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Short Communication

Response of Black Gram Genotypes to Moisture Stress Tolerance at Different Stages of Growth

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***Key words*:** Black gram, Moisture stress, Biometric, Yield, Gas exchange parameters

The important grain legumes grown in India are chickpea, pigeon pea, cowpea, lentil, peas etc. Among them, black gram (*Vigna mungo* L.) belonging to the family of leguminaceae is the third important pulse crop of India. Black gram seeds are highly nutritious containing higher amount of protein (24-26%) and also rich in vitamins (A_1, B_1, B_3) and minerals (potassium, phosphorus, calcium, and sodium). It has some medicinal properties and used in the treatment of diabetes, nervous disorders, digestive system disorders and rheumatic affliction [1]. It has been estimated that one-third of the world's population resides in water-stressed regions, and with increase in global temperature, it has been predicted that moisture stress could become more frequent and severe. Moisture stress largely affects production and yield stability of pulse crops particularly black gram. Even though black gram thrives moderately well under drought prone condition, there is a greater variability for yield performance of different genotypes under different drought conditions. Attempts to measure the degree of tolerance with a single parameter have limited scope because of the multiplicity of the factors and their interactive contribution under field conditions. Different workers used different methods to evaluate genetic differences in drought tolerance [2]. The present investigation has been planned to find out the moisture stress tolerant genotypes based on their response to induced moisture stress at different growth stages of the crop.

Apart from biometric parameters, gas exchange parameters viz. leaf photosynthetic rate (Pn), transpiration rate (Tr), stomatal conductance (Cs) and intercellular CO_2 concentration (c_i) will exhibit significant differences among the genotypes. The genotypes tolerant to moisture stress may have low stomatal conductance (Cs) and transpiration rate (Tr), which may be an adaptation to conserve moisture under moisture stress condition. At the same time, due to efficient moisture utilization, leaf photosynthetic rate and intercellular CO_2 concentration will be more in drought tolerant genotypes. Based on the above, the present work was attempted to screen the black gram genotypes for drought tolerance based on biometric, gas exchange and yield parameters at different growth stages.

Thirty genotypes of black gram (Table 1) obtained from various sources were raised in pot culture and evaluated for moisture stress tolerance by subjecting them to induced moisture stress at different growth stages. The experiment consisted of four treatments viz. control, T_1- withdrawal of irrigation at vegetative stage, T_2- withdrawal of irrigation at reproductive stage and T_3- withdrawal of irrigation both at vegetative and reproductive stages and the experiment was replicated thrice in CRD. The experiments were conducted at the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar (11°24'N latitude and 79°44'E longitude with an altitude of + 5.79 mts above mean sea level) from 2017-2018. Observations on biometric, gas exchange and yield parameters were recorded.

Table 1 Genotypes of black gram

S. No	Genotype	S. No	Genotype
1	VBN 6	16	ADT 5
2	VBN 3	17	LBG 806
3	VBN 4	18	LBG 787
4	VBN 5	19	LBG 752
5	VBN 8	20	CO 8
6	MDU1	21	LBG 808
7	NUL 7	22	LBG 884
8	VBN 7	23	CO 6
9	GOLDSTAR	24	CO 5
10	T9	25	TU-04
11	PU 31	26	MDU 1
12	NRIB002 (SRI)	27	NUL7(VISWAS)
13	IPU94-1	28	GBG 2
14	GBG1	29	MASH114
15	TBG 104	30	BG-SRI

Biometric parameters

The height of the plant was measured from the ground level to the tip of the plant and expressed in cm plant^{-1}. Number of days taken from sowing to first flowering was recorded and the mean value is expressed as days to first flowering in whole number. Numbers of days taken from sowing to 50 per cent flowering in each genotype was recorded and the mean value was expressed as days to 50% flowering in whole number.

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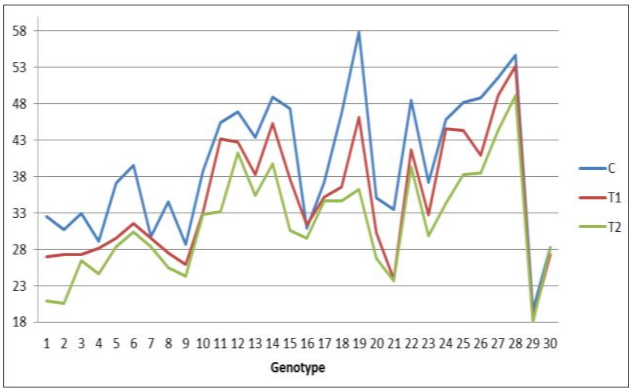

Fig 1 Effect of moisture stress on plant height

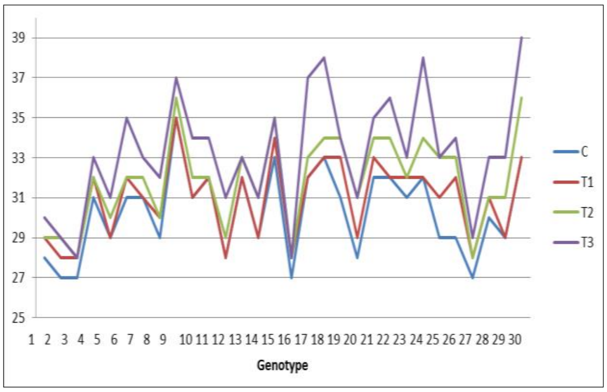

Fig 2 Effect of moisture stress on days to first flowering

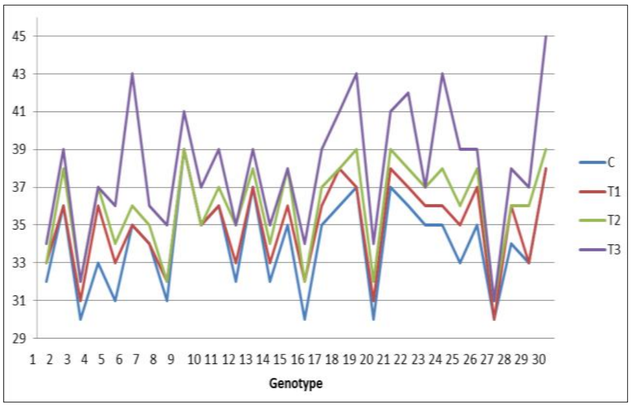

Fig 3 Effect of moisture stress on days to 50% flowering

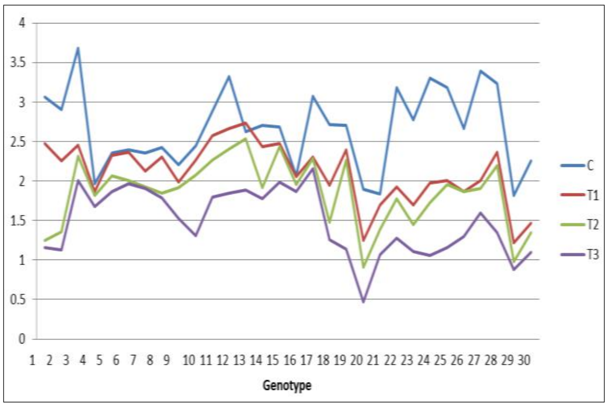

Fig 4 Effect of moisture stress on No. of clusters branch^{-1}

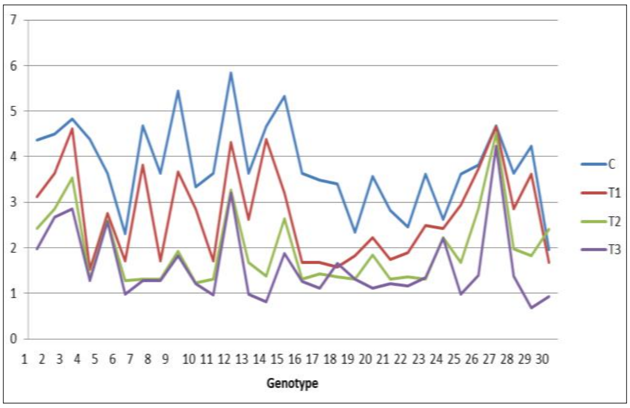

Fig 5 Effect of moisture stress on pod length (cm)

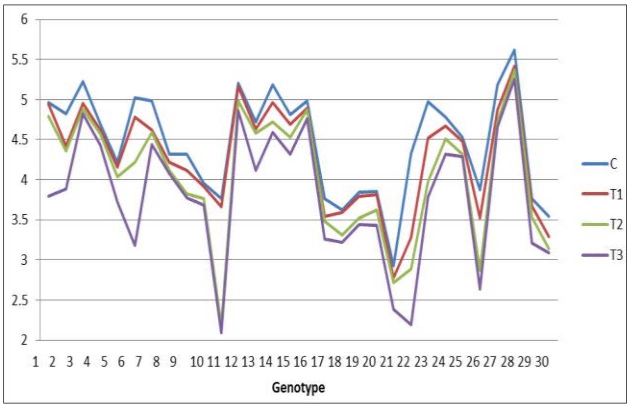

Fig 6 Effect of moisture stress on No. of seeds pod^{-1}

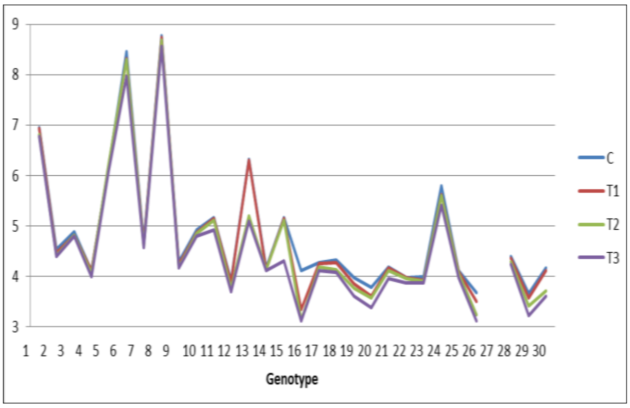

Fig 7 Effect of moisture stress on 100 seed weight (g)

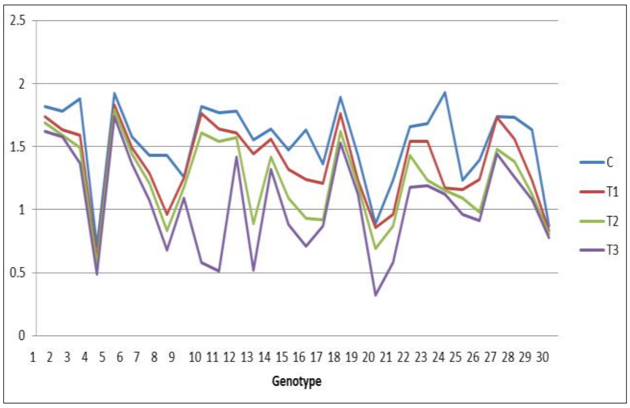

Fig 8 Effect of moisture stress on pod weight (g)

Yield parameters

Total number of pods in marked ten plants in each genotype was counted and mean number per plant was recorded replication wise and the mean was expressed in whole number. The pods from ten randomly selected plants earlier tagged were separately harvested and the seeds from each pod were separated, counted and averaged out to get number of seeds per pod. Hundred seeds collected from the matured pods were weighed and expressed in grams. Seeds from the ten marked plants were collected manually, cleaned, dried to constant moisture content and weighed. The mean seed yield was recorded and expressed as g plant^{-1}.

Gas exchange parameters

Gas exchange parameters viz. leaf photosynthetic rate (Pn), transpiration rate (Tr), stomatal conductance (Cs) and intercellular CO_2 concentration(ci) were measured from two uppermost fully expanded leaves from all the genotypes using LICOR-6400 XT Portable Photosynthetic system (Lincoln, USA). and expressed as mg CO_2 m^{-2} s^{-1}, mg H_2O m^{-2} s^{-1}, µmol mol^{-1} and mol m^{-2} s^{-1} respectively. All these estimations and measurements were made between 10.00–11.00 a.m. from each treatment replication wise and mean values were worked out.

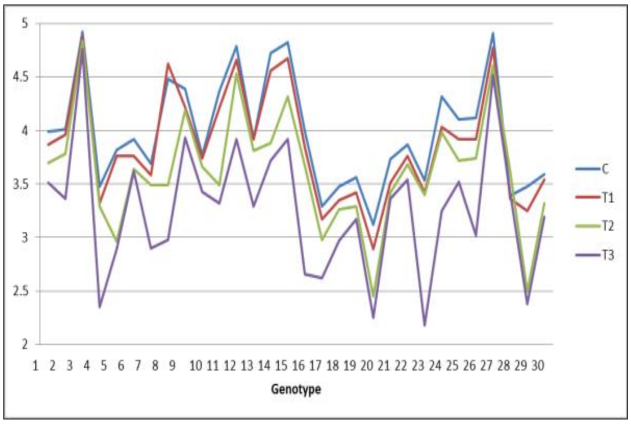

Fig 9 Effect of moisture stress on pod length (cm)

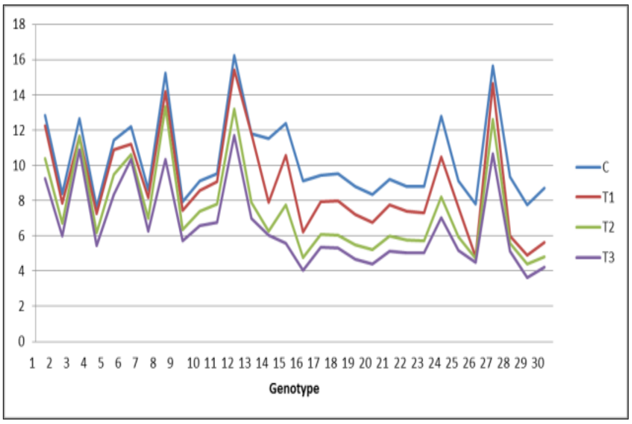

Fig 10 Effect of moisture stress on seed yield plant^{-1}

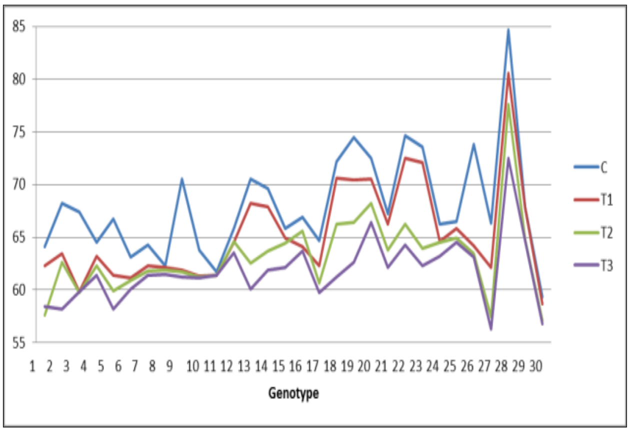

Fig 11 Effect of moisture stress on photosynthetic rate

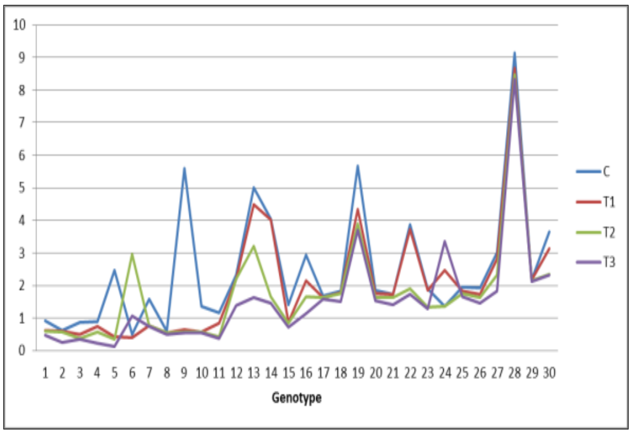

Fig 12 Effect of moisture stress on transpiration rate

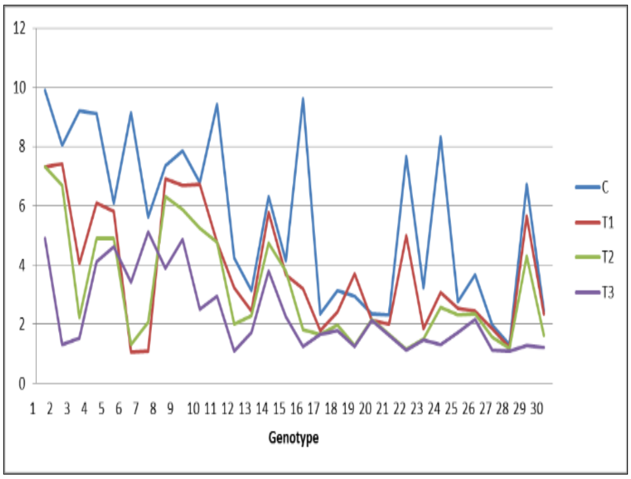

Fig 13 Effect of moisture stress on intercellular CO_2 concentration

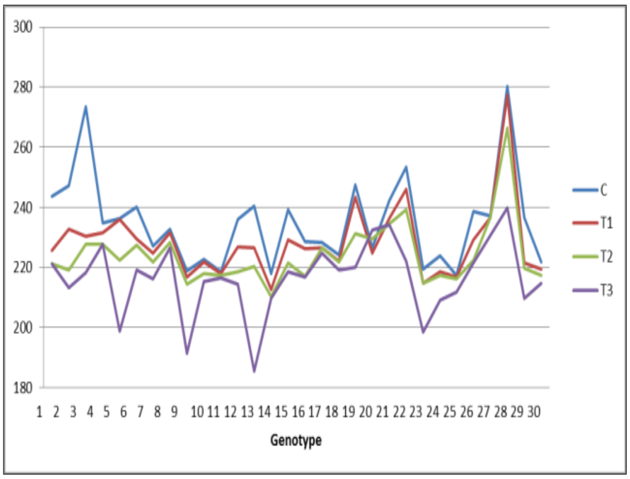

Fig 14 Effect of moisture stress on stomatal conductance

Statistical analysis

The mean values were computed for each genotype over three replications for each genotype. The variances and the corresponding standard errors of the mean were computed from the deviations of the individual values [3].

The results obtained for biometric and yield characters viz. plant height, days to first flowering, days to 50 % flowering, number of clusters per plant, number of pods plant^{-1}, number of seeds pod^{-1}, 100 seed weight, seed yield plant^{-1} and four gas exchange parameters viz. leaf photosynthetic rate

(Pn), transpiration rate (Tr), stomatal conductance (Cs) and intercellular CO_2 concentration (Ci).

The results indicated that biometric, yield (Fig 1–10) and gas exchange parameters (Fig 10–14) studied were significantly affected by moisture stress conditions. Water stress induced at both vegetative and reproductive stages showed significant dragging effect for all the traits viz. plant height, days to first flowering, days to fifty per cent flowering, number of clusters per branch, number of pods per cluster, number of seeds per pod, 100 seed weight, pod weight, pod length, seed yield per plant, photosynthetic rate, transpiration rate, stomatal conductance and intercellular CO_2 concentration respectively.

Among the biometric parameters, plant height for control ranged from 19.6 cm to 57.9 cm among the genotypes MASH 114 and LBG 752. The genotypes LBG 752 (57.9 cm), followed by GBG 1 (54.7 cm) and ADT 4 (51.6 cm) have recorded maximum plant height in control as well as treatments. The mean performance for days to first flowering ranged from 27 days to 35 days in the genotypes viz. VBN 3, VBN 4, ADT 4, ADT 5 and Goldstar under control. Earliest flowering were recorded in VBN 3, VBN 4, ADT 4 and ADT 5. The same trend was observed for the trait days to 50 per cent flowering for both control and treatments [4].

Higher biometric parameters under moisture stress condition may be due to enhanced photosynthetic processes as evidenced by increased photosynthetic rate and intercellular CO_2 concentration which may be the inherent potential of the genotype [5]. Moisture stress had significant reduction in all yield related traits, such as number of clusters per branch, number of pods per cluster, number of seeds per pod, 100 seed weight, pod weight, pod length and seed yield per plant. However, moisture stress induced during vegetative and reproductive stages was much pronounced by their imminent dragging effect on yield compared to control. The trait number of clusters per branch ranged from 1.82 to 3.68 among the genotypes MASH 114 and VBN 4 for control and whereas among the treatments, moisture stress at vegetative stage recorded 1.22 to 2.73 number of clusters per branch in the genotypes MASH 114 and IPU 94-1, moisture stress at reproductive stage recorded from 0.91 to 2.53 among the genotypes CO8 and IPU 94-1 whereas moisture stress at both vegetative and reproductive stages recorded from 0.47 to 2.16 number of clusters per branch among the genotypes CO 8 and LBG 806.

The trait number of pods per cluster ranged from 1.96 to 5.84 among the genotypes BG-SRI and NRIB002 under control, whereas among the treatments, moisture stress induced at vegetative stage produced 1.53 to 4.66 pods per cluster among the genotypes VBN 5 and ADT 4, moisture stress at reproductive stage recorded 1.23 to 4.51 pods per cluster among the genotypes T 9 and ADT 4, and moisture stress induced at both vegetative and reproductive stages recorded 0.68 to 4.24 pods per cluster among the genotypes MASH 114 and ADT 4 respectively. The same trend was observed for the traits viz. number of seeds per pod, 100 seed weight, pod weight and pod length. Effect of moisture stress on yield per plant ranged from 7.62 to 16.23 g among the genotypes VBN 5 and NRIB002 in control plants, whereas among the treatments, moisture stress induced at vegetative stage recorded 5.97 g (GBG 1) to 15.42 g (NRIB002), moisture stress at reproductive stage recorded 4.42 g (MASH 114) to 13.32 g (VBN 7) and in moisture stress induced at both vegetative and reproductive stages produced 3.61 g (MASH 114) to 11.72 g (NRIB002). Even under heavy moisture stress, the genotypes NRIB002, VBN 7 and ADT 4 were found promising. Higher seed yield may be attributed to increased yield parameters like more number of branches, more number of pods plant^{-1}, seeds pod^{-1} and 100 seed weight which may be due to the genetic makeup of the seed [6].

Not only growth and yield but physiological traits such as, photosynthetic rate, transpiration rate, stomatal conductance and intercellular CO_2 Concentration were also affected by moisture stress. Photosynthesis is one of the most vital physiological processes contributing to plant growth and productivity by enhancing dry matter. However, rate of photosynthesis is adversely affected by different abiotic conditions leading to reduced plant growth and yield. In the present study also, photosynthetic rate was significantly reduced due to moisture stress imposed at both vegetative and reproductive stages when compared to control. The photosynthetic efficiency ranged from 59.3 mg CO_2 m^{-2} s^{-1} to 84.7 mg CO_2 m^{-2} s^{-1} for control, whereas among the treatments, moisture stress at vegetative stage recorded photosynthetic rate of 58.7 mg CO_2 m^{-2} s^{-1} to 80.6 mg CO_2 m^{-2} s^{-1}, moisture stress at reproductive stage recorded from 57.1 mg CO_2 m^{-2} s^{-1} to 77.6 mg CO_2 m^{-2} s^{-1} and in moisture stress induced at both vegetative and reproductive stages, it ranged from 56.8 mg CO_2 m^{-2} s^{-1} to 72.5 mg CO_2 m^{-2} s^{-1} for the genotypes BG-SRI and GBG 1 respectively. Similar trend was noted for transpiration rate, stomatal conductance and intercellular CO_2 concentration.

Stomatal regulation of photosynthesis in plant s is an avoidance mechanism for reducing water losses during drought [7]. Moderate water deficits almost lead to decreased stomatal conductance in C_3 plants like mungbean [8]. Increasing water deficit, stomata closes in response to a decreased turgor and/or leaf water potential [9]. Drought frequently causes rapid closure of stomata, thus reducing water loss through transpiration which leads to decrease of internal CO_2 concentration and a decline in leaf photosynthesis [10]. Hence, inhibition or damage in the photosynthetic machinery may occur [11]. The low intercellular CO_2 concentration suggests that photosynthesis is limited by atmospheric CO_2 diffusion to the sub stomatal cavity due to stomatal closure. Stomatal conductance is a key variable influencing leaf gas and water vapor exchange. The effects of drought stress on leaf growth, stomatal conductance and plant water relations have been well addressed in soybean [12].

Genotypic differences in the ability to keep stomata open despite internal water stress in soybean has been reported by [13]. They also reported that legumes such as green gram (*Vigna radiata*), black gram (*Vigna mungo*) and cowpea (*Vigna unguiculata*) exhibited better stomatal control over water loss when compared with soybean [14].

SUMMARY

Thirty black gram genotypes were screened for moisture stress tolerance by subjecting them to induced moisture stress condition at different growth stages viz. vegetative, reproductive and both at vegetative and reproductive stages under pot culture. The observations on biometric and yield characters viz. plant height, days to first flowering, days to 50% flowering, number of clusters per plant, number of pods plant^{-1}, number of seeds pod^{-1}, 100 seed weight, seed yield plant^{-1} and four gas exchange parameters viz. leaf photosynthetic rate (Pn), transpiration rate (Tr),

stomatal conductance (Cs) and intercellular CO_2 concentration (Ci) were recorded. The results revealed that among the genotypes studied, NRIB002, VBN 7 and ADT 4 were found promising under induced moisture stress condition at both vegetative and reproductive stages. To conclude, moisture stress induced at both vegetative and reproductive stages, the genotypes NRIB002, VBN 7 and ADT 4 were found promising. Hence these genotypes can utilize in further breeding programme for Abiotic stress tolerance and /or also for selection.

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