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ORIGINAL ARTICLE

Effect of Salinity on Seed Germination of Four Different Groundnut Genotype

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Keywords

Agricultural productivity;
Salt- sensitivity;
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A B S T R A C T

Salinity is a significant ecological stressor that reduces agricultural productivity and sustainability in arid and semiarid regions by impacting germination rates, delaying the start of germination, and ultimately delaying seedling establishment. Globally, salt has a negative impact on agricultural yield, because most of cultivated plants are salt-sensitive glycophytes. Salt stress also influences seed germination and seedling establishment in three different ways: ion toxicity, oxidative stress, and osmotic stress. Four groundnut genotypes (KDG-128, GG-20, GJG-31, and TG-37A) were examined for their phenotypic variation and the impact of salt content on germination, growth, and yield metrics. Different KCl and Na_2SO_4 solution concentrations were used in saline treatments. Salinity had a serious influence on germination, according to the results. Finding salt tolerance genotypes was the main goal of this study. The TG-37A and GJG-31 genotypes were proven to be salt-tolerant based on the germination %, but the KDG-128 genotype is a moderately salt-tolerant genotype and the GG-20 genotype is a salt-susceptible genotype. Genotypes for tolerance are beneficial in the field of agriculture, and the findings unambiguously show that salinity cannot restrict plant growth and development.

Introduction

A self-pollinating, intermediate annual herbaceous crop, groundnut (*Arachis hypogaea* L.), often known as peanut or earthnut, is a member of the family Leguminoceae. (Adinya *et al.*, 2010). In many countries around the world, including India, groundnut (*Arachis hypogaea* L.) is a staple food. With 48% oil, 3% fibre, 26% protein, high levels of thiamine, niacin, and calcium as well as compounds with medicinal value like resveratrol, polyphenols (p-coumaric acid, flavonoids, and isoflavones), antioxidants, vitamins, especially vitamin E, niacin, and folic acid, it is well known for its health benefits (Francisco, 2008). Considering outputs of 6.69 million tonnes and 1.35 tonnes per hectare, respectively, India is the second-largest producer of groundnuts in the world (FAOSTAT, 2018).

There are different ways to hasten seed germination (Sappalani *et al.*, 2021; Hossinifarahi *et al.*, 2022). Seeds of many species incapable germinate when they're exposed to favorable micro environment factors like excessive salinity, low oxygen tension, or harsh temperatures (Corbineau *et al.*, 1995; Ungar *et al.*, 1995; Lotfi *et al.*, 2009; Goudarzi *et al.*, 2023). According to reports, mature plants' resistance to salinity is 10 to 100 times higher than it is during the germination and early development stages (Mayer, *et al.*, 1975; Vyas, *et al.*, 2013).

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The groundnut seed has two cotyledons, a hypocotyl, an epicotyl, and a radicle. There may be 4-5 leaf primordia in the embryo of seeds; five are fully developed in large seeds and four in tiny ones. All primordial leaves, which the seedlind will generate within the first few days following germination, are present in the seed. The cotyledons turn green shortly after emergence due to epigeal germination. Cotyledons, vegetative axes, and the main axis make up the seedling. When the plant is young, the hypocotyl is white and immediately visible, but as it becomes older, it blends in with the root (Prasad, *et al.*, 2010).

Numerous pathogenic fungi influence the rate of groundnut seed germination. It has been discovered that groundnut plant development and productivity are affected by diseases that are transmitted through seeds. Seed-borne pathogens that are present on the outside, within, or in close proximity to the seed as contaminants can cause seed absorption, seed rot, seed necrosis, reduced germination potential, as well as seedling damage and disease infection (Sayed, *et al.*, 2020).

One of the most significant abiotic stressors that impair plant development and growth all throughout the world is salinity. Salinity is the measure of the amount of salt that has dissolved in a specific amount of water. Salt tolerance refers to a plant's capacity to endure and continue growing in salty environments (Nithila, *et al.*, 2013; Pal, *et al.*, 2017; Heidarian and Roshandel, 2021; Gharibiyan *et al.*, 2023). The ability of plants to survive and thrive in salty soils is crucial for agriculture because it shows that the afflicted plants have the genetic potential for salt tolerance, which is a highly desirable feature. Salinity is known to cause stress in plants (Mahmood *et al.*, 2000, Mensah, *et al.*, 2006, and Rao, *et al.*, 2006).

In arid and semiarid regions, salinity impacts agricultural productivity and its quality by moving salts from the plant *root* zone. Salinity is another consequence of poor water management. Numerous facets of how salinity affects plant behaviour are covered in the research of plant tolerance to salt stress, including changes at the morphological, physiological, and molecular levels (Francois *et al.*, 1994; Heidarian and Roshandel, 2021).

The responses of crop plants to salinity range widely. Osmotic and ionic stress is two of salt stress's two main negative consequences. Water intake by the root is reduced by osmotic stress, and ionic stress is brought on by ion acumination and toxicity (Behzadi Rad *et al.*, 2021). A plant's growth rate is slowed down by ionic and osmotic stress, and it eventually dies. Oxidative damage, secondary stress, and stress may follow primary stress (Gupta, *et al.*, 2014).

Additionally, changes in morphology, anatomy, and metabolism may be associated with the effects of salinity on plant growth and development (Amrijani *et al.*, 2010, Molassiotis, *et al.*, 2006), However, the degree of damage, period of stress exposure, and kind of plant all have a significant role in how these parameters are adjusted (Dash, *et al.*, 2001). Salinity hinders seed germination (Singh *et al.*, 1989; Aboutalebi Jahromi and Hosseini Farahi, 2016) and reduces seedling growth (Janila, *et al.*, 1999; Nautiyal, *et al.*, 1989; and Seckin, *et al.*, 2009). Which have negative effects on plant growth and development (Anuradha, *et al.*, 2001; Lianes, *et al.*, 2005). Seed germination can be affected by salinity due to the harmful effects of ions on embryo viability or the creation of osmotic potential, which limits water uptake (Pal, *et al.*, 2021).

The purpose of this research is to identify the genotype that can tolerate a saline environment and help expand the current boundaries of cultivation by screening four genotypes that are frequently farmed by indigenous farmers.

Materials and Methods

Collection of sample

The seeds of KDG-128, GG-20, and TG-37A genotypes were collected from the market based on their pod size, seed colour, (Ratnakumar *et al.*, 2013) and GJG-31 genotype was collected from ICAR Directorate of Groundnut Research, Junagadh, India.

We have selected four groundnut genotypes viz., GJG-31 (Gujarat Junagadh Groundnut-31) is a Spanish bunch habitat, TG-37A, a Spanish bunch habitat, GG-20 (Gujarat Groundnut 20) is a semi-spreading variety, and KDG-128 phule Warna suitable for the Virgiana bunch habitat (Ratnakumar *et al.*, 2013)

Preparation of saline water

A concentration of 25mM, 50mM, 100mM, KCl, and 25mM, 50mM, 100mM, Na_2SO_4 solutions was prepared in a plastic beaker just before each treatment by dissolving a weighted amount of commercially available salt in distilled water to make the desired concentration.

Seeds germination experiment

The Laboratory experiment was carried out in department of Life sciences, Bhakta Kavi Narsinh Mehta University. The seeds of a genotype of groundnut were surface sterilized with 0.1% HCl solutions for 5 min to prevent some microorganism growth. The seeds were washed thoroughly five times with distilled water. Twenty sterilized seeds were arranged in pertridish of 9cm in diameter on whatman no.1 filterpaper and moistened with two salts (KCl and Na_2SO_4) with three concentrations (control, 25mM, 50mM, and 100mM). Daily observation was recorded and counting of the number of seeds that were germinated and ungerminate seeds in salt concentration then transferred to another pertridish, giving distilled water treatment, and the ungerminate seeds which were germinate and showed good recovery. In a germination experiment, germination percentage as well as recovery percentage were recorded. Statistical analysis was carried out using MS Excel. A Least Significant Difference (LSD) test was carried out to determine the difference between treatment group means for germination rate of germination and recovery percent germination.

Germination percentage:

This parameter was calculated, according to Kandil *et al*. (2012).

$$GP = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds sown}} \times 100$$

Results

Salinity inhibit physiological parameter such as germination percentage, growth parameter, germination speed, however the response of salinity depended on genotype. Some genotypes can tolerate salt stress, but some are susceptible to salt stress under saline conditions.

Table 1. Germination and recovery percentage of four Groundnut genotype with different salt concentrations.

Sr no.	Genotype	Concentration	Salt	Germination%	Recovery%
		0 mM	Control	100%	0%
		25mM		88.00%	33%
		50mM	KCl	88%	33%
1	KDG-128	100mM		88%	50%
		25mM		88%	0%
		50mM	Na_2SO_4	93%	50%
		100mM		90%	50%
		0mM	Control	70%	24.25%
		25mM		78%	33%
		50mM	KCl	58%	31.42%
2	GG-20	100mM		58%	35.25%
		25mM		33%	18.35%
		50mM	Na_2SO_4	43%	22.50%
		100mM		28%	24.72%
		0mM	Control	100%	0%
		25mM		100%	0%
		50mM	KCl	90%	100%
3	GJG-31	100mM		93.30%	100%
		25mM		90%	100%
		50mM	Na_2SO_4	83.30%	11.11%
		100mM		83.30%	61.11%
		0mM	Control	100%	0%
		25mM		95%	0%
		50mM	KCl	100%	0%
4	TG-37A	100mM		100%	0%
		25mM		92.50%	50%
		50mM	Na_2SO_4	100%	0%
		100mM		100%	0%

Where, KDG-128= Phule warma, GG-20= Gujarat Groundnut, GJG-31= Gujarat Junagadh Groundnut, TG-37A= Thom-Bay Groundnut.

Seeds of KDG-128 genotype showed 100% Germination observed in non-saline condition. 88% Germination was observed in 25, 50,100mM KCl and 25mM Na_2SO_4 salt treatment. 93% Germination observed in 50mM Na_2SO_4 salt treatment. 90% germination observed in 100mM Na_2SO_4 salt treatment. Compare to both salt KCl and Na_2SO_4 maximum Germination 93% observed in 50mM Na_2SO_4 and minimum Germination 88% observed in 25mM KCl, 50mM KCl, 100mM KCl and 25mM Na_2SO_4 salt treatment.

When ungerminated seeds in salt concentration transferred to distilled water showed good recovery. 0% recovery observed in non-saline condition. 33% recovery observed in 25, 50, mM KCl salt treatment. 50% recovery was observed in 100mM KCl, 50mM Na_2SO_4, and 100mM Na_2SO_4 salt treatment. Compare to both salt KCl and Na_2SO_4 maximum 50% recovery observed in 100mM KCl, 50mM Na_2SO_4, 100mM

Na_2SO_4 and minimum recovery 0% observed in 25mM Na_2SO_4 salt treatment.

Seeds of GG-20 genotype showed 70% germination observed in non-saline condition. 78% germination was observed in 25mM KCl salt treatment. 58% germination was observed in 50,100mM KCl salt treatment. 33% germination was observed in 25mM Na_2SO_4 salt treatment. 43% germination was observed in 50mM Na_2SO_4 salt treatment. 28% germination was observed in 100mM Na_2SO_4 salt treatment. Compare to both salt KCl and Na_2SO_4 maximum germination 78% was observed in 25mM KCl and minimum germination 28% was observed in 100mM Na_2SO_4 compare to control.

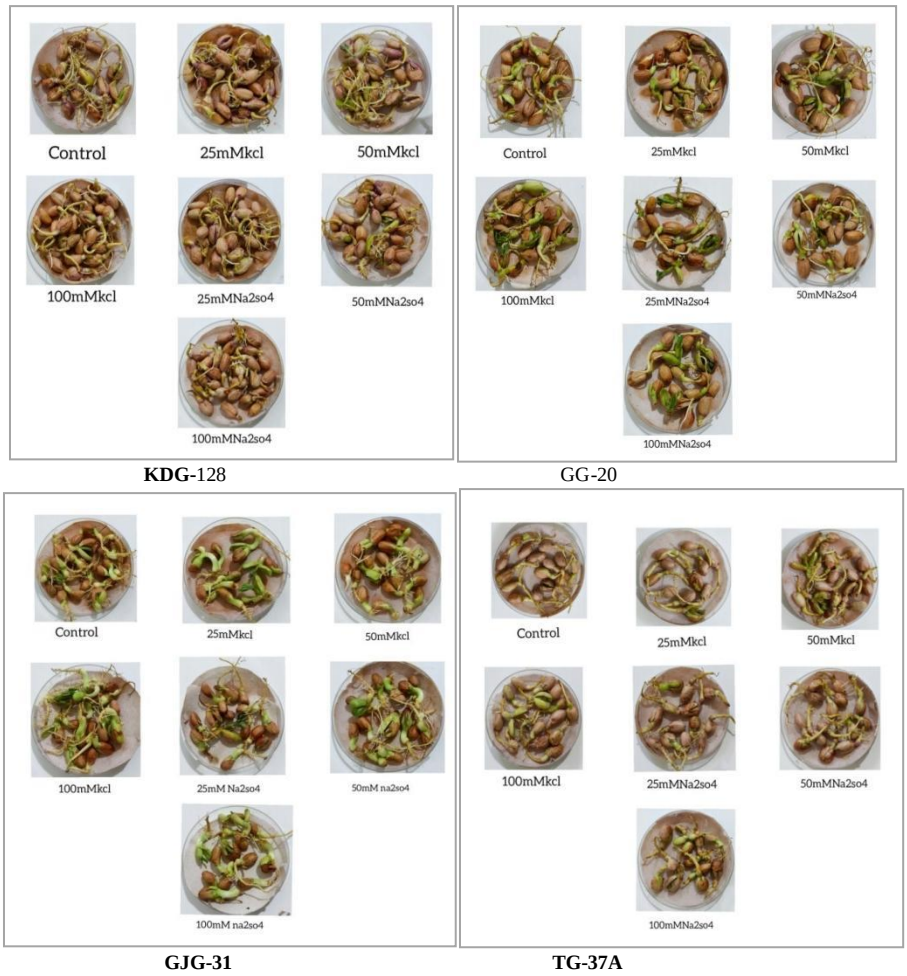
When ungerminated seeds in salt concentration transferred to distilled water showed good recovery. 24.25% recovery observed in non-saline condition. 33% recovery was observed in 25mMKCl salt treatment. 31.42% recovery observed 50mM KCl salt treatment. 35.25% recovery observed 100mM KCl salt treatment. 18.35% recovery was observed in 25mM Na_2SO_4 salt treatment. 22.50% recovery observed 50mM Na_2SO_4 salt treatment. 24.72% recovery was observed in 100mM Na_2SO_4 salt treatment. Compare to both salt KCl and Na_2SO_4 maximum recovery 35.25% was observed in 100mM KCl and minimum recovery 18.35% was observed in 25mM Na_2SO_4 salt treatment.

Seeds of GJG-31 Genotype showed 100% Germination was observed in non-saline condition.100% germination was observed in 25mM KCl salt treatment. 90% germination was observed in 50mM KCl salt treatment. 93.30% germination was observed in 100mM KCl salt treatment. 90% germination observed in 25mM Na_2SO_4 salt treatment. 83.30% Germination was observed in 50mM Na_2SO_4 salt treatment. 83.30% germination was observed in 100mM Na_2SO_4 salt treatment. Compare to both salt KCl and Na_2SO_4 maximum germination 100% was observed in 25mM KCl and minimum Germination 83.30% was observed in 50mM Na_2SO_4 and 100mM Na_2SO_4.

When ungerminated seeds in salt concentration transferred in distilled water showed good recovery. 0% recovery was observed in non-saline condition and 25mM KCl salt treatment. 100% recovery was observed in 50mM, 100mM KCl and 25mM Na_2SO_4 salt treatment. 11.11% recovery was observed in 50mM Na_2SO_4 salt treatment. 61.11% recovery was observed in 100mM Na_2SO_4 salt treatment. Compare to both salt KCl and Na_2SO_4 maximum 100% recovery was observed in 50mM KCl, 100mM KCl, 25mM Na_2SO_4 and minimum recovery was 11.11% observed in 50mM Na_2SO_4.

Seeds of TG-37A genotype showed 100% Germination was observed in non-saline condition. 100% Germination was observed in 50mM and 100mM KCl salt and 50mM and 100mM Na_2SO_4 salt treatment. 95% Germination was observed in 25mM KCl salt treatment. 92.50% Germination was observed in 25mM Na_2SO_4 salt treatment. Compare to both salt KCl and Na_2SO_4 maximum Germination 100% was observed in 50mM KCl, 100mM KCl, 50 mM Na_2SO_4, 100mM Na_2SO_4 and minimum Germination 92% was observed in 25MmM Na_2SO_4 salt treatment.

Ungerminated seeds in salt concentrations transferred in distilled water treatment showed good recovery. 50% recovery was observed in 25mM Na_2SO_4 salt treatment and 0% recovery was observed in non-saline condition with 25mM, 50mM, 100mM KCl and 50mM, 100mM Na_2SO_4 salt treatment. Compare to both salt KCl and Na_2SO_4 maximum recovery 50% was observed in 25mM Na_2SO_4 salt treatment and minimum 0% recovery was observed in 25mM, 50mM, 100mM KCl and 50mM, 100mM Na_2SO_4 salt treatment.



KDG-128 GG-20

GJG-31 **TG-37A**

Fig. 1. results of seed germination of four Groundnut genotype in different concentrations of various salts. Where, **KDG-128**= Phule Warna, **GG-20**= Gujarat Groundnut, **GJG-31**= Gujarat Junagadh Groundnut, **TG-37A**= Thom Bay Groundnut.

Statistical analysis

In order to do the statistical analysis, MS Excel was used. In order to compare the percentage germination rate means between treatment groups, a Least Significant Difference (LSD) test was used. The effects of these salts, as well as varying concentrations of the same salt were statistically significant, and germination decreased as the concentration of two separate salts (KCl and Na_2SO_4) increased. We demonstrated in this LSD test that the germination experiment follows an alternate hypothesis and rejects the null hypothesis.

Table 2. LSD test comparing seed germination of four Groundnut genotype in different concentrations of various salts.

Sr no.	Genotype	Concentration	Salt	Germination	DFC	L(0.05)	L(0.01)
1	KDG-128	0 mM	Control	100	0	0	0
		25mM	KCl	87.5	12.5	31.8599	159.616
		50mM		87.5	12.5	31.8599	159.616
		100mM		87.5	12.5	95.5798	478.847
		25mM	Na_2SO_4	87.5	12.5	31.8599	159.616
		50mM		92.5	7.5	31.8599	159.616
		100mM		90	10	0	0
2.	GG-20	0mM	Control	70	0	63.7198	319.231
		25mM	KCl	77.5	7.5	95.5798	478.847
		50mM		57.5	12.5	95.5798	478.847
		100mM		57.5	12.5	31.8599	159.616
		25mM	Na_2SO_4	32.5	37.5	31.8599	159.616
		50mM		42.5	27.5	95.5798	478.847
		100mM		27.5	42.5	95.5798	478.847
3.	GJG-31	0mM	Control	100		0	0
		25mM	KCl	100		0	0
		50mM		90	10	42.0551	210.693
		100mM		93.3	6.7	0	0
		25mM	Na_2SO_4	90	10	42.0551	210.693
		50mM		83.3	16.7	127.44	638.462
		100mM		83.3	16.7	127.44	638.462
4	TG-37A	0mM	Control	100		0	0
		25mM	KCl	95	5	63.7198	319.231
		50mM		100	0	0	0
		100mM		100	0	0	0
		25mM	Na_2SO_4	92.5	7.5	31.8599	159.616
		50mM		100	0	0	0
		100mM		100	0	0	0

Non-significant; significant at p≤0.05; significant at p≤0.01 Where **KDG-128**= Phule Warna, **GG-20**= Gujarat Ground Nut, **GJG-31**= Gujarat Junagadh Groundnut, **TG-37A**= Thom-Bay Groundnut.

To verify the accuracy and dependability of the gathered data, the obtained data was put through a number of data analysis processes showed in table 2. After then, several statistical analysis were performed on the gathered data to determine whether they were overall acceptable. Germination tests on four groundnut genotypes used specialised analysis including LSD-Least Significant Difference.

Discussion

In case of the KDG-128 genotype, salt treatments with 25mM KCl, 50mM KCl, 25mM Na_2SO_4, and

50mM Na_2SO_4 resulted in 0.05 level of probability significance differences of 31.859 and 0.01 level of probability significance differences of 159.616. In the treatment with 100mM KCl salt, the 0.05 level of probability significance difference is observed to be 95.579, and the 0.01 level of probability significance difference is observed to be 478.847.

For the GG-20 genotype, the 0.05 level of probability significance difference under control is observed to be 63.7198, while the 0.01 level of probability significance difference under control is observed to be 319.231. In treatments with 25mM, 50mM, and 100mM KCl salts, the observed 0.05 level of probability significance difference is 95.579, and the observed 0.01 level of probability significance difference is 478.847. In the treatment with 100mM KCl and 25mM Na_2SO_4 salt, a 0.05 level of probability significance difference was observed to be 31.859, and a 0.01 level of probability significance difference to be 159.616.

In the instance of the GJG-31 genotype, 0.05 level of probability significance difference observed is 42.055 and 0.01 level of probability significance difference detected is 210.693 in 50 mM KCl and 25 mM Na_2SO_4 salt treatment. In the 50 mM and 100 mM Na_2SO_4 salt treatments, the observed 0.05 level of probability significance difference is 127.44, and the observed 0.01 level of probability significance difference is 638.462.

When using 25mM KCl salt as a treatment, the TG-37A genotype shows a 0.05 level of probability significance difference of 63.719 and a 0.01 level of probability significance difference of 319.231 in the situation in question. In the 25mM Na_2SO_4 salt treatment, the 0.05 level of probability significance difference was observed to be 31.859, and the 0.01 level of probability significance difference was observed to be 159.616.

There were four different groundnut genotypes evaluated; the genotypes GJG-31 and TG-37A showed the highest germination percentage, whereas KDG-128 and GG-20 showed the lowest germination percentage. The present study's findings demonstrated that the genotypes TG-37A and GJG-31, which are salt-tolerant based on germination %, KDG-128, which is only moderately salt-tolerant, and GG-20, which is salt-susceptible, are all distinct from one another. The current findings are consistent with Francois *et al*., (1994) and Francois *et al*., (1985) findings on sorghum and squash, respectively, which showed that germination % decreased with increasing salt.

Conclusions

The ideal cycle duration of peanuts increased with an increase in salt concentration, resulting in an inhibiting influence on the early growth of the seedlings. Compared to roots, shoots are more sensitive to salinity stress. It has been concluded from present investigation that identifying and selecting this groundnut genotype TG-37A and GJG-31 for salt tolerance nature compared to GG-20 and KDG-128 based on the above results of the germination experiment. This tolerance genotype is very important for agricultural farmers. This tolerance genotype grows in saline soil for better crop protection, high yield, high production, and future use in breeding programs.

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Conflict of interests

I Rushita Parmar, declares that he has no conflict of interest.

Human rights statements and informed consent

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation

Human Rights

This article does not contain any studies with human subjects performed by the any of the authors.

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