RESEARCH ARTICLE

Screening of Blackgram (*Vigna mungo* L.) Genotypes for Salt Tolerance at the Vegetative Stage

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ABSTRACT

Soil salinity is a major abiotic stress that limits agricultural productivity, especially in arid and semi-arid regions where irrigation is essential. Black gram (*Vigna mungo* L.), an important pulse crop in Southeast Asia, is particularly sensitive to saline conditions. Identification of salt-tolerant genotypes is therefore essential to sustain production in salt-affected areas. The present study aimed to screen seven black gram genotypes at the vegetative stage under controlled pot culture conditions. Salinity stress was imposed at three levels (0, 50, and 100 mM NaCl) in a Randomized Complete Block Design with three replications. Growth and physiological parameters, viz., plant height, number of leaves, shoot and root biomass, relative water content, chlorophyll content, injury score, and survival percentage, were recorded. The results indicated a significant reduction in all the traits under salinity, with marked genotypic variability. Vamban (VBN) 8 and VBN 10 showed better growth, higher RWC and SPAD values, and superior survival percentage under salinity, while ADT 6 and KKM 1 were highly susceptible. The study concludes that VBN 8 and VBN 10 can be promising donors for future breeding programs and potential cultivars in salt-affected environments.

Keywords: Blackgram, Salinity stress, Relative water content, Survival percentage

INTRODUCTION

Soil salinity is a major global challenge, affecting over 20 percent of irrigated lands and threatening food security (FAO, 2021). Factors such as unsustainable irrigation, seawater intrusion, and climate change accelerate salt buildup in soils, thereby reducing crop productivity. Salinity causes both osmotic and ionic stress, restricting water uptake and disrupting nutrient balance through toxic ions such as Na^+ and Cl^- (Munns and Tester, 2008). These effects lead to stunted growth, chlorosis, premature senescence, and severe yield losses (Parihar *et al.*, 2015). Black gram (*Vigna mungo* L.), an important pulse crop for protein supplement and soil fertility improvement in Southeast Asia, suffers greatly under saline conditions. In India, especially in Tamil Nadu and Andhra Pradesh, salinity arising from rice-fallow systems and poor drainage limits productivity to 450–600 kg/ha, far below its potential (ICAR, 2019; DPD, 2020). The vegetative

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stage is highly sensitive to salt stress, affecting canopy development and yield. Therefore, screening genotypes based on plant height, biomass, leaf area, relative water content, chlorophyll content, and survival rate is crucial for identifying tolerance (Sairam and Tyagi, 2004). Exploring genetic variability among cultivars can provide valuable sources for breeding salt-tolerant varieties (Bansal *et al*., 2014). Considering these aspects, the present study aims to assess the effects of salinity on black gram and to identify salt-tolerant genotypes through morphological and physiological traits at the vegetative stage, thereby contributing to breeding strategies for sustainable productivity in saline-prone regions.

MATERIALS AND METHODS

The experiment was conducted during the Rabi season of 2025 at the Plant Breeding and Genetics Laboratory of Nalanda College of Agriculture, Tiruchirappalli, Tamil Nadu, India, located in a semi-arid tropical zone. A Randomized Complete Block Design (RCBD) with a factorial arrangement (Genotype × Salinity level) and three replications was adopted. Seven black gram genotypes *viz.,* Aduthurai (ADT) 6, Killikulam (KKM) 1, VBN 6, VBN 8, VBN 10, VBN 11, and VBN 12 were evaluated under three salinity levels imposed using NaCl solutions: T_0 (0 mM, control), T_1 (50 mM), and T_2 (100 mM), representing moderate to high field salinity (Rengasamy, 2010). Salinity stress was initiated 14 days after sowing and maintained for 21 days through regular irrigation with respective saline solutions. Plants were grown in 3-litre-capacity plastic pots filled with sterilized soil, sand and FYM (2:1:1). A single healthy seedling per pot was maintained, and uniform nutrient application was ensured. The data were recorded for morphological and physiological traits *viz.,* plant height, number of leaves, shoot and root biomass, relative water content (Barrs and Weatherley, 1962), chlorophyll content (SPAD) (Ling *et al*., 2011), visual injury score (Ashraf and Harris, 2004), survival percentage. All data were analyzed using a two-way ANOVA with genotype (G), salinity (S), and the G × S interaction. Mean comparisons were made using Tukey's HSD test ($p \leq 0.05$) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The study evaluated seven black gram (*Vigna mungo* L.) genotypes, *viz.,* ADT 6, KKM 1, VBN 6, VBN 8, VBN 10, VBN 11, and VBN 12, under 0, 50, and 100 mM NaCl to assess genotypic variation in salinity tolerance at the vegetative stage. Plant height and leaf number declined significantly with increasing salinity (Table 1 and Figure 1). At 100 mM NaCl, reductions were highest in ADT 6 and KKM 1 (55–60 percent), while VBN 8 and VBN 10 recorded moderate declines (26–28 percent). Maintenance of vegetative growth under saline conditions indicates better osmotic adjustment and reduced ion toxicity (Munns and Tester, 2008).

Biomass accumulation was markedly affected, with shoot and root dry weights decreasing over 60 percent in susceptible genotypes, whereas tolerant lines (VBN 8, VBN 10) retained ~65 percent of control biomass (Table 2 and Figure 2). Higher biomass retention suggests efficient water uptake and photosynthetic performance under stress (Parida and Das, 2005). RWC declined with salinity, falling below 50 percent in ADT 6 and KKM 1 but remaining around 70 percent in VBN 8 and VBN 12. High RWC reflects superior osmotic adjustment through solute accumulation and improved maintenance of hydration (Sairam and Tyagi, 2004; Ashraf and Foolad, 2007). Chlorophyll content decreased across genotypes, with tolerant ones (VBN 8, VBN 10) maintaining higher readings (34–35) than susceptible ones (20–21)

Table 1. Effect of salinity on the plant height of black gram genotypes under salinity stress

Genotype	Control (0 mM)	50 mM	100 mM	Reduction % at 100 mM
ADT 6	32.1	22.5	14.3	55.4
KKM 1	34.2	23.8	16.1	52.9
VBN 6	31.7	24.6	20.3	35.9
VBN 8	33.9	29.8	26.4	22.1
VBN 10	34.5	28.2	25.0	27.5
VBN 11	32.8	25.0	21.6	34.1
VBN 12	31.9	26.8	23.4	26.7

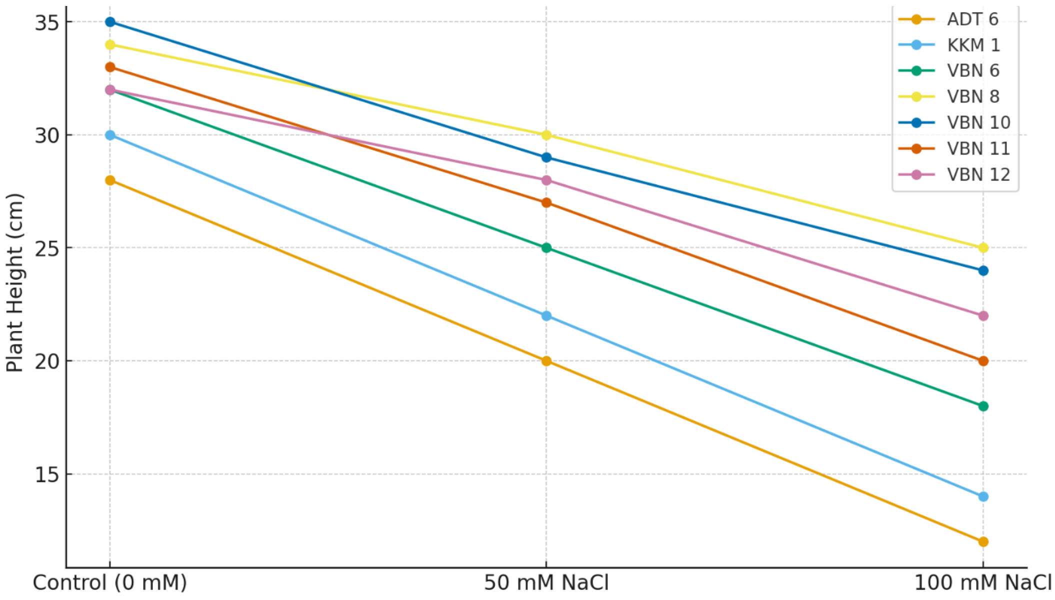

Figure 1. Effect of salinity on the plant height of black gram genotypes

Table 2. Shoot dry weight under salinity stress

Genotype	Control	50 mM	100 mM	% Retention at 100 mM
ADT 6	2.40	1.35	0.77	32.1
KKM 1	2.55	1.48	0.94	36.8
VBN 6	2.31	1.65	1.28	55.4
VBN 8	2.47	2.05	1.68	68.0
VBN 10	2.52	2.00	1.70	67.5
VBN 11	2.33	1.70	1.25	53.6
VBN 12	2.41	1.85	1.45	60.2

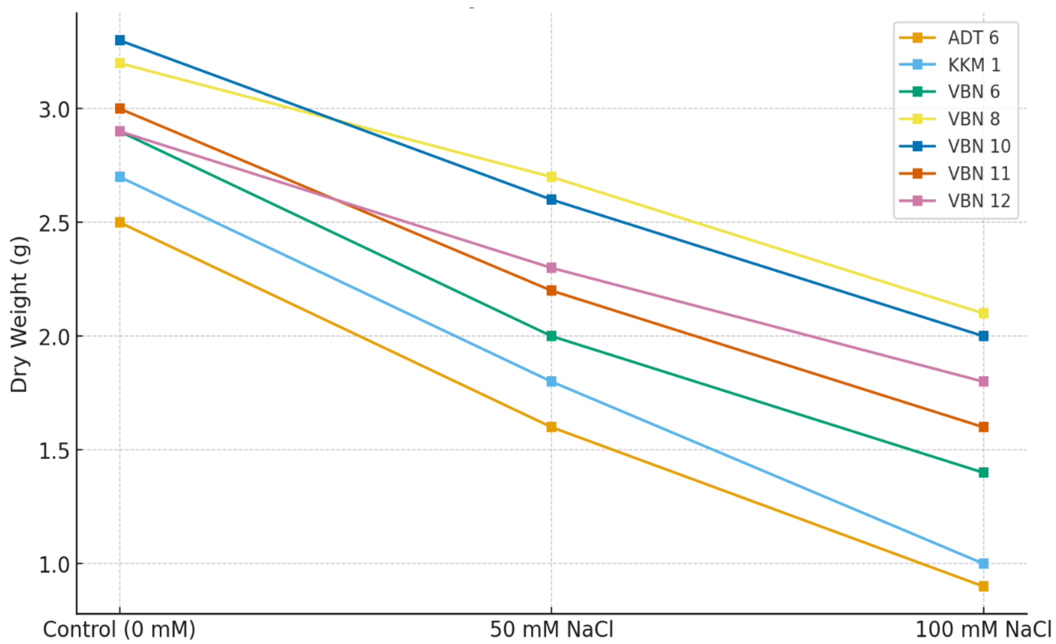

Figure 2. Effect of Salinity on Biomass

(Table 3 and Figure 3). Chlorophyll stability indicates stronger antioxidant protection and sustained photosynthetic activity (Parihar *et al*., 2015). Visual injury and survival percentage varied widely (Table 4 and Figure 4). At 100 mM NaCl, ADT 6 and KKM 1 showed severe leaf necrosis (injury score 8) and <45 percent survival, while VBN 8 recorded an injury score of 3 and 90 percent survival. Survival percentage integrates multiple tolerance mechanisms, including ion regulation and membrane stability (Munns and James, 2003). Overall, salinity stress significantly impaired black gram growth and physiology but marked genotypic variation was evident. VBN 8 and VBN 10 consistently outperformed other genotypes across all parameters, maintaining higher plant height, biomass, RWC, chlorophyll content, and survival percentage, indicating robust tolerance mechanisms. These results align with previous findings in black gram and other legumes (Manivannan *et al*., 2007; Shanthi *et al*., 2021). Traits such as RWC, SPAD value, biomass retention, and survival percentage proved reliable, simple, and cost-effective for screening. Hence, VBN 8 and VBN 10 can serve as promising donors in breeding programs to enhance salinity tolerance in black gram.

CONCLUSION

The present study clearly demonstrated that salinity stress (50 and 100 mM NaCl) significantly impaired growth, biomass accumulation, physiological stability, and survival of black gram genotypes at the vegetative stage, with significant genotype, salinity,

Table 3. Relative Water Content and SPAD values at 14 days after stress

Genotype	RWC Control	RWC 100 mM	SPAD Control	SPAD 100 mM
ADT 6	82.3	48.5	39.1	20.6
KKM 1	84.0	45.3	40.2	21.2
VBN 6	83.1	64.2	38.5	29.8
VBN 8	85.4	71.0	41.0	35.6
VBN 10	84.9	69.2	40.6	34.5
VBN 11	83.0	63.8	38.8	28.5
VBN 12	84.5	70.1	39.9	33.4

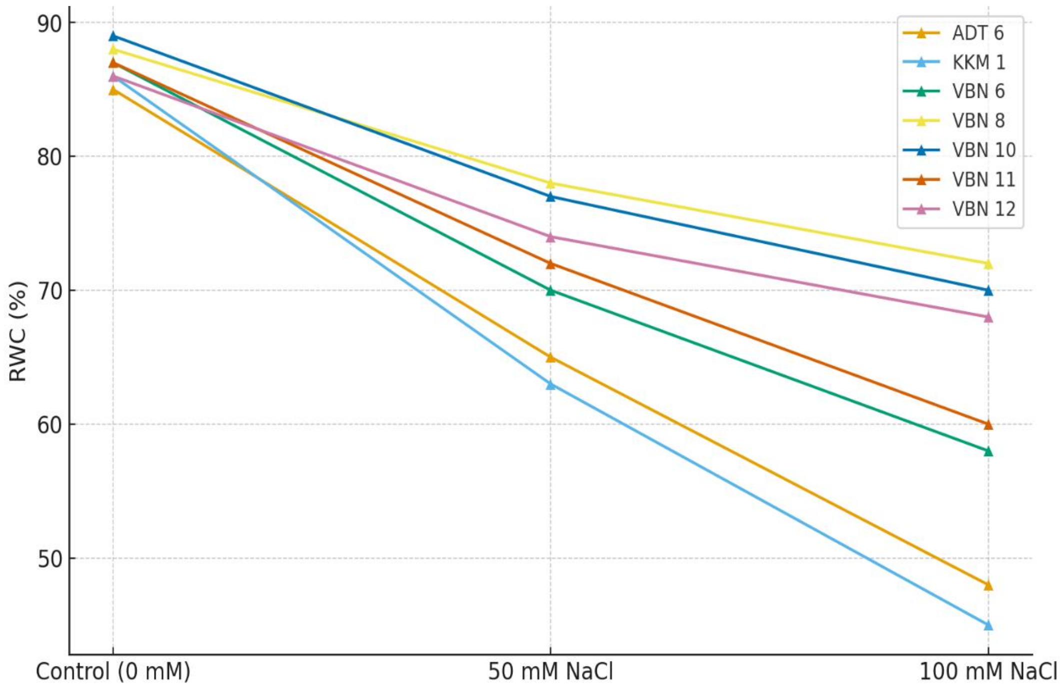

Figure 3. Relative Water Content under Salinity

Table 4. Survival percentage and visual injury score at 100 mM

Genotype	Survival (%)	Injury Score (1–9)
ADT 6	45	8
KKM 1	40	8
VBN 6	70	5
VBN 8	90	3
VBN 10	85	4
VBN 11	72	5
VBN 12	78	4

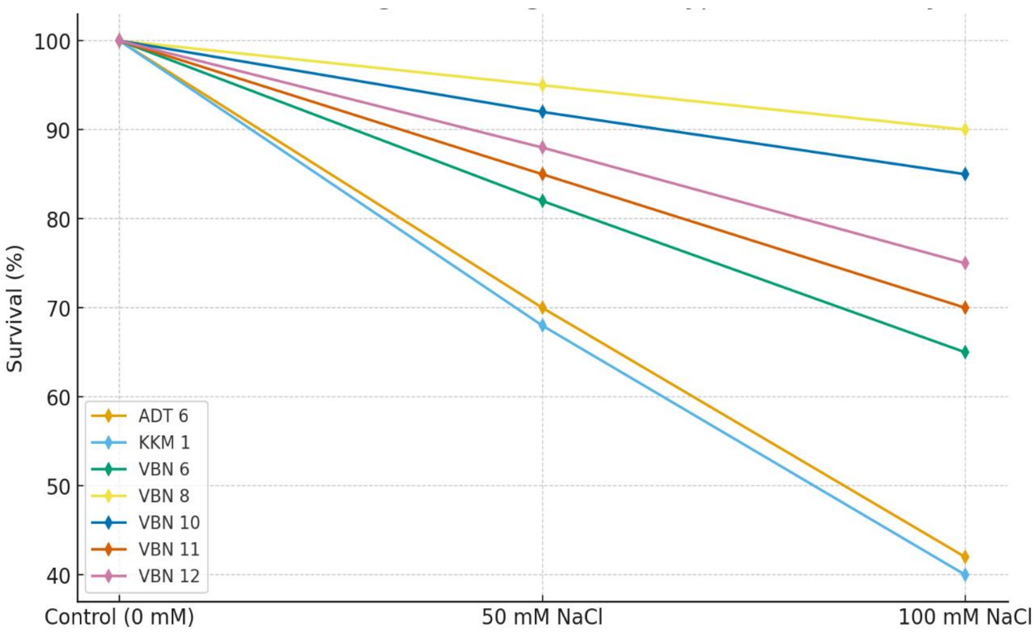

Figure 4. Survival percentage of black gram genotypes under salinity

and G × S interaction effects. Marked genetic variability was observed among the seven genotypes tested, confirming the feasibility of selecting salt-tolerant lines at early growth stages. Among them, VBN 8 and VBN 10 consistently maintained higher plant height, biomass retention, relative water content, chlorophyll content, and survival percentage with lower injury scores under 100 mM NaCl, indicating superior osmotic adjustment and stress tolerance mechanisms. In contrast, ADT 6 and KKM 1 were highly susceptible, exhibiting severe reductions in growth and physiological performance. The findings establish that traits such as RWC, SPAD value, biomass retention, and survival percentage are reliable and practical screening indices for salinity tolerance in black gram. Overall, VBN 8 and VBN 10 can serve as promising donor parents for breeding salt-tolerant cultivars suited to salt-affected regions. Future work may focus on multi-location field validation, biochemical and ionic profiling, and molecular characterization to strengthen breeding applications.

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Ethics Statement

The research involved only plant materials (black gram genotypes) grown under controlled pot culture conditions. Therefore, ethical approval was not required.

Originality and Plagiarism

The authors affirm that this manuscript is an original work and has not been published previously nor is it under consideration for publication elsewhere. All sources of information have been properly cited. The manuscript complies with the journal's plagiarism policy

Consent for Publication

All authors have read and approved the final version of the manuscript and agree to its submission and publication in the journal.

Competing Interests

The authors declare that they have no competing financial or non-financial interests that could have influenced the outcomes or interpretation of this research.

Data Availability

All data generated or analyzed during this study are included within the manuscript. Any additional information related to the dataset is available from the corresponding author upon reasonable request.

Author Contributions

M. Venkatesh and A. L. Nivetha conceptualized and designed the study, analyzed the data, interpreted the results and prepared the initial draft of the manuscript. B. Gokulraj and A. S. Pavithra conducted the experiments and collected the data. Mohan Raj corrected the draft and finalized the manuscript. All authors contributed to manuscript revision, approved the final version, and agreed to its submission.

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