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Effect of Salinity on Six Genotypes of *Avena Sativa* during Germination and Seedling Growth

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Abstract: *Avena sativa* is a promising crop valued for its nutritional benefits, adaptability and rapid growth. The rapidly increasing global salinisation threatens more than 10% of arable land, lowering the average yield of major crops. To examine the impact of salinity on seed germination and seedling development in six *Avena* genotypes (JHO Kent, JHO 822, JHO 851, JHO 2009-1, JHO 2010-1, and JHO 2012-2) subjected to different salinity levels (EC 4, EC 8, EC 12, EC 16 dS/m), including distilled water. The seeds were germinated in petri plates. The germination and seedling vigour were significantly affected by increasing salinity, with notable declines observed at EC 12 and EC 16. Among the genotypes, JHO 822 and JHO 2009-1 displayed the highest salinity tolerance. JHO 822 achieved 90% germination in distilled water at EC 12 and exhibited superior radicle (19 cm) and plumule (20.76 cm) lengths. Similarly, JHO 2009-1 retained 85% germination at EC 16 and exhibited strong seedling growth, with maximum radicle and plumule lengths. JHO Kent, JHO 851, and JHO 2012-2 showed moderate salinity tolerance, attaining germination rates above 75% at EC 16 but with reduced seedling growth metrics. In contrast, JHO 2010-1 demonstrated the lowest resilience, with germination declining to 40% and minimal radicle and plumule development at EC 16. Across all genotypes, lower salinity levels (EC 4 and EC 8) supported optimal germination and growth. Thus, the study highlights substantial genotypic variability in salinity tolerance, with JHO 822 and JHO 2009-1 emerging as promising genotypes for cultivation in saline environments.

Keywords: *Avena sativa*, salinity, abiotic stress, germination, seedling vigour

I. Introduction

Healthy soil is the lifeblood of plant growth. It provides a stable anchor for roots, supplies essential nutrients, and facilitates the exchange of water and air. Soil salinity is a major abiotic threat to agriculture worldwide, estimating that more than 6% of the world's total land area is affected by salinity. Saline-sodic soils in India occupy approximately 7% of the total land area (1 billion ha) and 20% of the irrigated arable land in arid and semi-arid regions. This area is increasing (Agarwal *et al*. 2013). This causes osmotic stress, ionic toxicity and oxidative stress, affecting beneficial soil microbes, seed germination, seedling establishment, water uptake, metabolic function and overall crop yield. Seed germination is considered a key stage in the plant's life cycle and is affected by many ecological factors such as temperature, drought, salt stress, light and soil pH. Salinity impacts germination through osmotic stress, ion-specific effects, and oxidative stress, reducing germination rates and prolonged germination times (Malaviya *et.al*., 2019). Effects of salinity are categorised as primary and secondary. Primary effects include metabolic disruption and inhibited growth and development, while secondary effects of salinity are nutrient deficiency and osmotic dehydration. By increasing external osmotic potential, salinity reduces water uptake during imbibition. Approximately 99% of the world's plant species are sensitive to even low salinity levels ($ECe < 4$ dS m^{-1}). Under moderate salinity conditions (EC 4–8 dS m^{-1}), the average yield of major glycophytic crops decreases by 50–80%. It was observed that tolerance at germination, early seedling, and vegetative growth stages are of great importance in determining the ultimate tolerance of the crop. Notable advancements have been achieved in breeding salt-tolerant green vegetables and crops. However, forage species, particularly those derived from wild germplasm, have more promising solutions for the reclamation of soil. These species carry genes that provide resistance to both biotic and abiotic stresses.

Plants react to salinity through two mechanisms: a reduction in external water potential caused by elevated soil salt levels and the ongoing uptake and accumulation of ions within their tissues. This results in the mortality of sensitive species caused by nutrient deficiency and osmotic dehydration. Salinity adversely impacts seed germination and plant growth, thereby diminishing crop yield. The tolerance of a crop during germination, early seedling, and vegetative growth stages is crucial for assessing species tolerance.

Oats (*Avena sativa* L.), belonging to the family Gramineae (Poaceae), hold significance as they rank sixth in global cereal production and are extensively cultivated for food, feed, and fodder. The genus includes diploid, tetraploid, and hexaploid species with a basic chromosome number of $X = 7$ (Kushwaha *et al*., 2003). Cultivated oats are allohexaploids ($2n = 6x = 42$) derived from three ancestral diploid *Avena* genomes (A, C, and D) (Bennet and Leitch, 1995). In India, oats are grown on approximately 0.5 million hectares, while the global cultivation area spans 9 million hectares annually for grain, fodder, and straw production (Sánchez-Martín *et al*., 2014). The crop's global importance is rising due to its ease of cultivation and profitability. Oats are a favoured winter cereal fodder crop in northwestern and central India and are increasingly grown in eastern and southern regions. They yield palatable and nutritious forage and are gaining popularity as a healthy food source because of their high dietary fibre content, particularly beta-glucan (Villaluenga and Penas, 2017). Because of their high beta-glucan content, a soluble fibre that lowers cholesterol, oats are also known to have positive effects on diabetes management (Singh *et al*., 2003). While moderately tolerant to drought, cold, and mineral deficiencies, oats are more sensitive to salt stress than cereals like barley and wheat. Nevertheless, they can grow in diverse soil types and exhibit substantial saline-alkali tolerance The study aims to identify tolerant and susceptible oat genotypes by examining their germination ability, and seedling traits under varying levels of salinity. This evaluation is crucial for selecting genotypes that can be used in breeding programs to develop oat varieties suitable for salinity-affected areas.

II. Material and Methods

Seeds of six genotypes of oat were procured from ICAR-Indian Grassland & Fodder Research Institute, Jhansi.

Screening for germination and seedling vigour in vitro

Five different electrical conductivity (EC) treatments, including control, were given in six genotypes: JHO2009-1, JHO2010-1, JHO2012-2, JHO Kent, JHO822, and JHO851. To induce salinity stress during germination, solutions with varying levels of electrical conductivity (4, 8, 12, 16 dS/m) were prepared by mixing NaCl, $MgCl_2$, $CaSO_4$, and Na_2SO_4 salts in varying quantities in distilled water (Dheeravathu *et. al*., 2018). Twenty seeds per genotype for every treatment were placed on sterilised filter paper in petri dishes. For control sets, the filter papers were soaked with distilled water (DW), while for saline treatments, soaking was done with saline water with electrical conductivity (EC) of EC4, EC8, EC12, and EC16 dS/m. Data on germination were recorded 7 days after soaking, and the total number of germinated seeds with radicle and plumule growth was recorded. Radicle and plumule lengths were recorded on 3 seedlings in each set on the 15th day to measure seedling growth.

Data Analysis

Salinity intensity index (SII) was determined using the formula SII = 1 - XSS/XNS, where XSS and XNS represent the average values for all accessions in salinity-stressed (SS) and non-stressed (NS) conditions, respectively, as (Fisher and Maurer,1978).

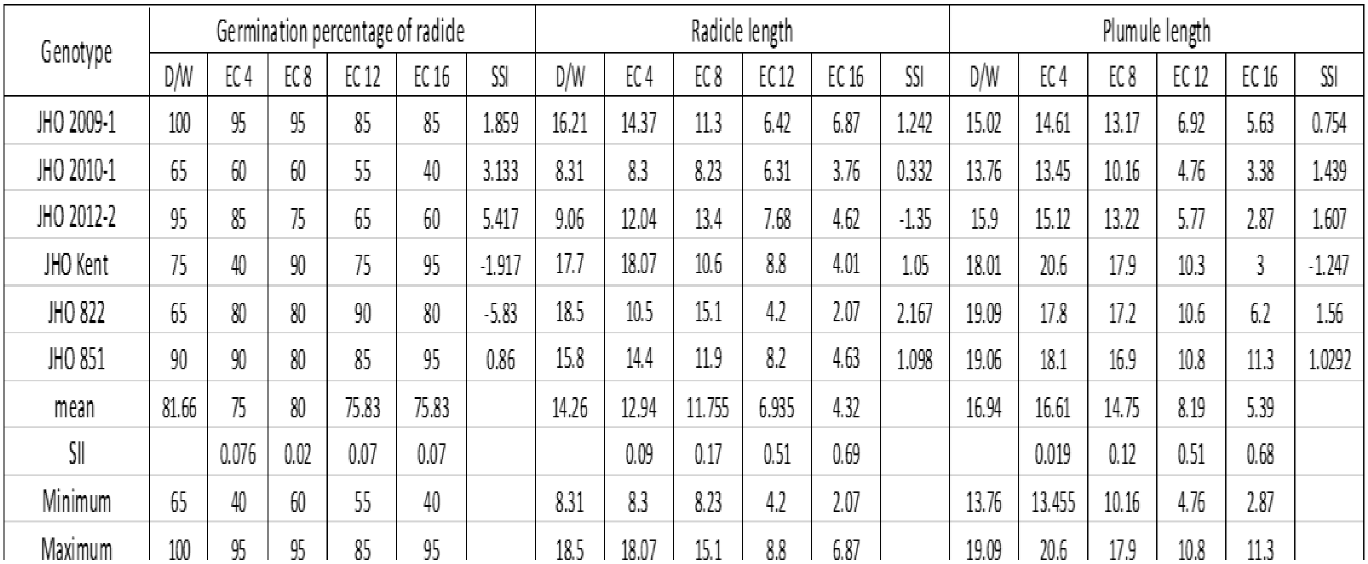
The salt susceptibility index (SSI) was calculated using the formula SSI = (1 - YSS/YNS)/SII, where YSS and YNS are the mean values for a specific accession under stressed and non-stressed conditions, respectively, (Bayuelo-Jiménez *et al*. 2002).

Based on the SSI values, genotypes were categorised as susceptible, tolerant, or highly tolerant, with lower SSI values indicating greater tolerance. Statistical analyses, including standard deviation calculations, Student's t-tests, two-factor analysis of variance, and regression analyses, were performed using the MS Excel software.

III. Results and Discussion

Germination% was mainly driven by genetic differences in this particular set of data. Even at higher salinity (EC12, EC16), genotypes JHO 2009-1 and JHO 851 still showed high germination. Radicle length was strongly inhibited by higher salinity for all genotypes (i.e., the "salinity effect" dwarfed the "genotype effect"). Radicle length does differ significantly across salinity levels (DW > EC4 > EC8 > EC12 > EC16), while differences among genotypes are not large enough. Plumule length was impacted significantly by both genotype and salinity. Genotypes JHO 851 and JHO 822 consistently produced longer shoots, but all genotypes tended to show shorter shoots as salinity went up. As salinity increases, plumule length generally decreases (with a few exceptions). Meanwhile, genotypes JHO 851, and JHO 822 maintain longer shoots overall than JHO 2010-1.

Table 1- Mean, SII and SSI in *Avena sativa* genotypes at different salinity levels:



Genotype	Germination percentage of radide						Radicle length						Plumule length					
	D/W	EC 4	EC 8	EC 12	EC 16	SSI	D/W	EC 4	EC 8	EC 12	EC 16	SSI	D/W	EC 4	EC 8	EC 12	EC 16	SSI
JHO 2009-1	100	95	95	85	85	1.859	16.21	14.37	11.3	6.42	6.87	1.242	15.02	14.61	13.17	6.92	5.63	0.754
JHO 2010-1	65	60	60	55	40	3.133	8.31	8.3	8.23	6.31	3.76	0.332	13.76	13.45	10.16	4.76	3.38	1.439
JHO 2012-2	95	85	75	65	60	5.417	9.06	12.04	13.4	7.68	4.62	-1.35	15.9	15.12	13.22	5.77	2.87	1.607
JHO Kent	75	40	90	75	95	-1.917	17.7	18.07	10.6	8.8	4.01	1.05	18.01	20.6	17.9	10.3	3	-1.247
JHO 822	65	80	80	90	80	-5.83	18.5	10.5	15.1	4.2	2.07	2.167	19.09	17.8	17.2	10.6	6.2	1.56
JHO 851	90	90	80	85	95	0.86	15.8	14.4	11.9	8.2	4.63	1.098	19.06	18.1	16.9	10.8	11.3	1.0292
mean	81.66	75	80	75.83	75.83		14.26	12.94	11.755	6.935	4.32		16.94	16.61	14.75	8.19	5.39	
SII		0.076	0.02	0.07	0.07			0.09	0.17	0.51	0.69			0.019	0.12	0.51	0.68	
Minimum	65	40	60	55	40		8.31	8.3	8.23	4.2	2.07		13.76	13.455	10.16	4.76	2.87	
Maximum	100	95	95	85	95		18.5	18.07	15.1	8.8	6.87		19.09	20.6	17.9	10.8	11.3	

Fig. 1-

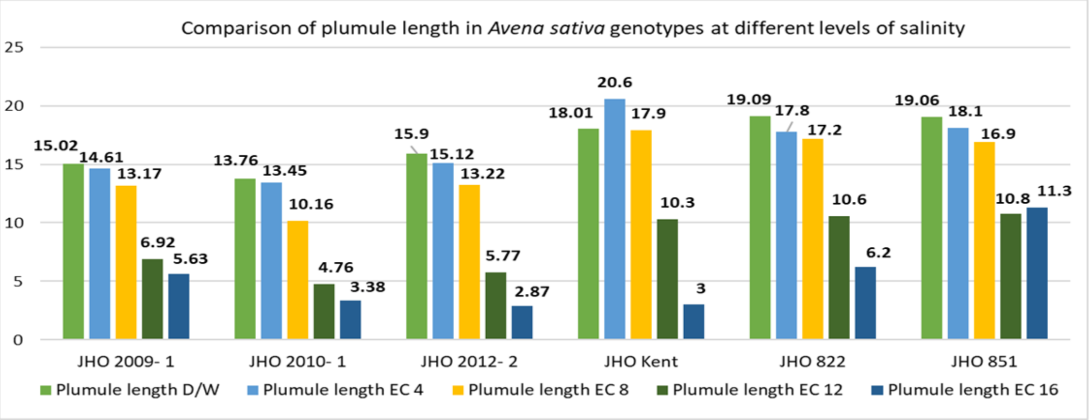


Fig. 2-

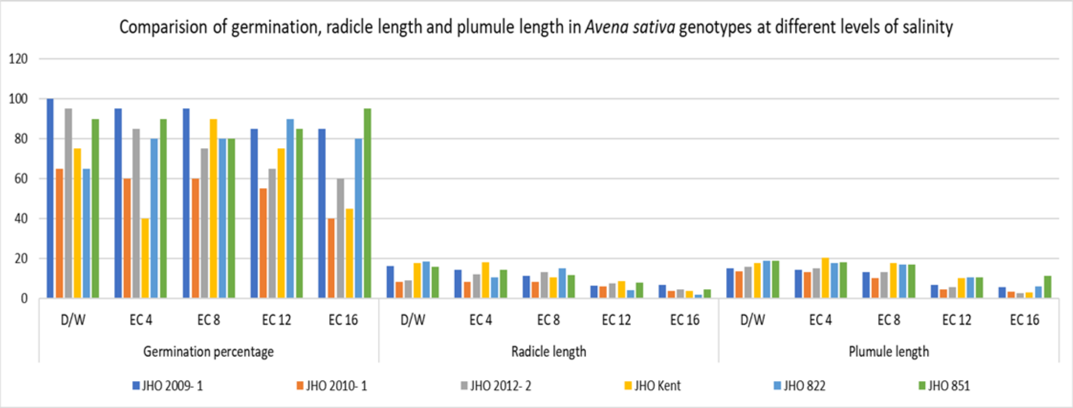


Fig. 3-

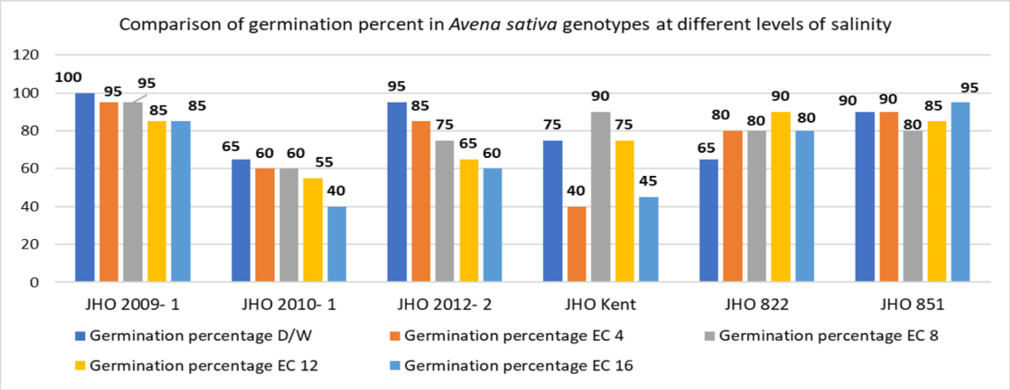
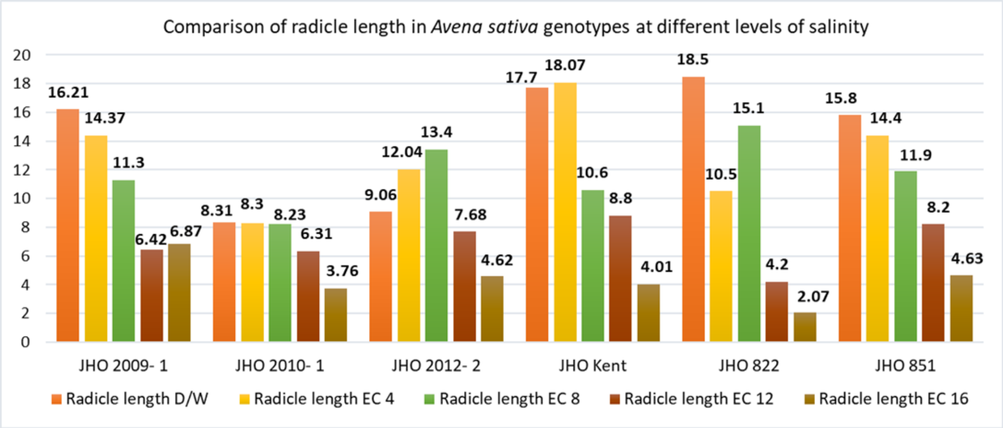


Fig. 4-



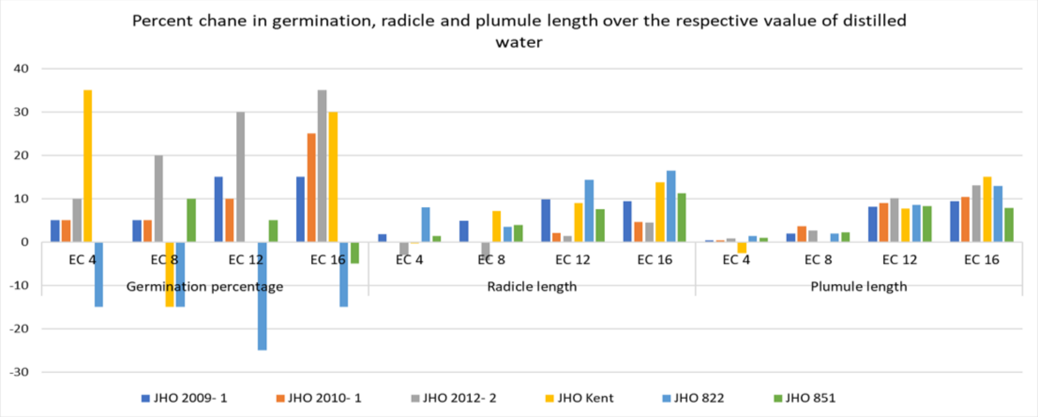
Our findings revealed significant genotypic differences in salinity tolerance among the tested oat genotypes. While certain genotypes demonstrated resilience during the germination stage (JHO 2009-1 and JHO 851), others exhibited tolerance at the seedling stage (JHO 822). This dual-stage variability underscores the importance of selecting genotypes based on specific growth phases when developing salt-tolerant varieties having negative SSI values, indicating their salinity-tolerant nature (Roy *et. al.*, 2021).

Consistent with previous studies (Akbarimoghaddam *et al.*, 2011; Kumawat *et al.*, 2022), our data showed a reduction in germination rates as salinity levels increased. High salinity exerts detrimental effects on germination due to ion toxicity, which results from simultaneous increases in anions and cations in the surrounding solution. This imbalance disrupts critical processes like water imbibition and enzyme activation, reducing germination efficiency.

Table 2- Germination%, radicle and plumule length at different levels of salinity in *Avena sativa* genotypes:

Genotype	Germination percentage				Radicle length				Plumule length			
	EC 4	EC 8	EC 12	EC 16	EC 4	EC 8	EC 12	EC 16	EC 4	EC 8	EC 12	EC 16
JHO 2009- 1	5	5	15	15	1.84	4.91	9.79	9.34	0.41	1.85	8.1	9.39
JHO 2010- 1	5	5	10	25	0.01	0.08	2	4.55	0.31	3.6	9	10.38
JHO 2012- 2	10	20	30	35	-2.98	-4.34	1.38	4.44	0.78	2.68	10.13	13.03
JHO Kent	35	-15	0	30	-0.37	7.1	8.9	13.69	-2.59	0.11	7.71	15.01
JHO 822	-15	-15	-25	-15	8	3.4	14.3	16.43	1.29	1.89	8.49	12.89
JHO 851	0	10	5	-5	1.4	3.9	7.6	11.17	0.96	2.16	8.26	7.76

Fig. 5-



Higher salinity also significantly impacted seedling growth by interfering with the plant's ability to absorb essential nutrients. This aligns with findings by Chauhan *et al.* (2016) and Veeral *et al.* (2018), which suggest that high salt concentrations in the soil solution inhibit the uptake of crucial ions such as potassium and calcium. The reduction in nutrient availability leads to stunted growth and diminished vigour, particularly in susceptible genotypes.

Studies (Chauhan *et al.*, 2016; Devi *et al.*, 2018) emphasise that plant expansion—including radicle and plumule elongation—is a vital indicator of salt tolerance. In our study, genotypes like JHO 851 maintained relatively longer radicle and plumule lengths under salinity stress, highlighting their adaptive mechanisms to mitigate ion toxicity and osmotic stress. These traits suggest the potential of JHO 851 for breeding salt-tolerant oat varieties.

IV. Conclusion

The variability in salinity tolerance across different genotypes and developmental stages demonstrates the complex interaction between genetic and environmental factors. Targeting specific traits, such as germination efficiency and seedling elongation under stress, can aid in selecting and breeding salt-tolerant oat genotypes. These findings contribute to sustainable agricultural practices in saline-affected regions.

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References

1. Agarwal, P. K., Shukla, P. S., Gupta, K., & Jha, B. (2013). Bioengineering for salinity tolerance in plants: State of art. Molecular Biotechnology, 54, 102–123. https://doi.org/10.1007/s12033-012-9538-3
2. Akbarimoghaddam, H., Galavi, M., Ghanbari, A., & Panjehkeh, N. (2011). Salinity effects on seed germination and seedling growth of bread wheat cultivars. Trakia Journal of Sciences, 9(1), 43–50.

3. Bayuelo-Jiménez, J. S., Craig, R., & Lynch, J. P. (2002). Salinity tolerance of Phaseolus species during germination and early seedling growth. Crop Science, 42, 1584–1594.
4. Bennett, M. D., & Leitch, I. J. (1995). Nuclear DNA amounts in angiosperms. Annals of Botany, 76, 113–176. https://doi.org/10.1006/anbo.1995.1085
5. Chauhan, A. N., Nidhi, R., Deepak, K., Ashok, K., & Chaudhry, A. K. (2016). Effect of different salt concentrations on seed germination and seedling growth of different varieties of oat (Avena sativa L.). International Journal of Information Research and Review, 3(7), 2627–2632.
6. Devi, S., Phogat, D. S., Satpal, & Goyal, V. (2019). Responses of oat (Avena sativa L.) genotypes under salt stress. International Journal of Current Science, 7(3), 734–737.
7. Fisher, R. A., & Maurer, R. (1978). Drought resistance in spring wheat cultivars I. Grain yield responses. Australian Journal of Agricultural Research, 29, 897–912.
8. Kumawat, S., Kumawat, R., Kumawat, K. R., Gothwal, D. K., & Yadav, S. (2022). Explore salt-tolerant fenugreek genotypes seedlings using salt tolerance index. The Pharma Innovation Journal, 11(4 Suppl), 1925–1931.
9. Kushwaha, N., Dwivedi, K., Choubey, R. N., Malaviya, D. R., Roy, A. K., Anand, A., Baig, M. J., & Kaushal, P. (2002). Germination and seedling vigour of grasses under different levels of salinity. In National Symposium on Grassland and Fodder Research in New Millennium (pp. 26–27).
10. Malaviya, D. R., Roy, A. K., Anand, A., Choubey, R. N., Baig, M. J., Dwivedi, K., Kushwaha, N., & Kaushal, P. (2019). Salinity tolerance of Panicum maximum genotypes for germination and seedling growth. Range Management and Agroforestry, 40(2), 227–235.
11. Roy, A. K., Malaviya, D. R., Anand, A., Choubey, R. N., Baig, M. J., Dwivedi, K., & Kaushal, P. (2021). Salinity tolerance of Avena sativa fodder genotypes (Tolerancia de genotipos de avena forrajera a la salinidad). Tropical Grasslands–Forrajes Tropicales, 9(1), 109–119.
12. Sánchez-Martín, P. L., Chen, M. K., Pessarakli, M., Hill, H. J., Gore, M. A., & Jenks, M. A. (2014). Effects of temperature and salinity on germination of non-pelleted and pelleted guayule (Parthenium argentatum A. Gray) seeds. Industrial Crops and Products, 55, 90–96. https://doi.org/10.1016/j.indcrop.2014.02.018
13. Seva Nayak, D., Tyagi, V. C., Gupta, C. K., & Antony, E. (2018). Manual on plant stress physiology. ICAR-Indian Grassland and Fodder Research Institute.
14. Singh, C., Singh, P., & Singh, R. (2003). Modern techniques of raising field crops (2nd ed., pp. 429–436). Oxford and IBH Publishing Co. Pvt. Ltd.
15. Veeral, K. M. D., Sangameshwari, P., & Kalaimathi, P. (2018). Laboratory studies on the effects of different salt concentrations on seed germination. Open Access Journal of Agricultural Research, 3(1). https://doi.org/10.23880/OAJAR-16000158
16. Villaluenga, C., & Peñas, E. (2017). Health benefits of oats: Current evidence and molecular mechanism. Current Opinion in Food Science, 14, 26–31. https://doi.org/10.1016/j.cofs.2017.01.004