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EFFECT OF SALT STRESS ON SEED GERMINATION, PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS OF VIGNA RADIATA AND VIGNA MUNGO

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ABSTRACT
The response of two bean cultivars – Vigna radiata and Vigna mungo against four different salinity levels namely 0, 50, 100 and 150 mM NaCl were studied at germination and early seedling stage. This investigation was performed as laboratory experiment under completely randomized design (CRD) with three replications for each salinity level. The effect of salt stress on various Germination, Physiological and Biochemical parameters was observed. The results indicated the adverse effect of salt stress on all the studied parameters in both the cultivars. The maximum adverse effect was seen on the seeds under 150 mM NaCl treatment. The results also concluded that V. radiata is comparatively more tolerant to salt stress than V. mungo.

Keywords: Salt stress, Seed Germination, Protein, Starch, Reducing Sugar, Vigna radiata, Vigna mungo

1. INTRODUCTION

Plants are frequently exposed to a variety of stress conditions such as drought, salinity, low temperature, extremes of soil pH and heat which causes reduction of plant growth and productivity. (Atta, Pal, and Jana, 2021). In fact, abiotic stresses are the principal cause of crop failure, decreasing average yields for major crops by more than 50% (Wu et al., 2011). Among these, salinity and drought are the most severe ones (Kaymakanova, 2009) due to the high magnitude of their impact and wide occurrence (Bartels and Sunkar, 2005). Salinity is a major environmental constraint to crop productivity throughout the arid and semi-arid regions of the world (Foolad and Lin, 1997). It has been estimated that more than 20% of all cultivated lands around the world contain salt levels high enough to cause salt stress to crop plants (Moud and Maghsoudi, 2008).

In saline environment adaptation of plants to salinity during germination and early seedling stages is crucial for the establishment of species. Seedlings are the most vulnerable stage in the life cycle of plants and germination determines when and where seedling growth begins (Llanes, Reinoso, and Luna, 2005). Salt tolerance at germination stage is important factor, where soil salinity is mostly dominated at surface layer. High concentration of salts has detrimental effects on germination of seeds (Kayani and Rahman, 1987; Sharma et al., 2004; Saboora et al., 2006). Plant growth is ultimately reduced by salinity stress but plant species differ in their sensitivity or tolerance to salts (Munns and Termaat, 1986; Rogers et al., 1995).

There have been numerous reports on the effects of salt stress. Several studies have reported that salinity induces morphological, physiological, and biochemical changes in many crops

(Ashraf and Foolad, 2007). Tolerance to various stresses differ depending upon the species, varieties, and even ecotypes (Ullah et al., 2008). Increasing NaCl concentration reduces the germination percentage, the growth parameters and the relative water content (Sidari et al., 2007). The seed germination of Panicum turgidum has been significantly reduced and slowed at high concentrations of both NaCl and KCl and was completely inhibited at 300 and 400 mM (El-Keblawy, 2004). Both NaCl and KCl has been reported to reduce the final germination percentage and germination rate of two arid-land varieties of wheat (Triticum aestivum L.); furthermore, the salt had increased the production of abnormal seedlings (Al-Ansari, 2003). Seed germination and the growth of young seedlings of sugar beet (Beta vulgaris L.) have been reported to be inhibited by NaCl treatment (Wang et al., 2011; Ghoulam and Fares, 2001).

Many studies confirm the inhibitory effect of salinity on biochemical processes. Carbohydrates such as sugars (glucose, fructose, sucrose, fructans) and starch accumulate under salt stress (Parida et al., 2002), playing a leading role in osmoprotection, osmotic adjustment, carbon storage, and radical scavenging. A decrease in starch content and an increase in both reducing and nonreducing sugars and polyphenol levels have been reported in leaves of Bruguiera parviflora (Parida et al., 2002). In a report, three species of Vigna (V. radiata, V. mungo and V. unguiculata) were subjected to different doses of NaCl Viz., 0 (Control), 50, 75, 100, 125 and 150 mM treatment and it has been reported that germination percentage, seedling growth, relative water content, relative growth rate and the photosynthetic pigments were decreased with increasing concentration of NaCl treatment in all species of Vigna. While, metabolite solutes such as reducing sugar, starch, protein, proline content and an enzyme peroxidase activity were increased at increasing concentration of NaCl in both shoot and root compared to respective control. (Arulbalachandran, Ganesh and Subramani, 2009).

Legumes are considered as the major source of protein and dietary amino acid for man and farm animals (Dubey, 1999). Green gram (Vigna radiata L. Wilczek) is an important traditional legume crop the world over. It is of short duration, requires low inputs, yields highly and serves as an excellent source of protein as seed or sprout. Black gram (Vigna mungo (L.) Hepper) is an important pulse crop occupying unique position in Indian agriculture. It is under cultivation in India about 3.25 million hectares and an annual production is 1.45 million tons. Major obstacles to the growth and productivity of widely cultivated green gram and black gram in arid and semiarid regions are the ever-increasing salinity and solidity of soils and the scarcity of good quality of irrigation water (Alqurainy, 2007; Khedr et al., 2003).

Since Vigna species are a product of economic value playing an important role in nutrition and due to its high sensitivity to salinity, the aim of this study was to investigate the effects of salinity on seed germination, physiology, and biochemical traits of Vigna radiata and Vigna mungo.

2. MATERIALS AND METHODS

This study was a laboratory experiment carried out at the Department of Botany, Bioinformatics and Climate Change Impacts Management, School of Sciences, Gujarat University, Ahmedabad, Gujarat, India.
The seeds of Vigna radiata and Vigna mungo were used as the experimental materials.

2.1 Experiment Design

The experiment was carried out in a Customized Random Design.
The first factor was species – V. radiata and V. mungo. The second factor was NaCl salt concentration – at 50 ,100 or 150 mM molarity. The experimental design with three treatments and a control was arranged for both the species - V. radiata and V. mungo. Also, three replicates were kept for all the treatments as well as for control.

1. Control (C): seeds germinated in Distilled water.
2. Treatment X: seeds germinated in 50 mM NaCl concentration.
3. Treatment Y: seeds germinated in 100 mM NaCl concentration.
4. Treatment Z: seeds germinated in 150 mM NaCl concentration.

2.2 Germination Test

Seeds with uniform size were selected. The Petri dishes of 9 cm diameter were taken, surface sterilized with methanol and then lined with germination paper. 20 seeds of similar size were selected and kept in each petri dish for germination. Germination paper was imbibed with 5ml of Distilled water, or NaCl solution (50mM, 100mM, and 150mM) in each of the respective petri-dishes. The petri-dishes were covered with their lids and kept at room temperature. The germination papers were replaced when needed. Similarly, respective salinity solutions were added when required. A seed was considered to have germinated when the radicle was 2 mm long (Kaya et al., 2006; Kim et al., 2006). The germination percentage was determined by counting the number of germinated seeds every 24 hours and also on the 7^{th}day after sowing. The radicle length and the early seedling fresh and dry weights were also measured on the 7th day. Following parameters were calculated for the Germination Test.

Germination percentage (%)
The emergence of radicle was taken as index of germination. Initiation and completion of germination was recorded daily. The germination percentage was recorded daily for 7 days and germination percentage was calculated with the following formula (Cokkizgin and Cokkizgin, 2010):

$$\text{Germination percentage (\%)} = \frac{\text{Number of germinated seeds} \times 100}{\text{Number of total seeds}}$$

Germination index
Germination Index (GI) was calculated as described by the Association of Official Seed Analysts (AOSA, 1983) as follows:

$$\text{Germination index} = \sum (Gt/Tt)$$

Where, Gt = number of seeds germinated on t^{th} day; Tt = number of days up to t^{th} day.

Mean Germination Time
The mean germination time (MGT) was calculated to assess the rate of germination (Ellis and Roberts, 1981) as follows:

$$MGT = \frac{\sum(Dn)}{\sum n}$$

where n is the number of seeds germinated on each day and D is the day of counting.

Salt tolerance index (%)
Salt tolerance index was calculated using the formula (Carpýcý, Celýk, and Bayram, 2009).

$$\text{Salt tolerance index (\%)} = \frac{\text{TDW at } S_x}{\text{TDW at } S_0} \times 100.$$

TDW = Total dry weight,
S_0 = control; S_x = a given concentration out of three salt concentration.

Seed vigour index
Seed vigour index (SVI) was calculated according to Abdul-Baki and Anderson (1973) as follows:
SVI= Seedling length (cm) x GP (%)
where, GP = Germination percentage.

2.3 Physiological Parameter
Relative water content (RWC):
Relative water content was calculated using the formula :(Sidari et al., 2007)
Relative water content RWC (%) = (FW-DW/FW) × 100
where, FW is Fresh weight of seedlings (7 Days After Sowing) and DW is dry weight of seedlings.

2.4 Biochemical Parameters

Standard protocol of Total Protein by Bradford, (1976), was followed for the estimation of Total Protein. Standard protocol of Starch by Chinoy, (1939), was followed for the estimation of Starch. Standard protocol of Total Reducing Sugar by Somogyi, M, (1952), was followed for the estimation of Total Reducing Sugar.

3. RESULTS AND DISCUSSION

The results showed that the measured components were significantly affected by salt concentrations. In the present study, all the parameters were measured on the 7th Day After Sowing (DAS).

3.1 GERMINATION AND PHYSIOLOGICAL PARAMETERS

Table 3.1: Effect of different salinity levels on Germination Parameters of Vigna radiata and Vigna mungo.

Cultivars	Treatment	GP	GI	MGT	STI	SVI
V. radiata	**C (0 mM)**	100 ± 0.00	36.47 ± 3.56	4.39 ± 0.10	-	636.00 ± 71.19
	X (50 mM)	98.33 ± 2.89	33.10 ± 0.80	4.47 ± 0.01	92.29 ± 3.82	353.33 ± 23.18
	Y (100 mM)	96.67 ± 2.89	31.57 ± 1.57	4.50 ± 0.02	84.58 ± 2.19	267.37 ± 36.93
	Z (150mM)	88.33 ± 2.89	26.58 ± 1.39	4.59 ± 0.04	82.71 ± 3.77	117.77 ± 20.97
V. mungo	**C (0 mM)**	100 ± 0.00	36.69 ± 0.58	4.37 ± 0.01	-	488.00 ± 49.96
	X (50 mM)	98.33 ± 2.89	32.99 ± 1.09	4.46 ± 0.01	95.56 ± 3.36	344.37 ± 20.54
	Y (100 mM)	93.33 ± 2.89	30.14 ± 1.45	4.48 ± 0.03	78.44 ± 6.68	190.00 ± 16.89
	Z (150mM)	91.67 ± 2.89	26.09 ± 0.94	4.64 ±0.04	74.89 ± 1.39	112.53 ± 10.65

Values are written as 'Mean ± S.D'
GP – Germination Percentage; GI – Germination Index; MGT – Mean Germination Time; STI – Salt Tolerance Index; SVI – Seed Vigour Index.

Table 3.2: Effect of different salinity levels on Germination and Physiological Parameters of Vigna radiata and Vigna mungo.

Cultivars	Treatment	RL	FW	DW	RWC
V. radiata	**C (0 mM)**	6.36 ± 0.71	0.57 ± 0.01	0.16 ± 0.01	71.44 ± 0.80
	X (50 mM)	3.59 ± 0.21	0.51 ± 0.01	0.15 ± 0.01	71.3 ± 0.84
	Y (100 mM)	2.76 ± 0.29	0.46 ± 0.06	0.14 ± 0.00	70.01 ± 3.42
	Z (150mM)	1.33 ± 0.23	0.40 ± 0.01	0.13 ± 0.01	66.54 ± 0.68
V. mungo	**C (0 mM)**	4.88 ± 0.50	0.51 ± 0.01	0.15 ± 0.01	70.11 ± 0.80
	X (50 mM)	3.50 ± 0.11	0.45 ± 0.02	0.14 ± 0.02	68.17 ± 0.22
	Y (100 mM)	2.03 ± 0.12	0.37 ± 0.03	0.12 ± 0.03	68.15 ± 1.94
	Z (150mM)	1.23 ± 0.09	0.34 ± 0.04	0.11 ± 0.04	67.05 ± 4.26

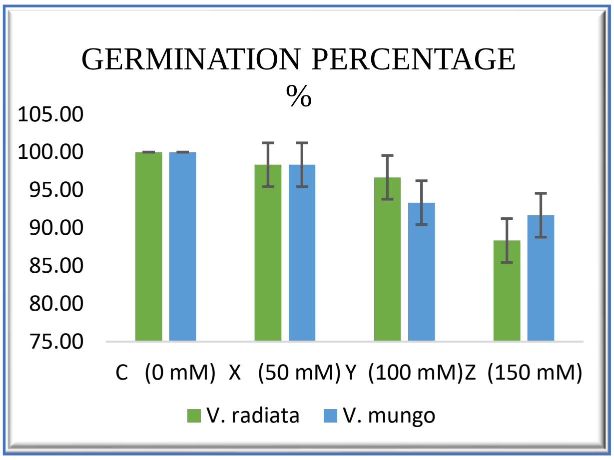
Values are written as 'Mean ± S.D' RL – Radicle Length; FW – Seedling Fresh Weight; DW – Seedling Dry Weight; RWC – Relative Water Content.

Germination Percentage % (GP):

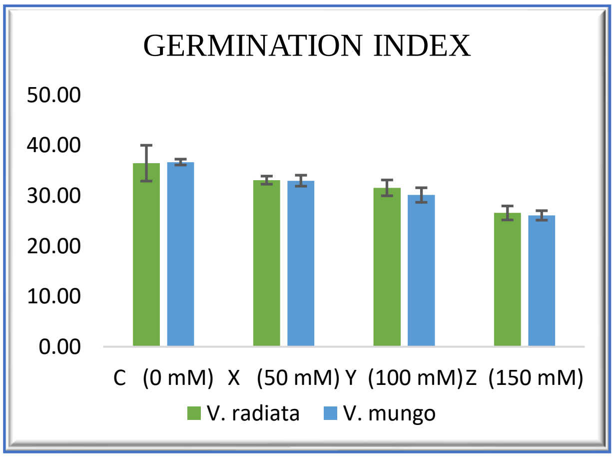
Germination percentage gradually decreased, with the increasing salt concentration in both the species of Vigna as measured on the 7th DAS (Table 3.1). The lowest GP was observed in the Treatment Z in both the species of Vigna. The maximum GP was 100% as observed in Control seeds of both V. radiata and V. mungo. And the minimum GP was 88.33% and 91.67% in Treatment Z of V. radiata and V. mungo respectively. Our results are in line with the findings of Sidari et al., (2007), who reported that the increasing NaCl concentration reduced the germination percentage in four lentil genotypes that were treated with salt stress (50 mM, 100mM, 150 mM and 200 mM NaCl concentration). Salt tolerance during seed germination is a measure of the seed's ability to withstand effects of high concentration of salts in the medium. Excessive salt depresses the water potential of the germination medium, making water less available to the seed and thus lowers the rate of, or completely inhibits, germination. El-keblawy (2004) and Cokkizgin (2012) have also reported the decrease in Germination percentage with increase in salt concentration in seeds of Panicum turgidum and Phaseolus vulgaris respectively.

In Vigna radiata and Vigna mungo, the GP in Control as well as Treatment X was similar. But it can be compared from the graph 3.1 that in Treatment Y, it was observed that V. radiata has more GP (96.67 %) compared to V. mungo (93.33%). Whereas, in Treatment Z, V. mungo (91.67%) has comparatively more GP than V. radiata. (88.33%).

Germination Index (GI):



Graph 3.1 Effect of different salinity levels on Germination Percentage (%)



Graph 3.2 Effect of different salinity levels on Germination Index

Germination index gradually decreased, with the increasing salt concentration in both the species of Vigna as measured on the 7th DAS. (Table 3.1). In V. radiata, the highest GI was in Control seeds (36.47 %) and the lowest GI was observed in Treatment Z (26.58%). Similarly, in V. mungo also, GI was 36.69 % i.e., the highest in Control and the lowest in Treatment Z (26.09 %). The decrease in GI with increasing salinity was in conformity with results obtained in seed germination of lentil genotypes (Sidari et al., 2007) and maize cultivars (Khayatnezhad and Gholamin, 2011) under salinity stress conditions.

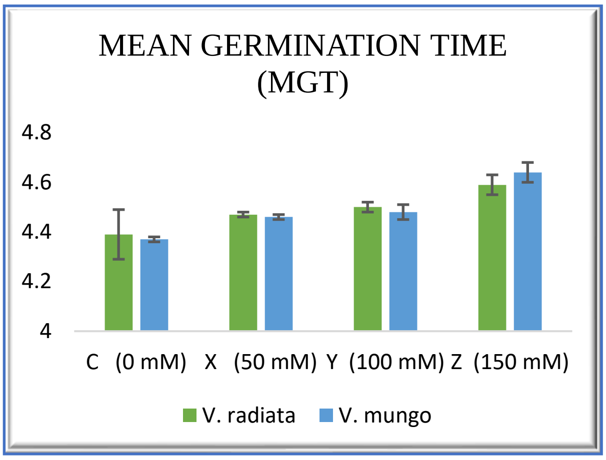
GI of V. radiata was higher than V. mungo in Control (36.47% > 36.69 %), Treatment X (33.10% > 32.99%), Treatment Y (31.57% > 30.14 %) and Treatment Z (26.58% > 26.09%) i.e., throughout in control and all the treatments. (Graph 3.2)

Mean Germination Time (MGT):

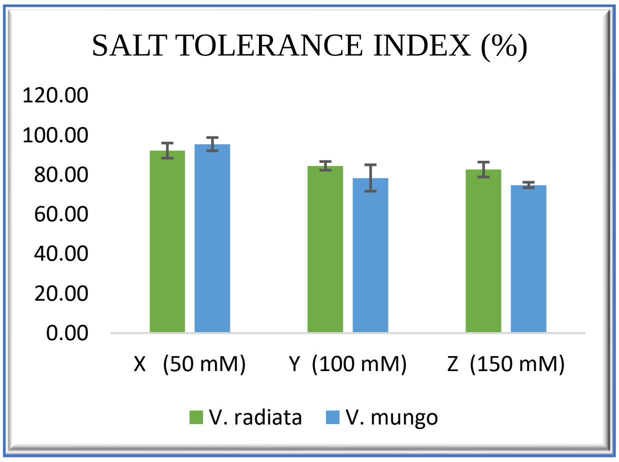
MGT is found to be increasing, with the increase in NaCl concentration. Therefore, the lowest MGT was observed in Control seedlings and the highest MGT was observed in Treatment Z seedlings – in both species of Vigna. (Table 3.1). In Vigna radiata maximum MGT was observed in Treatment Z (4.59 days) and minimum MGT in Control (4.39 days). Similarly, in

Vigna mungo, maximum MGT in Treatment Z (4.64 days) in and minimum MGT (4.37 days) in Control was observed. The present results agree with those reported by Pujol et al., (2000) who observed that increase in salinity induces both reduction in germination percentage and delayed initiation of the germination process. Khodadad (2011) with study on 6 genotypes of safflower reported that the MGT increased with increase in the osmotic potential in NaCl solution.

MGT of V. mungo was lower (4.37 days) than V. radiata (4.39 days) in Control. Whereas in Treatment Z, V. radiata had lower MGT (4.59 days) compared to V. mungo (4.64 days).



Graph 3.3 Effect of different salinity levels on Mean Germination Time (MGT)



Graph 3.4 Effect of different salinity levels on Salt Tolerance Index (STI) (%)

Salt Tolerance Index (STI):
With the increasing concentration of salt, the salt tolerance index (STI) decreased in both the species of Vigna. In V. radiata, maximum STI was observed in the Treatment X (92.29 %) and minimum STI was observed in the Treatment Z (82.71 %). Similarly, in V. mungo, maximum (95.56 %) in Treatment X and minimum (74.89 %) in Treatment Z was observed. (Table 3.1) Our results are in line with those reported by Carpıcı, Celık and Bayram, (2009) who observed that as the salt concentrations increased the salt tolerance indices of cultivars decreased and the lowest STI was seen in the treatment with maximum salt concentration.

In Treatment X, Vigna mungo had comparatively greater STI (95.56 %) than Vigna radiata (92.29 %). Whereas in Treatments Y and Z, Vigna radiata showed more STI (84.58 % and 82.71 %) compared to Vigna mungo (Y - 78.44 % and Z - 74.89 % respectively.) (Graph 3.4)

Seed Vigour Index (SVI):
In Seed Vigour Index (SVI) also, similar trend was observed as seen in all other germination parameters. In Vigna radiata maximum SVI was observed in Control (636.00) and minimum SVI in Treatment Z (117.77). Similarly, in Vigna mungo, maximum SVI (488.00) in control and minimum SVI (112.53) in Treatment Z. (Table 3.1) The present results are in agreement with those obtained by Khodarahmpour, Ifar and Motamedi (2012) who reported the adverse effect of NaCl Salt stress on Seed Vigour, Radicle length and Germination percentage on different maize cultivars.
It can be clearly observed from Graph 3.5 that SVI of V. radiata was higher than V. mungo in Control (636 > 488), Treatment X (353.33 > 344.37), Treatment Y (267.37 > 190.00) and Treatment Z (117.77 > 112.53) i.e., throughout in control and all the treatments.

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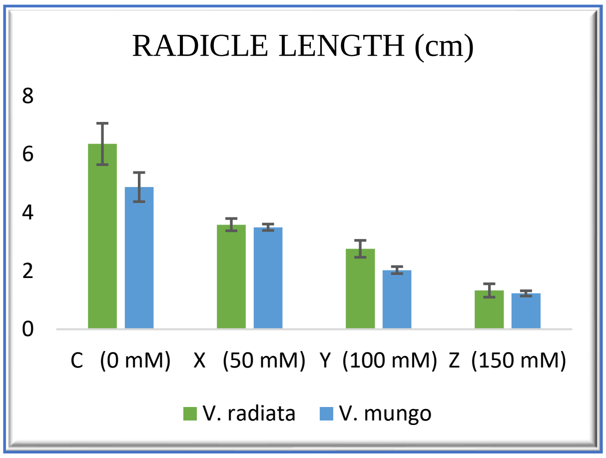
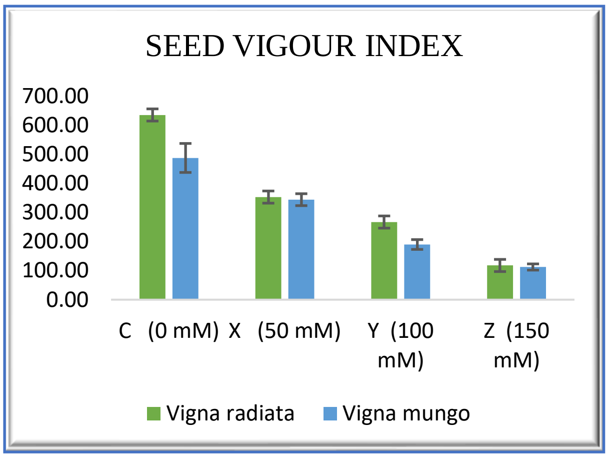
Graph 3.6 Effect of different salinity levels on Radicle length (RL) cm



Graph 3.5 Effect of different salinity levels on Seed Vigour Index (SVI)



Radicle Length (RL):

The Radicle length (RL) was measured in cm, on the 7th DAS. It can be observed from Table 3.2 that Seeds of V. radiata and V. mungo had longest RL in control (6.36 cm and 4.88 cm respectively) and it was observed to be decreasing gradually – with the increasing salt concentration. And thus, the shortest RL was observed in Treatment Z (1.33 cm and 1.23 cm respectively). These results are in agreement with many researches (Gholamin et al., 2010; Farsiani and Ghobadi, 2009) who reported that the radicle length was maximum in the Control and the minimum was in high NaCl concentration.

It can be clearly observed from Graph 3.6 that RL of V. radiata was higher than V. mungo in Control (6.36 cm > 4.88 cm), Treatment X (3.59 cm > 3.50 cm), Treatment Y (2.76 cm > 2.03 cm) and Treatment Z (1.33 cm > 1.23 cm) i.e., throughout in control and all the treatments.

Seedling Fresh Weight (FW):

As observed from Table 3.2, Seedling Fresh weight (FW) was observed to be decreasing gradually with the increase in salt concentration in both species of Vigna. Thus, Control shows the highest FW i.e., 0.57 g in V. radiata and 0.51 g in V. mungo. And Treatment Z seedlings have the lowest FW i.e., 0.40g in V. radiata and 0.34g in V. mungo. The present results were in agreement with the report of Tunçtürk et al., (2011) who observed that fresh weights of plants under salt stress at final harvest were significantly reduced as compared to those of plants in the control treatment.

Graph 3.7 shows that FW of V. radiata was higher than V. mungo in Control (0.57 g > 0.51 g), Treatment X (0.51g > 0.45g), Treatment Y (0.46 g > 0.37 g) and Treatment Z (0.40 g > 0.34 g) i.e., throughout in control and all the treatments.

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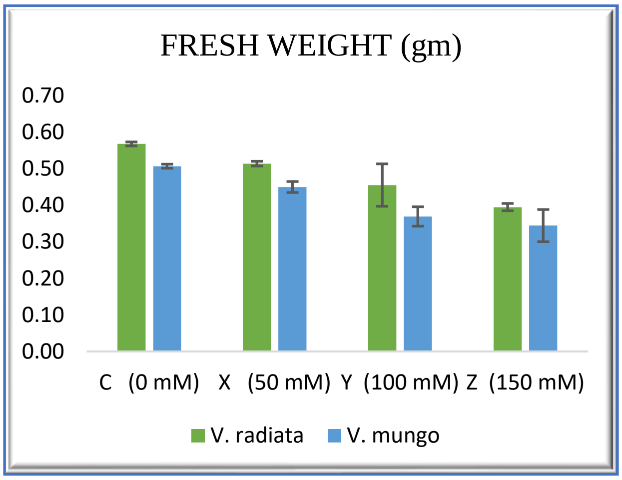
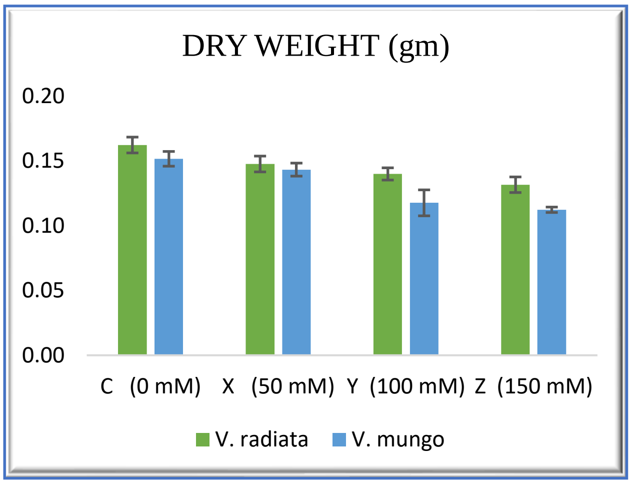


Graph 3.7 Effect of different salinity levels on Seedling Fresh weight (gm)



Graph 3.8 Effect of different salinity levels on Seedling Dry Weight (gm)

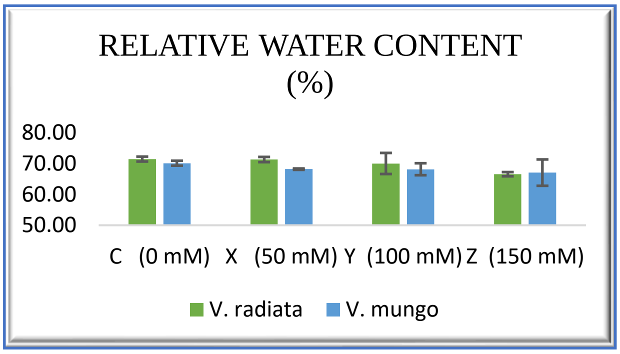
Seedling Dry Weight (DW):

As observed from Table 3.2, Seedling Dry weight (DW) was observed to be decreasing gradually with the increase in salt concentration in both species of Vigna. Thus, Control shows the highest DW i.e., 0.16 g in V. radiata and 0.15 g in V. mungo. And Treatment Z seedlings have the lowest DW i.e., 0.13g in V. radiata and 0.11g in V. mungo. Our results are in line with those reported by Carpıcı, Celık and Bayram (2009) who observed that shoot dry weight and root dry weights of all corn hybrids decreased as the levels of salinity increased.

Graph 3.8 shows that DW of V. radiata was higher than V. mungo in Control (0.16 g > 0.15 g), Treatment X (0.15g > 0.14g), Treatment Y (0.14 g > 0.12 g) and Treatment Z (0.13 g > 0.11 g) i.e., throughout in control and all the treatments.

Relative Water Content (RWC):

With the increasing concentration of salt, the Relative water content (RWC) decreased in both the species of Vigna. In V. radiata, maximum RWC was observed in Control (71.44 %) and minimum RWC was observed in the Treatment Z (66.54 %). Similarly, in V. mungo, maximum (70.11 %) in control and minimum (67.05 %) in Treatment Z was observed. (Table 3.2) Our results were in conformation with the reports of Sidari et.al., (2007) who observed that increasing of NaCl concentration reduced the germination percentage, the growth parameters and the relative water content; the water uptake in seeds decreased with increasing level of salinity stress and under higher salinity concentrations a greater decrease in imbibition was observed.



Graph 3.9 Effect of different salinity levels on Relative Water Content (RWC) (%)

It can be clearly observed from Graph 3.9 that RWC of V. radiata was higher than V. mungo in Control (71.44 % > 70.11%), Treatment X (71.30% > 68.17%) and Treatment Y (70.01% > 68.15%). However, in Treatment Z, RWC was seen higher in V. mungo (67.05%) than V. radiata. (66.54 %).

3.2 BIOCHEMICAL PARAMETERS

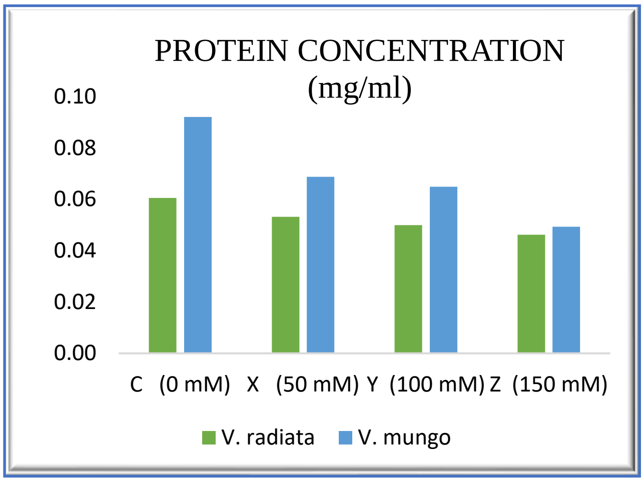
Protein

The Total Protein content in the seedlings is observed to be reducing in a gradual manner as we go from Control to Treatment Z – in both the species of Vigna. (Table 3.3). In Vigna radiata maximum protein content was observed in Control (0.06 mg/ml) and minimum protein content in Treatment Z (0.05 mg/ml). Similarly, in Vigna mungo, maximum protein (0.09 mg/ml) in control and minimum protein content (0.05 mg/ml) in Treatment Z was observed. Our results are in agreement with the findings of Bohnert and Jensen (1996) who stated that when the plant is subjected to any stress, protein synthesis is one of the most negatively affected anabolic processes. Jaleel et al., (2008), with their study on Catharanthus roseus and Khosravinejad et al., (2009) with their study on barley Hordeum vulgare also observed that the treatment with sodium chloride reduced protein content in the plant seedlings.

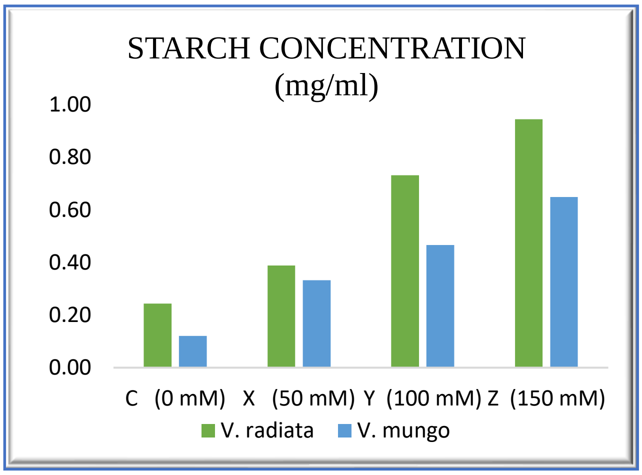
Graph 3.10 shows that protein content of V. mungo was higher than V. radiata in Control (0.09 mg/ml > 0.06 mg/ml), Treatment X (0.07 mg/ml > 0.05 mg/ml) and Treatment Y (0.06 mg/ml > 0.05 mg/ml). In Treatment Z, the protein content was observed to be similar in both species i.e., (0.05 mg/ml).

Table 3.3: Effect of different salinity levels on Biochemical Parameters of Vigna radiata and Vigna mungo.

Cultivars	Treatment	Protein (mg/ml)	Starch (mg/ml)	Reducing Sugar (mg/ml)
V. radiata	**C (0 mM)**	0.06	0.24	0.03
	X (50 mM)	0.05	0.39	0.03
	Y (100 mM)	0.05	0.73	0.02
	Z (150mM)	0.05	0.95	0.01
V. mungo	**C (0 mM)**	0.09	0.12	0.03
	X (50 mM)	0.07	0.33	0.03
	Y (100 mM)	0.06	0.47	0.02
	Z (150mM)	0.05	0.65	0.01



Graph 3.10 Effect of different salinity levels on Protein concentration (mg/ml)



Graph 3.11 Effect of different salinity levels on Starch concentration (mg/ml)

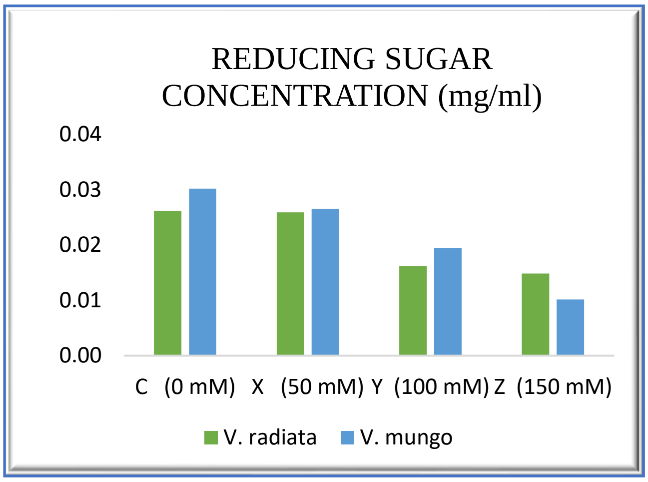
Starch

Starch content is found to be increasing, with the increase in NaCl concentration treatments. (Table 3.3). In Vigna radiata maximum starch content was observed in Treatment Z (0.95 mg/ml) and minimum starch content in Control (0.24 mg/ml). Similarly, in Vigna mungo, maximum starch in Treatment Z (0.65 mg/ml) and minimum starch content (0.12 mg/ml) in Control was observed. Our results are in agreement with those reported by Taffouo et al., (2009) who observed the accumulation of starch under abiotic stress. According to Stivsev, Ponnamoreva and Kuznestov (1973), accumulation of starch under salt stress may play a leading role in osmoprotection, osmotic adjustment, carbon storage and radical scavenging.

Graph 3.11 shows that starch content of V. radiata was higher than V. mungo in Control (0.24 mg/ml > 0.12 mg/ml), Treatment X (0.39 mg/ml > 0.33 mg/ml), Treatment Y (0.73 mg/ml > 0.47 mg/ml) and Treatment Z (0.95 mg/ml > 0.65 mg/ml) i.e., in control and all the treatments.

Reducing Sugar

Total Reducing Sugars (RS) were observed to be decreasing gradually with the increasing salt concentration in both species of Vigna. (Table 3.3) In Vigna radiata maximum RS content was observed in control (0.03 mg/ml) and minimum RS content in Treatment Z (0.01 mg/ml). Similarly, in Vigna mungo, maximum RS in control (0.03 mg/ml) in and minimum RS content (0.01 mg/ml) in Treatment Z was observed. The results of the present study were in contrast to those reported by Parida et al., (2002) who observed an increase in both reducing and nonreducing sugars with the increase in salt concentration in leaves of Bruguiera parviflora. V. mungo seedlings showed greater concentration of Total reducing sugars in Control (0.030 mg/ml > 0.026 mg/ml), Treatment X (0.027 mg/ml > 0.026 mg/ml) and Treatment Y (0.019 mg/ml > 0.016 mg/ml) – as compared to seedlings of V. radiata. Whereas in Treatment Z, V. radiata (0.015 mg/ml) seedlings have higher concentration of total reducing sugars than V. mungo seedlings (0.010 mg/ml). (Graph 3.12).



Graph 3.12 Effect of different salinity levels on Reducing Sugar concentration (mg/ml)

4. CONCLUSION

The results of the present study conclude that there is adverse effect of salt stress on Germination, Physiological and Biochemical Parameters in both the Cultivars of Vigna i.e., V. radiata and V. mungo. The best level was found in Control, in all the investigated parameters. There was reduction in the Germination Percentage, Germination Index, Salt Tolerance Index, Seed Vigour Index, Radicle length, Fresh weight, Dry weight and Relative Water Content of seedlings – with the increase in salinity level. The maximum reduction was thus seen at the salinity level of 150mM. Mean Germination Time increased with the increase in salt concentration. Biochemical parameters like Protein and Reducing Sugars also showed reduced concentration with the increasing salinity level. On the other hand, Starch concentration increased with the increase in Salinity level as a response to salt stress. This study also concludes that V. radiata is more tolerant to salt stress when compared to V. mungo – as evident from the results of Germination Percentage, Germination Index, Seed Vigour Index, Radicle length, Fresh weight, Dry weight and Relative Water Content.

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