PAKISTAN JOURNAL OF AGRICULTURE
ISSN: 3079 – 3866 (ONLINE), 3079 – 3858 (PRINT)
https://isciencepress.com/journals/index.php/pja
Research Article

Impact of Different Water Qualities on Germination and Seedling Growth of *Triticum aestivum*, *Hordeum vulgare*, *Coriandrum sativum*, and *Raphanus sativus*

Gul Sika Tareen[1*], Tabinda Shahid[1], Saeeda Bibi[1], Asma Abdul Hayee[1] and Aneela Kanwal Shahzadi[2*]

*[1]Department of Plant Sciences, Sardar Bahadur Khan Women's University, Quetta, Pakistan, [2]Institute of Botany, Bahauddin Zakariya University, Multan, Pakistan (*Correspondence: shinning.gul077@gmail.com; aneelakshahzadi@gmail.com)*

Received: 20.02.2025, **Accepted:** 05.05.2025, **Published Online:** 09.05.2025 **DOI:** https://doi.org/10.38211/PJA.2025.02.95

Abstract | Irrigation water quality is a key factor affecting seed germination and early seedling development, which are important stages in the life cycle of crops. This study aimed to evaluate the effects of different water qualities on germination and seedling growth of four economically and nutritionally important plant species: *Triticum aestivum* (wheat), *Coriandrum sativum* (coriander), *Hordeum vulgare* (barley), and *Raphanus sativus* (radish). Seeds were sown in pots and irrigated with different water samples, including tube well water, mineral water, domestic wastewater, tap water, and three different salt concentrations (1, 2, and 3%). Germination percentage and seedling growth were estimated at regular intervals (1st, 2nd, 3rd, and 4th week). The results indicated that wheat exhibited the highest germination rate (47.0%) and seedling growth (4.84 cm), followed by barley (25.5% and 3.89 cm) and radish (22.5% and 2.10 cm). Coriander showed the lowest mean germination percentage (9.92%) and seedling growth (1.26 cm) in all water qualities except three salt concentrations. Notably, under saline conditions, only wheat and barley exhibited germination and growth at lower salt concentrations (1 and 2%). However, neither plant species showed growth performance at 3% salt concentrations. It was concluded that all water qualities except saline are suitable for germination and growth, wastewater can be used as an inexpensive fertilizer, and salt-tolerant varieties (wheat and barley) should be used in saline areas to ensure their survival.

Keywords: Water quality, Salinity, Seedling growth, Germination, Coriander, Barley, Wheat, Radish

Introduction

Water quality is a major environmental factor that influences agricultural production, especially in the context of current global challenges, including climate change, urbanization, and freshwater scarcity (Okorogbona et al., 2018).

In many developing regions, the increasing demand for irrigation water has led to the use of marginal water sources, including saline water, municipal and industrial wastewater, and untreated surface water (Zaman et al., 2018). These sources often include excessive salts, organic pollutants, heavy metals, and microbial contamination, which can pose significant risks to soil health and plant growth (Ali et al., 2019; Malakar et al., 2019).

The germination of seeds and early seedling development are extremely sensitive stages in the life cycle of plants and are affected by irrigation water quality. Germination begins with the uptake of water, which triggers key metabolic processes that result in radical and shoot emergence. This includes enzymatic hydrolysis, nutrient transport, cellular expansion, and energy transfer processes that depend on water quality and availability (Nonogaki, 2019).

The adverse characteristics of water, including high salinity or toxic chemical compounds, can disrupt the imbibition process by hindering enzyme activities and interfering with nutrient uptake, ultimately decreasing germination percentage, delaying emergence, and weakening seedling vigor (Farooq et al., 2009; Munns & Tester, 2008). These early setbacks often translate into reduced crop growth and yield under field conditions.

The response to poor quality water varies between plant species and cultivars. Cereals such as *Hordeum vulgare* (barley) and *Triticum aestivum* (wheat) are

relatively more tolerant to ionic imbalance and osmotic stress than horticultural crops such as *Raphanus sativus* (radish) and *Coriandrum sativum* (coriander), which are known for their sensitivity and susceptibility to saline and toxic elements (Ashraf & Foolad, 2007; Shahbaz & Ashraf, 2013). Understanding the specific responses of these species is essential for improving crop selection in areas where freshwater is limited or contaminated. Despite the recognized importance of water quality in agriculture, comparative studies evaluating its effects on cereal and vegetable crops under similar conditions are limited.

The current study was conducted to evaluate the effects of different irrigation water qualities, ranging from tap water and wastewater to saline water, on the germination and seedling growth of four commonly cultivated species: *Triticum aestivum*, *Coriandrum sativum*, *Hordeum vulgare*, and *Raphanus sativus*. The results obtained from this study will contribute valuable insights into the crop selection for cultivation under different compromised water conditions and will aid in the development of adaptive irrigation strategies in arid and semi-arid regions.

Materials and Methods

The experiment was conducted both in the greenhouse and the laboratory.

Experimental Design: The experiment was conducted to evaluate the effect of different water qualities on seedling growth and germination rate of different crops and vegetables. Four different test species were selected, i.e. barley (*Hordeum vulgare*) genotype (Sanober 96), coriander (*Coriandrum sativum*), radish (*Raphanus sativus*), and wheat (*Triticum aestivum*) genotype (Azri 96). Seeds were collected from the Balochistan Agriculture Research Center. The present study was conducted in the botanical garden of SBK Women's University, Quetta. The experiment was conducted in suitable environmental conditions (25-18 ºC day/night and relative humidity 43-51%) in plastic pots. Ten healthy seeds of each species with a 95% germination rate were sown in pots and irrigated with different water samples, including tube well water, mineral water, domestic wastewater, tap water, and three different salt concentrations (1, 2, and 3%). These salt-concentrated solutions were considered saline solutions.

Preparation of salt-concentrated solution: The saline solution was prepared by dissolving 10 g NaCl in 100 ml of distilled water. The other solutions were prepared by the same method.

Measurement of parameters: Data was estimated weekly over four weeks to assess growth parameters, germination percentage, and species-specific tolerance levels. Germination rate and seedling growth (length of plumule) of the test species were checked against different water samples (Abdul-Baki & Anderson, 1973). The length of the plumule was measured with a scale (cm). The germination rate was calculated by using the following formula: Germination rate = Number of seeds germinated / Total number of seeds x 100.

Chemical analysis of water samples: In the laboratory, the electrical conductivity (EC), Total dissolved solids (TDS), and pH were determined (Association, 1926; Radojevic & Bashkin, 2007). Different TDS, EC, pH, and salinity values for all testing samples are presented in Table 1. The chemical composition of wastewater and tube well was highly suitable for the growth of test species.

Statistical analysis: All germination and growth data were analyzed by descriptive statistical analysis (mean and coefficient of variation (CV)), which was performed to assess the variability among treatments. The statistical analysis of data was performed by using MS Excel 2016.

Table 1. Chemical analysis (electrical conductivity (EC), total dissolved solids (TDS), pH, and salinity) of tested water samples

Parameter	Domestic wastewater	Tubewell water	Tap water	Mineral Water	Salinity		
					1%	2%	3%
Salinity (g/L)	1.6	0.75	0.8	0.7	2.4	2.7	3.4
EC mS/cm	3.9	8	8.2	11.9	19.5	34.7	48.6
TDS (mg/L)	2574	8.8	8.72	621	848	1154	1186
pH	6.7	6.9	7.2	6.7	8.2	8.24	8.3

Results

The present study was conducted to check the effects of different water samples on germination rate and seedling growth of the test species. The observation was taken every week. Tap water was taken as a control. The result revealed that after the first week, the germination percentage for all test species was affected differently for all water samples when compared with tap water. The domestic wastewater showed the highest germination percentage in wheat, barley, and radish, while 0% germination was observed for coriander in all water samples except tube well water, which showed 16%

germination (Table 2). At the same time, seedling growth was also noticed, which revealed that domestic wastewater also increases the growth of seedlings. All test species showed 0% germination (Table 2), and no seedling growth under all concentrations of saline water (Figure 1).

Table 2. Germination percentage of *Triticum aestivum, Hordeum vulgare, Raphanus sativus*, and *Coriandrum sativum* under different water qualities

Duration	Plant cultivars	Germination percentage (%)						
		Domestic water	Tubewell water	Tap water	Mineral Water	Salinity		
						1%	2%	3%
1st week	Wheat	60	73	60	53	0	0	0
	Radish	25	20	5	15	0	0	0
	Coriander	0	16	0	0	0	0	0
	Barley	45	20	15	15	0	0	0
2nd week	Wheat	73	80	66	53	93	0	0
	Radish	25	65	15	50	1	0	0
	Coriander	5	21	1	3	0	0	0
	Barley	50	35	20	25	0	0	0
3rd week	Wheat	73	80	73	60	80	13	0
	Radish	25	80	20	65	15	0	0
	Coriander	10	25	58	6	0	0	0
	Barley	45	45	30	45	50	10	0
4th week	Wheat	60	73	73	50	66	6	0
	Radish	25	80	20	65	15	0	0
	Coriander	11	23	88	11	0	0	0
	Barley	45	45	30	45	80	20	0

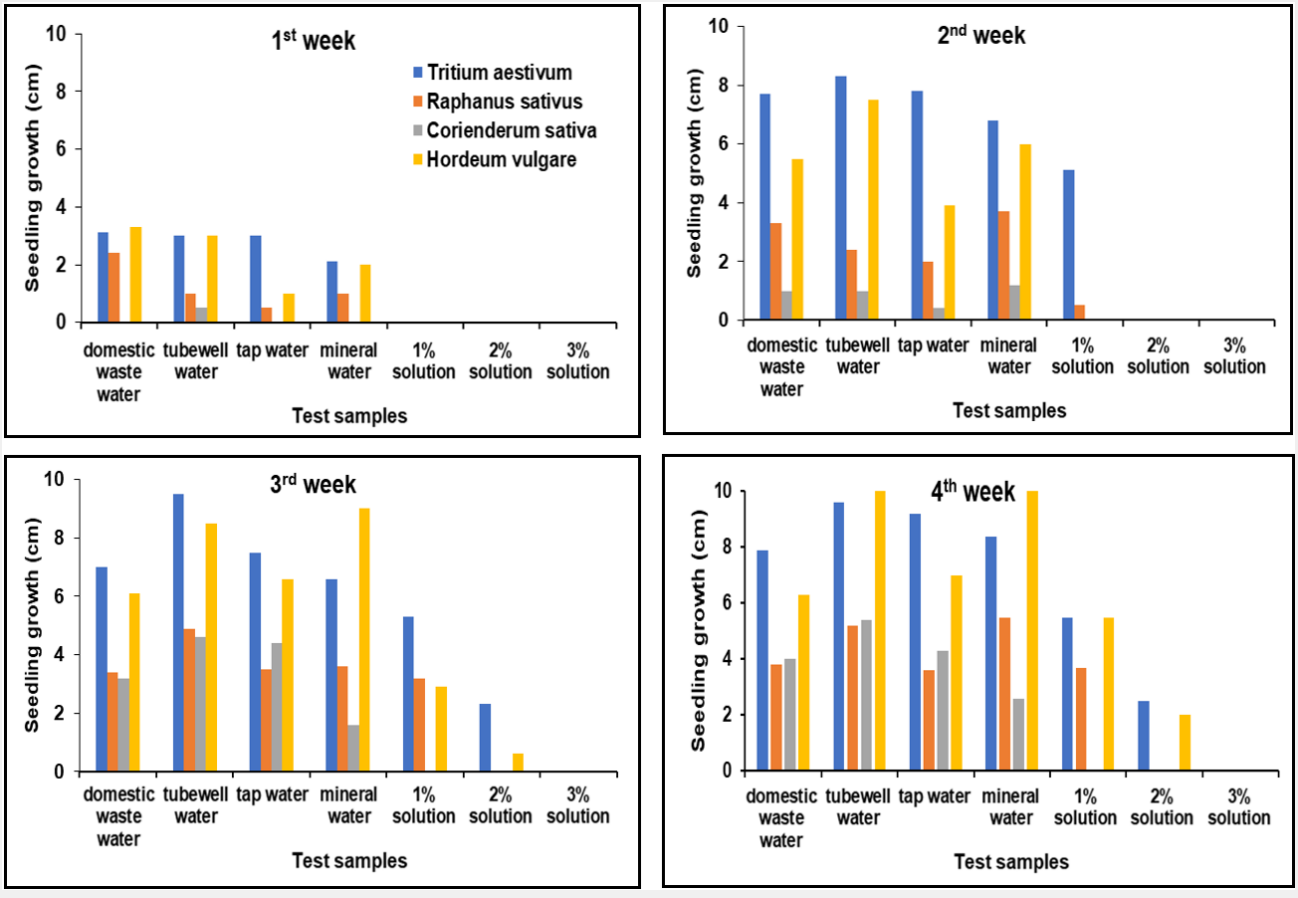


Figure 1. Effect of different water qualities on seedling growth of *Triticum aestivum, Hordeum vulgare, Raphanus sativus*, and *Coriandrum sativum* across four weeks

In the second week, tube well water had the highest percentage in all test species when compared with the tap water. Wheat in 1% saline water exhibited 93% germination, which was greatest among all test species treated with different water samples, while other salt concentrations showed 0% germination in all test species (Table 2). Seedling growth was observed to be greater in tube well water as compared with other water samples. Domestic and tap water also increased the seedling growth in all test species (Figure 1). The highest growth value was recorded in wheat, followed by barley, and the lowest value was recorded in coriander. Wheat and radish also germinated well in 1% salt concentration, showing resistance towards salinity. In the third week, tube well water showed the highest germination in all test species than other water samples, while saline water in all concentrations had 0% germination for all test species (Table 2). All the water samples were suitable for seedling growth except for the 3% salt concentration (Figure 1). It was also noticed that barely germinated and grew in the 3rd week, showing its resistance towards salinity. Salinity highly affected the germination of coriander in the 3rd week, showing its sensitivity to saline water. The growth of radish under mineral water was observed higher during the 3rd week. In the fourth week, the highest germination was observed in coriander with tap water. Barley showed a high germination rate with 1% saline water. Its high resistance towards salinity was observed, while other plants revealed great susceptibility towards salinity and did not germinate under saline water concentrations (Table 2). Barley showed the highest growth with tube well water. Among all other plants, wheat grew the best in domestic wastewater and tap water. In the 4th week, barley and wheat still showed high resistivity towards 1% and 2% salt concentrations, while no germination and growth took place under 3% salt concentration, which concluded that germination and seedling growth can take place at low concentrations, while higher concentrations may decrease plant growth and germination percentage (Figure 1). It was represented as a mean germination of growing plants. It is concluded that the highest germination occurs in wheat, followed by barley and radish. The mean also represents the lower germination rate in coriander. The statistics for the growth of selected plants were also significant (Table 3). The mean table represents the growth of all plants, which revealed the highest growth in wheat (4.84 cm) followed by barley (3.89 cm), and the lowest growth in coriander.

Table 3. Descriptive statistics (mean and coefficient of variation (CV)) for germination percentage and seedling growth of test species

Variable	Plant cultivars	Mean	Coefficient of variance (CV) (%)
Germination percentage	Barley	25.53	64.44
	Coriander	9.92	145.92
	Radish	22.53	106.54
	Wheat	47.0	66.65
Seedling growth	Barley	3.89	77.53
	Coriander	1.26	100.64
	Radish	2.10	72.98
	Wheat	4.84	60.48

Discussion

The results of this study clearly show that water quality plays a significant role in determining seed germination rate and seedling growth in different crop varieties. The significant variation among treatments suggests that both the chemical composition and salinity levels of irrigation water can promote or inhibit early plant growth. The superior performance of wheat and barley under tap and tube well and tap water treatments is consistent with previous studies, which have shown that cereals are generally more tolerant to moderate environmental stresses during germination compared to sensitive vegetable crops (Ashraf & Foolad, 2007; Shahbaz & Ashraf, 2013). Moreover, wheat and barley showed maximum germination (47.0%, 25.5%) and growth (4.84 cm, 3.89 cm) respectively in all quality water. In contrast, coriander exhibited the minimum germination percentage and poorest seedling growth, indicating its susceptibility to osmotic and ionic stress, especially in wastewater and saline water treatments. The complete or partial inhibition of germination in salt-irrigated pots confirms that high salinity concentration disrupts the uptake of water and metabolic activation in seeds, leading to the failure of radicle emergence (Hasegawa, 2013). In low concentrations of salinity, the germination and growth of wheat were not affected by either low or higher concentrations of salt. Salinity is one of the environmental factors that has a critical influence on seed germination and plant growth. It is the main cause of crop failure. Both salinity and plant growth are inversely proportional to each other (Shahzadi et al., 2021). Similar results were determined by Abdelkader et al. (2007) that the higher concentration of salts inhibits the absorption of water by germinating seeds and causes a decline in germination. With the increase in salt stress, there is a significant decrease in the germination percentage in plants as the mineral content is increased. The results of the current study showed that at a 3% salt concentration, all seeds of barley (*Hordeum vulgare*), coriander (*Coriandrum sativum*), radish (*Raphanus sativus*), and wheat (*Triticum aestivum*) failed to germinate. Toscano et al. (2025) showed similar results in microgreens (garden rocket and radish) growing in different salt concentrations. Garden rocket, being salt tolerant, achieved the highest germination percentage at high salt concentration, whereas radish, being salt sensitive, did not germinate at high salinity concentration. Crops' tolerance for salinity ranges from salt-sensitive to highly salt-tolerant plants. Plants sensitive to salts during germination seem to tolerate high salinities during vegetative stages. In the present investigation, barley and wheat show significant tolerance

against salinity in 2% salt concentration and grow best. This is compatible with the findings of Munns & Tester (2008), who reported that the presence of excessive salt ions (Na^+, Cl^-) in the soil solution creates an adverse osmotic environment, inhibiting the germination of seeds and early growth.

The employment of domestic wastewater in the present study stimulates the strong and fair growth of plants, especially wheat, with 73% growth, which does not affect the germination percentage. The permeability of the seed coat to domestic wastewater is almost the same as that of water, but the increased concentration may reduce germination. These results showed similarity with the results of Gassama et al. (2015). Seed germination in kidney beans, millet, and rice was favored in low effluent concentrations but restricted in higher concentrations.

Overall, these observations are consistent with earlier reports that poor quality water negatively affects enzymatic activity, decreases energy metabolism, and disrupts the uptake of nutrients. These are the factors critical during seed germination and seedling growth (Farooq et al., 2009). The data emphasizes the importance of evaluating water sources before using them in agriculture, especially in arid and semi-arid regions where scarce water is often the only option.

Conclusion

In crux, tap water and tube well water promoted germination and seedling growth, particularly in wheat and barley. In contrast, saline-water treatments severely suppressed germination and growth, with coriander being the most sensitive species. The absence of seed germination in high salt-irrigated pots of all species confirms the damaging effect of salinity on the establishment of seedlings. These results spotlight the importance of water quality in the selection of crops and also suggest that cereal crops may perform better under suboptimal water conditions than certain vegetables.

Acknowledgements

The authors are thankful to the Department of Plant Sciences, Sardar Bahadur Khan Women's University, Quetta, Pakistan for providing the necessary facilities.

Author Contribution

GST & TS: Experimentation, conceptualization, data curation, formal analysis, writing original draft; SB & AAH: Investigation, methodology, software, AKS: Validation; software, writing review and editing.

Conflict of Interest

No competing interests are disclosed by the authors.

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