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Effect of GABA on Morphology, Yield and Yield Attributes in Black Gram (*Vigna mungo* (L.) Hepper) Under Salt Stress Condition

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ABSTRACT

A study was carried out in the Department of Plant physiology, Banaras Hindu University, Varanasi to investigate the effect of GABA on morphological characters and yield attributes of black gram. The results revealed that the maximum Plant height was observed at all the growth stages 30, 45, 60 DAS for T_3 (NaCl 50mM + GABA 70mM) compared to all other treatments respectively. Least plant height was recorded in T_8 (NaCl 100mM). GABA gives its best result when stress is present such as salt stress, higher total plant dry matter weight recorded for T_3 (NaCl 50mM+GABA 70mM) over all other treatment at 30 DAS, 45 DAS and 60 DAS. Least plant dry weight was recorded in T_8 (NaCl 100mM) and the highest number of pods per plant was recorded in T_3 (NaCl 50mM+GABA 70mM) over all other treatment at 45 DAS and 60 DAS . The least number of pods per plant was recorded in T_8 (100mM NaCl). The data pertaining to grain yield per plant .The maximum grain yield 3.9g was recorded in T_3 which was significantly superior over all other treatment and control was recorded.

Key words: *Black gram, effect of GABA, Nacl, Salt stress Condition, Morphological parameter.*

INTRODUCTION

India is the largest producer and consumer of pulses in the world. However pulse production has been stagnant at between 11 and 14 million tons over the last two decades. Per Capita pulses consumption over the years has come down from 61 g/day in 1951 to 30 g/day in 2008. It emphasises the expansion of area under short duration varieties, development of multiple disease/pest resistance varieties, use of micro-nutrients like zinc and sulphur and increase in area under rabi pulse crops to increase pulse production. The minimum support price is not effective for pulse crop, prevailing market prices should be taken into account while fixing the MSP to bridge the gap between demand and supply. In India, the area, production and productivity of pulses were 25.23 million hectares, 19.27 million tons and 764 kg per hectare, respectively during 2013-14[1]. The black gram in India is mainly grown in the states of Madhya Pradesh, Uttar Pradesh, Bihar, Punjab, Maharashtra, West Bengal and Tamilnadu. Black gram is mostly grown as a rainfed crop during summers in Northern India and in winters in Peninsular and Southern India with increase in irrigation potential, the area under blackgram cultivation has registered an increase in recent years.

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The production of pulses, in general black gram in particular, has not been able to keep pace with the rapid increase in demand by ever increasing population. This has resulted in decreasing trends of their per capita availability. The low productivity of black gram is attributed to low yield potential plant architecture, excessive vegetable growth, high rate of flower and fruit drop, non- synchronous maturity, pod shattering in some cultivars and above all and susceptibility to insect and pests. Lack of good quality seeds and crop management, extremely limited use of rhizobial cultures, phosphate fertilizers and fungicides also contribute to all this attracts our attention towards the major possible causes which contribute towards the low productivity of pulses in India. Recent studies have revealed that the molecular and metabolic response of plant to a combination of drought and heat is unique and cannot be directly extrapolated from the response of plants to each of these different stresses applied individually Gamma-Aminobutyric acid (GABA) is a four-carbon non-protein amino acid conserved from bacteria to plants and vertebrates. It was discovered in plants more than half a century ago, but interest in GABA shifted to animals when it was revealed that GABA occurs at high levels in the brain, playing a major role in neurotransmission. Thereafter, research on GABA in vertebrates focused mainly on its role as a signalling molecule, particularly in neurotransmission. In plants and in animals, GABA is mainly metabolized via a short pathway composed of three enzymes, called the GABA shunt because it bypasses two steps of the tricarboxylic acid (TCA) cycle. The pathway is composed of the cytosolic enzyme glutamate decarboxylase (GAD) and the mitochondrial enzymes GABA transaminase (GABA-T) and succinic semi aldehyde dehydrogenase (SSADH). The regulation of this conserved metabolic pathway seems to have particular characteristics in plants. Indeed, interest in the GABA shunt in plants emerged mainly from experimental observations that GABA is largely and rapidly produced in response to biotic and abiotic stresses. The GABA shunt has since been associated with various physiological responses, including the regulation of cytosolic pH, carbon fluxes into the TCA cycle, nitrogen metabolism and deterrence of insects, protection against oxidative stress, osmoregulation and signaling recent evidences and experiment, mainly from Arabidopsis functional genomic approaches, pointing towards the possible role of GABA as a signal molecule in plants, as well as roles in plant responses to stress and in the carbon: nitrogen (C:N) balance.[2] GABA has been found in virtually every plant and plant part that has been examined. This contrasts sharply with the highly restricted distribution of other non-protein amino acids. Plants respond to environmental stresses, and a role for GABA in stress responses would help to explain its ubiquitous distribution. If GABA has a stress related function, then levels would be expected to be greatest in tissues exposed to stress. This reviewed by [2] reports that the GABA content of aerobically soaked seeds was seven times higher than that of anaerobically soaked seeds. Likewise, the GABA content of aerobically grown tobacco cultures was reportedly higher than that of cells grown anaerobically[3]. GABA content of stressed and nonstressed tissues has consistently found higher levels of GABA associated with stressed tissue.

MATERIALS AND METHODS

A pots experiment was carried out at the net house of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi with one Urdbean genotypes (PU-31) consisting nine treatments and three replications during *Kharif* season 2015. Soil was collected from Experimental Farm, Institute of Agricultural Sciences, Banaras Hindu University. It was cleaned by removing the stone weeds and the soil to be used in the pots were dried, powdered and mixed thoroughly. The pots were washed with tap water and then kept for drying. The outlet present in the bottom of the plastic pots was regulated in such a way that they drain out the

excess of water after that Urdbean seeds were surface sterilized with 0.01% $HgCl_2$ for 3–5 minutes and subsequently washed in sterilized distilled water 3–4 times and air dried. Seeds were sown into 27 plastic pots. The depth of sowing was 5 cm. The pots were watered 4 to 5 days interval and the soil was fertilized in order to ensure healthy growth of the seedlings. Twenty-seven pots of plastic (20 × 20) were kept under net house condition and consistent care and precaution was taken. Seedlings were maintained at normal supply of moisture. Plants were watered with tap water 4 to 5 days interval early in morning. Treatment of GABA was given after sowing foliar spray-Control(without treatment) (T0), NaCl + GABA(50mM + 50mM) (T1), NaCl + GABA (100mM + 50mM) (T2), NaCl + GABA (50M + 70mM), (T3), NaCl + GABA (100mM + 70mM) (T4), GABA (50mM) (T5), GABA (70mM) (T6), NaCl (50mM) (T7), NaCl (100mM) (T8). Observations on different morphological parameters were recorded after 30, 45 and 60 DAS. Each pot containing five plants were taken as one replication for determination of morphological and growth parameters plant height of one plant, from each treatment and under each replication was measured in centimetre from the base of the plant to the growing tip of the main shoot with the help of a meter scale and expressed in cm. The plant height of three plants (one from each replication) was averaged to obtain the height of per plant for each treatment. Plant heights were measured at 30, 45 and 60 days after sowing. All the plant parts (shoot and leaves) of plants were well washed and the dry weight of cleaned plant samples recorded after putting them into an electric oven, first at the temperature of 110^0 C for an hour to kill the metabolic activities followed by the constant temperature of 70^0 C for a period of 72 hours. Regular weighing was made on digital electronic balance till a constant dry weight of the plant material was attained. The plant dry weight was recorded 30, 45 and 60 days after sowing. Statistical analysis done by adopting method of "Analysis of Variance" for completely randomized design. Critical difference was calculated at 1 per cent and 5 per cent level of significance in order to compare treatment means.

RESULTS AND DISCUSSION

Morpho-physiological attributes

Plant Height (cm)

Significant differences were observed in plant height among different treatment as presented in Table1. The maximum Plant height was observed at all the growth stages 30, 45, 60 DAS for T_3 (NaCl 50mM + GABA 70mM) compared to all other treatments respectively. Least plant height was recorded in T_8 (NaCl 100mM). GABA gives its best result when stress is present such as salt stress, (as listed in Table.1). In treatment T_3 (NaCl 50mM + GABA 70mM) plant height was more as compare to T_4 (NaCl 100mM + GABA 70mM) followed by T_1 (NaCl 50mM+GABA 50) and T_2(NaCl 100mM+GABA 50mM) showing that GABA gives its best result under stress condition. In treatment where GABA alone is applied plant height increase as compare to T_0 (control). Similarly in treatment where NaCl alone is applied plant height decreases. Plant height increased from 30 DAS to 45 DAS and 60 DAS in all the treatments and at slower rate till harvest. The GABA treated plants showed increased plant height than that of control Reduction in shoot growth due to salinity is commonly expressed by a reduced leaf area and stunted shoot[4].

Plant Dry Matter (gplant^{-1})

There was significantly higher total plant dry matter weight recorded for T_3 (NaCl 50mM + GABA 70mM) over all other treatment at 30 DAS, 45 DAS and 60 DAS (Table 2.). Least plant dry weight was recorded in T_8 (NaCl 100mM). In treatment T_3 (NaCl 50mM + GABA 70mM) plant dry weight was more as compare to T_4 (NaCl 100mM + GABA 70mM) followed by T_1 (NaCl 50mM + GABA 50) and T_2 (NaCl 100mM + GABA 50mM) showing that GABA gives its best result under stress condition. In treatment where GABA alone is applied plant dry weight increase as compare to T_0 (control). Similarly in treatment where

NaCl alone is applied plant height decreases. Plant dry weight increased from 30 DAS to 45 DAS and 60 DAS in all the treatments and at slower rate till harvest. Plant height, stem diameter, dry weight decreased with increasing levels of salinity[5,6]. Total dry matter production was significantly influenced by the application of different doses of GABA on urdbean. The result is supported by the result of [7]who reported that the application of GABA (range 0.5-2.0 mgL^{-1}) increased total dry matter over control in groundnut with being the highest in 2.0 mgL^{-1} GABA application at 45 DAS. Similar results were also reported by Dakua[8] in lentil and Rahim[9] in soybean.

Number of pods Plant^{-1}

The highest number of pods per plant was recorded in T_3 (NaCl 50mM + GABA 70mM) over all other treatment at 45 DAS and 60 DAS (Table 3.). The least number of pods per plant was recorded in T_8 (100mM NaCl). The treatments T_4 and T_1, T_2 were found significantly superior to T_5 and T_6 at 45 and 60 DAS. Similarly in treatment where NaCl alone is applied number of pods per plant decrease in treatments T_7 and T_8. Soil salinity caused reduction in flowering and severe yield loss in many crop plants including legumes viz., soyabean, mungbean, wheat, barley, bean, rice and cotton[10] decreased number of pods in alone treatment (NaCl 50mM and NaCl 100mM). The result of the present study is similar to the findings of [11] who carried out field experiment to study the effect of salinity on number of pod plant^{-1} of mungbean and that increasing salinity decreased number of pods plant^{-1}.

Test weight (1000 Grain weight) and Grain Yield Plant^{-1} (g)

The highest 1000 grain weight was recorded in T_3 (NaCl 50mM+GABA 70mM) over all other treatment at after harvesting. The least 1000 grain weight was recorded in T_8 (100mM NaCl). The treatments T_4, T_1 and T_2 were found significantly superior to T_5 and T_6 at after harvesting. Similarly in treatment where NaCl alone is applied 1000 grain weight decrease in treatments T_7 and T_8. (Table 4.). The data pertaining to grain yield per plant expressed in grain is presented in Table 4 .The maximum grain yield 3.9g was recorded in T_3 which was significantly superior over all other treatment and control was recorded. The least grain weight 2.083g the treatments T_4, T_1 and T_2 were found significantly superior to T_5 and T_6. Similarly in treatment where NaCl alone is applied grain yield per plant decrease in treatments T_7 and T_8. The effect of GABA at different concentration increased the graint yield plant^{-1} of urbean This result is supported by Sultan[12] , In our study, decreased grain yield plant^{-1} in alone treatment (NaCl 50mM and NaCl 100mM).[13] carried out a field experiment found that similar decrease in seed yield with

Table 1: Effect of GABA on Plant height (cm) in blackgram (*Vigna mungo* (L.) under salt stress condition

Treatment	30 DAS	45 DAS	60 DAS
	Mean	Mean	Mean
T_0	17.13	32.17	45.50
T_1	18.70	34.46	46.65
T_2	17.84	32.96	46.00
T_3	21.34	37.68	47.98
T_4	20.83	35.65	46.99
T_5	17.16	32.65	45.45
T_6	17.96	33.53	45.82
T_7	13.59	31.03	44.99
T_8	12.29	29.10	44.01
SEm±	0.43	0.54	0.58
CD at 1%	1.30	1.63	1.73

T_0 = Control, T_1 = Nacl+GABA (50mM+50mM) T_2 = Nacl+GABA (100mM+50mM) T_3 = NaCl+GABA (50mM+70mM) T_4 = NaCl+GABA (100mM+70mM) T_5 = GABA ((50mM) T_6 = GABA (70mM) T_7 = NaCl (50mM) T_8 = NaCl (100mM)

Table 2: Effect of GABA on drymatter g plant $^{-1}$ in leaves of on blackgram (*Vigna mungo* (L.) under salt stress condition

Treatment	30 DAS	45 DAS	60 DAS
	Mean	Mean	Mean
T_0	1.70	2.03	2.23
T_1	2.13	2.70	3.40
T_2	1.93	2.53	3.20
T_3	2.46	3.13	3.70
T_4	2.26	2.86	3.50
T_5	1.73	2.10	2.40
T_6	1.93	2.50	2.80
T_7	1.33	1.66	1.76
T_8	1.13	1.46	1.56
SEm±	0.083	0.075	0.064
CD at 1%	0.249	0.223	0.191

T_0 = Control, T_1 = Nacl+GABA (50mM+50mM) T_2 = Nacl+GABA (100mM+50mM) T_3 = NaCl+GABA (50mM+70mM) T_4 = NaCl+GABA (100mM+70mM) T_5 = GABA ((50mM) T_6 = GABA (70mM) T_7 = NaCl (50mM) T_8 = NaCl (100mM)

Table 3: Effect of GABA on number of pod plant^{-1} on blackgram (*Vigna mungo* (L.) under salt stress condition

Treatment	45 DAS	60 DAS
	Mean	Mean
T_0	19.00	32.33
T_1	21.00	33.00
T_2	19.66	32.33
T_3	22.00	36.00
T_4	21.66	34.33
T_5	19.33	31.33
T_6	20.66	31.66
T_7	14.66	27.00
T_8	13.00	26.66
SEm±	0.875	0.720
CD at 1%	2.62	2.15

T_0 = Control, T_1 = Nacl+GABA (50mM+50mM) T_2 = Nacl+GABA (100mM+50mM) T_3 = NaCl+GABA (50mM+70mM) T_4 = NaCl+GABA (100mM+70mM) T_5 = GABA ((50mM) T_6 = GABA (70mM) T_7 = NaCl (50mM) T_8 = NaCl (100mM)

Table 4: Effect of GABA test wt (1000 Grain weight) and grain yield plant^{-1} (g) in blackgram (*Vigna mungo* (L.) under salt stress condition

Treatment	test wt (1000 Grain weigh)(g)	grain yield plant^{-1} (g)
	Mean	Mean
T_0	37.81	3.41
T_1	41.04	3.63
T_2	40.13	3.50
T_3	44.60	3.93
T_4	42.06	3.73
T_5	38.71	3.43
T_6	39.02	3.54
T_7	35.97	2.51
T_8	34.63	2.08
SEm±	0.807	0.142
CD at 1%	2.417	0.424

T_0 = Control, T_1 = Nacl+GABA (50mM+50mM) T_2 = Nacl+GABA (100mM+50mM) T_3 = NaCl+GABA (50mM+70mM) T_4 = NaCl+GABA (100mM+70mM) T_5 = GABA (50mM) T_6 = GABA (70mM) T_7 = NaCl (50mM) T_8 = NaCl (100mM)

CONCLUSION

Plant height showed an increase with increasing GABA concentration. Plant height was found maximum at all the growth stages 30, 45, 60 days after sowing (DAS) for T_3 (NaCl 50mM + GABA 70mM) compared to all other treatments respectively. There was significant increase in higher total plant dry matter weight recorded for T_3 (NaCl 50mM + GABA 70mM) over all other treatment at 30, 45 and 60 DAS. The data on number of pods plant^{-1} significant differences between the treatments, highest pods plant^{-1} was observed in T_3 which is significantly higher than other treatments. There was a significant difference recorded for 1000 grain weight among the treatment and over control which is significantly highest T_3 recorded 1000 grain weight (Test weight). Similarly the maximum grain yield 3.9.g was recorded in T_3 which was significantly superior over all other treatment and control was recorded.

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