J. Hortic. Sci.
Vol. 20(2), 2025

https://doi.org/10.24154/jhs.v20i2.3110

Original Research Paper

Effect of irrigation with sodic water with and without amendment on flowering, fruiting and yield attributing parameters of guava cv. Hisar Safeda

Akshay[1], Rajkumar[2], Singh M.[3], Singh N.[4*], Kumar A.[5] and Mann A.[6]

[1&3]Chaudhary Charan Singh Haryana Agricultural University, Hisar - 125 004, India
[2,4,5,6]ICAR-Central Soil Salinity Research Institute, Karnal - 132 001, India
[*]Corresponding author Email: nirmalsingh@hau.ac.in

ABSTRACT

An investigation was carried out on one-year-old nursery plants of guava cv. Hisar Safeda, irrigated with different combinations of residual sodium carbonate (RSC) water and amendments (press mud and gypsum) to assess the effects of RSC_{iw} on flowering, fruiting and yield traits and to evaluate the role of amendments in mitigating the effects of RSC_{iw}, during 2021 to 2023. Ten different treatments including best available water (non-sodic water as control) and three RSC levels (2.5, 5.0, and 7.5 meq/L) with or without amendments were arranged in randomised block design with five replications. Results revealed that highest number of flowers/plant, fruit set, fruit retention and yield attributing parameters such as number of fruits/plant, fruit weight, fruit length, fruit width, and fruit volume were recorded when plants were irrigated with BAW. Different level of RSC_{iw} (2.5, 5 and 7.5 meq/L) showed negative effects on flowering, fruiting except fruit drop, and yield attributing parameters; addition of gypsum and press mud with RSC_{iw} showed positive effects on all parameters except fruit drop in comparison to alone RSC_{iw}; Notably, irrigation with RSC at 2.5 meq/L yielded comparable effects on flowering, fruiting and yield attributing parameters to non-sodic water irrigation (control/BAW), recommending it as a sustainable approach for guava cultivation. This research contributes valuable insights into sustainable horticultural practices, offering practical solutions for guava cultivation under challenging soil and water conditions in India.

Keywords: Amendments, flowering, guava, irrigation, sodic water, yield

INTRODUCTION

Guava (*Psidium guajava* L.) is one of major fruit crops belongs to the family Myrtaceae. The guava plant boasts a high vitamin C content and contains significant amounts of minerals, including potassium, calcium, phosphorus, and magnesium, along with natural antioxidants (Flores et al., 2015). Guava is one of the most resilient tropical fruit trees in terms of ability to adapt to a wide range of environmental circumstances (Rajkumar et al., 2014).

Water scarcity is increasingly limiting global crop production, and in India, groundwater is the main source of supplemental irrigation (Yadav & Dagar, 2016). However, 32–84% of aquifers used for irrigation across the country have poor water quality (Minhas et al., 2019). In Haryana, most agricultural land depends on canals and unreliable sources like rainfall or wells/tube wells that supply low quality water. Sodic water, defined by residual sodium carbonate (RSC) > 2.5 meq/L, is considered unsuitable for irrigation (Kumar et al., 2023; Machra et al., 2025), with sodium carbonate and bicarbonate being common in such sources. Continuous irrigation with such poor quality water rich in carbonates and bicarbonates leads to the development of sodic soils over time. Gypsum (calcium sulphate), a common sodic soils amendment, aids reclamation by displacing sodium ions from exchange sites, forming soluble calcium-sodium complexes that improve soil structure (Basak et al., 2021). Press mud, a sugar industry byproduct rich in organic matter and nutrients, effectively reclaims sodic soils (Sheoran et al., 2020). Its organic carbon improves structure and water retention, boosts fertility and microbes, while organic acids displace sodium ions and stabilize aggregates. As a sustainable, cost-effective conditioner, it aids sodic soil restoration.

Irrigation with sodic water adversely affects flowering, fruiting, and yield-related traits in fruit crops, but applying amendments like gypsum and press mud can mitigate these negative effects and improve flowering,

Table 1 : Meteorological data during investigation

Month	Average temperature (°C)		Relative humidity (%)		Total rainfall (mm/day)
	Maximum	Minimum	Morning	Evening	
July 2021	34.2	26.6	87.7	72.4	668.1
August 2021	33.0	26.4	92.4	76.9	146.1
September 2021	31.6	24.8	94.9	76.1	224.6
October 2021	31.5	19.0	88.9	49.5	85.6
November 2021	27.4	10.9	93.0	35.3	00.0
December 2021	21.2	07.6	97.2	62.5	01.2
January 2022	15.3	08.1	98	83	93.1
February 2022	21.1	08.1	97	56	29.9
March 2022	30.7	14.8	91	41	00.0
April 2022	39.6	19.6	54	15	00.0
May 2022	37.4	24.5	69	39	111.0
June 2022	38.4	25.6	70.2	42.4	52.8
July 2022	33.3	26.8	92.4	75.8	472.0
August 2022	33.1	26.1	92.9	75.5	108.4
September 2022	32.2	24.4	96.1	72.3	441.6
October 2022	31.0	18.4	93.6	50.2	18.0
November 2022	27.4	12.3	92.6	44.5	00.0
December 2022	20.8	07.9	97.1	62.1	01.2
January 2023	16.5	06.8	96	73	22.6

fruiting, and overall yield parameters compared to sodic water alone. Keeping these aspects in view, the proposed experiment was planned to study the effect of irrigation with sodic water on flowering, fruiting and yield attributing parameters of guava cv. Hisar Safeda and to evaluate the role of amendments in mitigating the effect of RSC_{iw}.

MATERIALS AND METHODS

The study was conducted at ICAR - Central Soil Salinity Research Institute, Karnal (29°42′ N, 76°57′ E; 250 m amsl), which has a semi arid, sub-tropical monsoonic climate. The region receives 350-400 mm annual rainfall, about 70-80% of which occurs from July to September. Summers are very hot, with mean maximum temperatures of 40–45°C in May to June, while, December and January are the coldest months, with temperatures sometimes dropping to about 0°C. The meteorological data during the experimental period are presented in Table 1.

One year old planting material of guava cv. Hisar Safeda were obtained from National Horticulture Board approved nurseries to ensure genetic purity and quality. The experiment was carried out in 100/ kg capacity lysimeters (53 cm × 40 cm) fitted with drainage holes, filled with a well balanced potting mix of garden soil : organic compost : sand (3:1:1). The soil mixture was homogenized, with a total of 85 kg soil and a bulk density of 1.50 g cm^3 in each lysimeter. During the rainy season of 2021, healthy and disease free saplings were transplanted into the prepared lysimeters, and different treatments were applied regularly based on the bulk density and porosity of the potting mixture. All management practices were followed as per package of practices for guava followed by Chaudhary Charan Singh Haryana Agricultural University, Hisar, India.

The experiment was laid out using randomized block design with 10 treatments *viz*., T_1 - BAW, T_2 - RSC~2.5 meq/L, T_3 - RSC~2.5 meq/L + press mud, T_4 - RSC~2.5 meq/L + gypsum, T_5 - RSC~5 meq/L, T_6 - RSC~5 meq/L + press mud, T_7 - RSC~5 meq/L + gypsum, T_8 - RSC~7.5 meq/L, T_9 - RSC~7.5

Table 2 : Soil and water parameters at commencement of experiment

Soil parameter	Value	Soil water saturation paste extract	Value
pH	7.21	Na^+	3.79
EC_e (dS/m)	1.40	K^+	0.59
Texture	Sandy loam	Ca^{2+}	5.2
Sand/silt/clay (%)	64.33/18.67/17.00	Mg^{2+}	4.4
Organic carbon (%)	1.1	SO_4^{2-}	7.50
Available nitrogen (kg/ha)	227.52	Cl^-	6.50
Available phosphorus (kg/ha)	64.5	CO_3^{2-}	Nil
		HCO_3^-	1.1

All cations and anions are in meq/L

meq/L + press mud, T_{10} - RSC~7.5 meq/L + gypsum) and five replications. Both, gypsum and press mud was added at commencement of each season; gypsum was added with water and press mud was applied in soil. Quantity of used gypsum was 1.08 g, 3.78 g and 6.48 g for RSC~2.5 meq/L, RSC~5 meq/L and RSC~7.5 meq/L, respectively in 9.04 L water (quantity of water requirement was calculated according to total soil weight and bulk density of soil). However, for RSC~2.5 meq/L, RSC~5 meq/L and RSC~7.5 meq/L treatments, press mud was added 193.2 g, 386.4 g and 579.6 g, respectively. The BAW at ICAR-Central Soil Salinity Research Institute, Karnal, India, was used for control irrigation. The pH, EC and RSC (meq/L) of BAW were 6.2, 0.2 dS/m and nil, respectively. The underground sodic water (RSC_{iw}~10 meq/L) was brought from village Mundri, Kaithal and stored in a plastic tank. Initial soil and water properties were given in Table 2. Dilutions with normal water were carried out to maintain RSC_{iw}~ 2.5, 5.0, and 7.5 meq/l. Data of different parameters were taken during summer season (15th July 2022 to 15th August 2022) and winter season (15th December, 2022 to 15th January, 2023). Total number of flowers and fruits were counted manually. The fruit drop was determined by conducting a subtraction between the count of fruits that were initially set and the total number of fruits that were retained upon maturity. Fruit retention was calculated by dividing the number of fruits retained at harvest by the number of initial fruits set at the initial stage. Fruit weight was taken with the help of digital weighing machine. The length and width of the fruit were measured with a digital vernier calliper. The water displacement method was used to determine the fruit volume.

Statistical analysis of data was carried out as per Panse & Sukhatme (1981). All the values described as mean of the replicates with the evaluation of CD at 5% level of significance by using software GRAPES (Gopinath et al., 2020).

RESULTS AND DISCUSSION

Flowering and fruiting parameters

Results revealed that irrigation with different levels of RSC water with or without amendment (press mud and gypsum) had a significant effect on flowering and fruiting parameters of guava cultivar Hisar Safeda during both season (summer and winter). Maximum number of flowers per plant, fruit set (%) and fruit retention (%) was maximum when plants were irrigated with the BAW. Additionally, increasing level of RSC decreased number of flowers per plant, fruit set (%) and fruit retention (%) and maximum reduction in these parameters was associated with highest level of RSC (7.5 meq/L) followed by 5 meq/L and 2.5 meq/L. Fruit drop (%) was maximum (50.71 %) when plants were irrigated with highest level of RSC water (7.5 meq/L), while, minimum (30.23 %) was recorded when plants were irrigated with BAW. The Maximum number of flowers per plant, fruit set and fruit retention were 46.2, 55.60 % and 69.77 % during summer season; and was 79.6, 60.90 % and 71.62 % during winter season when plants were irrigated with BAW (T_1), respectively. However, minimum number of flowers per plant, fruit set and fruit retention were 22.0, 36.54% and 49.29% during summer season; and was 41.4, 35.32% and 52.01% during winter season when plants were irrigated with highest level of RSC

Table 3 : Effect of different level of RSCiw with and without amendments (press mud and gypsum) on flowering and fruiting parameters of guava cv. Hisar Safeda

Treatment	Flowers/plant (Nos.)		Fruit set (%)		Fruit drop (%)		Fruit retention (%)	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
T_1	46.2^{a}	79.6^{a}	55.60^{a}	60.90^{a}	30.23^{d}	28.38^{e}	69.77^{a}	71.62^{a}
T_2	43.2^{b}	73.6^{b}	51.86^{a}	56.27^{b}	33.47^{cd}	31.81^{de}	66.53^{ab}	68.19^{ab}
T_3	44.4^{ab}	76.6^{ab}	53.57^{a}	59.82^{ab}	31.96^{cd}	30.11^{de}	68.04^{ab}	69.89^{ab}
T_4	45.2^{ab}	77.6^{a}	54.37^{a}	60.20^{ab}	30.34^{d}	29.65^{de}	69.66^{a}	70.35^{ab}
T_5	32.6^{d}	54.4^{d}	39.20^{cd}	41.60^{de}	43.03^{abc}	40.67^{abc}	56.97^{bcd}	59.33^{cde}
T_6	35.0^{cd}	58.6^{c}	42.89^{bc}	43.34^{cd}	39.45^{abcd}	37.79^{bcd}	60.55^{abcd}	62.21^{bcd}
T_7	36.0^{c}	61.4^{c}	44.42^{b}	46.26^{c}	37.19^{bcd}	35.27^{cde}	62.81^{abc}	64.73^{abc}
T_8	22.0^{e}	41.4^{f}	36.54^{d}	35.32^{f}	50.71^{a}	47.99^{a}	49.29^{d}	52.01^{e}
T_9	23.2^{e}	44.6^{ef}	38.74^{cd}	37.24^{f}	48.89^{ab}	45.81^{ab}	51.11^{cd}	54.19^{de}
T_{10}	24.0^{e}	45.4^{e}	40.92^{bcd}	38.89^{ef}	47.13^{ab}	43.40^{abc}	52.87^{cd}	56.60^{cde}
$CD_{0.05}$	2.47	3.97	4.97	4.25	12.09	8.39	12.09	8.39

water (7.5 meq/L) without any amendment (T_8), respectively. While maximum fruit drop (%) was 50.71 and 47.99% when plants were irrigated with highest level of RSC water (7.5 meq/L) without any amendment (T_8); and minimum was 30.23 and 28.38% when plants were irrigated with BAW (T_1) during summer and winter season, respectively (Table 3).

Flowering and fruiting are critical stages in fruit crops, as their traits directly determine yield. The number and timing of flowers set the potential fruit load, and more flowers generally mean higher fruiting potential. The proportion of flowers that set fruit (fruit set) and the subsequent growth and development of those fruits are key yield parameters, with proper fruit set and development directly contributing to final yield. Similar findings of negative effects on flowering and fruiting parameters due to irrigation with RSC water was also reported by Grieve et al. (2007). Carbohydrate supply at flowering is a primary determinant of fruit set and the reduced leaf area due to irrigation with sodic water in addition to lower assimilation rate can be a limiting factor for the assimilate supply to the inflorescence during fruit set. Amendments like press mud and gypsum are known to mitigate negative effect of RSC_{iw}. Addition of amendment (press mud and gypsum) to each level of RSC_{iw} had a beneficial effect on flowering and fruiting parameters on each level of RSC. Amendments (press mud and gypsum) increased number of flowers per plant, fruit set (%) and fruit retention (%) on each level of RSC but decreased fruit drop (%). Gypsum and press mud are applied to sodic soils to improve physical and chemical properties, enhance soil health, and boost productivity; gypsum supplies readily available Ca^{2+} that displaces Na^{+} from exchange sites, reduces sodicity, flocculates soil particles, improves structure, porosity, water infiltration, and drainage, and lowers soil pH for better plant growth, while press mud, a sugar mill by product, adds organic matter, improves soil structure, aeration, water retention, nutrient availability, and microbial activity, and supplies nutrients including some calcium and micronutrients. These amendments improve soil conditions, leading to better vegetative growth and ultimately higher yield, with gypsum generally showing more promising effects than press mud, because its highly soluble Ca^{2+} (from $CaSO_4 \cdot 2H_2O$) is quickly available for exchange with Na^{+}, whereas press mud provides calcium in less soluble, less readily available forms, making its Ca^{2+} less effective for rapid Na^{+} displacement compared to gypsum (Choudhary, 2017). Reduction in negative effects of RSC water due to amendments (press mud or gypsum) is in accord with previous reports (Kumar et al., 2016). The beneficial effect of gypsum and press mud (a rich source of Ca) in increasing flowers per plant, fruit set, and fruit retention may be attributed to higher photosynthesis resulting from the ameliorative impact of these amendments, along with their role in hormone metabolism that promotes auxin synthesis, which is essential for fruit set and growth. Moreover, adding these amendments to sodic irrigation water likely minimized specific ion toxicities while ensuring adequate nutrient supply in a favourable soil

Table 4 : Effect of different level of RSCiw with and without amendments (press mud and gypsum) on yield attributing parameters of guava cv. Hisar Safeda

Treatment	Fruits/plant (Nos.)		Fruit weight (g)		Fruit length (mm)		Fruit width (mm)		Fruit volume (cm^3)	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
T_1	17.8^{a}	34.6^{a}	99.62^{a}	105.07^{a}	57.29^{a}	62.50^{a}	55.40^{a}	58.60^{a}	97.44^{a}	102.84^{a}
T_2	14.8^{c}	28.2^{c}	94.65^{bc}	99.59^{ab}	54.00^{a}	58.30^{b}	52.50^{a}	55.20^{bc}	91.76^{bc}	96.42^{b}
T_3	16.2^{bc}	31.8^{b}	96.69^{ab}	102.44^{a}	55.80^{a}	60.20^{ab}	53.20^{a}	56.80^{ab}	94.30^{ab}	99.14^{ab}
T_4	17.0^{ab}	33.6^{a}	97.81^{ab}	103.60^{a}	56.60^{a}	60.90^{ab}	54.30^{a}	57.50^{ab}	95.58^{ab}	100.10^{ab}
T_5	7.2^{e}	13.4^{f}	84.95^{e}	88.67^{cd}	46.00^{b}	50.29^{d}	46.79^{b}	49.20^{ef}	80.80^{ef}	84.60d^{e}
T_6	9.0^{d}	15.8^{e}	88.16^{de}	91.88^{c}	47.30^{b}	51.79^{cd}	48.00^{b}	51.39^{de}	85.60^{de}	88.26^{cd}
T_7	10.0^{d}	18.4^{d}	90.17^{cd}	92.93^{bc}	48.80^{b}	54.19^{c}	49.50^{b}	52.50^{cd}	87.56^{cd}	90.80^{c}
T_8	3.8^{f}	7.6^{h}	74.75^{f}	80.14^{e}	39.40^{c}	41.50^{e}	41.50^{c}	44.29^{g}	70.10^{h}	73.62^{g}
T_9	4.6^{f}	9.0^{gh}	76.75^{f}	83.11^{de}	41.00^{c}	43.60^{e}	43.00^{c}	46.00^{g}	74.18^{gh}	77.78^{fg}
T_{10}	5.2^{f}	10.0^{g}	78.15^{f}	84.59^{de}	42.20^{c}	44.69^{e}	43.80^{c}	46.80^{fg}	76.14f^{g}	79.90^{ef}
$CD_{0.05}$	1.52	1.90	4.93	7.27	3.30	3.59	2.96	3.15	5.19	5.45

environment, thereby enhancing reproductive growth and ultimately yield; these findings are in line with those reported by Izhar ul Haq et al. (2007).

Yield attributing parameters

It was observed that average value of yield attributing parameters was maximum when plants were irrigated with BAW but these values were decreased when plants were irrigated with RSC_{iw}; minimum values of yield attributing parameters were observed when plants were irrigated with maximum RSC level (7.5 meq/L) followed by RSC ~5.0 meq/L and RSC ~ 2.5 meq/L.

The maximum number of fruits per plant, fruit weight, fruit length, fruit width, and fruit volume were 17.8, 99.62 g, 57.29 mm, 55.40 mm and 97.44 cm^3 during summer season, respectively; and was 34.6, 105.07 g, 62.50 mm, 58.60 mm and 102.84 cm^3 during winter season, respectively when plants were irrigated with BAW (T_1). However, minimum number of fruits per plant, fruit weight, fruit length, fruit width, and fruit volume were 3.8, 74.75 g, 39.40 mm, 41.50 mm and 70.10 cm^3 during summer season; and was 7.6, 80.14 g, 41.50 mm, 44.29 mm and 73.62 cm^3 during winter season when plants were irrigated with highest level of RSC water (7.5 meq/L) without any amendment (T_8). It was also observed that value of above-mentioned parameters was high during winter season in comparison to summer season (Table 4).

Decreased yield attributing parameters due to irrigation with RSC water was also observed by Kumar et al. (2016). Yield reduction in guava irrigated with RSC water may be due to early growth stress, which inhibits growth parameters and leads to poor fruit set and high fruit drop, thereby reducing yield attributing traits (Chhabra, 2021). This could also result from nutrient imbalance or deficiency caused by impaired uptake and distribution of essential minerals under increased abiotic stress from sodic irrigation (Rajkumar et al., 2020). Additionally, alkalinity induced physiological stress may alter dry matter production and its partitioning, especially towards reproductive organs, ultimately affecting yield related parameters. Additionally, fruit size is closely related to leaf potassium level and we found lower leaf potassium levels (0.62, 0.77 & 0.94 % at 7.5, 5.0 & 2.5 meq/L, respectively) due to irrigation with RSC water in our experiment, and lower level of leaf potassium might be responsible for reduced fruit weight, fruit length, fruit width, and fruit volume. Both amendments (press mud and gypsum) have positive effects on above-mentioned yield attributing parameters at each level of RSC. Furthermore, it was noticed that gypsum had more promising effects on yield attributing parameters than press mud at same level of RSC. Fruit weight was increased due to addition of press mud and gypsum by 2.15 & 3.34% at RSC~2.5 meq/L; 3.78 & 6.14% at RSC~5 meq/L and 2.67 & 4.54% at RSC~7.5 meq/L during summer season, respectively. However, it was increased by 2.86 & 4.02% at RSC~2.5 meq/L; 3.62 & 4.80% at RSC~5 meq/L and 3.70 & 5.55% at RSC~7.5 meq/L during winter season, respectively. This improvement may be attributed to a more conducive soil

environment created by the application of ameliorants, which help alleviate alkaline stress caused by high RSC irrigation water. The improved physico-chemical properties of soil through gypsum and press mud application likely enhanced plant physiology, leading to better growth and higher yield as observed in this study.

CONCLUSION

It was observed that the use of sodic water alone adversely affected the flowering and yield parameters of guava cv. Hisar Safeda. A negative effect of RSC water could be decreased with soil amendments like gypsum and press mud at higher levels of RSC. Gypsum is more promising in mitigating effects of RSC water in comparison to press mud in guava cultivation. RSC water irrigation reduced number of flowers and fruit set to a higher level in Hisar Safeda although gypsum and press mud improved but still less than control condition. RSC~2.5 meq/L irrigation water has at par effect with BAW on overall fruit yield; hence, it can be recommended for guava irrigation.

ACKNOWLEDGEMENT

The authors are thankful to ICAR-Central Soil Salinity Research Institute, Karnal, India, for providing necessary facilities for completing this study.

REFERENCES

Basak, N., Sheoran, P., Sharma, R., Yadav, R. K., Singh, R. K., Kumar, S., & Sharma, P. C. (2021). Gypsum and pressmud amelioration improve soil organic carbon storage and stability in sodic agroecosystems. *Land Degradation & Development*, *32*(15), 4430-4444. https://doi.org/10.1002/ldr.4047

Chhabra, R. (2021). Management and reclamation of saline soils. In R. Chhabra (Eds.), *Salt-affected Soils and Marginal Waters: Global Perspectives and Sustainable Management* (pp. 101-160). Springer, Cham. https://doi.org/10.1007/978-3-030-78435-5_3

Choudhary, O. P. (2017). Use of Amendments in ameliorating soil and water sodicity. In S. Arora, A. Singh, & Y. Singh (Eds.), *Bioremediation of Salt Affected Soils: An Indian Perspective* (pp. 195-210). Springer, Cham. https://doi.org/10.1007/978-3-319-48257-6_10

Flores, G., Wu, S. B., Negrin, A., & Kennelly, E. J. (2015). Chemical composition and antioxidant activity of seven cultivars of guava (*Psidium guajava*) fruits. *Food chemistry*, *170*, 327-335. https://doi.org/10.1016/j.foodchem.2014.08.076

Gopinath, P. P., Parsad, R., Joseph, B., & Adarsh, V. S. (2020). GRAPES: General R shiny based analysis platform empowered by statistics. https://www.kaugrapes.com/home. version 1.0.0. doi: 10.5281/zenodo.4923220

Grieve, A. M., Prior, L. D., & Bevington, K. B. (2007). Long-term effects of saline irrigation water on growth, yield, and fruit quality of 'Valencia'orange trees. *Australian Journal of Agricultural Research*, *58*(4), 342-348. https://doi.org/10.1071/AR06198

Kumar, A., Yadav, A. C., Ansul, A., Kumar, V., & Singh, A. (2016). Evaluation of the effects of FYM and gypsum on onion (*Allium cepa* L.) production under sodic water irrigation. *Journal of Applied and Natural Science*, *8*(4), 1878-1883. https://doi.org/10.31018/jans.v8i4.1056

Kumar, R., Singh, A., Kumar, A., Mehla, M. K., & Kumar, A. (2023). Salinity and sodicity stresses differentially influence growth and physiology in sapota (*Achras zapota* L.). *South African Journal of Botany*, *160*, 739-748. https://doi.org/10.1016/j.sajb.2023.07.046

Machra, A., Kumar, R., Singh, A., Mishra, D. S., Patel, P. J., Singh, N., Kundu, A., & Kumar, A. (2025). Gypsum and press mud application alleviate the deleterious effects of sodic water irrigation in Guava (*Psidium guajava* L. cv. Taiwan Pink). *BMC Plant Biology*, 25(1), 1783. doi: 10.1186/s12870-025-07780-4

Minhas, P. S., Qadir, M., & Yadav, R. K. (2019). Groundwater irrigation induced soil sodification and response options. *Agricultural Water Management*, *215*, 74–85. https://doi.org/10.1016/j.agwat.2018.12.030

Panse, V. G., & Sukhatme, P. V. (1981). Statistical methods for agricultural workers. ICAR, New Delhi, India. https://doi.org/10.2134/agronj1956.00021962004800070014x

Rajkumar, R., Singh, A., Mann, A., & Yadav, R. K. (2020). Performance evaluation of pomegranate (*Punica granatum*) genotypes under saline conditions. *The Indian Journal of Agricultural Sciences*, *90*(5), 957-962. https://doi.org/10.56093/ijas.v90i5.104370.

Rajkumar, Tiwari, J. P., and Lal, S. (2014). Effect of foliar application of zinc and boron on fruit yield and quality of winter season guava (*Psidium guajava*) cv. Pant Prabhat. *Annals of Agri-Bio Research*, *19*(1), 105-108.

Izhar-ul-Haq, I., Shah, S. A., Iqbal, F., Ruhullah, R., & Zahoor-ul-Haq, Z. (2007). Effect of different amendments on crop production under poor quality tubewell water. *Sarhad Journal of Agriculture*, *23*(1), 87.

Sheoran, P., Kumar, A., Kumar, A., Raju, R., Sharma, R., Parjapat, K., & Singh, A. K. (2020). Impact of pressmud application in reclamation of high RSC irrigation water induced soil sodification and sustaining rice (*Oryza sativa*)–wheat (*Triticum aestivum*) production in Indo-Gangetic plains. *Indian Journal of Agricultural Sciences*, *90*, 206-211. https://doi.org/10.56093/ijas.v90i1.98681

Yadav, R. K., & Dagar, J. C. (2016). Innovations in utilization of poor-quality water for sustainable agricultural production. In J. Dagar, P. Sharma, D. Sharma, & A. Singh (Eds.), *Innovative Saline Agriculture* (pp. 219-263). Springer, New Delhi. https://doi.org/10.1007/978-81-322-2770-0_11

(Received : 27.6.2024; Revised : 5.8.2025; Accepted : 9.8.2025)