAS and 16.1 and 15.9 percent at 75 DAS in *rabi* 2015-16 and 2016-17 respectively compared to respective irrigated treatments (Table 1a & 1b).

Among blackgram genotypes tested LBG-680 recorded highest plant height under irrigated (45.11 and 43.59 cm) as well as moisture stress (30.23 and 33.47) conditions in both the years plant height was after imposed moisture stress condition. In moisture stress condition plant height was not affected in TBG-104 in both the seasons followed by KU-12-13. NDU-12-300 recorded lowest plant height under irrigated (28.91 and 27.27) and moisture stress (24.54 and 23.45) conditions in both seasons. A similar result of decrease in plant height due to moisture stress was reported in greengram Baroowa *et al.*[1], in chickpea[17] and in blackgram[8].

Increase the number of nodules up to 30 DAS and thereafter it was decreased relatively as the crop reached maturity during both the years of testing Significant differences were observed among treatments, genotypes and their interactions from 15 DAS to 75 DAS both the years. Similar results were reported in common bean[15] and cowpea[10].

Mean number of nodules significantly decreased after imposition of moisture stress from 45 to 60 DAS in moisture stress treatment compared to irrigated treatment in both years. The extent of decrease was 30.8 and 33.4 percent at 45 DAS, 52.8 and 46.7 percent at 60 DAS and 38.6 and 36.5 per cent at 75 DAS in *rabi* 2015-16 and 2016-17 years compared to respective irrigated treatments (Table 2a & 2b). Similarly, declines the nodule weight along with nodule number due water deficit in chickpea was reported by Jain *et al.*[6].

Among the genotypes tested TBG-104 maintained significantly higher nodule number in irrigated control as well as moisture condition throughout crop growth followed by KU-12-13 and LBG-685 during both years of testing.

Soil dehydration results in a two-stage inhibition of nodule activity. The first stage clearly involves a rapid and simultaneous decrease in nitrogenase activity. The second stage of inhibition occurs under severe drought stress, when nodule activity is less than half of the initial rates finally decrease root nodule number reported by Serraj[18].

Leaf area per plant is an important determinant in production and photosynthesis[23]. The leaf area per plant showed a gradual increase up to 45 DAS and then declined in all the genotypes irrespective of the treatments both the years of testing due to occurrence of senescence. Significant differences were observed among moisture stress treatments, genotypes and interactions except 15 DAS during both the years. Similar significant differences were reported in chickpea[24] and blackgram and greengram[1].

Due to imposition of moisture stress at flowering initiation stage i.e. from 40-60 DAS, mean leaf area decreased significantly and the extent of decrease was 18.9 and 19.9 per cent at 45 DAS, 29.8 and 33.6 per cent at 60 DAS in *rabi* 2016 and *rabi* 2017 years respectively compared to irrigated control treatments Leaf area decreased continuously with an increase in soil moisture stress as in mungbean[16] and blackgram and greengram[12].

Among blackgram genotypes tested KU-12-37 recorded highest leaf area under irrigated (1306.73 and 1257.71 cm^2) as well as moisture stress (820.84 and 798.56 cm^2) conditions. However in TBG-104 leaf area was affected in moisture stress treatments (512.0 cm^2) compared to irrigated treatment (537.93 cm^2) at 75 DAS followed by KU-12-13 in both the *rabi* seasons LBG-645 recorded lower leaf area among all the genotypes tested during both seasons (Table 3a & 3b).

Modification in leaf area is one of the basic causes which lead to reduction in average leaf size under water limiting situation of greengram and blackgram[2].

Root dry weight had a continuous increase up to 45 DAS, thereafter it has increased with decreasing trend during both the years of testing viz., *rabi* 2015-16 and *rabi* 2016-17. Root dry weight showed significant differences were observed among treatments, genotypes and interactions except 15 DAS in both the years. Similar results were reported in mungbean[3], chickpea[13].

Mean root dry weight of stress treatment increased (1.04 g $plant^{-1}$) numerically compared to control treatments (1.01 g $plant^{-1}$).The increase observed in root weight under moisture stress indicate greater density of root and or greater depths of root penetration both of these are important morphological adaptations to moisture deficit and results in greater extraction of soil water[5]. However, such effect was not sum as moisture stress progressed (60 DAS).

KU-12-13 maintained higher root dry matter irrigated (2.14 and 1.90) as well as moisture stress (1.93 and 1.74) conditions followed by LBG-623, KU-12-37 and TBG 104 where as. NDU-12-300 showed lowest root drymatter (Fig 1a & 1b). Similar results were found in chickpea[9,14].

The data on stem dry weight throughout growing season followed similar trend as that of root dry weight. Stem dry weight also showed significant differences among treatments, genotypes and their interactions.

Shoot dry weight was affected under moisture stress condition compared to irrigated. Decrease in shoot dry matter under lower soil moisture might be due to reduction of leaf area and photosynthetic rate. The extent of decrease was 23.4 and 24.7 percent at 45 DAS, 58.9 and 58.2 per cent at 60 DAS and 26.9 and 34.2 percent at 75 DAS compared to respective irrigated treatments in *rabi* 2015-16 and 2016-17 years compared to respective irrigated treatments (Fig 2a & 2b). TBG-104 maintained higher stem dry weight during irrigated control moisture stress at 60 DAS and 75 DAS compared to all genotypes followed by KU-12-13.in both the years, where as NDU-12-300 recorded lower stem dry weight under irrigated and moisture stress conditions.

Decrease in shoot dry matter under lower soil moisture might be due to reduction of leaf area and photosyntheticrate. Retention

of green leaves under drought conditions has been used as a selection criterion for drought resistance[7].

Similar to stem dry weight, leaf dry weight also showed significant differences among treatments, genotypes and their interactions. Similar results were reported in mungbean[22].

Mean leaf dry weight decreased significantly due to moisture stress from 45-60 DAS in moisture stress treatments compared to irrigated treatments. The extent of decrease was 0.69 and 3.53 percent at 45 DAS, 4.84 and 1.44 percent at 60 DAS compared to respective irrigated treatments. These results indicated that moisture stress at grand growth stage affected leaf growth and leaf dry weight. in mungbean[21].

Among the genotypes tested TBG-104 recorded highest leaf dry weight under irrigated (5.01 and 4.90 g plant^{-1}) as well as moisture stress (4.96 and 4.80 g plant^{-1}) conditions during *rabi* 2015-16 and 2016-17 followed by KU-12-13 and KU-12-37 (Fig 3a & 3b). These results reveal that moisture stress affect leaf growth to prevent transpiration in blackgram crop also, however genotypic differences exists in sustaining leaf growth and its dry weight under low soil moisture conditions Superiority of TBG-104 and KU-12-13 in maintaining leaf area and leaf dry weight under moisture stress condition helped in sustaining photosynthesis and accumulation of photosynthates.

The decrease in dry weight of leaves among KU-12-55, NDU-12-300, LBG-645 genotypes occurs due to reduced rate of current photosynthesis and lower leaf turgor potential under stressed environment, which restricted the cell enlargement and division and hence reduction in expansion of leaf area, and it ultimately affected the active sink at the time of reproductive phaseas opined by Burman *et al*.

Table 1a. Evaluation of blackgram genotypes for plant height (cm) under imposed moisture stress condition during *rabi* 2015-16

	15 DAS			30DAS			45 DAS			60 DAS			At harvest		
Genotypes	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**
KU-12-55	9.15	9.10	**8.94**	16.6	14.92	**15.76**	25.55	24.72	**25.13**	27.28	26.74	**27.01**	28.30	27.8	**28.05**
LBG-623	8.88	8.90	**9.00**	21.29	21.61	**21.45**	35.88	31.27	**33.58**	39.48	31.75	**35.62**	41.23	33.25	**37.24**
LBG-680	11.14	11.15	**11.15**	19.09	20.12	**19.61**	30.3	27.13	**28.72**	41.01	28.34	**34.68**	45.11	30.23	**37.67**
NDU-12-300	8.25	8.30	**8.49**	18.66	19.92	**19.29**	24.03	21.52	**22.78**	26.52	23.84	**25.18**	28.91	24.54	**26.73**
LBG-685	9.24	9.29	**9.30**	20.81	23.83	**22.32**	31.63	26.99	**29.31**	35.34	28.74	**32.04**	37.26	31.44	**34.35**
KU-12-14	9.61	9.59	**9.76**	18.45	19.04	**18.75**	23.93	21.51	**22.72**	28.5	25.24	**26.87**	29.65	26.4	**28.03**
LBG-645	11.33	11.38	**11.20**	34.46	20.03	**27.25**	35.28	24.02	**29.65**	39.75	28.9	**34.33**	41.55	31.42	**36.49**
KU-12-37	11.94	11.99	**12.07**	22.31	25.11	**23.71**	37.8	32.59	**35.20**	40.52	34.16	**37.34**	43.19	37.21	**40.20**
TBG-104	11.08	11.11	**11.17**	19.31	21.18	**20.25**	28.87	26.33	**27.60**	32.39	29.93	**31.16**	35.10	32.87	**33.99**
KU-12-13	10.31	10.38	**10.50**	20.86	23.34	**22.10**	33.82	31.85	**32.84**	39.34	33.26	**36.30**	42.96	36.9	**40.13**
LBG-752	10.22	10.27	**10.33**	20.17	21.37	**20.77**	32.5	31.48	**31.99**	39.43	34.97	**37.20**	43.35	37.16	**40.06**
LBG-20	9.80	9.83	**9.98**	22.4	24.19	**23.30**	31.82	28.3	**30.06**	37.48	32.56	**35.02**	39.63	33.35	**36.49**
Mean	**10.08**	**10.11**		**21.20**	**21.22**		**31.95**	**27.70**		**35.59**	**29.87**		**38.02**	**31.88**	
	T	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**
SE m ±	0.006	0.45	0.02	1.15	2.70	4.00	0.04	1.30	0.17	0.55	1.41	1.89	0.091	1.59	0.31
CD (P=0.05)	N.S	1.29	N.S	NS	NS	NS	0.321	3.72	N.S	0.55	1.40	6.18	0.598	4.55	NS

M_0: Irrigated (control), M_1: Moisture stress

Table 1b. Evaluation of blackgram genotypes for plant height (cm) under imposed moisture stress condition during *rabi* 2016-17

	15 DAS			30DAS			45 DAS			60 DAS			At harvest		
Genotypes	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**
KU-12-55	6.67	7.89	**7.28**	16.01	15.97	**15.99**	24.51	20.94	**22.73**	26.47	20.03	**23.25**	31.00	25.47	**28.24**
LBG-623	7.85	8.12	**7.99**	20.38	21.59	**20.99**	30.59	26.88	**28.74**	36.41	27.86	**32.14**	40.28	32.41	**36.35**
LBG-680	10.74	10.25	**10.50**	18.83	20.22	**19.53**	28.49	25.81	**27.15**	38.12	27.4	**32.76**	43.59	33.47	**38.53**
NDU-12-300	7.52	8.06	**7.79**	16.66	18.47	**17.57**	21.55	18.7	**20.13**	25.56	20.46	**23.01**	27.27	23.45	**25.36**
LBG-685	9.56	9.83	**9.70**	19.46	23.41	**21.44**	30.54	25.56	**28.05**	34.17	25.9	**30.04**	36.67	29.50	**33.09**
KU-12-14	8.88	9.19	**9.04**	17.09	17.91	**17.50**	21.33	18.94	**20.14**	26.59	22.83	**24.71**	29.17	26.78	**27.98**
LBG-645	10.00	11.01	**10.51**	30.15	21.58	**25.87**	34.99	23.4	**29.20**	36.91	26.71	**31.81**	40.12	33.12	**36.62**
KU-12-37	9.60	10.99	**10.30**	21.29	25.14	**23.22**	35.35	30.19	**32.77**	39.08	32.47	**35.78**	42.88	36.36	**39.62**
TBG-104	9.67	10.80	**10.24**	18.61	20.4	**19.51**	27.71	26.47	**27.09**	30.02	29.19	**29.61**	33.74	31.96	**32.85**
KU-12-13	9.57	11.34	**10.46**	20.18	23.87	**22.03**	31.18	29.98	**30.58**	36.88	34.97	**35.93**	42.21	38.01	**40.11**
LBG-752	8.69	10.97	**9.83**	19.57	22.87	**21.22**	30.98	26.07	**28.53**	37.21	29.71	**33.46**	40.18	34.57	**37.38**
LBG-20	7.13	9.26	**8.20**	20.45	22.45	**21.45**	31.37	26.34	**28.86**	35.62	28.4	**32.01**	41.44	32.10	**36.77**
Mean	**8.82**	**9.81**		**19.89**	**21.16**		**29.05**	**24.94**		**33.59**	**27.16**		**37.38**	**31.43**	
	T	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**
SE m ±	0.05	0.42	0.18	0.023	0.056	0.078	0.06	1.19	0.230	0.10	1.37	0.37	0.106	0.089	0.366
CD (P=0.05)	0.032	1.20	N.S	0.15	0.16	0.25	0.41	3.41	N.S	0.66	3.92	N.S	0.69	0.25	0.56

M_0: Irrigated (control), M_1: Moisture stress

Table 2a. Evaluation of blackgram genotypes for number of nodules per plant under imposed moisture stress condition during *rabi* 2015-16

	15 DAS			30DAS			45 DAS			60 DAS			At harvest		
Genotypes	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**
KU-12-55	6.33	8.22	**7.27**	30.11	29.22	**29.66**	5.83	4.22	**4.42**	8.22	3.00	**6.22**	4.55	2.11	**3.33**
LBG-623	10.78	11.33	**11.05**	36.55	30.14	**33.35**	17.00	8.22	**13.42**	12.88	9.83	**10.55**	7.33	2.33	**4.83**
LBG-680	6.55	7.44	**7.00**	23.33	31.33	**27.33**	14.00	9.55	**11.08**	15.89	8.17	**12.72**	7.55	3.78	**5.67**
NDU-12-300	9.55	12.55	**11.05**	27.89	26.78	**27.33**	21.50	5.78	**15.92**	11.11	10.33	**8.44**	4.78	2.99	**3.89**
LBG-685	8.89	8.78	**8.83**	35.89	46.11	**41.00**	22.72	12.44	**17.11**	15.88	6.50	**15.16**	7.00	5.33	**6.16**
KU-12-14	9.66	9.22	**9.44**	27.11	30.44	**28.77**	17.83	8.44	**12.58**	15.78	7.33	**12.11**	3.66	1.67	**2.66**
LBG-645	6.55	7.55	**7.05**	35.55	43.11	**39.33**	14.72	20.66	**11.94**	27.88	9.17	**24.27**	7.89	5.78	**6.83**
KU-12-37	13.33	17.33	**15.33**	45.22	42.00	**43.61**	16.33	11.55	**12.67**	22.00	9.00	**16.78**	10.77	8.61	**9.69**
TBG-104	16.55	14.00	**15.27**	27.89	27.67	**27.78**	24.50	19.11	**17.39**	28.50	13.11	**11.77**	10.55	8.66	**9.61**
KU-12-13	10.99	11.33	**11.16**	30.00	33.55	**31.78**	16.33	17.55	**14.22**	22.00	12.11	**17.78**	9.88	8.22	**9.05**
LBG-752	12.00	14.00	**13.00**	26.00	25.66	**25.83**	17.50	13.66	**11.08**	15.11	4.67	**19.39**	12.88	6.22	**9.55**
LBG-20	10.11	7.66	**8.89**	42.44	46.33	**44.39**	9.67	5.77	**6.67**	10.11	3.67	**7.94**	8.22	2.55	**5.39**
Mean	**10.11**	**10.78**		**32.33**	**34.36**		**16.50**	**11.41**		**17.11**	**8.07**		**7.92**	**4.85**	
	T	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**
SE m ±	0.02	0.46	0.06	0.05	1.40	1.89	0.074	0.64	0.25	0.08	0.61	0.29	0.048	0.30	0.16
CD (P=0.05)	0.11	1.31	1.85	0.33	3.98	5.63	0.47	1.83	2.62	0.52	1.74	2.50	0.30	0.86	1.24

M_0: Irrigated (control), M_1: Moisture stress

Table 2b. Evaluation of blackgram genotypes for number of nodules per plant under imposed moisture stress condition during *rabi* 2016-17

	15 DAS			30DAS			45 DAS			60 DAS			At harvest		
Genotypes	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**
KU-12-55	5.12	7.90	**6.51**	28.46	28.48	**28.47**	4.10	3.01	**4.42**	6.14	2.39	**6.22**	3.27	2.57	**2.62**
LBG-623	9.97	10.76	**10.37**	37.59	32.94	**35.27**	18.24	7.24	**13.42**	10.89	6.41	**10.55**	6.51	3.16	**4.84**
LBG-680	5.12	6.98	**6.05**	20.61	30.33	**25.47**	13.27	8.78	**11.08**	12.24	7.33	**12.72**	7.00	2.99	**5.00**
NDU-12-300	10.47	11.89	**11.18**	25.34	25.10	**25.22**	22.54	6.89	**15.92**	10.17	8.02	**8.44**	5.29	2.66	**3.98**
LBG-685	9.51	8.98	**9.25**	33.52	48.01	**40.77**	25.25	13.00	**17.11**	13.66	7.87	**15.16**	8.66	4.33	**6.50**
KU-12-14	8.12	9.07	**8.60**	24.44	32.97	**28.71**	18.29	9.67	**12.58**	14.56	8.12	**12.11**	4.97	3.81	**2.17**
LBG-645	7.77	6.59	**7.18**	32.16	42.17	**37.17**	14.07	10.66	**11.94**	25.24	8.97	**24.27**	8.47	6.49	**7.48**
KU-12-37	12.90	15.55	**14.23**	31.69	43.88	**37.79**	15.26	10.88	**12.67**	21.66	10.24	**16.78**	10.56	8.56	**9.56**
TBG-104	15.20	13.48	**14.34**	35.25	28.47	**31.86**	17.88	15.50	**17.39**	11.33	12.00	**11.77**	10.99	9.76	**10.38**
KU-12-13	11.39	11.88	**11.64**	27.99	33.12	**30.56**	15.33	13.47	**14.22**	15.02	10.25	**17.78**	11.27	9.72	**10.89**
LBG-752	10.24	12.58	**11.41**	25.16	26.79	**25.98**	15.66	12.58	**11.08**	13.71	3.33	**19.39**	10.26	3.01	**6.64**
LBG-20	9.67	8.82	**9.25**	40.03	43.68	**41.86**	10.55	4.15	**6.67**	9.97	2.67	**7.94**	7.33	2.97	**4.70**
Mean	**9.62**	**10.37**		**30.19**	**34.66**		**15.87**	**9.65**		**13.72**	**7.30**		**7.88**	**5.00**	
	T	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**	**T**	**G**	**T x G**
SE m ±	0.01	0.43	0.05	0.03	1.36	0.12	0.09	0.59	0.33	0.08	0.50	0.29	0.049	0.048	0.017
CD (P=0.05)	0.10	1.24	1.75	0.22	3.88	5.49	0.58	1.69	2.42	0.53	1.44	2.08	0.32	0.14	0.28

M_0: Irrigated (control), M_1: Moisture stress

Table 3a. Evaluation of blackgram genotypes for leaf area (cm^2 $plant^{-1}$) under imposed moisture stress condition during *rabi* 2015-16

	15 DAS			30DAS			45 DAS			60 DAS			At harvest		
Genotypes	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**
KU-12-55	33.79	32.32	**32.73**	217.60	167.60	**192.60**	595.40	515.31	**555.35**	454.05	343.17	**398.61**	405.04	336.69	**370.87**
LBG-623	38.17	38.13	**38.15**	287.58	279.98	**283.78**	876.35	569.97	**723.16**	660.07	434.61	**547.34**	638.86	412.18	**525.52**
LBG-680	46.51	45.43	**47.64**	276.73	290.56	**283.64**	675.43	625.17	**650.30**	1352.45	367.33	**859.89**	807.47	354.84	**581.16**
NDU-12-300	36.62	35.72	**34.50**	204.05	210.27	**207.16**	421.29	416.40	**418.85**	379.31	259.95	**319.63**	357.36	227.36	**292.36**
LBG-685	36.39	37.41	**37.40**	246.74	287.30	**267.02**	702.86	303.30	**503.08**	499.05	458.19	**478.62**	475.62	443.45	**459.53**
KU-12-14	40.64	40.34	**40.49**	194.59	224.03	**209.31**	380.64	355.41	**368.03**	442.51	407.91	**425.21**	366.63	354.00	**360.32**
LBG-645	44.32	45.40	**45.36**	211.93	242.42	**227.18**	793.64	776.43	**785.03**	1030.83	395.19	**713.01**	985.79	382.38	**684.09**
KU-12-37	44.91	44.78	**46.51**	286.42	293.70	**290.06**	1306.73	820.84	**1063.79**	759.35	534.64	**646.99**	711.49	526.83	**619.16**
TBG-104	42.87	42.71	**42.79**	221.16	246.44	**233.80**	894.26	877.14	**885.70**	555.40	537.17	**546.29**	505.86	327.20	**416.53**
KU-12-13	37.31	38.50	**39.57**	301.73	309.94	**305.84**	939.22	865.52	**902.37**	902.81	847.09	**874.95**	701.40	324.67	**513.03**
LBG-752	44.39	43.35	**40.37**	305.53	297.63	**301.58**	860.47	800.97	**830.72**	645.83	415.75	**530.79**	570.02	412.65	**491.34**
LBG-20	41.86	43.36	**43.78**	384.85	387.31	**386.08**	866.64	625.85	**746.25**	792.67	513.61	**653.14**	700.82	463.12	**581.97**
Mean	**40.65**	**40.62**		**261.58**	**269.77**		**776.08**	**629.36**		**706.19**	**459.55**		**602.20**	**380.45**	
	T	**G**	**T × G**	**T**	**G**	**T × G**	**T**	**G**	**T × G**	**T**	**G**	**T × G**	**T**	**G**	**T × G**
SE m ±	0.18	1.41	0.64	0.27	11.73	0.94	0.14	31.68	0.49	4.94	27.70	17.12	3.29	23.42	11.42
CD (P=0.05)	N.S	4.0	N.S	1.68	33.45	NS	0.88	90.32	127.74	34.49	78.97	113.97	20.34	66.77	95.61

M_0: Irrigated (control), M_1: Moisture stress

Table 3b Evaluation of blackgram genotypes for leaf area (cm^2 $plant^{-1}$) under imposed moisture stress condition during *rabi* 2016-17

	15 DAS			30DAS			45 DAS			60 DAS			At harvest		
Genotypes	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**	**M_0**	**M_1**	**Mean**
KU-12-55	32.47	30.10	**31.29**	220.80	173.90	**197.35**	533.14	501.49	**517.32**	428.76	323.10	**375.93**	392.01	298.63	**345.32**
LBG-623	36.17	36.13	**36.15**	243.48	210.18	**226.83**	848.61	547.55	**698.08**	658.97	411.09	**535.03**	604.22	394.20	**499.21**
LBG-680	48.51	46.77	**47.64**	218.18	227.82	**223.00**	642.35	509.74	**576.05**	961.23	300.29	**630.76**	732.10	357.08	**544.59**
NDU-12-300	34.67	35.78	**35.23**	188.50	200.52	**194.51**	398.47	390.90	**394.69**	358.01	232.19	**295.10**	312.56	199.97	**256.27**
LBG-685	32.69	34.91	**33.80**	235.84	241.38	**238.61**	688.70	286.23	**487.47**	474.89	422.76	**448.83**	433.70	397.45	**415.58**
KU-12-14	40.84	41.54	**41.19**	286.97	294.38	**290.68**	368.94	321.80	**345.37**	408.91	369.71	**389.31**	373.12	299.87	**336.50**
LBG-645	40.15	42.20	**41.18**	323.19	410.47	**366.83**	767.22	744.10	**755.66**	991.29	349.50	**670.40**	922.14	356.90	**639.52**
KU-12-37	37.71	38.09	**37.90**	269.94	378.40	**324.17**	1257.71	798.56	**1028.14**	709.33	495.68	**602.51**	698.27	492.17	**595.22**
TBG-104	40.17	41.11	**40.64**	239.97	250.56	**245.27**	877.63	849.57	**863.60**	600.72	585.40	**593.06**	537.93	512.55	**525.24**
KU-12-13	38.24	35.90	**37.07**	224.92	298.21	**261.57**	888.60	841.11	**864.86**	881.23	791.91	**836.57**	659.04	484.76	**571.90**
LBG-752	46.36	43.38	**44.87**	298.65	321.44	**310.05**	843.37	779.99	**811.68**	589.33	397.87	**493.60**	530.86	382.22	**456.54**
LBG-20	39.22	40.70	**39.96**	354.11	385.37	**369.74**	847.55	603.60	**725.58**	719.60	487.73	**603.67**	644.37	407.09	**525.73**
Mean	**38.93**	**38.88**		**258.71**	**282.72**		**746.86**	**597.89**		**648.52**	**430.60**		**570.03**	**381.91**	
	T	**G**	**T × G**	**T**	**G**	**T × G**	**T**	**G**	**T × G**	**T**	**G**	**T × G**	**T**	**G**	**T × G**
SE m ±	0.022	0.082	0.075	0.559	1.142	1.370	0.61	30.14	2.11	4.76	26.40	16.49	3.28	2.44	11.38
CD (P=0.05)	N.S	0.24	0.35	2.59	3.25	5.00	3.76	85.94	121.58	29.37	75.26	108.26	21.53	6.80	16.20

M_0: Irrigated (control), M_1: Moisture stress

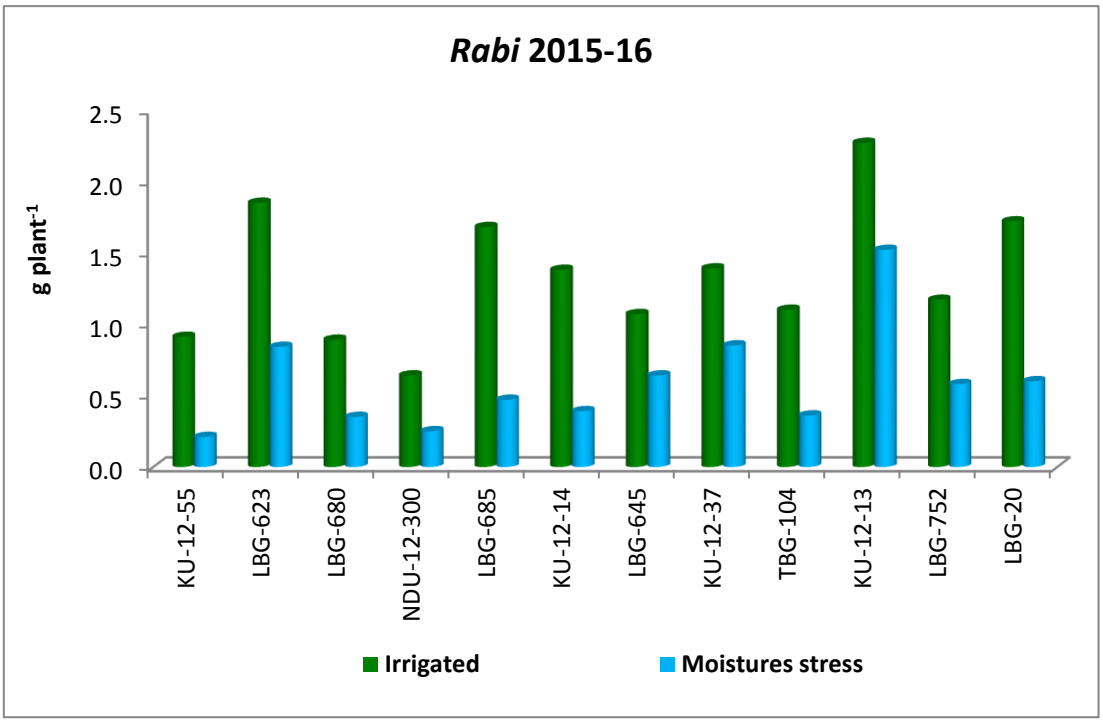

Fig. 1a Evaluation of blackgram genotypes for root dry weight (g $plant^{-1}$) under imposed moisture stress condition during *rabi* 2015-16 at 60 DAS

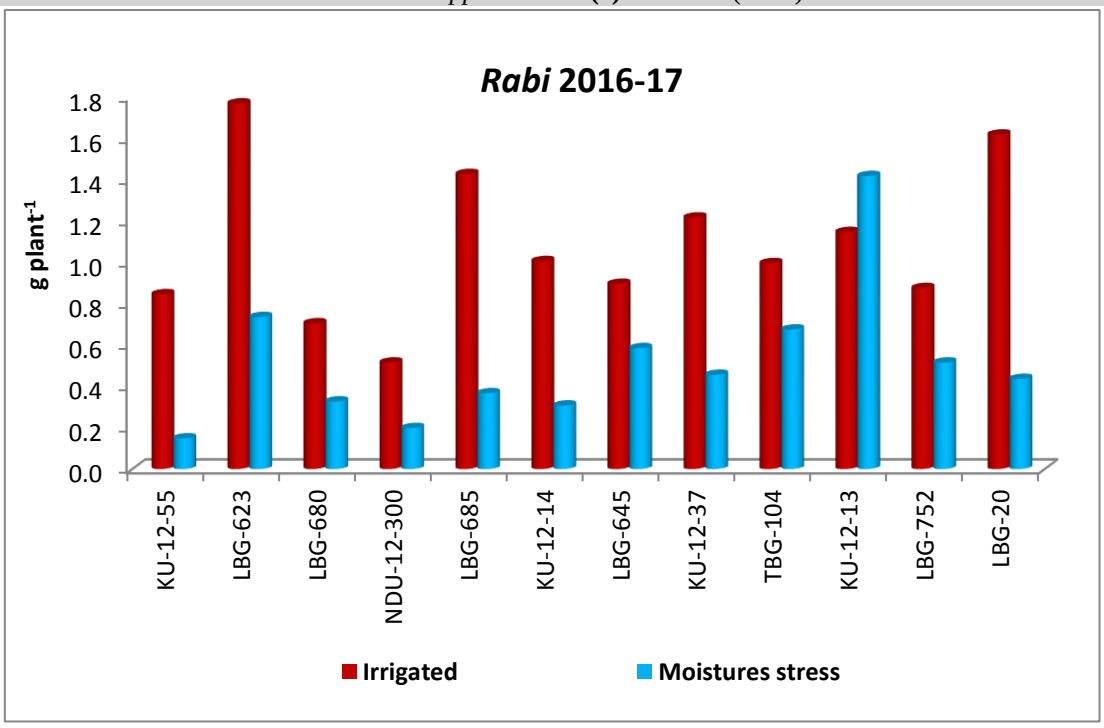

Fig. 1b Evaluation of blackgram genotypes for root dry weight (g palnt^{-1}) under imposed moisture stress condition during *rabi* 2016-17 at 60 DAS

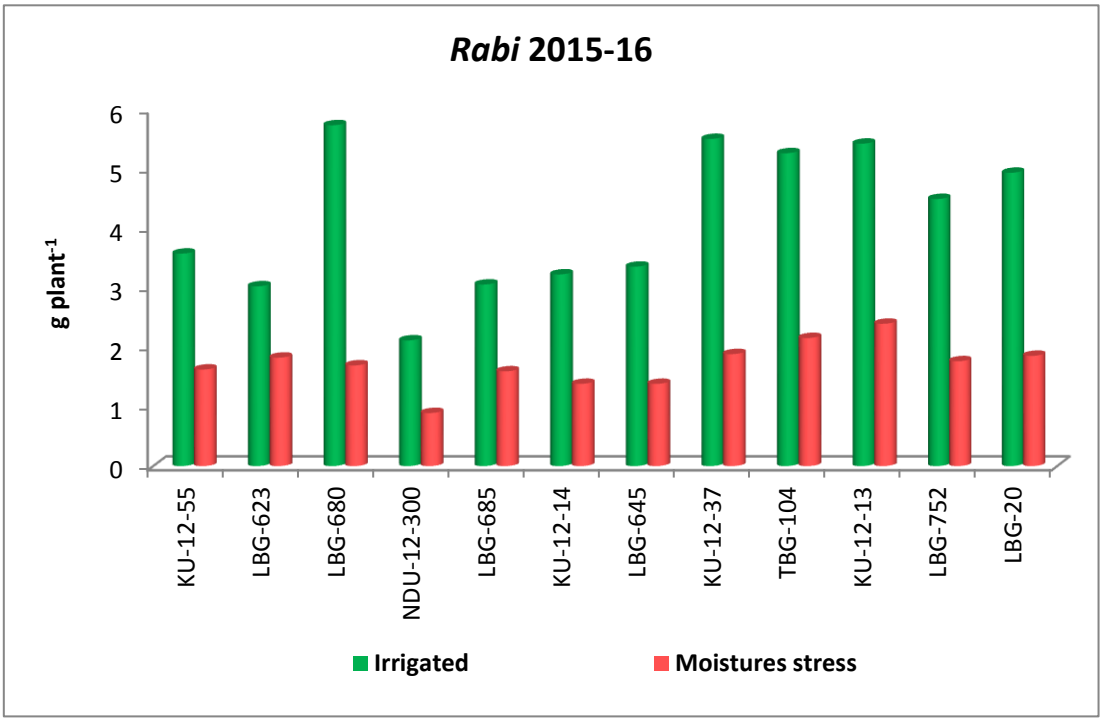

Fig. 2a. Evaluation of blackgram genotypes for stem dry weight (g plant $^{-1}$) under imposed moisture stress condition during *rabi* 2015-16 at 60 DAS

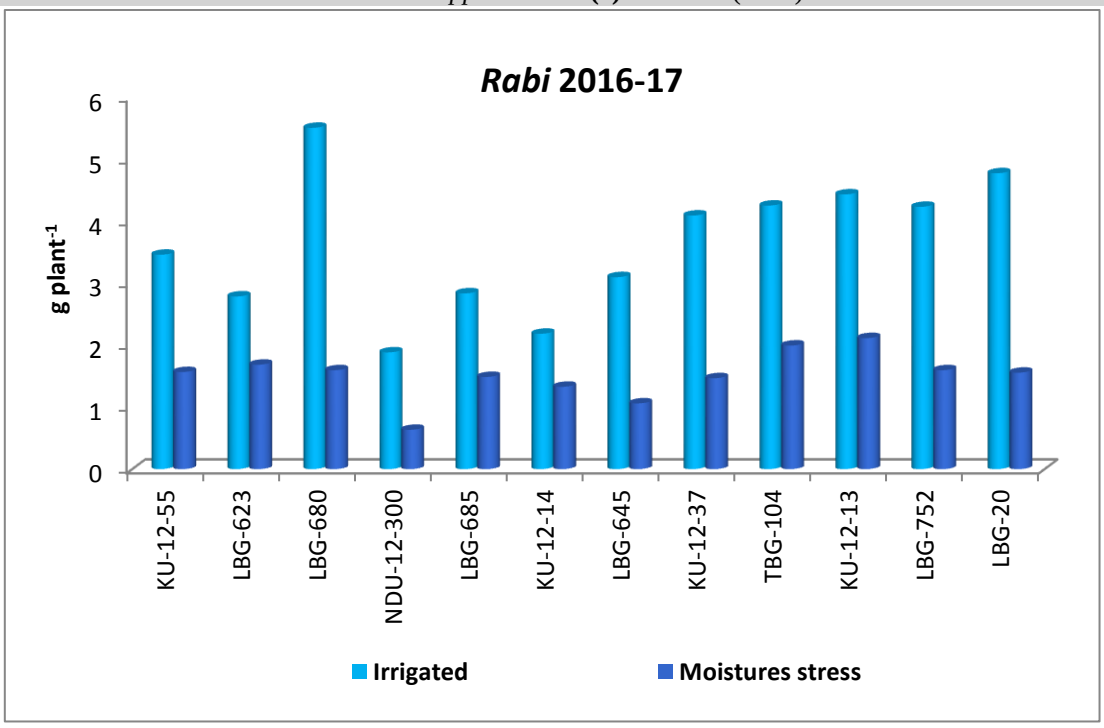

Fig. 2b. Evaluation of blackgram genotypes for stem dry weight (g plant^{-1}) under imposed moisture stress condition during *rabi* 2016-17 at 60 DAS

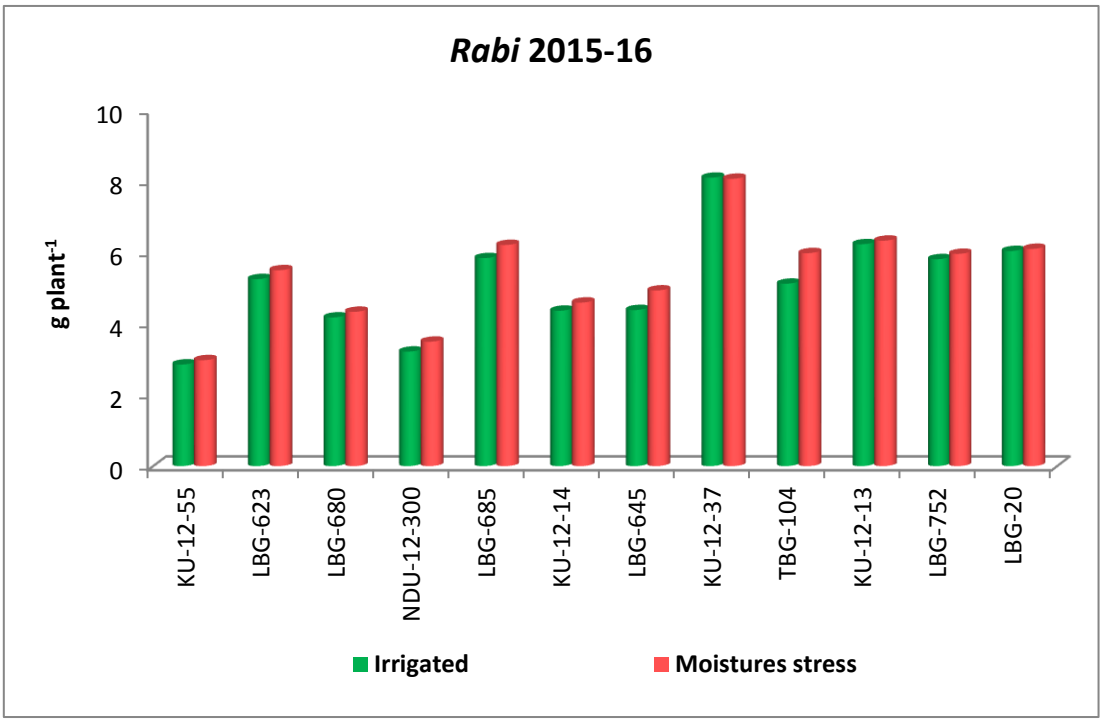

Fig. 3a. Evaluation of blackgram genotypes for leaf dry weight (g plant^{-1}) under imposed moisture stress condition during *rabi* 2015-16 at 60 DAS

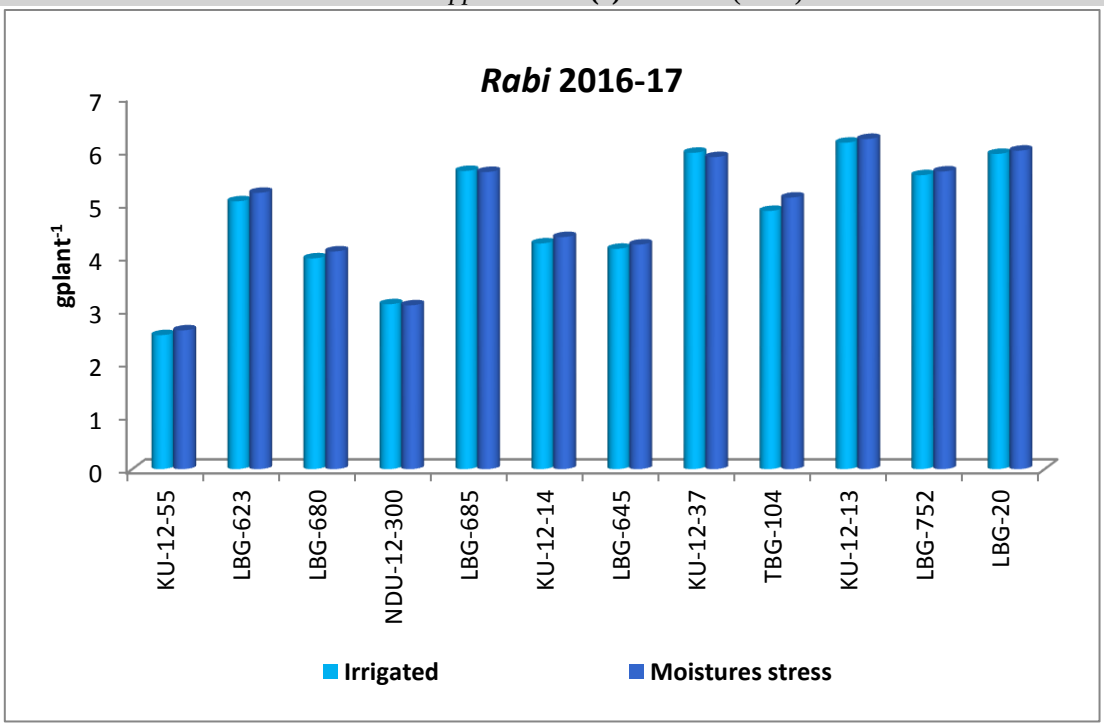

Fig. 3b. Evaluation of blackgram genotypes for leaf dry weight (g plant^{-1}) under imposed moisture stress condition during *rabi* 2016-17 at 60 DAS

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