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Water Stress Induced by Mannitol in Sesame Cultivars

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ABSTRACT

Plants are subject to a range of stressors, which can lead to structural damage and altered physiological performance. One of the environmental conditions that reduce plant growth and production is water stress. The current study aims to investigate the effects of mannitol-induced water stress on seed germination and seedling growth in sesame cultivars. Seeds of two sesame cultivars (GT-10 and JTS-8) were subjected to different water stresses induced by mannitol. Mannitol inhibited seedling germination and growth through limiting water content in a concentration-dependent manner. With an increase in mannitol content, both varieties' seed germination and seedling growth dropped. However, under the stress of 0.5 M mannitol concentration, the seedling growth has been demonstrated to be greater in JTS-8.The results revealed that JTS-8 shows more tolerance in different mannitol concentrations than that of GT-10 due to higher osmotic adjustment ability.

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INTRODUCTION

Plants respond to fluctuations in environmental stress through a number of ways which enable them adjust in order to cope with such stresses. Germination may be affected by seed's ability to use resources more efficiently (Rao and Sinha 1993). The production of seeds is generally considered as an essential stage in seed establishment and thus plays a major role in the estimation of crop yields. Water stress might be particularly severe during seed germination and early seedling growth. A significant financial loss due to reduced crop production and lower prices for uneven plant batches can result from uneven or poor seed germination followed by uneven growth of the seed. Sesame (*Sesamum indicum* L.) is an economically important oil seed crop that is widely grown around the world. It has been observed that it is susceptible to a wide variety of environment conditions, including air temperature, salt levels, precious metals and soil moisture which all have an influence on its development and production (Bor *et al.* 2009). The different responses to osmotic stress from species, variety, osmotic concentration, growth conditions and developmental stage of plants were all shown Lokhande *et al.* (2010), Yadav *et al.* (2019). Crop fresh and dry mass output was lowered as a result of the negative effect of water stress. Nevertheless, thorough investigations on sesame responses to environmental conditions are underutilized and reports are scarce Nath *et al.* (2001), Olowe *et al.* (2009).

Many workers also observed toxic effect of different mannitol concentrations on the germination of black sesame. They reported fast germination at lower concentration and delayed germination in case of higher concentration of mannitol (Abirami 2023).The soluble salt levels in soil are diminishing the osmotic capacity of soils to disrupt water and nutrient uptake, which results in an imbalance of ions resulting in plant toxicity. The adverse effects of these variables on certain physiological and biochemical processes lead to a decrease in plant development (Munns 2002, Hamdia and Shaddad 2010). Mannitol is an osmotic adjustment chemical that is used to regulate the osmotic potential in culture media or nutrient solutions in order to create water deficit conditions (Chaves and Oliveira 2004). It is employed in plants to cause osmotic stress. Mannitol, an important osmolyte is generally abundantly produced in many plant species (Su *et al.* 1999, Mitoi *et al.* 2009). Despite the fact that mannitol is essential for osmotic equilibrium Shen *et al.* (1997), Srivastava *et al.* (2010). Unfortunately, the literature on mannitol's role for stress tolerance in agronomical relevant plants does not show much evidence. To measure drought tolerance of wheat, artificial techniques such as mannitol are employed in the laboratory to simulate water stress on plants Molnar *et al.* (2004). The current study compared the response of seed germination and seedling growth of sesame cultivars (GT-10 and JTS-8) to Mannitol-induced water conditions.

MATERIALS AND METHODS

The results of this study were to assess the effects of mannitol caused by drought stress for seed germination and early seedling growth in two sesame cultivars, which are GT-10 and JTS-8. The current research was conducted in the Environmental Biology Research Laboratory, Department of Botany, TNB College, TM Bhagalpur University, Bhagalpur, Bihar. The seeds of the two cultivars GT 10 and JTS 8 were extracted from the Agricultural University in Sabour Bhagalpur, Bihar. Before beginning the experiment, select healthy, uniform size sesame seeds that have been cleaned with a 2% sodium hypochlorite solution for 2 minutes and then rinsed with distilled water. The sterilized seeds were placed on glass petridishes with a tight-fitting, sterilized filter paper-lined matrix for seed germination. Sesame seeds were simulated at 29°C using A Completely Randomized Design with two replicates of 10 seeds per petridis per cultivar. Each variety specifies eight mannitol concentrations: 0.05 M, 0.1 M, 0.15 M, 0.2 M, 0.25 M, 0.3 M, 0.4 M and 0.5 M, respectively. As a control, distilled water was used. Every 24 hrs, observations were taken. The length of the seedling and the fresh weight of each cultivar were measured after 96 and 144 hrs.

RESULTS AND DISCUSSION

Under mannitol stress, the germination rate of two sesame cultivars (GT 10 and JTS 8) diminished discernibly. Mannitol-induced water deficit hampered both germination and seedling development. Mannitol had a retarding effect on germination in both cultivar (GT-10 and JTS -8) at all concentrations up to 0.5 m. In both cases, a declining trend with increasing mannitol concentrations were found as shown in Tables 1-3 and Figs.1 and 2. JTS 8 has higher mannitol tolerance than GT-10 in terms of seedling length and fresh weight after 96 and 144 hrs, respectively. GT -10 showed highest mannitol sensitivity. The current findings revealed that when the concentration of mannitol increases, seedling length and fresh weight decrease.

Mannitol treatment decreased the germination process by lowering seed water intake and thereby decreasing germination. These findings are consistent with some previous findings by other researchers (Gao *et al.* 2004). In their studies on wheat, found that while mannitol had no effect on seed germination, it had a substantial negative impact on seedling length (Almansouri *et al.* 2001). Lower seedling growth is

Table 1. Effect of different mannitol concentrations on the germination percentage of sesame cultivars (GT-10 and JTS-8).

Treatment	Germination % GT-10	JTS-8
Control	65	90
0.05 M	60	80
0.1 M	60	75
0.15 M	55	75
0.2 M	50	70
0.25 M	50	65
0.3 M	50	60
0.4 M	45	60
0.5 M	40	55

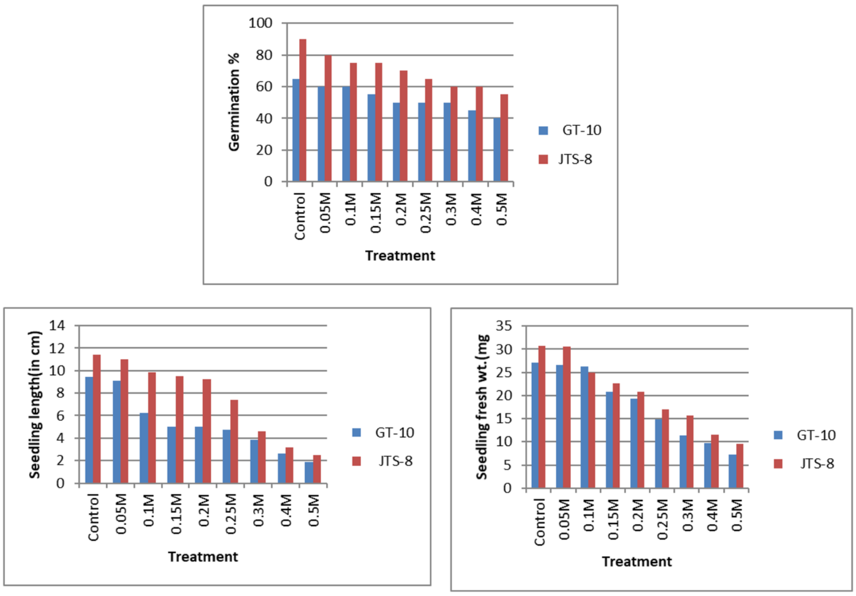

Fig. 1. Effect of different mannitol concentrations on germination percentage (%), seedling length (cm) and seedling fresh weight (mg) of sesame cultivars (GT-10 and JTS-8) after 96 hrs.

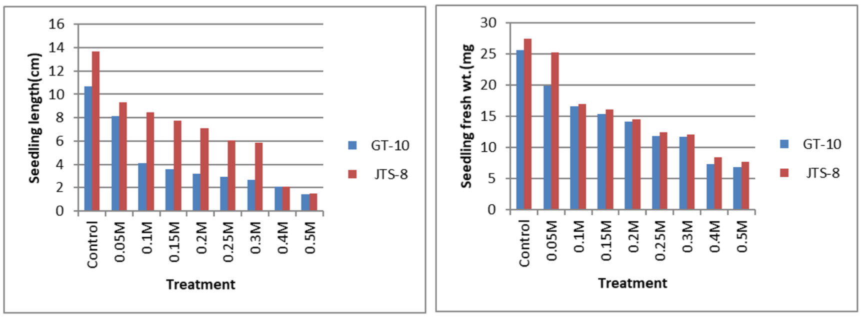

Fig. 2. Effect of different mannitol concentrations on seedling length (cm) and seedling fresh weight (mg) of sesame cultivars (GT-10 and JTS-8) after 144 hrs.

Table 2. Effect of different mannitol concentrations on the seedling length of sesame cultivars (GT-10 and JTS-8). R= Length of Radicle, H= Length of Hypocotyl, T=Total.

Treatment	Seedling length (cm) after 96 hrs						Seedling length (cm) after 144 hrs					
	GT-10			JTS-8			GT-10			JTS-8		
	R	H	T	R	H	T	R	H	T	R	H	T
Control	4.17	5.246	9.416	5.421	6.023	11.444	4.221	6.467	10.688	6.074	7.562	13.636
0.05 M	3.734	5.348	9.082	6.050	4.946	10.996	3.192	4.914	8.106	4.297	5.016	9.313
0.1 M	4.059	2.149	6.208	5.026	4.823	9.849	2.320	1.761	4.081	3.737	4.695	8.432
0.15 M	1.880	3.126	5.006	6.748	2.780	9.528	2.454	1.098	3.552	3.868	3.886	7.754
0.2 M	3.075	1.910	4.985	5.611	3.647	9.258	0.933	2.289	3.222	4.937	2.679	7.072
0.25 M	2.505	2.259	4.764	1.347	6.034	7.381	1.445	1.489	2.934	3.924	2.135	6.059
0.3 M	2.108	1.764	3.872	3.411	1.199	4.61	1.501	1.192	2.693	3.943	1.911	5.854
0.4 M	1.897	0.715	2.612	0.986	2.151	3.137	1.493	0.584	2.077	1.675	0.408	2.083
0.5 M	1.422	0.466	1.888	1.743	0.741	2.484	1.023	0.397	1.42	1.194	0.293	1.487

Table 3. Effect of different mannitol concentrations on the seedling fresh weight of sesame cultivars (GT-10 and JTS-8). (R= Fresh weight of Radicle, H= Fresh weight of Hypocotyl, T=Total.

Treatment	Seedling fresh wt (mg) after 96 hrs						Seedling fresh wt (mg) after 144 hrs					
	GT-10			JTS-8			GT-10			JTS-8		
	R	H	T	R	H	T	R	H	T	R	H	T
Control	16.443	10.717	27.16	17.389	13.258	30.647	9.356	16.223	25.579	9.472	18.017	27.489
0.05 M	14.068	12.440	26.508	19.884	10.711	30.595	4.685	15.180	19.865	7.885	17.409	25.294
0.1 M	15.401	10.823	26.224	14.038	10.841	24.879	5.059	11.503	16.562	5.146	11.798	16.944
0.15 M	6.956	13.921	20.877	13.695	8.882	22.577	2.726	12.645	15.371	4.462	11.597	16.059
0.2 M	8.253	11.128	19.381	12.650	8.156	20.806	4.230	9.972	14.202	5.392	9.179	14.571
0.25 M	5.216	9.659	14.875	3.686	13.327	17.013	2.334	9.486	11.82	3.900	8.584	12.484
0.3 M	3.905	7.528	11.433	3.790	11.835	15.625	3.281	8.429	11.71	4.735	7.338	12.073
0.4 M	3.132	6.514	9.646	3.502	7.995	11.497	1.422	5.858	7.28	1.730	6.743	8.473
0.5 M	1.960	5.198	7.158	1.986	7.573	9.554	1.737	5.135	6.872	1.745	5.976	7.721

found at greater osmotic potentials of mannitol, implying that mannitol generates mild toxic effects at higher concentrations, as demonstrated (Luan *et al.* 2014). Mannitol inhibited the development of cucumber seedlings but had no impact on pea seedlings growth (Stahlberg and Cosgrove 1997). Additionally, these researchers verified that mannitol did not enter seedling root cells and that the mannitol-induced depletion in xylem pressure was resulted in the cucumber seedlings' which cause slower development rate. The results of seedling growth in both cultivars showed that mannitol-induced osmotic stress had a negative effect on water intake by germinating seeds (Mozdzen *et al.* 2015).

CONCLUSION

Mannitol concentrations had a deleterious effect on two different sesame cultivars (GT 10 and JTS 8). JTS 8 appeared to be more tolerant to different water stress during germination than GT 10, whereas GT 10 was found to be more sensitive to stress during the seedling stage. Overall, both sesame cultivars showed satisfactory development under the control conditions. The current findings reveal a decrease in germination percentage and seedling growth as mannitol concentration increases. Many workers also found that as mannitol concentration increased moisture content and seedling length reduced in soybean cultivars (Seong *et al.* 1988). The reduction in yields due to reduced photosynthetic rates, interrupted transport and distribution of the assimilates is a typical plant response to water stress. Osmotic dehydration stress lowers germination, water intake, and inhibits sesame seed germination. These findings about varietal resilience to abiotic stress are critical for farmers, plant breeders and scientific study.

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REFERENCES

Abirami K (2023) Effects of salinity and water stress factors on seed germination, early seedling growth and proline content in an oil crop, black sesame (*Sesamum indicum* L.). *J Stress Physiol Biochem* 19 (1) : 77—96.

Almansouri M, Kinet JM, Lutts S (2001) Effect of salt and osmotic stresses on germination in durum wheat (*Triticum durum* Desf.). *Pl Soil* 231 (2) : 243—254.

Bor M, Seckin B, Ozgur R, Yilmaz O, Ozdemir F, Turkan I (2009) Comparative effects of drought, salt, heavy metal and heat stresses on gamma-aminobutryric acid levels of sesame (*Sesamum indicum* L.). *Acta Physiologiae Plantarum* 31 (3) : 655—659.

Chaves MM, Oliveira MM (2004) Mechanisms underlying plant resilience to water deficits : Prospects for water-saving agriculture. *J Experim Bot* 55 (407) : 2365—2384.

Gao D, Knight MR, Trewavas AJ, Sattelmacher B, Plieth C (2004) Self-reporting Arabidopsis expressing pH and Ca^2 indicators unveil ion dynamics in the cytoplasm and in the apoplast under abiotic stress. *Pl Physiol* 134 (3) : 898—908.

Hamdia MA, Shaddad MAK (2010) Salt tolerance of crop plants. *J Stress Physiol Biochem* 6 (3) : 64—90.

Lokhande VH, Nikam TD, Penna S (2010) Differential osmotic adjustment to iso-osmotic NaCl and PEG Stress in the *in vitro* cultures of *Sesuvium portulacastrum* (L.). *J Crop Sci Biotechnol* 13 (4) : 251—256.

Luan Z, Xiao M, Zhou D, Zhang H, Tian Y, Wu Y, Guan B, Song Y (2014) Effects of salinity, temperature and polyethylene glycol on the seed germination of sunflower (*Helianthus annuus* L.). *The Scientific World J* pp 1—9.

Mitoi EN, Holobiuc I, Blindu R (2009) The effect of mannitol on antioxidative enzymes *in vitro* long term cultures of dianthus tenuifolius and dianthus spiculifolius. *Romanian J Biol Pl Biol* 54 : 25—30.

Molnar I, Gaspar L, Sarvari E, Dulai S, Hoffmann B, Molnar-Lang M,Galiba G (2004) Physiological and morphological responses to water stress in *Aegilops biuncialis* and *Triticum aestivum* genotypes with differing tolerance to drought. *Functional Pl Biol* 31 (12) : 1149—1159.

Mozdzen K, Bojarski B, Rut G, Migdałek G, Repka P, Rzepka A (2015) Effect of drought stress induced by mannitol on physiological parameters of maize (*Zea mays* L.) seedlings and plants. *J Microb Biotechnol Food Sci* 4 (2) : 86—91.

Munns R (2002) Comparative physiology of salt and water stress. *Plant Cell Environment* 25 (2) : 239—250.

Nath R, Chakraborty P, Chakraborty A (2001) Effect of climatic variation on yield of sesame (*Sesamum indicum* L.) at different dates of sowing. *J Agron Crop Sci* 186 (2) : 97—102.

Olowe VIO, Adeyemo YA, Adeniregun OO (2009) Sesame : The underexploited organic oilseed crop. *J Sci Sustain Develop* 2 (1) : 29—32.

Rao DG, Sinha SK (1993) Efficiency of mobilization of seed reserves in sorghum hybrids and their parents as influenced by temperature regimes. *Seed Res* 2 (2) : 97—100.

Srivastava AK, Ramaswamy NK, Suprasanna P, D'Souza SF (2010) Genome-wide analysis of thiourea-modulated salinity stress responsive transcripts in seeds of *Brassica juncea* : Identification of signalling and effector components of stress tolerance. *Annals Bot* 106 (5) : 663—674.

Seong RC, Chung HJ, Hong EH (1988) Varietal responses of soybean germination and seedling elongation to temperature and polyethylene glycol solution. *Korean J Crop Sci* 33 (1) : 31—37.

Stahlberg R, Cosgrove DJ (1997) Mannitol inhibits growth of intact cucumber but not pea seedlings by mechanically collapsing the root pressure. *Pl Cell Enviro* 20 (9) : 1135—1144.

Shen BO, Jensen RG, Bohnert HJ (1997) Increased resistance to oxidative stress in transgenic plants by targeting mannitol biosynthesis to chloroplasts. *Pl Physiol* 113 (4) : 1177—1183.

Su J, Chen PL, Wu R (1999) Transgene expression of mannitol-1-phosphate dehydrogenase enhanced the salt stress tolerance of the transgenic rice seedlings. *Scientia Agricultura Sinica* 32 : 101—103.

Yadav AK, Carroll AJ, Estavillo GM, Rebetzke GJ, Pogson BJ (2019) Wheat drought tolerance in the field is predicted by amino acid responses to glasshouse-imposed drought. *J Experiment Bot* 70 (18) : 4931—4948.