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Physiological characterization of green gram (*Vignaradiata* L.) genotypes for drought and salt stress tolerance

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Abstract

The production and productivity of several crops continues to be adversely affected due to various biotic and abiotic stress. With rise in atmospheric temperature, the biotic and abiotic stresses are predicted to become more severe and adversely affect the stability and productivity in pulse crops. The abrupt climatic change, particularly the erratic rainfall is one of the major causes for reduction of pulse production in India. Drought is the major constraints faced in rain fed areas so screening of genotypes for drought tolerance is the need of the day, by using physiological traits as a parameter. Drought during the late vegetative period (Trifoliate leaf formation) is tolerance in legume plants. Salinity in agricultural field is thus a severe constraint to crop growth and productivity in many regions and the situation as become a global concerns. *In vitro* drought and salt screening methods facilitates progress in our understanding of drought and salt resistance in pulse crop. The higher molecular weight substance poly ethylene glycol (PEG) causes osmotic shock which is one of the component to induce drought. Three green gram varieties were used for screening study. The green gram varieties VBN 2, ADT3, CO 8 were screened for tolerance to four levels of drought stress created by using poly ethylene glycol (PEG6000). Drought stress was applied in four concentrations of PEG 6000 that provide solutions with water potential equal to -0.1 MPa, -0.2 MPa, -0.3 MPa, -0.6 MPa. For imposing salt stress $NaHCO_3$ solution of 25mM and 50mM were prepared and compared with control. The statistical design adopted is FCRD. *In vitro* condition the following parameters Viz., Germination percentage, Shoot and root length, vigour index and stress tolerance index was measured. Based on the drought and salt tolerance screening results revealed that with increasing concentrations of PEG and salts lead to decrease in seedling growth. Seed germination and seedling growth are major factors deciding the establishment of crops under stress conditions. Among these varieties VBN 2 recorded higher stress tolerance index followed by ADT 3 and CO 8. To conclude the tolerant greengram genotype could effectively utilized in hybridization programme to develope drought and salt tolerant greengram genotype.

Keywords: Physiological, green gram, salt stress tolerance

Introduction

India is a major pulse growing country in the world, which shares 33% and 28% of the global area and production respectively. Pulses are the major source of protein in Asia and constitute an important supplement to the cereal based diet. With rise in atmospheric temperature, the biotic and abiotic stresses are predicted to become more severe and adversely affect the stability and productivity in pulse crops. The abrupt climatic change, particularly the erratic rainfall is one of the major causes for reduction of pulse production in India. Occurrence of drought during very early vegetative stage impaired the seed germination and plants stand establishment. Drought during the late vegetative period (Trifoliate leaf formation) is tolerance in legume plants. Moisture stress during reproductive stage is often the most critical phase reduced the yield by 43.4% by reduced photosynthetic rate and distributed the activity of various enzymes (Subbaramamma *et al*., 2017) [9].

In vitro drought screening methods facilitates progress in our understanding of drought resistance. The higher molecular weight substance poly ethylene glycol (PEG 6000) causes osmotic shock which is one of the components of drought (Nandi and Bera, 1995) [6]. Among the pulse crop, Green gram is stagnant production because of susceptibility to biotic and abiotic stress at different growth stages. Among the abiotic stress, next to drought, saltstress is more atrocious limiting factor. About 37% of world cultivated area issodic, 23% is saline (Nirmalasehrawat, Mukeshyadav (2015) [7]. The soil salinity may cause several deleterious effect on growth and development of plants at physiological and biochemical level (Munns, 2002) [5].

Seed germination and seedling growth are major factors deciding the establishment of crops under saline conditions (Kitajima and Fenner, 2000) [3]. Salinity may cause significant reductions in germination leading to reduced crop yields. Salt tolerance at germination stages is important factor. High concentration of salts has detrimental effects on germination of seeds (Saboora and Kiarostami, 2006) [8].

Materials and Methods

The seeds of green gram varieties VBN 2obtained from national pulses research station, Vamban, ADT3 obtained from Tamil Nadu Rice Research Institute, Aaduthurai and CO 8 obtained from KVK, Papparapatti, the details of the study and methodologies are discussed below. Green gram varieties were screened for tolerance to various levels of drought and sodicity stresses based on germination percentage, seedling growth and vigour index. Seeds were allowed to germinate in germination sheet. The *in vitro* study was conducted by roll towel method. The green gram varieties were screened for tolerance to four levels of drought stress created by using poly ethylene glycol (PEG 6000). Drought stress was applied in four concentrations of PEG 6000 that provide solutions with water potential equal to -0.1MPa, -0.2MPa, -0.3MPa, -0.6MPa. PEG solutions were prepared by using the formula described by Michel and Kaufmann (1973). Twenty no of seeds were placed on germination sheet and placed in glass beakers containing osmotic and salt solutions respectively. The beakers were kept in laboratory condition under room temperature for 15 days. The seeds were allowed to germinate by pouring the PEG and salt solution in 5 days. Distilled water was used for maintaining the control and experiment was carried out with three varieties imposed with four drought treatments (-0.1MPa,-0.2MPa, -0.3MPa, -0.6MPa) and two sodicity treatments (25mM and 50mM) and replicated thrice. The statistical design adopted is FCRD. The germin ability was recorded on the fifteenth day after sowing (DAS) and number of seeds germinated was expressed as percent. Shoot length was measured from the collar region to the tip of the longest leaf and expressed as cm. Root length of the seedlings was measured from the base of the stem to the tip of the longest root and expressed as cm. The vigour index of the seedlings was calculated using the following formula proposed by Abdul-Baki and Anderson (1973) and expressed as percent. Stress tolerance index was calculated using the following formula proposed by Dhopte and Livera (1989) and expressed as percent.

Results and Discussion

Germination percentage is one of the growth parameter while observing the effect of drought and sodicity stress of greengram varieties. The observation is taken at 15DAS. Increase the concentrations of PEG and $NaHCO_3$ decline the germination percentage. Among three varieties tested VBN 2 performed better followed by ADT 3 and CO 8. At higher PEG (-0.6MPa) and $NaHCO_3$ (50mM) concentrations VBN 2 recorded the germination percentage of 36.66% and 68.33% (Table 1). Among three varieties, VBN 2 recorded the highest shoot length, root length, vigour index and stress tolerance index followed by ADT 3. In the view of Dutta *et al.,* (2008) [2] and Rajwider *et al*., (2011) in mung bean. There was gradual decrease in germination percentage and shoot length with increased concentrations of PEG and $NaHCO_3$.

Increase the concentration PEG and $NaHCO_3$ decline the root length. Among three varieties tested VBN 2 performed better followed by ADT 3 and CO 8. At higher PEG (-0.6MPa) and $NaHCO_3$ (50mM) concentration VBN 2 recorded the root length of 4.98cm and 8.07cm (Table 2).Shoot length are important criteria in studying the response of plants to drought and sodicity stress. Among three varieties tested VBN 2 performed better followed by ADT 3 and CO 8. At higher PEG (-0.6MPa) concentration VBN 2 recorded the shoot length of 3.30cm and $NaHCO_3$ (50mM) concentration ADT 3recorded the shoot length of 6.89cm (Table 3).

There was decline in seed vigour index with increase the concentrations PEG and $NaHCO_3$. Among three varieties tested VBN 2 performed better followed by ADT 3 and CO 8.At higher PEG (-0.6MPa) and $NaHCO_3$(50mM) concentration VBN 2 recorded the vigour index of 303.54 and 1000.35 (Table 4). Decrease in stress tolerance index was observed with increase in PEG and $NaHCO_3$ Concentration. Among three varieties tested VBN 2 performed better followed by ADT 3 and CO 8. At higher PEG (-0.6MPa) and $NaHCO_3$ (50mM) concentration VBN 2 recorded the higher stress tolerance index of 8.92 and 29.42 (Table 5), (Fig 1) & (Fig 2). Germination is a complex phenomenon involving many physiological and biological changes leading to the activation of embryo. Seed germination is the most critical and sensitive stage of abiotic stresses. Babbar and Dhingra (2007) [1] reported decrease in seed germination and seedling growth rate with increasing levels of salinity in mung bean varieties. Salt stress caused low intra-cellular water potential and water scarcity around the root zone due to which roots failed to absorb sufficient water and nutrients for adequate plant growth (Mohammed, 2007; Sunil *et al.*, 2012) [4, 10].

Table 1: Effect of drought and sodicity on germination percentage of greengram varieties

Varieties	Control	PEG				$NaHCO_3$	
		-0.1 MPa	-0.2 MPa	-0.3 MPa	-0.6 MPa	25mM	50Mm
ADT 3	95.00	50.00	48.30	45.00	35.00	61.66	53.33
VBN 2	93.33	73.30	55.00	51.66	36.66	78.33	68.33
CO 8	95.00	73.30	55.00	43.33	28.30	55.00	36.66
SEd	2.77					3.30	
CD(0.05)	5.82					6.94	

Table 2: Effect of drought and sodicity on of shoot length (cm) of greengram varieties

Varieties	Control	PEG				$NaHCO_3$	
		-0.1 MPa	-0.2 MPa	-0.3 MPa	-0.6 MPa	25mM	50mM
ADT 3	15.04	9.97	6.83	4.51	2.24	9.15	6.89
VBN 2	19.33	13.55	9.32	6.70	3.30	8.80	6.57
CO 8	16.79	12.14	8.80	5.05	3.00	6.96	6.58
SEd	0.27					0.17	
CD(0.05)	0.54					0.35	

Table 3: Effect of drought and sodicity on root length (cm) of greengram varieties

Varieties	Control	PEG				$NaHCO_3$	
		-0.1 MPa	-0.2 MPa	-0.3 MPa	-0.6 MPa	25mM	50mM
ADT 3	13.49	10.60	9.30	8.73	4.63	8.48	6.71
VBN 2	17.10	11.13	8.56	8.70	4.98	9.65	8.07
CO 8	13.10	11.08	7.52	6.48	3.02	7.50	4.76
SEd	0.25					0.05	
CD(0.05)	0.51					0.10	

Table 4: Effect of drought and sodicity on vigour index of greengram varieties

Varieties	Control	PEG				$NaHCO_3$	
		-0.1 MPa	-0.2 MPa	-0.3 MPa	-0.6 MPa	25mM	50mM
ADT 3	2710.35	528.41	779.07	693.00	240.45	1087.06	725.28
VBN 2	3400.01	1809.14	983.40	795.56	303.54	1352.93	1000.35
CO 8	2839.55	1702.72	897.60	285.82	170.00	795.30	415.72
SEd	12.4						
CD(0.05)	24.7						

Table 5: Effect of drought and sodicity on stress tolerance index of greengram varieties

Varieties	PEG				$NaHCO_3$	
	-0.1 Mpa	-0.2 MPa	-0.3 MPa	-0.6 MPa	25 Mm	50mM
ADT 3	19.48	28.74	25.56	8.81	39.10	26.75
VBN 2	53.20	28.92	23.39	8.92	39.79	29.42
CO 8	59.96	31.61	10.06	5.98	28.00	14.64
SEd	0.56					
CD(0.05)	1.12					

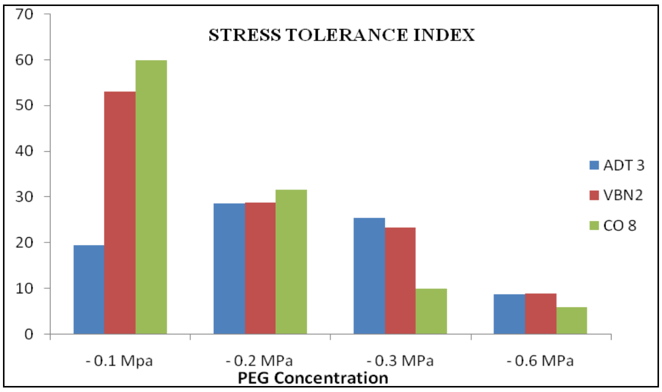

Fig 1: Effect of drought on stress tolerance index of greengram varieties

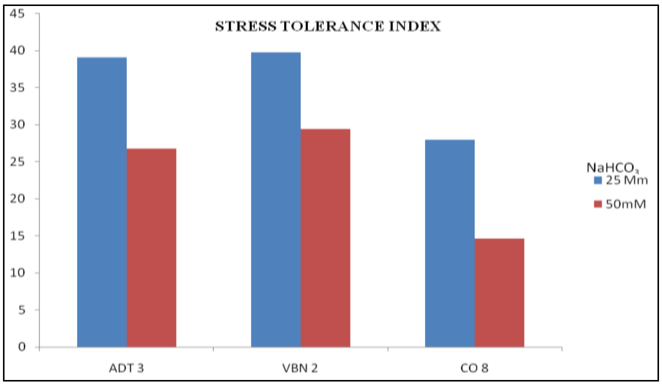

Fig 2: Effect of sodicity onstress tolerance index of greengram varieties

Conclusion

In vitro drought screening methods facilitates progress in our understanding of drought resistance. The higher molecular weight substance polyethylene glycol (PEG) causes osmotic shock which is one of the components of the drought. Seed germination and seedling growth are major factors deciding the establishment of crops under saline conditions.

In laboratory condition the study was conducted to determine the effect of growth parameters by measuring the plant characters like germination percentage, shoot and root length, vigour index and stress tolerance index. By screening the growth parameters results revealed that with increasing concentrations of PEG and salts leads to decrease in seedling growth. Among these varieties VBN 2 recorded higher growth parameters by measuring the plant characters followed by ADT 3 and CO 8.

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