A-6008
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RESEARCH ARTICLE Indian Journal of Agricultural Research, Volume Issue : ()

Early Identification of Salt-tolerant Genotypes in Finger Millet (*Eleusine coracana* L.) at Germination stage by Observing the Morphological Characters

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10.18805/IJARe.A-6008

ABSTRACT

Background: The major abiotic stress limiting the plant growth and productivity across the globe is salinity. This may be overwhelmed by growing salt tolerant varieties. Hence, the present study has been figured out to sort out the salt tolerant and salt sensitive cultivars of finger millet.

Methods: In this study 15 cultivars of finger millet (*Eleusine coracana* L.) seeds were grown at different NaCl concentrations (50 mM, 100 mM, 150 mM and 200 mM) on germination stage. Germination percentage, root length, shoot length, fresh weight, dry weight and vigour index of the seedlings were measured using different concentrations of NaCl.

Result: Salt tolerant cultivars were discovered to be GPU 28, GPU 67, ML 365, Udurumallige, PYR1 and GPU 48 at 150 Mm and ML 365 at 200 Mm salt accumulation, while cultivars such as VL 400 and KM252 were very much sensitive to NaCl. Accessions with tolerance to salinity are precious genetic material for future crop improvement program.

Key words: Finger millet, Salinity, Sodium chloride.

INTRODUCTION

Increasing agricultural yields in both normal and less productive soils, as well as in salinized soils, is a must if the world is to be fed. The major abiotic stress affecting the plant growth and development is salinity. Around 1 billion hectares of land are affected by salinity around the world. This equates to over 20% of the global irrigated land and more than 6% of the world's total farmed area (Kakar *et al.,* 2019). Salinity is referred as the presence of high concentration of soluble salts in the soil moisture of root zone which leads to huge decrease in yield. These high concentrations of soluble salts reduce plant growth through their high osmotic pressures by limiting the uptake of water by the roots. Osmotic and ionic stress are the two major threats to plant growth. Various physiological and metabolic processes of plants are highly influenced when the plants were infested with salinity stress which results in variety of symptoms such as the reduction in leaf area, rise in leaf thickness and succulence, abscission of leaves, necrosis of root and shoot and decrease of internode lengths (Parida and Das, 2005). Constant increases in salinity threaten crop productivity in both intensively irrigated and dry land cropping systems, necessitating the development of crop species that can better tolerate soil salinity. Finger millet [*Eleusine coracana* L. (Geartn)] is a valuable crop grown in Asia and Africa's dry and semi-arid regions (Chivenge *et al.* 2015). Its grains have superior antioxidant, nutrient and storage capabilities when compared to other cereals (Kumar *et al.* 2016). Finger millet, like other members of the poaceae family, is glycophytic in nature and so suffers from saline stress (Ibrahim 2016; Hema *et al.* 2014). Despite the relevance of this limitation and the crop, relatively little research on the salinity response of finger millets had been done. Hence, the present investigation has been carried out which aims to find out NaCl tolerant and NaCl sensitive cultivars of finger millet at the germination stage.

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How to cite this article: Divya, S., Geetha, K., Kumar, R.S., Prabu, P.C., Parasuraman, P., Kumari, A.N. and Sharavanan, P.T. (2022). Early Identification of Salt-tolerant Genotypes in Finger Millet (*Eleusine coracana* L.) at Germination stage by Observing the Morphological Characters. Indian Journal of Agricultural Research. DOI: 10.18805/IJARe.A-6008.

Submitted: 12-05-2022 **Accepted:** 16-06-2022 **Online:** 25-07-2022

MATERIALS AND METHODS

Seeds of fifteen finger millet cultivars were tested for salt tolerance activity using NaCl of 4 different NaCl salt concentrations *i.e.*, 50, 100, 150 and 200 mM. Twenty seeds of each of the 15 cultivars were germinated on filter paper in closed petri dishes for 7 days in 15 mL of NaCl solution with four different concentrations in room temperature. Germination percentage was observed at 7 days after treatment. Twenty typical seedlings from individual petri dish were utilized for the measurement of root and shoot length, fresh weight, dry weight and vigour index. Based on the results, resistant and susceptible cultivars were categorized.

RESULTS AND DISCUSSION

In the present investigation, the result of NaCl stress on morphological features such as percentage of germination, root length, shoot length and dry weight of seedlings in 15 different cultivars of finger millet were explored. Good selection criteria to screen the finger millet genotypes against the salinity is based on the decrease of those growth variables during germination stage as NaCl concentration increase.

Effect of NaCl stress on seed germination in different genotypes of finger millet is represented in the Table 1. Broad range of variation was observed for germination percentage. Highly significant correlation with declining seed germination was observed at 7 days after treatment with increased NaCl concentration. The peak concentration of NaCl used in the experiment is 200 mM in which only one cultivar *i.e.*, ML365 recorded maximum of 90% germination. With regard to 150 mM NaCl concentration treatment, the cultivar GPU28 recorded the highest percentage of germination of 100% followed by Udurumallige (90%), GPU 67 (85%), PYR 1 (80%), ML 365 (70%) and GPU 48 (70%). In case of 100 mM NaCl treatment, the cultivar GPU28 recorded the highest percentage of germination of 100% followed by Udurumallige (95%) and ML 365 (90%). With minimum concentration of 50 mM the genotypes GPU 28, GPU 67, ML 365 and PYR 2 recorded germination percentage of 100%. The results indicated that there is negative correlation between the treatments and germination percentage. As the salt concentration rises, there is gradual reduction in germination of seeds representing salt encouraged inhibition of seed germination. Throughout the germination, salinity induces osmotic stress or ion toxicity which limits the water absorption capacity of seeds and disturbs the hydrolysis of seed reserves or causing death of seeds (Begum *et al.* 2010). Rahman *et al.* (2014) reported similar results in finger millet. Rice did not exhibit better germination when compared to salinity tolerance trials in other crops at 150 and 200 mM of NaCl whereas finger millet recorded 90% germination even in 200 mM NaCl concentration which indicates their inherent potential to tolerate salinity.

The shoot lengths of various cultivars were presented in Table 2. Salinity affects both shoot length and root length. Significant reduction in the shoot and root length of the finger millet genotypes were observed with increasing salt concentration. Shoot growth was highly affected in finger millet than root length. Reduced supply of metabolites and nutrients to the developing shoots due to salinity stress results in reduced shoot length. Significant decrease in shoot length with increase in NaCl concentration was observed. Genotypes ML 365, GPU 28, Udurumallige, PYR1, GPU48 and GPU 67 showed increased shoot length (>1.10 cm) under stressed condition.

The root lengths of various cultivars were presented in Table 3. The trait root length was also affected due to toxic effects of salinity. Genotypes PYR1, ML 365, GPU 28, Udurumallige, GPU 48 and GPU 67 exhibited increased root length (>1.5 cm). Shailaja and Tirumeni (2007) observed decreased root length with higher NaCl concentration in their study on 19 finger millet (*Eleusine coracana*) genotypes.

The fresh weight and dry weight of the seedlings was affected by salinity, with increase in salinity level the fresh weight and dry weight were significantly reduced (Table 4 and Table 5). Ions were present in the salinity solution which limits the uptake of water by seedlings results in decrease in weight of the seedlings (El-Kader *et al*. 2006). Similar results of decrease in fresh and dry weight under salinity has been observed in Maize seedlings (Cha-Um and Kirdmane, 2009) where salinity affects the nutrient absorption, utilization and photosynthesis (Jafari *et al.* 2009).

Table 1: Effect of NaCl stress on seed germination in different cultivars of finger millet.

Cultivars	Germination%				
	50 mM	100 mM	150 mM	200 mM	Mean
GPU 28	100%	100%	100%	55%	89%
PR1433	45%	65%	65%	40%	54%
Venchuruttai	15%	85%	5%	15%	30%
VL 400	25%	70%	25%	10%	33%
GPU 67	100%	95%	85%	50%	83%
KMR 301	95%	65%	65%	30%	64%
CO 15	95%	85%	60%	20%	65%
PR 202	85%	25%	0%	20%	33%
ML 365	100%	90%	70%	90%	88%
KM 252	70%	30%	15%	15%	33%
Udurumallige	85%	95%	90%	10%	70%
Karunchuruttai	55%	90%	15%	10%	43%
GPU 48	80%	60%	70%	55%	66%
PYR 1	90%	80%	80%	25%	69%
PYR 2	100%	40%	70%	10%	55%

Simultaneously vigour index has been decreased with increased salinity level. Genotypes ML 365, PYR1, GPU 48, GPU 28, Udurumallige and GPU 67 have vigour index more than 220 compared to other genotypes under stressed condition (Table 6).

Table 7 shows the correlation between various variables during the seedling stage. The germination percent had a substantial and positive relationship with shoot length (0.917**), root length (0.877**), fresh weight (0.659**) and vigour index (0.920**) according to the correlation coefficient matrix. Shoot length had a positive connection with root length (0.964**), fresh weight (0.773**), dry weight (0.517*) and vigour index (0.965**). Root length was found to have a positive association with fresh weight (0.794**), dry weight (0.627*) and vigour index (0.981**). The fresh weight showed positive association with dry weight (0.722*) and vigour index (0.762**). The dry weight recorded positive and significant association with vigour index (0.583*).

Salt stress inhibited the seed germination, root length, shoot length, fresh weight, dry weight and vigour index. The results help in understanding the effect of NaCl stress on plants. Unbalanced uptake of nutrients by seedlings is due to toxic effects of Na+ and Cl - ions existing in the salt which may be the reason for decrease in seedling growth. Growth of roots and shoot are affected due to decreased uptake of water by roots. The results of Demir and Arif (2003) indicated that the root growth was more harmfully affected compared to shoot growth by salinity whereas in the present study shoot growth was highly affected in finger millet than root length. Based on germination%, root length, shoot length

Table 2: Effect of NaCl stress on shoot length in different cultivars of finger millet.

Cultivars	Shoot length (cm)				
	50 mM	100 mM	150 mM	200 mM	Mean
GPU 28	1.37	0.89	1.29	0.60	1.04
PR1433	0.48	0.41	0.46	0.61	0.49
Venchuruttai	0.36	1.01	0.03	0.14	0.39
VL 400	0.32	0.54	0.09	0.00	0.24
GPU 67	1.48	1.13	1.64	0.66	1.23
KMR 301	2.25	0.75	0.46	0.32	0.95
CO 15	2.10	1.01	0.65	0.13	0.97
PR 202	0.74	0.17	0.09	0.18	0.30
ML 365	1.96	1.32	1.19	0.71	1.30
KM 252	0.63	0.62	0.12	0.00	0.34
Udurumallige	1.54	1.20	1.31	0.12	1.04
Karunchuruttai	1.10	1.71	0.28	0.11	0.80
GPU 48	1.73	0.85	1.47	0.55	1.15
PYR 1	2.02	0.57	1.40	0.09	1.02
PYR 2	1.14	0.36	1.02	0.10	0.66

Table 3: Effect of NaCl stress on root length in different cultivars of finger millet.

Cultivars	Root length (cm)				
	50 mM	100 mM	150 mM	200 mM	Mean
GPU 28	2.54	3.19	2.27	1.27	2.32
PR1433	0.88	1.41	0.48	1.38	1.04
Venchuruttai	0.69	3.89	0.04	0.43	1.26
VL 400	0.98	1.84	0.22	0.00	0.76
GPU 67	2.85	3.21	4.17	1.11	2.84
KMR 301	6.05	2.30	1.18	0.44	2.49
CO 15	4.43	2.74	1.07	0.13	2.09
PR 202	3.05	0.30	0.00	0.47	0.96
ML 365	5.01	5.11	2.04	1.41	3.39
KM 252	0.63	1.08	0.22	0.00	0.48
Udurumallige	3.67	3.45	2.66	0.12	2.48
Karunchuruttai	2.22	4.36	0.22	0.14	1.74
GPU 48	3.45	2.54	2.76	1.75	2.63
PYR 1	4.74	1.73	1.95	0.03	2.11
PYR 2	2.75	1.09	1.24	0.09	1.29

Table 4: Effect of NaCl stress on fresh weight in different cultivars of finger millet.

Cultivars	Fresh weight (g)				
	50 mM	100 mM	150 mM	200 mM	Mean
GPU 28	0.16	0.24	0.10	0.16	0.17
PR1433	0.19	0.17	0.09	0.21	0.17
Venchuruttai	0.15	0.10	0.17	0.13	0.14
VL 400	0.21	0.13	0.10	0.06	0.13
GPU 67	0.28	0.25	0.14	0.17	0.21
KMR 301	0.29	0.19	0.13	0.24	0.21
CO 15	0.38	0.19	0.14	0.17	0.22
PR 202	0.17	0.12	0.13	0.29	0.18
ML 365	0.40	0.28	0.21	0.27	0.29
KM 252	0.10	0.15	0.17	0.16	0.15
Udurumallige	0.18	0.32	0.11	0.06	0.17
Karunchuruttai	0.28	0.15	0.23	0.15	0.20
GPU 48	0.29	0.26	0.15	0.17	0.22
PYR 1	0.32	0.20	0.08	0.21	0.20
PYR 2	0.20	0.24	0.10	0.18	0.18

Table 5: Effect of NaCl stress on dry weight in different cultivars of finger millet.

Cultivars	Dry weight (g)				
	50 mM	100 mM	150 mM	200 mM	Mean
GPU 28	0.11	0.10	0.07	0.09	0.09
PR1433	0.13	0.10	0.07	0.04	0.09
Venchuruttai	0.13	0.09	0.06	0.06	0.09
VL 400	0.11	0.20	0.07	0.03	0.10
GPU 67	0.13	0.10	0.09	0.06	0.10
KMR 301	0.13	0.09	0.08	0.06	0.09
CO 15	0.14	0.09	0.07	0.09	0.10
PR 202	0.13	0.09	0.07	0.07	0.09
ML 365	0.17	0.11	0.10	0.10	0.12
KM 252	0.09	0.11	0.07	0.06	0.08
Udurumallige	0.13	0.10	0.08	0.04	0.09
Karunchuruttai	0.15	0.07	0.09	0.04	0.09
GPU 48	0.14	0.09	0.07	0.08	0.10
PYR 1	0.09	0.12	0.06	0.07	0.09
PYR 2	0.12	0.13	0.05	0.06	0.09

Table 6: Effect of NaCl stress on vigour index in different cultivars of finger millet.

Cultivars	Vigour Index				
	50 mM	100 mM	150 mM	200 mM	Mean
GPU 28	390.50	407.25	356.00	102.58	314.08
PR1433	61.20	118.46	60.45	79.20	79.83
Venchuruttai	15.68	416.50	0.33	8.51	110.26
VL 400	32.50	166.43	7.50	0.03	51.62
GPU 67	432.50	411.59	493.00	88.00	356.27
KMR 301	788.50	198.41	106.28	22.58	278.94
CO 15	619.88	318.33	102.90	5.20	261.58
PR 202	321.73	11.63	0.00	12.80	86.54
ML 365	697.00	577.80	225.40	189.90	422.53
KM 252	88.20	50.70	5.10	0.08	36.02
Udurumallige	442.00	440.80	356.85	2.40	310.51
Karunchuruttai	182.60	545.85	7.43	2.48	184.59
GPU 48	413.60	203.10	295.75	125.95	259.60
PYR 1	607.95	183.20	267.60	2.88	265.41
PYR 2	388.00	57.80	157.85	1.85	151.38

and dry weight, it was discovered that cultivars such as GPU 28, ML 365, GPU 67, Udurumallige, PYR1 and GPU 48 were salt tolerant at 150 Mm salt accumulation and in that the cultivar ML 365 recorded its salt tolerance even at 200 Mm salt concentration which depicts its higher potential to grow against salinity, whereas cultivars such as VL 400 and KM252 were extremely sensitive to NaCl (Plate 1 to Plate 8). Tolerance observed at the seedling stage is of

Table 7: Pearson correlation of morphological traits in finger millet under salt stress at germination stage.

	Germination %	Shoot length (cm)	Root length (cm)	Fresh weight (cm)	Dry weight (cm)	Vigour index
Germination %	1					
Shoot length (cm)	0.917**	1				
Root length (cm)	0.877**	0.964**	1			
Fresh weight (cm)	0.659**	0.773**	0.794**	1		
Dry weight (cm)	0.493	0.517*	0.627*	0.722**	1	
Vigour index	0.920**	0.965**	0.981**	0.762**	0.583*	1

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

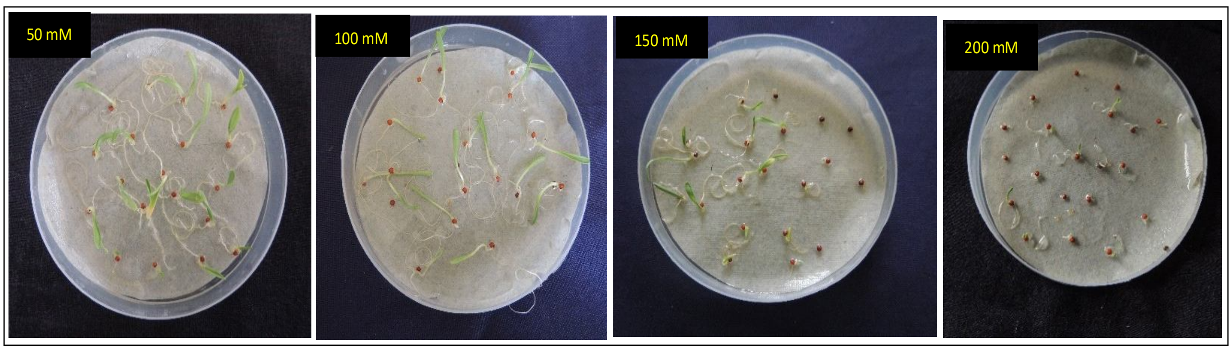

Plate 1: Seedling growth in ML 365 (Tolerant) in different concentration of NaCl.

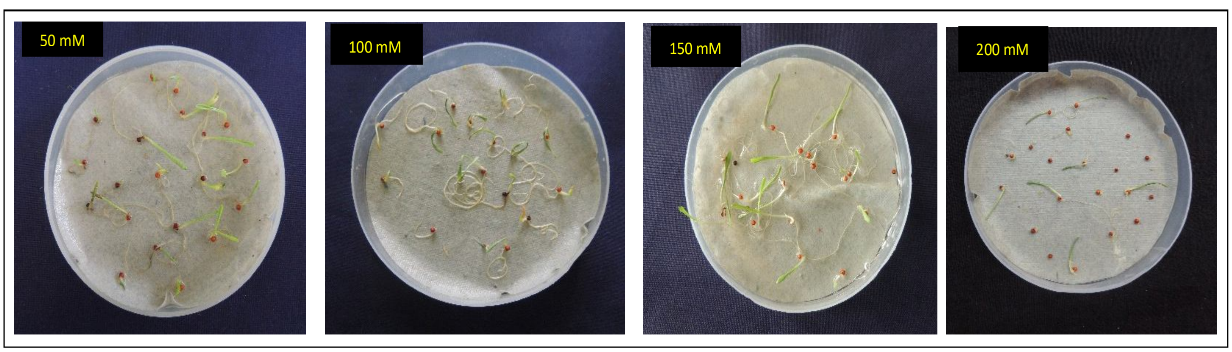

Plate 2: Seedling growth in GPU 67 (Tolerant) in different concentration of NaCl.

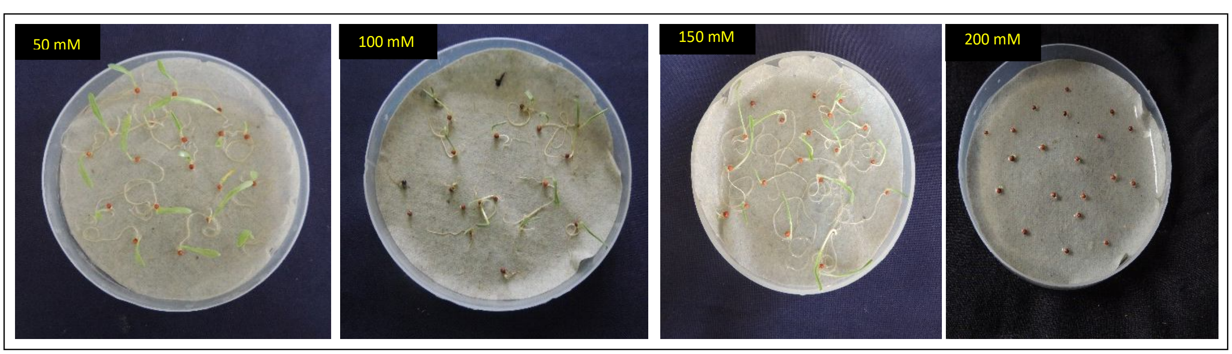

Plate 3: Seedling growth in PYR 1 (Tolerant) in different concentration of NaCl.

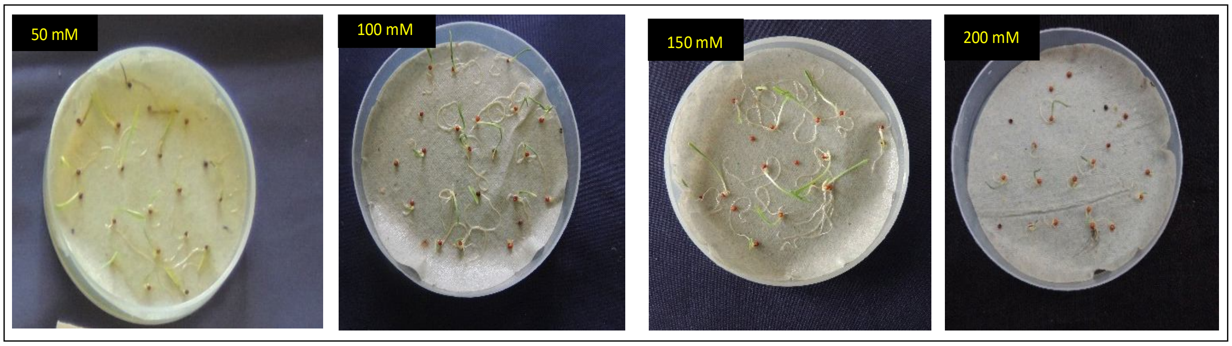

Plate 4: Seedling growth in GPU 28 (Tolerant) in different concentration of NaCl.

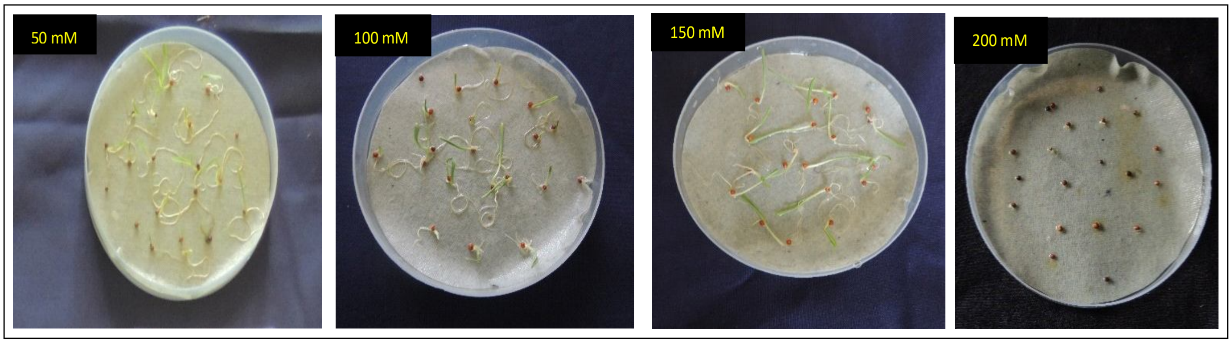

Plate 5: Seedling growth in Udurumallige (Tolerant) in different concentration of NaCl.

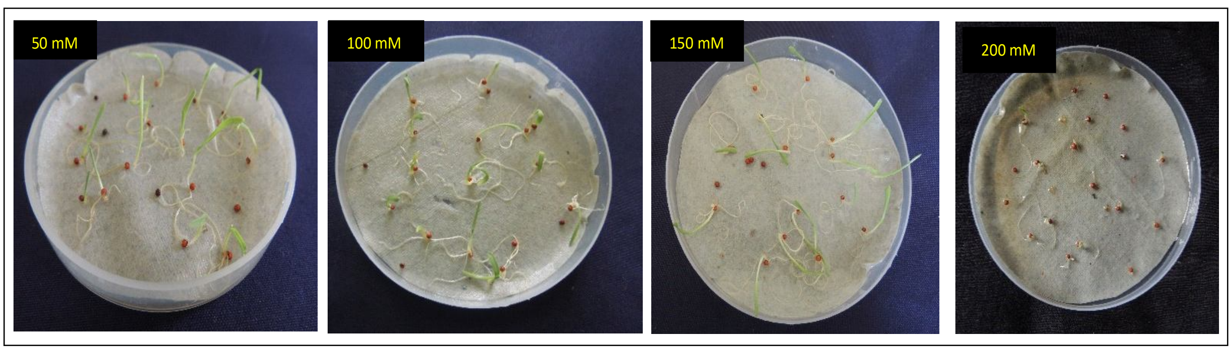

Plate 6: Seedling growth in GPU 48 (Tolerant) in different concentration of NaCl.

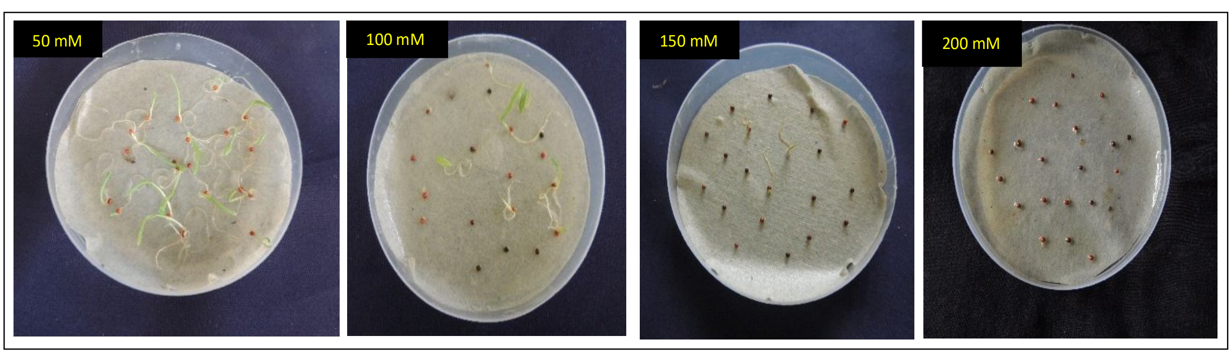

Plate 7: Seedling growth in KM 252 (Susceptible) in different concentration of NaC.

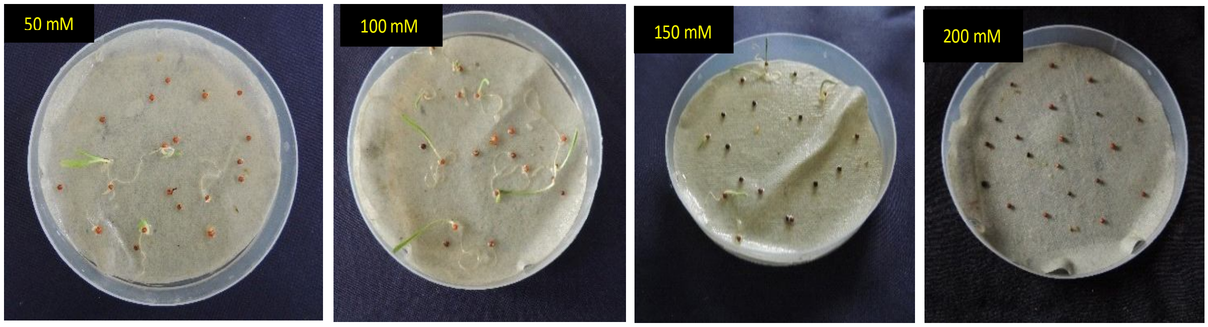

Plate 8: Seedling growth in VL 400 (Susceptible) in different concentration of NaCl.

considerable value because it has been observed that the screening of cultivars for salt tolerance at vegetative stage of plants is useful in determining the ultimate tolerance of the species.

CONCLUSION

The effect of NaCl stress treatments on the morphological features of fifteen finger millet genotypes was examined in-depth in the present study. Finally, our findings revealed salinity reactions on the evaluated characteristics, with significant varietal differences among the plants investigated. We hypothesised that the varieties *viz.,* GPU 28, ML 365, GPU 67, Udurumallige, PYR1 and GPU 48 are promising genetic resources with comparative high salinity resistance and that they could be used for further evaluation for crop breeding efforts toward better salinity tolerance. The identified salinity tolerant finger millet varieties need to be tested under a variety of environmental circumstances and salt types. Finally, it's important to remember that this research was done in a laboratory environment (artificial conditions), which may not reflect the crop's diverse natural environment.

ACKNOWLEDGEMENT

We acknowledge the support provided by Regional Research Station, Paiyur, for our research work.

Conflict of interest: None.

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