



# An Incubation Experiment on Screening of Black Gram Varieties for Tolerance to Saline Irrigation Water

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

Water is a second most important resource in agriculture followed by land. The water availability for irrigation is often scarce, is one of the most critical input for agriculture production in most areas. Productivity in these areas can be enhanced by better management of rainwater and /or development of groundwater. So the present investigation was carried out to study the effect of saline water irrigation on the growth of blackgram. The various treatment included in the study were three ruling varieties of blackgram as factor V viz., V<sub>1</sub>- VBN 6, V<sub>2</sub>- VBN 4 and V<sub>3</sub>- VBN 3 and four salinity levels as factor S viz., S<sub>1</sub>-EC-3 dS m<sup>-1</sup> and Sodium Absorption Ratio (SAR) - 4; S<sub>2</sub>-EC- 3 dS m<sup>-1</sup> and SAR-6; S<sub>3</sub>-EC-3 dS m<sup>-1</sup> and SAR-8; S<sub>4</sub>-EC-6 dS m<sup>-1</sup> and SAR-6. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications. The results of the study concluded that the soil application of saline water (EC-3 dS m<sup>-1</sup> and SAR-4) irrigation to saline tolerant blackgram variety VBN 3 (S<sub>1</sub>V<sub>3</sub>) was identified as best treatment combination to realize the maximum germination of blackgram under saline water irrigation.

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## 1. INTRODUCTION

The presence of excessive concentration of soluble salts in the soil is defined as salinity, which is harmful plant growth. In more specific definition soil with low pH (<8.5), high Electrical Conductivity ( $EC > 4.0 \text{ dS m}^{-1}$ ) and low Exchangeable Sodium Percentage (ESP <15%). The main salt present in saline soil is NaCl. However, some other salts like  $\text{Na}_2\text{SO}_4$ ,  $\text{MgSO}_4$ ,  $\text{CaSO}_4$ ,  $\text{MgCl}_2$  and KCl are also present. The deleterious effects of salinity on plant growth are associated with: 1. Low osmotic potential of soil solution (water stress), 2. Nutritional imbalance, 3. Specific ion effect (salt stress), or a combination of these above factors Rajagopal et al. [1]. Nowadays, the competition for freshwater in the development of urbanization, industry and agriculture caused the decline of fresh water for irrigation. The progressive decrease of fresh water resources is leading towards the inevitable use of saline water for irrigation purpose [2]. Saline waters are characterized by their high EC ( $> 4.0 \text{ dS m}^{-1}$ ), low SAR ( $<10 \text{ mmols L}^{-1}$ ) and low RSC ( $< 2.5 \text{ meq lit}^{-1}$ ) which constitute most important source of supplemental irrigation, provided they are used judiciously and carefully. Such waters are found in vast areas of entire coastal belts of Tamilnadu. The scarcity of fresh water restricts sustainable agricultural development in coastal regions. At the same time, the quality of irrigation water has also deteriorated. As a result, deficit irrigation and saline water irrigation have been used more prevalently in agriculture to overcome drought and sustain crop yields. Salt stress in arid and semi-arid regions is one of the major stresses that can severely limit plant growth and productivity. Overcoming salt stress is a main issue in these regions to ensure agricultural sustainability and crop production. In this context, salinity is currently one of the most severe abiotic factors, limiting agricultural production. In majority of the coastal soils, the plants are subjected throughout their life cycle to different stresses; some of these plants can tolerate these stresses in different ways depending upon that plant species and type of stress. Excessive salinity reduces the productivity of many agricultural crops including most of the pulses. Knowledge of salt tolerance in pulse crops is necessary to increase productivity and profitability of crops irrigated with saline waters.

Blackgram [*Vigna mungo* (L.) Hepper] is the third important pulse crop of India which is cultivated over a wide range of agro-climatic zones of the country. It grows well in both abnormal and normal weather situation. It occupies about 3.25 million ha area in the country producing 1.5 million tonnes of seed with average productivity of  $462 \text{ kg ha}^{-1}$  Shanti et al. [3]. Kota district of Rajasthan occupies 13441 ha area with average productivity of  $800 \text{ kg ha}^{-1}$  of urd bean which is slightly higher against the Rajasthan average productivity of  $516 \text{ kg ha}^{-1}$  [4]. In Tamil Nadu, it is cultivated in 4.56 lakh hectares of area with a production of 2.36 lakh tonnes and the average productivity is  $518 \text{ kg ha}^{-1}$ . The average productivity of pulses in Tamil Nadu is very low when compared to India's average of  $610 \text{ kg ha}^{-1}$ . Production of black gram is low in general due to poor management and low soil fertility status. The main black gram growing states of India are Madhya Pradesh, Maharashtra, Uttar Pradesh, Tamil Nadu, Orissa and Gujarat. The productivity potential of pulses is not realized and the reason for low productivity of blackgram is large scale cultivation under rainfed and marginal lands and may be under low input conditions Kim et al. [5]. The productivity of pulse crops including blackgram is not sufficient enough to meet the domestic demand of the population. Hence, there is need for enhancement of the productivity of blackgram by proper management practices. Black gram production in India is less and imported from other countries to meet out the requirement. Among the entire yield limiting factors, poor irrigation is imperative to ensure better crop production on exhausted soils as irrigation play a vital role in increasing the seed yield in pulses Rajagopal et al. [6].

## 2. MATERIALS AND METHODS

A laboratory experiment was conducted to optimize the salinity level and identify the best saline tolerant blackgram variety to grown under saline water condition. In order to screen a saline/salt tolerant blackgram variety, a laboratory experiment was conducted in the Department of Soil Science to and Agricultural Chemistry, TRIARD. Three ruling varieties of blackgram namely V<sub>1</sub>- VBN 6, V<sub>2</sub>- VBN 4 and V<sub>3</sub>- VBN 3 were collected and used in this study. The treatments consisted of four salinity levels viz., S<sub>1</sub>-EC-3 dS m<sup>-1</sup> and SAR-4; S<sub>2</sub>-EC- 3 dS m<sup>-1</sup> and SAR-6; S<sub>3</sub>-EC-3 dS m<sup>-1</sup> and SAR-8; S<sub>4</sub>-EC- 6 dS m<sup>-1</sup> and SAR-6. The experiment was laid

out in a Factorial Completely Randomized Design (FCRD) with three replications. The 25 seeds of 3 ruling varieties were soaked in saline water as per treatment schedule for 12 hours and placed on the country filter paper in the petridish. Each treatment was replicated thrice. The experiment was maintained up to 21 days. The germination of seeds and vigour index of the seedling were observed at every two days interval up to 10<sup>th</sup> days. Based on the observation speed of germination, germination energy, germination percentage and vigour index were worked out using the formula given below.

#### Speed of Germination:

$$\text{Speed of germination} = \frac{\text{No.of germinated seeds}}{\text{Days to first count}} + \frac{\text{No.of germinated seeds}}{\text{Days to final count}}$$

#### Germination energy:

$$\text{Germination energy} = \frac{\text{No.of germinated seeds at 6 DAS}}{\text{Total No.of seeds tested}} \times 100$$

#### Final germination percentage:

$$\text{Final germination percentage} = \frac{\text{No.of final germinated seeds}}{\text{Total number of seeds tested}} \times 100$$

#### Seedling length:

$$\text{Seedling length (cm)} = \text{Shoot length} + \text{Root length}$$

#### Vigour index:

$$\text{Vigour index} = \text{Germination percentage} \times (\text{Root length} + \text{Shoot length}) \text{ cm}$$

The calculation of different concentration of water salinity levels or EC and SAR ratios (calculating the quantities of different salts) was carried out according to Dagar [7]. The saline water was prepared by dissolving different levels of salts per liter of deionised water respectively thus, prepared saline water was used for laboratory experiments. The quantity of salts used to prepare the different level of salinity water were EC-3 and SAR-4 (NaCl – 1.5g, Na<sub>2</sub>SO<sub>4</sub> – 10.5 g, CaCl<sub>2</sub> – 13.5 g and MgSO<sub>4</sub> – 4.5 g), EC -3 and SAR - 6 EC-3 (NaCl – 4.4g, Na<sub>2</sub>SO<sub>4</sub> – 11.4 g, CaCl<sub>2</sub> – 10.5 g and MgSO<sub>4</sub> – 3.5 g), EC – 3 and SAR -8 (NaCl – 6.6 g, Na<sub>2</sub>SO<sub>4</sub> – 12.2 g, CaCl<sub>2</sub> – 8.3 g and MgSO<sub>4</sub> – 2.7 g) and EC – 6 and SAR - 6 (NaCl – 3.8 g, Na<sub>2</sub>SO<sub>4</sub> – 21.2 g, CaCl<sub>2</sub> – 26.1 g

and MgSO<sub>4</sub> – 8.7 g). Data obtained from laboratory experiments were statistically analysed as suggested by Gomez and Gomez [8]. For significant results, the critical difference was worked at five per cent probability level.

### 3. RESULTS AND DISCUSSION

#### 3.1 Germination Energy of Blackgram Seeds (Table 1)

Increase in the salinity level of water decreased the germination energy of all the three blackgram varieties tried. The highest mean germination energy of 82.22 was noticed with saline water (S<sub>1</sub>). This was followed by S<sub>2</sub> (77.73 per cent), S<sub>3</sub> (72.42 per cent) and S<sub>4</sub> (68.47 per cent), respectively. All the three varieties tried, the observation showed that a significant variation in saline tolerance. Among the three varieties, VBN 3 recorded the highest mean speed of germination energy of 88.83 per cent. This was followed by VBN 4 (79.56 per cent) and VBN 6 (57.24 per cent). The interaction between the salinity levels and blackgram varieties was significant. The variety VBN 3 germinated in saline water recorded the highest germination energy of 95.77 per cent (V<sub>3</sub>S<sub>1</sub>). This was followed by the treatments V<sub>2</sub>S<sub>1</sub> (86.35 per cent) and V<sub>1</sub>S<sub>1</sub> (64.54 per cent). Among the three varieties tried VBN 3 recorded the highest germination energy at all levels of salinity as compared to other varieties. It can be hypothesized that the presence of NaCl/NaSO<sub>4</sub> even at low concentration, could have contributed to a decrease in the internal osmotic potential of germinating structures. Inhibition or delay in germination under saline conditions is due to an osmotic effect, which limits the uptake of water during seed germination rather than ion toxicity by hindering of membrane of cytosolic enzymes and hormones of gibberellic acid. The earlier report of Hasan et al. [9]; Anbarasu and vadivel [10] corroborate the present findings.

#### 3.2 Speed of Germination (Table 2)

The speed of germination among the varieties and salinity levels screened for three blackgram varieties was significant and the salinity level S<sub>1</sub> was superior among the other treatments and the variety VBN 3 performed well among other varieties. Increase in the SAR and EC of salinity water significantly decreased the speed of germination of blackgram seeds and it ranged from 6.99 to 5.62. The highest mean speed of germination of 6.99 was noticed in seeds germinated in salinity level S<sub>1</sub> (EC-3 & SAR-4).

All the three varieties tried, showed a significant variation in saline tolerance. Among the three varieties, VBN 3 recorded the highest speed of germination of 7.56. Based on the speed of germination of blackgram varieties, they are arranged in ascending order as  $V_1$ -VBN 6 (4.62) <  $V_2$ -VBN 4 (6.73) and  $V_3$ -VBN 3 (7.56). The variety VBN 6 received the lowest mean speed of germination of 4.62. The interaction between the levels of salinity and varieties was significant. The variety VBN 3 germinated in saline water recorded the highest speed of germination of 8.25. This was followed by the treatment pairs like  $V_2S_1$  (7.43) and  $V_1S_1$  (5.29), respectively. Among the three varieties tried, VBN 3 recorded the highest speed of germination at all levels of salinity as compared to other varieties. The lowest speed of germination of 3.96 was recorded in VBN 6 variety treated with (EC-6 dS  $m^{-1}$  and SAR-6) saline water. The speed of germination was positively influenced by the various salinity level to various blackgram varieties. Salt stress has three fold effects which reduces the water potential and causes ion imbalance and toxicity Spandana et al. [11] of salt stress affects some major process such as germination, speed of germination, root/shoot dry weight and  $Na^+/K^+$  ratio in root and shoot Farooq et al. [12].

### 3.3 Final Germination Percentage of Blackgram Seeds (Table 3)

The effect due to the different levels of salinity and different varieties of blackgram on final



Fig. 1. Experimental set up of blackgram seeds

germination percentage of blackgram was significant. The variety VBN 3 germinated in saline water recorded the highest total germination percentage of 99.70. This was followed by the treatments  $V_2S_1$  (89.67) and  $V_1S_1$  (63.26). This result clearly indicated that varieties tried, VBN 3 recorded the highest tolerance to salinity levels  $S_1$  (EC-3 dS  $m^{-1}$  and SAR-4) and  $S_2$  (EC-3 dS  $m^{-1}$  and SAR-6) induced by salts. The lowest total germination percentage of 48.39 was recorded in VBN 6 blackgram variety treated with saline water (EC-6 dS  $m^{-1}$  and SAR-6). The increase in the osmotic stress due to increase in salinity that in turn suppressed the growth of plants and yield attributing characters of brinjal. The result obtained was in accordance with the findings of Aloui et al. [13]; Sajal Roy et al. [14].

### 3.4 Seedling Length (Table 4)

The variety VBN 3 germinated in distilled water recorded the highest seedling length of 9.20 cm. This was followed by the treatment pairs like  $V_2S_1$  (8.19 cm) and  $V_1S_1$  (5.66 cm). Among the three varieties tried, VBN 3 recorded the highest seedling length at all the levels of salinity as compared to other varieties. The lowest seedling length of 4.29cm was recorded in  $V_1$  blackgram variety treated with saline water (EC-6 dS  $m^{-1}$  and SAR-6). The decreased growth with the increasing salinity level was possibly due to adverse effect, which hindered seedling growth and biomass production. These results are in harmony with those obtained by Reddy et al. [15]; Shanti et al. [3]; Jamal uddin et al. [16].



Fig 2. Germination of seeds

### 3.5 Vigour Index (Table 5)

The interaction between the level of salinity and varieties of blackgram was significant. Among the three varieties tried, VBN 3 recorded the highest vigour index at all levels of salinity as compared to other varieties. The variety VBN 3 germinated in saline water (S<sub>1</sub> - EC-3 dS m<sup>-1</sup> and SAR-4) recorded the highest vigour index of 548.35. This was followed by the treatment pairs like V<sub>2</sub>S<sub>1</sub> and V<sub>1</sub>S<sub>1</sub>. These treatments recorded a

mean vigour index of 495.28 and 361.76, respectively. The lowest vigour index of 282.31 was recorded in VBN 6 variety (V<sub>1</sub>) treated with saline water (EC-6 dS m<sup>-1</sup> and SAR-6). In general, increase in irrigation water salinity, increased the value of total soluble solids with a consequent reduction of water content in the fruits. Spandana et al. ([11]) also reported that irrigation with saline water slightly reduced the fruit water content and then vigour index.

**Table 1. Effect of different salinity levels and blackgram varieties on the germination energy**

S \ V	S <sub>1</sub> (EC-3 & SAR-4)	S <sub>2</sub> (EC-3 & SAR-6)	S <sub>3</sub> (EC-3 & SAR-8)	S <sub>4</sub> (EC-6 & SAR-6)	Mean
V <sub>1</sub> (VBN 6)	64.54	60.02	53.31	51.10	57.24
V <sub>2</sub> (VBN 4)	86.35	81.74	77.42	72.75	79.56
V <sub>3</sub> (VBN 3)	95.77	91.45	86.54	81.58	88.83
Mean	82.22	77.73	72.42	68.47	
	SEd		CD		
V	1.07		2.13		
S	1.41		2.81		
V × S	2.00		3.97		

**Table 2. Effect of different salinity levels and blackgram varieties on the speed of germination**

S \ V	S <sub>1</sub> (EC-3 & SAR-4)	S <sub>2</sub> (EC-3 & SAR-6)	S <sub>3</sub> (EC-3 & SAR-8)	S <sub>4</sub> (EC-6 & SAR-6)	Mean
V <sub>1</sub> (VBN 6)	5.29	4.86	4.40	3.96	4.62
V <sub>2</sub> (VBN 4)	7.43	6.97	6.51	6.02	6.73
V <sub>3</sub> (VBN 3)	8.25	7.78	7.35	6.88	7.56
Mean	6.99	6.53	6.08	5.62	
	SEd		CD		
V	0.13		0.29		
S	0.14		0.31		
V × S	0.18		0.39		

**Table 3. Effect of different salinity levels and blackgram varieties on the final germination percentage**

S \ V	S <sub>1</sub> (EC-3 & SAR-4)	S <sub>2</sub> (EC-3 & SAR-6)	S <sub>3</sub> (EC-3 & SAR-8)	S <sub>4</sub> (EC-6 & SAR-6)	Mean
V <sub>1</sub> (VBN 6)	63.26	58.30	53.20	48.39	55.78
V <sub>2</sub> (VBN 4)	89.67	84.66	78.92	72.82	81.51
V <sub>3</sub> (VBN 3)	99.7	94.58	89.27	82.40	91.48
Mean	84.21	79.18	73.79	67.87	
	SEd		CD		
V	1.10		2.15		
S	1.73		3.39		
V × S	2.49		4.87		

**Table 4. Effect of different salinity levels and blackgram varieties on the seedling length (cm)**

<b>S \ V</b>	<b>S<sub>1</sub> (EC-3 &amp; SAR-4)</b>	<b>S<sub>2</sub> (EC-3 &amp; SAR-6)</b>	<b>S<sub>3</sub> (EC-3 &amp; SAR-8)</b>	<b>S<sub>4</sub> (EC-6 &amp; SAR-6)</b>	<b>Mean</b>
V <sub>1</sub> (VBN 6)	5.66	5.23	4.74	4.29	4.98
V <sub>2</sub> (VBN 4)	8.19	7.76	7.28	6.82	7.51
V <sub>3</sub> (VBN 3)	9.20	8.75	8.33	7.85	8.53
Mean	7.68	7.24	6.78	6.32	
	SEd			CD	
V	0.14			0.29	
S	0.18			0.37	
V × S	0.20			0.41	

**Table 5. Effect of different salinity levels and blackgram varieties on the vigour index**

<b>S \ V</b>	<b>S<sub>1</sub> (EC-3 &amp; SAR-4)</b>	<b>S<sub>2</sub> (EC-3 &amp; SAR-6)</b>	<b>S<sub>3</sub> (EC-3 &amp; SAR-8)</b>	<b>S<sub>4</sub> (EC-6 &amp; SAR-6)</b>	<b>Mean</b>
V <sub>1</sub> (VBN 6)	361.76	335.45	308.54	282.31	322.01
V <sub>2</sub> (VBN 4)	495.28	468.96	442.39	416.43	455.76
V <sub>3</sub> (VBN 3)	548.35	522.03	495.32	468.45	508.53
Mean	468.46	442.14	415.41	389.06	
	SEd			CD	
V	10.93			21.65	
S	11.65			23.07	
V × S	12.98			25.71	

#### 4. CONCLUSION

The present investigation was clearly brought out the saline water irrigation for improving the growth of brinjal. From the results of the study, it was concluded that the soil application of saline water (EC-3 dS m<sup>-1</sup> and SAR-4) irrigation to saline tolerant blackgram variety VBN 3 was identified as best treatment combination (S<sub>1</sub>V<sub>3</sub>) to realize the maximum germination of blackgram under saline water irrigation. However, the results should be test verified under field condition for recommendation to the farmers.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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