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Salinity Stress Mediated Retardation of Seed Germination and Early Growth of Important Food Crops Cultivated in Gwalior

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ABSTRACT: The major ecological concern is the soil salinity in today's farming practices. Globally it is changing and creating many socio-economic problems. Salinity is mainly resulted from higher accumulation of the salts of SO_4^{-2}, NO_3^-, CO_3^{-2} , Cl^- and HCO_3^- etc. The main objective of the study is to find out the Salinity stress mediated retardation of seed germination and early growth of important food crops cultivated in Gwalior. Standard protocols were used to obtain the results. The results obtained indicated that accumulations of salts results into physiological draught condition by changing the water potential. This condition of soil salinity effects all stages of the crop growth specifically at the seed germination and early stages of the growth and ultimately significantly reduces the yield of the crops. This study will help the researchers in screening and identification salt tolerant varieties of the crops are the first step towards the selection and development tolerant varieties. The current study systematically identifies the local varieties of grains and pulses cultivated in the vicinity of Gwalior city, Madhya Pradesh, India.

Keywords: Salinity, Varieties, Water potential, Tolerance, Physiological draught, germination etc.

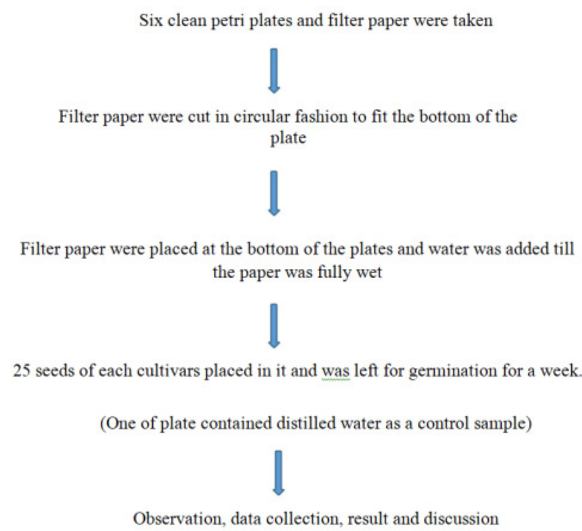
I. INTRODUCTION

Abiotic stress is a major environmental stress which limits agricultural productivity. Crops faces severe loss in production globally. These crop plants affected by environmental factors at every stage of its growth. This stress reduces their productivity. Major abiotic stress factor are salinity and drought especially in arid and semiarid agro ecology [1]. Many studies indicated that soil salinity is one of the major abiotic facto, in the arid and semi-arid areas, causes a major crop loss [2-4]. Studies have shown that soil salinity affects many stages of the plant growth such as germination, nodule formation, seedling growth which ultimately causes the crop loss [3]. The possible mechanism for these effects can be through creating osmotic potential which inhibits water uptake or through the ionic toxicity on embryo viability [5]. Moreover, seedling growth is retarded by soil salinity. The major studies have shown that reduction in cell division numbers and cell enlargement at the growing point of seedlings may be underlying mechanism for this phenomena [6]. Soil salinity is a global limiting factor which causes severe economic stress to the farmers. It is estimated that more than 10 million hectares of agriculture land is affected by the soil salinity globally [7]. One of the recent studies in the irrigated fields of Mekelle plateau and Tigary in Africa have shown severe effect of this. Enderta Wereda and Hintalo-Wajerat woreda regions in Tigray region shown that the dams which is heavily salinated causes soil salinity problems when the water from these dams were used for irrigation. The effect has been well studied in these region that how these salinity increases in this region by the progressing time. This also shows the effect quality of irrigation water may be a major contributing factor for soil salinity and the loss fertile agricultural land.

The prevalence of global soil salinity makes its important to study its effect on every stage of plant growth, starting from seed germination to adult stage. The studies expected to identify the salt tolerant crop varieties which will enhance agricultural productivity and uplift the economic condition of the farmers. The main area of study includes to identify the salt tolerant varieties and elucidation of salt tolerant mechanism involved in these varieties [8]. The upcoming area of research in plant breeding is to develop salt tolerant varieties to ensure the food security [9]. Seed germination is the primary stage of the plant growth where salt stress effects most prominently [8]. Well established studies have shown that soil salinity develops due to long term natural accumulation of salts through imbalanced salt containing irrigation water which contains excessive amounts of Na^+ and pH usually (>7.5) [10]. Which causes physiological draught condition and hence reduces the productivity. Mechanistically; it is well known that soil salinity creates osmotic around root cells of the plant [11]. Plant cells usually respond to salinity by evolutionary conserved mechanism such as lowering of cytosolc sodium concentration, sodium exclusion and compartmentalization in the vacuolar system [12]. An elegant study shows the sodium exclusion through the membrane bound Na^+/H^+ anti port transport system [13]. But the mechanism of salt tolerance in the plants is not well understood. Therefore; there is a need to understanding of salt tolerance mechanism in the plants. There are several steps involved for understanding the mechanism such as screening of different salt tolerant crop varieties; understanding of molecular mechanism for salt tolerance; identification of salt tolerant markers; employment of classical plant breeding or plant biotechnology techniques to develop tolerant varieties; acclimatization to the local environment etc. This study focus on the screening of prevalent crops of one of the most arid land of India located in Gwalior region in the state of Madhya Pradesh. In this study, we have screened seed germination and early growth of local cultivars of wheat, black gram, green gram, mustard and other crops in presence of different concentration of sodium chloride using *in vitro* Petri plate model. Interestingly, we have observed a significant dose dependent retardation of seed germination and early growth in many local varieties. The current study may start the research area to decipher molecular response of plant and determination of the unique genetic regulation mechanism upon salinity stress.

II. MATERIALS AND METHODS

Materials: Wheat, Green gram, Black gram & Black mustard seeds.
Other materials used for the experiment were NaCl (sodium chloride), petri plates, distilled water, filter paper and a good and hygienic germination site.
Methods: NaCl salt solution were prepared of different concentration i.e 50mM, 100mM, 200mM, 500mM and 1M along with distilled water as a control solution, to study the germination property of *Brassica nigra* in different salinity condition.
NaCl solution preparation:-
Molecular weight of NaCl is 58.44g/mol
Preparing 50mM solution:- As we know 1M=1000mM NaCl to be weighed to prepare 50mM solution is given by
M=(weight to be measured/58.44)*(1000/volume to be prepared)
So, calculated amount for 50mM was 1.401gm of NaCl in 1000ml distilled water.
Similarly for, 100mM, 2.9gm NaCl in 1000ml water 200mM, 5.8gm NaCl in 1000ml water 500mM, 14.6gm NaCl in 1000ml water 1M, 29.22gm NaCl in 1000ml water
All these prepared solution were stored in reagent bottles throughout the Experiment.
Flow Chart for experimental process



III. RESULTS

Salinity effects the germination and early growth of local wheat cultivars: The salt concentration tolerance was estimated up to 200 mM (Fig. 1). There was significant loss of germination at 200mM salt concentration. The cultivar in the representative figures shows significant tolerance at 100mM. However, there is significant loss of germination have similar effects (data not shown). The results indicated the average of three replicates. These observations suggest germination inhibition in the first week after sowing.

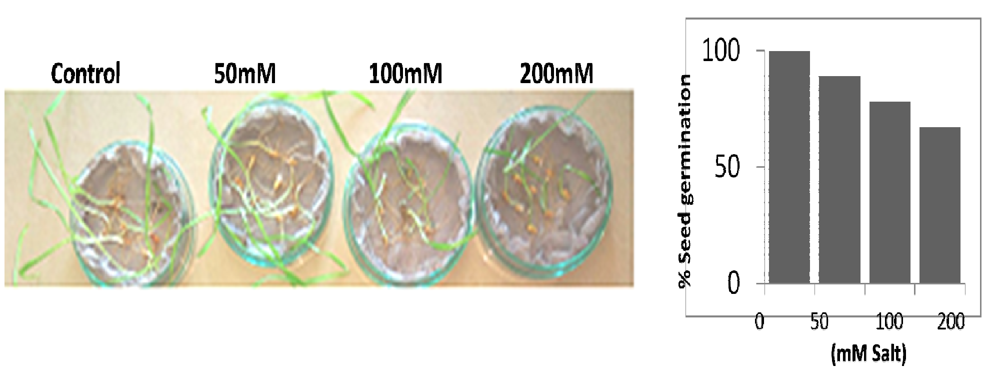


Fig. 1. Effect of salt on wheat germination and early growth.

Salinity effects the germination and early growth of local green gram cultivars: The salt concentration tolerance was estimated up to 200 mM (Fig. 1). There was significant loss of germination at 100mM salt concentration. Interestingly, the cultivars used in the experiment show severe susceptibility at 200 mM concentration. The cultivar in the representative figures (Fig. 2) shows significant tolerance at 50 mM. Moreover, there is significant loss of germination and have similar effects on the early growth has been observed in other cultivars of the green gram (data not shown). The results indicated the average of three replicates. These observations suggest germination inhibition in the first week after sowing [1, 2, 4, 6].

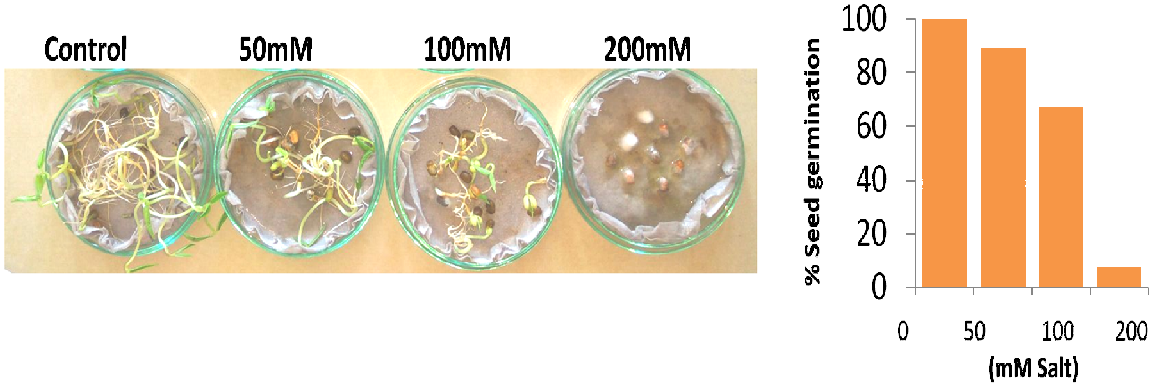


Fig. 2. Effect of salt on Green gram germination and early growth.

Salinity effects the germination and early growth of local Black gram cultivars: The salt concentration tolerance was estimated up to 200 mM (Fig. 3). There was significant loss of germination at 100mM salt concentration. Interestingly, the cultivars used in the experiment shows severe susceptibility at the early growth as it is shown in Fig. 3. The salat concentration of 200 mM inhibits the germination of this cultivar. However, early growth of the plant is severely inhibited at all the concentration of salts. Moreover, there is significant loss of germination and have similar effects on the early growth has been observed in other cultivars of the black gram (data not shown). The results indicated the average of three replicates. These observations suggest germination inhibition in the first week after sowing [8, 11].

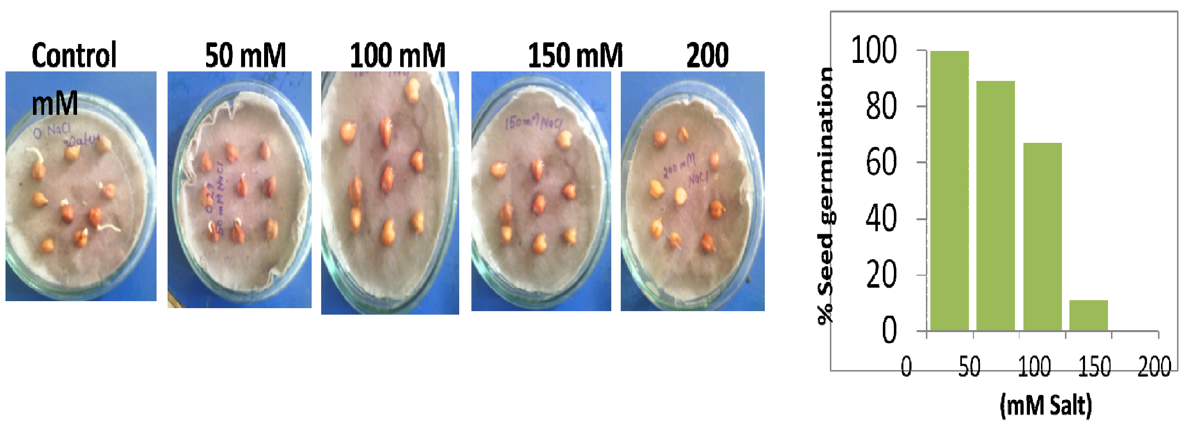


Fig. 3. Effect of salt on Black gram germination and early growth.

Salinity effects the germination and early growth of local Black Mustard cultivars: The salt concentration tolerance was estimated up to 500 mM (Fig. 4). There was significant loss of germination at 100mM salt concentration. Interestingly, the cultivars used in the experiment shows severe susceptibility at the early growth at or above 100 mM salt concentration as it is shown in Fig. 4. The salt concentration of 200 mM inhibits the germination of this cultivar. However, early growth of the plant is severely inhibited at all the concentration of salts. Moreover, there is significant loss of germination and have similar effects on the early growth has been observed in other cultivars of the black gram (data not shown). The results indicated the average of three replicates. These observations suggest germination inhibition in the first week after sowing.

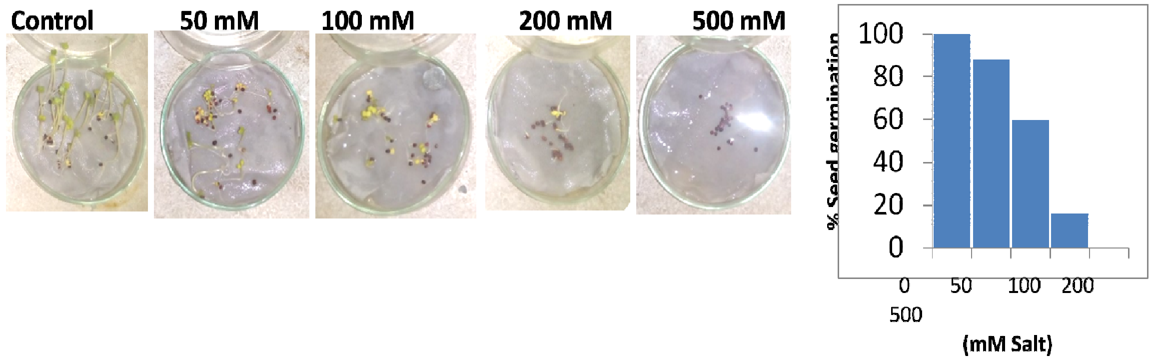


Fig. 4. Effect of salt on Black mustard germination and early growth.

IV. DISCUSSION

Based on the data collected, it is imperative to conclude that the concentration of salt affects germination, shoot and root length and water uptake of land races of Wheat, Green Gram, Black Gram & Black Mustard seeds from different areas of Gwalior. The germination of black mustard is reduced and the root underwent lysis and dries in high concentration of salt. Meanwhile, salt NaCl had different impact on the germination and growth of black mustard. As a result, NaCl has more impact on the germination of seed. However, the rate of growth is not as much enough and some seeds dried and lysised after few days of germination. At these concentration of salinity the seeds show a significant result as compared with the control. But at higher concentration of 100-200 mM and 1mM of NaCl the germination and growth of seeds is highly affected and none of the seeds germinated at these concentration and were dehydrated. This study confirms the previous studies on the effect of salt concentrations on the cultivars of different crops [14].

V. CONCLUSION

Our study shows that low concentrations of salts will not be able to overcome the toxic effects of crops. In this study we concluded that the application of different salts adversely affected the growth of different crops. High salt concentrations may reduce the growth and decrease in important constituents of the plants as has been observed in this study.

VI. FUTURE SCOPE

Salinity stress in different crops of Gwalior involves multifaceted responses at cellular, molecular, physiological and whole-plant levels. Its adverse effects include osmotic stress, ion toxicity and nutrient imbalances. Different crops have intrinsic tolerance through physiological mechanisms, many needs to be explored in this species. Different crops in Gwalior have distinct advantage of being a short-duration crop; it can grow in a range of soils and environments as a solo or as a relay crop. However, because it is sensitive to salinity, it has not been widely adopted by farmers. It is hoped that increasing osmotic stress tolerance would provide impetus for Different crops production under saline conditions.

Conflict of Interest. The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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