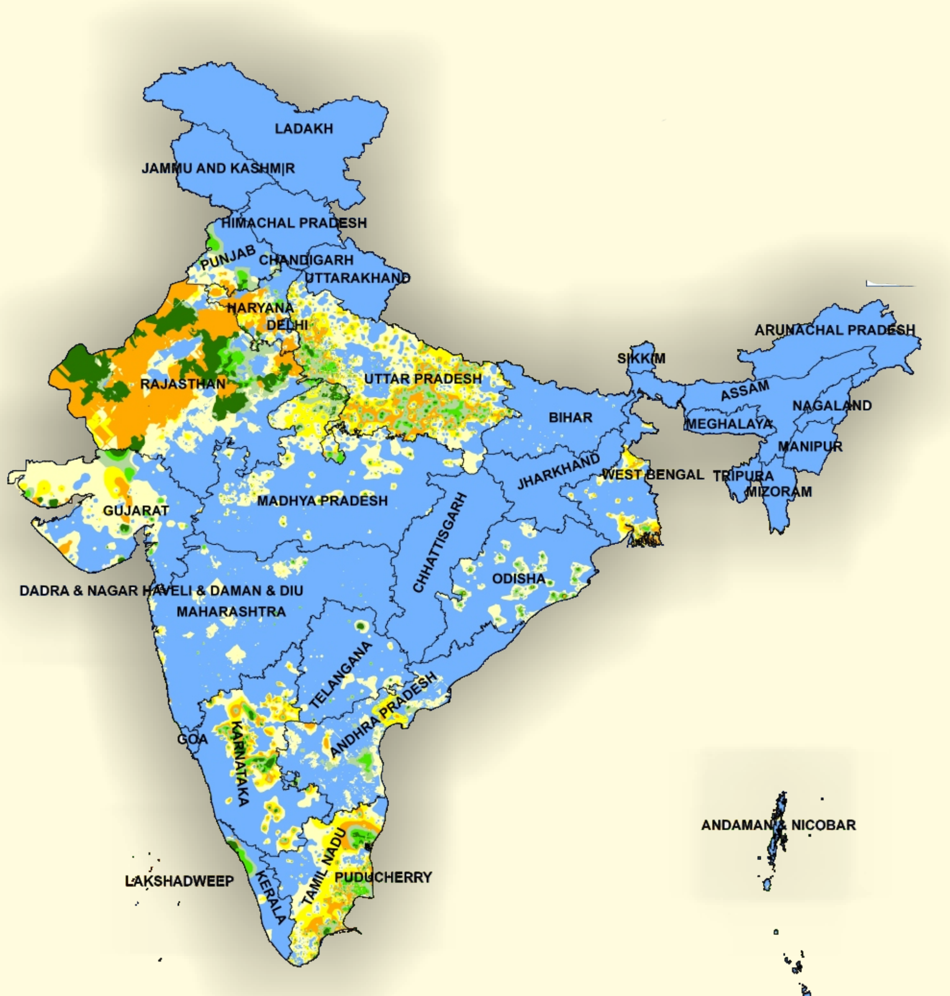
अखिल भारतीय समन्वित अनुसंधान परियोजना

लवणीय जल का प्रबंध एवं कृषि में संबंधित लवणीकरण

All India Coordinated Research Project

Management of Saline Water & Associated Salinization in Agriculture

द्विवार्षिक रिपोर्ट
Biennial Report
2023-2024



Groundwater Quality Map for Irrigation

परियोजना समन्वयन ईकाई
भाकृअनुप-केन्द्रीय मृदा लवणता अनुसंधान संस्थान
करनाल - 132 001 (भारत)
Project Coordinating Unit
ICAR-Central Soil Salinity Research Institute
Karnal - 132 001 (India)

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लवणग्रस्त मृदाओं का प्रबंध एवं खारे जल का कृषि में उपयोग

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Management of Saline Water & Associated Salinization in Agriculture

द्विवार्षिक प्रतिवेदन

Biennial Report

2023-2024

Main Cooperating Centres

1. Raja Balwant Singh College, Bichpuri, Agra (Uttar Pradesh)
2. Regional Research Station, ANG Ranga Agricultural University, Bapatla (Andhra Pradesh)
3. SK Rajasthan Agricultural University, Bikaner (Rajasthan)
4. Agricultural Research Station, University of Agricultural Sciences, Gangavathi (Karnataka)
5. Department of Soils, CCS Haryana Agricultural University, Hisar (Haryana)
6. AD Agricultural College and Research Institute, TN Agril. University, Tiruchirappalli (Tamil Nadu)

Volunteer Centres

1. Regional Research Station, Punjab Agricultural University, Bathinda (Punjab)
2. Khar Land Research Station, Dr. BSKVV, Panvel (Maharashtra)
3. Agriculture College, RVS Krishi Vishwa Vidyalaya, Indore (Madhya Pradesh)
4. Rice Research Station, Kerala Agricultural University, Vyttila, Kochi (Kerala)
5. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra)

भाकृअनुप
ICAR

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Karnal - 132 001 (India)

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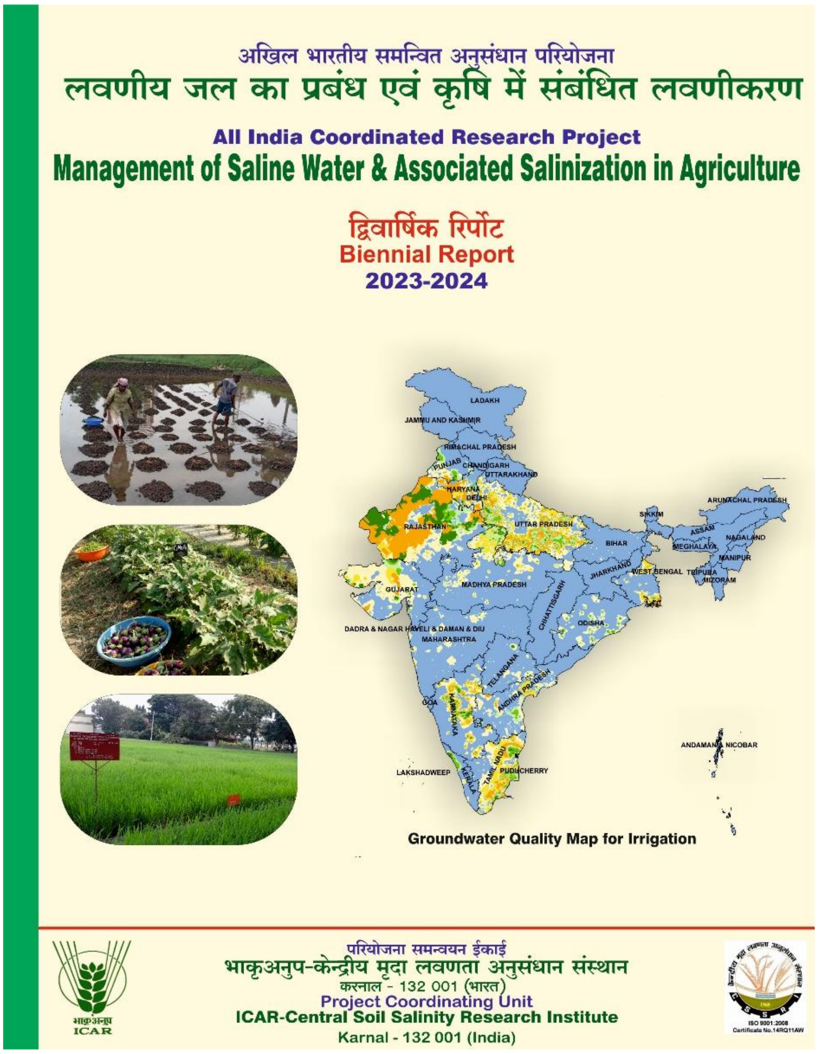

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Director

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FOREWORD

Contribution of Agriculture is significant in Indian economy and food and livelihood security. This sector contributes around 18.2% to GDP and provides livelihood supports to ~42.3% of the population of the country. The sector also contributes substantially to foreign exchange earnings through agricultural exports. Scientific research culminating in development of technology has been instrumental in transforming India from a food-deficient nation to self-sufficient for its population of over 1.4 billion. However, degradation of groundwater and surface water resources has emerged as a critical challenge, challannging agricultural sustainability and food security. This deterioration directly affects soil fertility, crop productivity, and farmer incomes, creating complex ecological and socioeconomic impacts. Under these conditions, sustainable crop production from 6.73-million-hectare salt-affected lands with limited fresh water and present poor-quality groundwater for irrigation is the key to meet food and fodder requirement of the country. The ICAR-Central Soil Salinity Research Institute, Karnal, and the All India Coordinated Research Project on “Management of Saline Water and Associated Salinity in Agriculture” AICRP (MSW&ASA) formerly known as “Management of Salt Affected Soils and Use of saline Water in Agriculture” have developed effective reclamation technologies and saline water management practices. Their work has enabled the reclamation of around 2.2 million hectares of degraded land, adding an estimated 16 million tonnes of food grains annually to the national food basket.

The eleven centres of the All India Coordinated Research Project (AICRP, MSW&ASA) function across diverse agro-ecological regions of India to address site-specific challenges of salt and water management. These centres investigate local soil and groundwater characteristics to develop sustainable, regionally suited technologies. Comprehensive studies have enabled the creation of soil and groundwater quality maps and the formulation of guidelines for their productive use. A major achievement includes revision of a national-level groundwater suitability map for irrigation in collaboration with ICAR-NBSS&LUP, Nagpur. Among the several developed/refined and field-demonstrated technologies are chemical and organic amendments for reclaiming black sodic soils, agronomic and irrigation management practices for utilizing saline and high RSC/SAR waters in alluvial regions, and crop production techniques suitable for the Gangetic plains and Coastal region. Subsurface drainage systems with regulated control for waterlogged saline Vertisols of southern India and economical groundwater recharge methods for poor-quality aquifer areas were also evaluated. The evaluated technologies also extend to vegetable production through micro-irrigation and fertigation in coastal and arid regions, vegetables cultivation with saline water under protected environment, and land-shaping and integrated farming models in coastal ecosystems. These interventions are likely to enhance soil and water quality, increase agricultural productivity, and promote sustainable resource use. The site-specific technologies emerging from the coordinated and collaborative efforts of the AICRP (MSW&ASA) units demonstrate wide adaptability, reaching beyond the confines of their respective states. The biennial report for 2023–24 encapsulates the outcomes of these research initiatives from eleven centres including five volunteer centres representing diverse production environments, including arid, semi-arid, irrigated, rain fed, and coastal ecosystems. The report is reflecting scientific advancements in management of saline and sodic soils and saline water for resilient agricultural development.

I extend my sincere appreciation and congratulations to Dr. Satyendra Kumar, In-Charge, Project Coordinating Unit, Dr. R.L. Meena, Principal Scientist and former OIC, Dr. B.L. Meena, Principal Scientist, and all staff members of the Unit for their dedicated efforts in successfully coordinating activities over the past two years and preparing the biennial report. I also reaffirm my full support to the project in realizing the goals outlined in the biennial workshop.

(R K Yadav)
Director

PREFACE

India with only ~ 4% of the world's freshwater, supporting 18% of the global population, leading to per capita water availability below the global average and placing vast regions under water stress or scarcity. Overexploitation of groundwater and increasing pollution of surface and groundwater sources further exacerbate this crisis. Under this scenario, the use of saline water in agriculture emerges as a strategic approach to sustain food production. The scientific and technological advances in managing salt-affected soils and saline irrigation water contribute significantly to food sustainability by expanding cultivable areas and enhancing crop productivity under challenging conditions. These efforts are crucial to meet the increasing food demand of a growing population while conserving freshwater resources, promoting sustainable agriculture, and reducing dependency on good quality water sources.

Significant efforts have been made by ICAR- Central Soil Salinity Research Institute (CSSRI), Karnal and the All India Coordinated Research Project (AICRP) on “Management of Saline Water and Associated Salinization in Agriculture” formerly known as “Management of Salt Affected Soils and Use of saline Water in Agriculture” to develop effective technologies for reclamation of salt affected soil and use of poor quality water in crop production. AICRP established in 1972, works with multidisciplinary team of scientists to develop technologies addressing both local issues and broader regional and national guidelines for managing salt-affected soils and saline water irrigation. Their efforts have restored the productivity of barren salt-affected lands and facilitated the irrigation use of saline and alkali waters. At present, AICRP is operating with six cooperating centres and five volunteer centres.

The present biennial report (2023-2024) contains information on various achievements such as survey and mapping of salt-affected soils and groundwater quality characterization for irrigation purposes, alternative land reclamation methods, controlled subsurface drainage, screening of salt-tolerant crops, low-cost methods for groundwater quality improvement, and micro-irrigation for efficient water use. The report also provides details about scientific publications, budget utilization, and staff postion at different centres.

I take this opportunity to express my sincere thanks and gratitude to Dr M.L. Jat, Secretary, DARE and DG, ICAR for providing financial support and taking keen interest in its activities. I also express my deep sense of gratitude to Dr A.K. Nayak, DDG (NRM), ICAR for guiding the technical program and providing unstinted support to the project. Heartfelt thanks are due to Dr. A. Velmurugan, ADG (Soil and Water Management), NRM Division, ICAR New Delhi, for his excellent support to the project and cooperation in all spheres. I wish to extend my sincere thanks to colleagues at AICRP centers for undertaking research programs and compiling centres report in time. I also extend my sincere thanks to Dr R K Yadav, Directoe, ICAR-CSSR, for providing constant support and guidance to unit activities. Special recognition is given to Dr. R.L. Meena, and Dr MJ Kaledhonkar,former In-charges of the Project Coordinating Unit, for his role in streamlining and coordinating project activities over the past two years. Dr. B.L. Meena receives thanks for his valuable cooperation and significant efforts in coordinating the biennial workshop, report compilation, and editing. The coordinating unit staff, including Sh. Amit Kumar Singh and Sh. Shashi Pal, are sincerely thanked for their willing support in project operations. It would be my pleasure to extend all support to the project that may be required to achieve the targets set forth in the biennial workshop.

(Satyendra Kumar)
In-charge, Project Coordinating Unit

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SUMMARY OF RESEARCH ACCOMPLISHMENTS

1. RESOURCE INVENTORIES OF POOR-QUALITY GROUND WATER AND SALT AFFECTED SOILS

1.1 Resource Inventories of Poor-Quality Groundwater for Irrigation

- **Characterization of groundwater for irrigation purpose in different districts of Uttar Pradesh**

The groundwater quality assessment of different districts of Uttar Pradesh, revealed that large areas in western, central and eastern parts of the state are affected by salinity and alkalinity issues, whereas good quality groundwater is found in northern, northeastern, and southeastern regions. This information is vital for effective irrigation water management, crop planning, and long-term soil health perspective.

Survey and characterization of underground irrigation water of different districts of Andra Pradesh

A groundwater quality survey was undertaken across three districts (Bapatla, Vizianagaram, and Visakhapatnam) of Andhra Pradesh during December 2022-March 2024 to revisit earlier monitoring sites to assess and characterize groundwater for irrigation. In Bapatla district, 883 groundwater samples were collected across all 38 mandals in December 2022. The pH ranged from 5.3 to 8.4, while electrical conductivity (EC) varied from 0.15 to 7.3 dS m^{-1}, covering non-saline to highly saline water. Carbonate and bicarbonate concentrations ranged from nil to 1.6 me L^{-1} and up to 21.2 me L^{-1}, respectively. Chloride levels extended from safe to crop-injurious ranges. High SAR alkali water was prominent in Gara, Kotturu, and Ponduru mandals. Comparison with data of 2007–08 indicated a decline in good-quality water and an increase in marginally saline and alkali types, reflecting gradual quality deterioration.

In Vizianagaram district, total 736 samples covering all 34 mandals were collected in February 2023. The analytical results revealed that chloride, magnesium, and sodium contents varied widely, with sulphate ranged between 0.01 and 4.8 me L^{-1}. Based on EC, 90.35% of collected samples were classified as good for irrigation without growth limitations, while based on chloride content, 73.78% were found excellent category. About 98% samples recorded pH > 7.0, and 42.66% were found strongly alkaline. However, based on SAR, 97.42% samples were characterized as safe, while 3.94% and 6.52% samples were classified as marginally alkaline and alkaline, respectively. Overall, 85% samples were found of good quality, which indicates that major part of groundwater of the district is safe for irrigation.

In Visakhapatnam district, 800 samples were collected from 43 mandals during Feb–Mar 2024. Results revealed pH > 7.0 for 60% samples, while > 8.0 for 2.88%. EC varied from non-saline to saline, and bicarbonate reached up to 29.4 me L^{-1}. Based on EC, 80.13% were found good for irrigation; while 58.13% samples were classified as excellent based on chloride concentration. About 95% of samples were characterized as safe for SAR, while 7.5% and 5.75% samples were marginally alkaline and alkaline respectively. Overall comparison with 2006–07 results of groundwater quality revealed a decrease in good-quality water from 96.9% to 85.63% and a rise in salinity, underscoring progressive groundwater degradation and the need for sustainable management.

- **Compilation and mapping of groundwater quality of Andhra Pradesh using GIS**

The groundwater analytical data of Krishna zone comprising erstwhile districts of Krishna, Guntur and Prakasam districts and scarce rainfall zone comprising of Kurnool, Nandyala, Ananthapuram and Annamaiah districts generated at Saline Water Scheme, Bapatla has been compiled into a common database. The data were cleaned and organized into required format for generation of thematic maps in QGIS. Initially the delimited text layer plotted and exported as shapefile. Further the shapefile containing groundwater location coordinates is clipped for the new district boundaries of the zone *viz*. Krishna, NTR, Bapatla, Guntur, Palnadu and Prakasam districts and the new district boundaries of the scarce rainfall zone

. Further data points were interpolated using IDW and thematic maps of pH, EC, chloride, sodium, RSC and SAR were generated in QGIS. Similarly considering all the data points, the water quality map was generated for Krishna Zone and Scarce rainfall zone in GIS environment.

- **Survey and Characterization of Underground Water for Irrigation in Rajasthan**

Suitability of groundwater for irrigation and its effect on soil while irrigating crop was analysed for Barmer and Jalore districts. In Barmer district, total 247 groundwater samples and 224 surface soil samples were collected from 141 villages spanning about eight tehsils-Dhorimana, Gudamalani, Sindhari, Siwana, Baytu, Sheo, Barmer Shahar, and Chohtan. The results revealed significant spatial variability in water and soil chemical composition. Good quality water was observed mostly in Siwana (73.53%) and Barmer Shahar (48.39%), whereas marginally saline water dominated in Chohtan (74.08%) and Sheo (57.58%). Saline water occurred in smaller proportions (3–18%) across some tehsils, while high SAR saline waters were notably high in Dhorimana (56.67%), Gudamalani (80.01%), and Sindhari (56.67%). Marginally alkali waters appeared only in Dhorimana and Gudamalani (3.33% each), and highly alkali waters were found in Sindhari (43.33%), Dhorimana (13.33%) and Gudamalani (10%). Soil pH_2 values ranged from 7.63 to 9.86, which is higher in Barmer Shahar (8.62–9.86) and Chohtan (8.55–9.44), while variability in EC_2 between 0.03 and 1.82 dS/m, reflects variable salinity levels.

In Jalore district (2023–24), groundwater samples from 240 tube wells across 141 villages and 239 soil samples were collected from eight tehsils namely Ahore, Bhadrajun, Bhinmal, Jalore, Jaswantpura, Sayla, Bagora, and Raniwara. Analysis of collected samples revealed that good quality water is dominant in Jaswantpura (74.29%), Raniwara (75.68%), Bhadrajun (72.41%), and Ahore (66.67%), while high SAR saline water is more in Sayla (66.33%), Bagora (50.00%), and Bhinmal (33.33%). Marginally saline water ranged from 6.67% in Ahore to 36.67% in Bagora, and highly alkali water was found highest in Jalore (12.90%) and Bhinmal (5.56%). Soil pH varied from 7.01 to 9.64, with mean values between 8.09 in Jalore and 8.69 in Bhadrajun, whereas ECe ranged from 0.06 to 3.99 dS/m. Mean soil EC values spanned from 0.50 in Ahore to 1.29 in Sayla, indicating broad spatial differences in salinity and overall groundwater-soil chemical variability across the district.

- **Survey and characterization of groundwater for irrigation of different districts of Haryana**

A survey and characterization of groundwater for irrigation was carried out in Barwala, Morni, Pinjaur, and Raipur Rania blocks of Panchkula district during 2022–23, and in Ambala, Charkhi Dadri, and Yamuna Nagar districts during 2023–24. In Panchkula district, most water samples (97.7%) were classified as good quality and only 2.3% fell under the marginally alkali category. In Ambala district, 90.48% samples were found under good quality category, followed by 7.14% and 1.19% categorized as marginally saline, and high SAR saline categories, respectively. In Charkhi Dadri district, only 28.89% of the samples were found of good quality. The remaining samples were distributed across marginally saline (22.22%), saline (0.44%), high SAR saline (30.67%), marginally alkali (15.56%), alkali (0.44%), and highly alkali (1.78%) categories. In contrast, in Yamuna Nagar district, all the water samples (100%) were characterized as good quality.

- **Survey and characterization of groundwater for irrigation of coastal districts of Tamil Nadu**

A detailed assessment of groundwater quality for suitability of irrigation was carried out in the inland districts of Kanchipuram (2023) and Salem (2024) in Tamil Nadu. In Kanchipuram district, 150 groundwater samples were collected with GPS locations. The pH of collected samples ranged from 3.29 to 8.49 and EC from 0.09 to 5.22 dS m^{-1}, indicates wide variation in alkalinity and salinity levels. The residual sodium corbonate (RSC) values varied from nil to 32 meq L^{-1}, while SAR ranged between 0.19 and 34.78. Overall, about 38% of samples were found under good quality, 25% alkali, 17% highly alkali, 15% marginally alkali, 3% marginal saline, and 5% high SAR saline. Block-wise, Uthiramerur and Sriperumbudur had the highest proportion of good-quality water, while alkali water was found the maximum in Kanchipuram (37%) and Walajabad (29%).

In Salem district, analysis of 200 groundwater samples revealed pH range of 7.08-8.58 and EC between 0.74 - 2.75 dS m^{-1}. RSC values varied from -7.3 to 10.1 meq L^{-1}, and SAR from 0.7 to 9.7. About 66.5% samples were classified as good quality, while 20.5% marginally saline, 8% marginally alkali, and 5% alkali. At block level, 100% samples of Yercaud were found under good-quality category, whereas 80% samples of Panamarathupatti, Kadayampatty and Magudanchavadi blocks were fell under good quality category. The marginally saline water was found in Omalur and Pethanaickenpalayam (40%), Salem and Veerapandi (30%). However, highlu alkaline water was found in Macecheri (30%) and Kolathur (20%). Overall assessment shows the moderate groundwater alkalinity and localized concerns across the district.

- **Survey and characterization, fluoride and nitrate content in groundwater of Barnala and Sangrur district of Punjab**

Groundwater quality assessment for irrigation in Barnala and Sangrur districts was performed based on EC, SAR, and RSC). In Barnala, 39% of groundwater samples were categorized as good, 40% as saline, and 21% as alkaline, whereas in Sangrur, only 3% were good and 87% were alkaline. Fluoride concentrations in Barnala ranged from 0.01 to 0.24 mg/L (mean 0.03 mg/L), with all samples ≤ 1.0 mg/L, making them suitable for drinking. However, nitrate levels varied from 22.0 to 408 mg/L (mean 92.41 mg/L), with 88% exceeding the BIS permissible limit, indicating potential health risks. In Sangrur, fluoride content was ≤ 1.0 mg/L in 94% of samples, while 6% exceeded this value. Nitrate concentrations ranged from 25.7 to 995 mg/L (mean 202.3 mg/L), but only 4% samples were within safe limits, demonstrating widespread nitrate contamination and degraded groundwater quality.

- **Survey and characterization of ground water for irrigation, salinity associate problems in Shajapur district of Madhya Pradesh**

Groundwater samples from various locations (101 samples from Gulana and 114 from Shajapur tehsil) in Shajapur district were analyzed for pH, EC, SAR, and RSC to assess irrigation suitability. Out of them, 93 and 107 samples of Gulana and Shajapur, respectively were classified as good-quality for irrigation, while the remaining samples were marginally saline. No alkalinity issues were detected in either tehsil.

1.2 Resource Inventories of Salt Affected Soils

- **Characterization and delineation of salt affected soils using remotely sensed and ground truth data of Shajapur district, Madhya Pradesh**

A detailed reconnaissance soil survey was conducted in Gulana and Shajapur tehsils of Shajapur district, Madhya Pradesh, to assess the extent and characteristics of salt-affected soils. A total of 101 surface soil samples (0-30 cm) were collected from different villages, and their analysis revealed that soil pHs ranged from 7.38 to 8.43, while electrical conductivity (ECe) varied between 0.94 and 1.99 dS m^{-1}. The sodium adsorption ratio (SAR) ranged from 0.29 to 0.81, and the cation exchange capacity (CEC) ranged between 30.1 and 51.5 cmol (p^+) kg^{-1}. The exchangeable sodium percentage (ESP) was found to vary from 6.5 to 23.0, indicating the presence of sodicity in certain locations.

2. MANAGEMENT OF POOR-QUALITY WATERS

2.1 Management of Alkali Water

- **Conjunctive use of alkali and canal water for Til and Lentil Cropping sequence**

A study was conducted during 2020–21 to 2023–24 to evaluate Sesame (til)–lentil crop rotation under conjunctive use of alkali (RSC 8 meq/l) and canal water with different combinations at Agra. Results showed that both grain and stover yields were highest (9.16 and 30.0 w/ha, respectively) under canal irrigation and lowest under alkali water. Both the treatment of alternating one canal irrigation with one alkali irrigation and the 1:1 mixing of canal and alkali water resulted in comparable yields (7.82 and 8.31 q/ha grain yield), with similar trends observed for til and lentil crops across treatments.

- **Management of Alkali water (High RSC) for enhancing the growth and yield of Sesame**

A field experiment conducted in 2024 in the Cauvery delta zone aimed to address the challenge of sesame cultivation after rice, where the use of alkaline bore well water adversely affect crop growth and yield. Alkali water was treated with gypsum to lower RSC levels to 4, 2.5, and 1.25 meq L^{-1}, with corresponding gypsum doses applied once as a basal soil treatment. The results indicated that reducing RSC to 2.5 meq L^{-1} was optimal, producing higher sesame yield and an improved benefit–cost ratio (> 1) under alkali soil conditions.

- **Conjuctive use of rainwater and borewell water for maximizing bhendi crop yield with effective alkali water management under drip irrigation system**

Field experiment was conducted with bhendi (CO (H) 4) crop to fix the ratio of rainwater, high RSC bore well water and gypsum treated bore well water for irrigation with drip system. The harvested rain water was mixed with high RSC (RSC 6) bore well water at 1:1 and 2: 1 ratio. The high RSC bore water was also treated with gypsum to reduce the RSC to the level of < 1.25 meq.L-1. The gypsum treated bore well water was applied either alone or in combination with harvested rain water at 1: 1 ratio. High RSC Bore well water and harvested rain water were also applied alone as a checks. The experiment was conducted in RBD and the treatments were replicated thrice. The results of the field experiment revealed that application of rainwater alone or in combination with gypsum-treated bore well water at 1: 1 ratio is effective in enhancing growth and yield of bhendi under drip irrigation.

2.2 Management of Saline Water

- **A case study on the functioning of Doruvu technology in farmers' fields in coastal area**

Over six years, water quality in Doruvu and shallow bore wells was monitored to assess irrigation suitability. Improved Doruvu wells consistently supplied good-quality water year-round, while bore wells showed higher salinity and reduced availability during summer. Cropping intensity was higher under Doruvu wells, though installation costs were substantially greater (₹1,00,000) compared to bore wells (₹2,000–3,000). From 2019–2025, electrical conductivity (EC) varied seasonally, maximum between June and July and minimum during October and December due to monsoon recharge. No clear long-term improvement or decline was observed, but EC levels in 2024–2025 were higher than those in 2021–2023, especially in bore wells. Doruvu wells maintained more stable EC, with slight increases from January to April. To address salinity risks, sustainable measures such as artificial recharge, conjunctive water use, crop scheduling based on EC cycles, and blending with better-quality water are recommended for long-term groundwater management.

- **Effect of saline water on yield and nutrient use efficiency of maize under drip fertigation**

Application of the recommended dose of fertilizers (RDF) through fertigation in coastal region of Andhra Pradesh was standardized. Results revealed fertigation combined with alternate use of saline water up to 4 dS m^{-1} along with good quality water, produced yields statistically like those obtained with alternate use of 2 dS m^{-1} water and the best available water (5850 kg ha^{-1}). However, these findings need to be validated through further studies.

- **Performance of water melon crop irrigated with saline water through drip system**

Effect of saline water irrigation using drip system on performance of water melon was studied. Results indicate decreased number of fruits per plant with increasing salt concentration. The highest number of fruits were recorded (1.5) at salinity level of <1.0 dS m^{-1} i.e. best available water (BAW) whereas, the lowest number of fruits were recorded (0.9) at higher salinity level.

- **Influence of levels of nitrogen and *Azospirillum* doses on rice crop in saline soils**

Field experiment on studying effect of nitrogen levels and Azospirillum doses on rice crop in saline soils revealed that Leaching + green manure incorporation @+ 25 per cent extra RDN+*Azosprillum* @750mL acre $^{-1}$ *recorded* the highest yield attributes and grain (6117 kg/ha) and straw yield (8663 kg/ha) of paddy.

- **Effect of saline water irrigation on growth, yield attributes and yield of different varieties of Fennel through Drip**

A field experiment conducted during the rabi season of 2021–22 at AICRP Bikaner to evaluated the effect of irrigation water salinity on fennel growth and yield. The study adopted four salinity levels viz. ECiw 0.25 (BAW), 4, 6, and 8 dS/m and four fennel varieties (AF-1, RF-157, RF-281, and RF-290) in a split-plot design with five replications. Results of the study indicate that irrigation salinity significantly affected plant height, umbels per plant, umbellets per umbel, seeds per umbellate, test weight, and seed yield. Based on pooled data, the highest values for plant height (129.33 cm), umbels per plant (17.95), umbellets per umbel (23.32), seeds per umbellate (22.33), test weight (5.44 g), and seed yield (11.17 q ha^{-1}) were obtained under BAW (ECiw 0.25 dS/m), closely followed by ECiw 4 and 6 dS/m. Salinity levels beyond ECiw 6 dS/m caused a marked decline in all growth and yield parameters. Among the tested varieties, RF-290 consistently exhibited superior performance, confirming its higher productivity and tolerance to moderate salinity conditions.

- **Effect of nitrogen fertigation utilizing good and saline water under drip irrigation system in vegetable crops**

A two-year study (2022–23 and 2023–24) examined the impact of saline water irrigation under fertigation on garlic and onion yields in Hisar. In 2022–23, garlic was grown under drip irrigation with varying nitrogen application levels (75%, 100%, and 125% of recommended dose of nitrogen-RDN) and irrigation water salinity (2.5 and 5.0 dS/m). At 75% RDN, yields were declined by 10.43% and 27.08% at 2.5 and 5.0 dS/m water, respectively, compared to canal water. At 100% RDN, reductions were 8.16% and 22.16%, and at 125% RDN, 7.67% and 20.04%. On average, garlic yield decreased by 8.62% at 2.5 dS/m and 22.78% at 5.0 dS/m. In 2023–24, onion exhibited similar trends: yield reduction at 75%, 100%, and 125% RDN were 5.48%, 5.13%, and 4.59% at 2.5 dS/m, and 27.26%, 22.62%, and 20.68% at 5.0 dS/m. Mean reductions were 5.05% with 2.5 dS/m water and 23.36% with 5.0 dS/m water irrigation. Higher nitrogen application (125% RDN) marginally mitigated salinity-induced yield losses in both crops.

- **Performance of mycorrhizal (*Glomus mosseae*) inoculation in cotton-wheat under saline water irrigation (Hisar)**

A two-year experiment (2022–23 and 2023–24) evaluated the impact of high salinity irrigation water (ECiw 8 dS/m) on cotton and wheat yields under varying nutrient management practices. In cotton, mean seed yield was declined by 20.01% in 2022 and 21.53% in 2023 with saline irrigation as compared to canal water. The lowest yields occurred in the control (35.75 g/plant in 2022; 33.33 g/plant in 2023), while the highest yield were achieved under RDF + FYM + Mycorrhiza (64.18 and 63.05 g/plant), statistically at par with RDF + Mycorrhiza (63.06 and 62.05 g/plant) and RDF alone (62.71 and 61.37 g/plant). In wheat, mean yields were decreased by 20.28% in 2022-23 and 28.76% in 2023-24 under saline irrigation. The lowest yields were in the control (25.92 g/pot; 24.65 g/pot), while the highest were in RDF + FYM + Mycorrhiza (51.86 and 52.27 g/pot), comparable to RDF + Mycorrhiza and RDF alone. The findings show that integrated nutrient management mitigates yield losses from saline irrigation.

- **Performance of vegetable guar with different doses of Sulphur and Potassium under different water quality**

An experiment was conducted at AICRP ccentre Bhatinda to study the effect of three doses of sulphur (0, 30, and 45 kg/ha) and potassium (0, 30, and 45 kg/ha) on vegetable guar under two irrigation water qualities—canal water and saline tube well water. Canal water was of good quality (ECiw < 2 dS/m; SARiw < 10 mmol/L; RSC < 2.5 meq/L), while tube well water was high-SAR saline (ECiw > 4 dS/m; SARiw > 10 mmol/L). Uniform nitrogen (22 kg/ha) and phosphorus (60 kg/ha) doses were maintained across treatments. Saline irrigation reduced germination, plant height, and green pod yield by 38.6%, 24.6%, and 15.1%, respectively, compared to canal water. However, saline water increased seed potassium and sulphur content by 8.1% and 2.1% and straw potassium and sulphur content by 15.7% and 7.5%, respectively.

2.3 Management of Waste Water

- **Effect of treated sewage water as a source of irrigation and nutrients supply for Marigold-Chrysanthemum rotation**

A field experiment was carried out in 2023–24 at Agra to study the effect of treated sewage water as a source of irrigation and nutrients supply for Marigold-Chrysanthemum rotation in sandy loam soil. Total eight treatment combinations of different water quality (sewage and tube well water) and varying dose of RDF were evaluated in a randomized block design. Results showed that crops irrigated with sewage water (SW) along with the recommended dose of fertilizer produced the highest flower yield compared to tube well water (TW). Treatments such as TW + 125% RDF, SW + 75% RDF, and 1SW:1TW + RDF recorded the second highest flower yields.

- **Effects of fluoride in irrigation water on yield and quality of brinjal**

An experiment was conducted at Bhatinda under polyhouse with varying concentration (0.12, 2.0, 4.0, 6.0, 8.0 and 10.0 mg F/L) of fluoride in irrigation water in two brinjal varieties namely PBH-4 (Long Fruited) and PBHR-42 (Oblong fruited). The brinjal yield was significantly reduced, whereas F content in leaf and fruits was significantly higher with increasing F concentration in irrigation water. PBHR-42 produced significantly higher yield as compared to PBHR-4, whereas PBH-4 contains significantly higher leaf and fruit fluoride content, but was found under safe limit (≤ 1.0 ppm).

3. MANAGEMENT OF IRRIGATION INDUCED SALINIZATION AND ALKALINIZATION

3.1 Management of Irrigation Induced Alkali Soils

- **Management of Sodic Vertisols through Conjunctive use of Gypsum and Gliricidia sepium under Paddy-Wheat Cropping System**

A field experiment on paddy (CSR-10) was conducted at Indore in sodic vertisols from 2023–2024 using three gypsum levels (0%, 50%, 75% GR) and three Gliricidia sepium leaf doses (0, 5, 10 t/ha) in a split-plot design. Application of 75% GR gypsum with 10 t/ha Gliricidia significantly reduced bulk density, pH, and EC while increasing organic carbon and available N, P, and K. Exchangeable Na^+ and ESP declined, improving soil health and reclamation process. Results also revealed that though gypsum improves productivity, Gliricidia alone records the highest net returns and benefit–cost ratio, indicates it as a sustainable, cost-effective option for managing salt-affected soils.

3.2 Management of Irrigation Induced Waterlogged Saline Soils and Coastal Saline Soils

- **Evaluation of different depth (head) of controlled drainage system in saline vertisols of TBP command**

A field experiment was carried out to evaluate different lateral head height in saline Vertisols under TBP command with 50 m drain spacing. Study was conducted at Thimmapur village (farmers' field) on a 2-hectare block with four drainage treatments viz. conventional subsurface drainage (SSD) and controlled SSD with lateral heads raised to 0.3 m, 0.6 m, and 0.7 m within the root zone. The soil saturated paste electrical conductivity (ECe) ranged from 4.04 to 23.41 dS m^{-1}, with mean values of 13.48, 14.40, 12.29, and 11.67 dS m^{-1} at depths of 0–15, 15–30, 30–60, and 60–90 cm, respectively. Over four Kharif seasons (2020-2023), higher average drain discharge was observed in conventional SSD (1.35 mm d^{-1}) compared to controlled SSD (1.04, 0.89, and 0.76 mm d^{-1} at 0.3, 0.6, and 0.7 m levels). The salinity of drainage effluent ranged from 6.90 to 7.74 dS m^{-1}, showing continuous salt leaching from the root zone. Average salt removal was highest (6.62 t ha^{-1}) in conventional SSD, followed by controlled SSD (5.90, 4.92, and 4.10 t ha^{-1} at 0.3, 0.6, and 0.7 m depths). Nitrogen losses decreased with increased head depth, ranging from 6.97 kg ha^{-1} in conventional SSD to 2.99 kg ha^{-1} at 0.7 m control. Paddy grain yield improved substantially compared to undrained conditions, registering gains of 102% under conventional SSD, 80.3%, 67%, and 54% under controlled SSD at 0.3, 0.6, and 0.7 m depth s, respectively. The study showed that controlled drainage effectively conserved nutrients and reduced discharge, though conventional SSD achieved higher salt removal and yield response.

- **Enhancing water use efficiency in reclaimed waterlogged saline Vertisols by implementation of subsurface srainage aystem**

A field investigation initiated to devise strategy for enhancing water use efficiency and minimizing nitrate-N losses from subsurface drainage installed field in TBP. The experiment consisted four treatments viz. conventional drainage with continuous flooding (CF, T_1), conventional drainage with alternate wetting and drying (AWD, T_2), CF with controlled subsurface drainage (CF-CDF, T_3), and AWD with controlled subsurface drainage (AWD-CDF, T_4). Across four Kharif and three Rabi seasons, CF had higher average drain discharge (1.22 mm d^{-1}) than AWD (0.93 mm d^{-1}). Drain water salinity maintained below 4.0 dS m^{-1} with little variation for different treatments. A greater salt and nitrogen losses were found with CF, while controlled drainage helped to minimize them. AWD saved 19.95 cm (kharif) and 17.8 cm (rabi) irrigation water, maintaining a shallower water table. Paddy yields increased in all treatments, with CF giving about 3%

higher yield, showing AWD with controlled drainage improves resource efficiency with minimal yield impact.

- **Feasibility of drip irrigation in puddled transplanted rice (PTR) under saline vertisols of TBP Command Area, Karnataka**

A field experiment was conducted during kharif-2023 to study the feasibility of drip irrigation in puddled transplanted rice (PTR) under saline Vertisols at the Agricultural Research Station, Gangavathi. Two rice varieties (GNV-1801 and GVT-05-01) under four irrigation levels (1.2, 1.4, 1.6, and 1.8 ET) were evaluated using a split-plot design. Despite 39% lower rainfall (332 mm), drip irrigation effectively met crop water demand through 14 irrigations and saved 34.7-45.2% water as compared to conventional methods. Soil salinity remained below 4 dS m^{-1}. GNV-1801 variety achieved higher grain (6165 kg ha^{-1}) and straw yields (6843 kg ha^{-1}) than GVT-05-01. The irrigation applied at 1.6 ET produced the highest yields (6592 and 7300 kg ha^{-1}) and water use efficiency (80.56 kg ha^{-1} cm^{-1}), followed by 1.4 ET, while the lowest under 1.2 ET irrigation. Economic returns were the highest for 1.6 ET irrigation and with GNV-1801, recorded gross returns of ₹1,57,989 ha^{-1}, net returns of ₹78,264 ha^{-1}, and a B:C ratio of 1.99, though varietal and irrigation interactions were insignificant.

- **Comparative efficacy of nano and conventional urea on growth and yield of rice (*Oryza sativa* L.) under waterlogged saline soil in Tungabhadra Command Area, Karnataka**

To assess efficacy of nano and conventional urea on rice growth and yield in waterlogged saline soils, a field experiment was conducted in kharif-2024 in the Tungabhadra Command Area, Karnataka. Total ten treatments in a randomized block design were tested. Initial soil pH and ECe ranged between 8.20–8.70 and 5.10–9.80 dS/m, respectively, and soil salinity declined at panicle initiation and rose slightly at harvest but remained within the safe limit (<4.0 dS/m). Treatment T5 (125% RDN + foliar spray of 1% conventional urea at active tillering and panicle initiation) achieved the highest plant height (81.10 cm), tillers per hill (15.1), panicles per hill (13.2), grain yield (5995 kg/ha), and straw yield (6388 kg/ha), and the performance was at par with T_2, T_9 and T_{10}. Findings suggest that combining higher RDN levels with foliar spray of conventional urea significantly boosts rice productivity while maintaining acceptable salinity under waterlogged saline conditions.

- **Effect of different levels of organic manures and mulching on vegetables (Brinjal, Chilli and Tomato) under drip irrigation (Panvel)**

A field experiment was conducted during *rabi* season 2022-2023 to study the effect of different levels of organic manures and types of mulch on performance of selected vegetables (Brinjal, Chilli and Tomato) under drip irrigation. Results indicate that plastic mulch significantly reduced soil electrical conductivity and pH as compared to paddy straw mulch and no mulch. It also maintained higher soil moisture than paddy straw mulch no mulch. However, paddy straw mulch recorded the highest yields of brinjal, chilli, and tomato. Moreover, combining paddy straw mulch with farmyard manure (7.5 t ha^{-1}) and vermicompost (2.5 t ha^{-1}) produced the highest yields, indicating that organic amendments under paddy straw mulch enhance soil conditions and crop productivity effectively.

- **Effect of planting windows and irrigation on dibbling of wal (Field bean) grown under zero tillage in coastal saline soils of Konkan**

A field experiment was conducted to evaluate the effects of sowing date and irrigation on the growth and yield of dibbling of wal (Field bean), as well as on changes in soil properties. The initial soil $EC_{(1:2.5)}$ was 2.89 dS/m. Three irrigation treatments (nil, one and two numbers) and three window of sowing (after harvest of Rice, 10 days and 20 days after harvest of rice) were evaluated. Results indicate two irrigations at flowering and pod formation reduced soil EC and pH while maintained higher moisture. Sowing field bean immediately after rice harvest further improved soil moisture, lowered EC, and raised pH. Though two irrigations enhanced soil properties, one irrigation also significantly increased yield, especially when combined with immediate post-rice sowing.

3.3 Management of Saline-Acidic Soils

- **Effect of method of planting in the establishment of rice seedlings in high salinity**

A field experiment with Vyttila 10 (KAU Lavanya) variety was undertaken to evaluate effect of different land preparation (mound, ridge, raking with tiller) and planting methods (sowing/transplanting manually or with a transplanter) on establishment of rice seedlings in high salinity by AICRP Vyttila center. In 2023, germination was nearly 100% on mounds, 75% on ridges or after tiller raking, and 50% with machine transplanting, but flooding destroyed the crop. Due experimented was repeated in 2024, which indicated T5 (transplanting on ridges) produced the highest yield (34.88 q ha^{-1}), which was comparable with T7, T8, T3, and T6. The lowest yield obtained in T4 (direct sowing without preparation) with only 1.16 kg ha^{-1} where germination was 10% only. Results indicate that ridge and mound-based transplanting enhance soil nutrient status, organic matter, and seedling establishment, thus improving productivity under saline Pokkali conditions.

- **Management of salinity and acidity of *Pokkali* soils using suitable amendments (Vyttila)**

This study investigated the effectiveness of of Calcium salts and silica on managing soil acidity and salinity and to find out a suitable ameliorant for economic yield in IFS in Pokkali ecosystem. Eight treatments were tested under randomized block design with three replications. Treatments consist of calcium salts (calcium nitrate, calcium chloride, calcium sulphate, rock phosphate, dolomite, lime) and rice husk ash @1000 kg ha^{-1}. The crop failed in 2023 due to flooding. Due experiment was repeated in 2024 with Vyttila-11 variety. Results indicate that all calcium amendments raised soil pH from initial value of 4.57, while calcium nitrate (5.69) and dolomite (5.56) was found most effective. Treatments reduced salinity, improved nutrient availability (notably with rock phosphate and dolomite), and Al solubility found below undetectable levels. Dolomite treatment recorded the maximum plant height, while most tillers and most productive tillers were found under gypsum and calcium nitrate treatments, respectively. Rice husk ash gave the highest grain yield (27.49 q ha^{-1}) and improved pH (5.53) due to silica-enhanced stress resistance, followed by dolomite (26.51 q ha^{-1} grain, 35.28 q ha^{-1} straw). Rice husk ash and dolomite appeared to be the most promising amendments for saline-acidic Pokkali soils.

4. ALTERNATE LAND USE

- **Development of Horticulture Based Agri-horti System under Saline Water Conditions (Bikaner)**

An experiment was initiated in 2018 to assess the suitability and economic viability of horticulture-based agri-horti systems under saline water conditions. Three irrigation waters with salinity levels (ECiw 0.25, 2.4, and 6.0 dS/m) were tested using cluster bean as an intercrop in bael tree alleys during kharif, and mustard, taramira, oat, and barley during rabi. Results of kharif 2023 and 2024 revealed significant decreases in cluster bean seed and straw yields with increasing irrigation salinity levels. The pooled (2018–2023) data indicates yield reductions of 13.41% and 45.92% at ECiw 2.4 and 6.0 dS/m, respectively. Yields of Rabi crops also declined under increased salinity, though reductions were mostly non-significant except in oat at 6.0 dS/m. Bael fruit yield, recorded from 2022 onward, was highest under BAW (0.25 dS/m), followed by 2.4 dS/m, and the lowest under 6.0 dS/m. Economic analysis found that irrigation with BAW and 2.4 dS/m as most profitable, while 6.0 dS/m reduced profits. The Cluster bean–

Bael–Mustard system proved most salinity-tolerant and economically viable, followed by barley, taramira, and oat.

5.0 SCREENING OF VARIETIES FOR SALINITY/SODICITY TOLERANCE

- **Screening of mustard cultivars for saline water irrigation (Agra)**

In 2022–23, four mustard genotypes were evaluated for saline water irrigation at Agra and CSCN 22-02 was found the best with the highest yield of 2252.15 kg/ha, while CSCN 22-01 recorded the lowest (1808.63 kg/ha). In 2023–24, five genotypes were tested, and CSCN 23-02 recorded the highest yield (1987.65 kg/ha), while CSCN 23-01 had the lowest (1423.76 kg/ha).

- **Screening of mungbean entries under alkali and saline water irrigation water (Agra)**

Under alkali water conditions, significant differences in grain yield were observed among different mungbean genotypes at Agra. The highest yield was recorded for entry SAS-24-12 (641.68 kg/ha), while the lowest yield was observed for SAS-24-02 (434.45 kg/ha). For saline water, entry SAS-24-12 was found the best (598.90 kg/ha), while the lowest yield was observed for SAS-24-06 (447.23 kg/ha).

- **Screening of newly released rice varieties for salinity tolerance (Baptal)**

The seven newly released rice varieties were tested for salinity tolerance at soil salinity level of 8 ECe. The variety MCM 100 was found the best performing with the highest grain (4917 kg/ha) and straw yield (7050 kg/ha) and better yield attributing characters viz., no. of productive tillers, filled grains panicle^{-1}, panicle length and lowest chaffy grains, followed by MCM 125 (4733 kg/ha), CSR 60 (4517 kg/ha), CSR56 (4150) and MTU 1290 (4400 kg/ha) varieties.

- **Screening of summer mustard genotypes under saline/alkaline conditions (Bikaner)**

During rabi 2023-24 in AVT of mustard at Bikaner, four entries were evaluated in randomized block design with four replications under saline conditions (ECiw 13 dS/m). The differences among the genotypes for seed yield was found significant. Highest seed yield was recorded for entry CSCN-23-04 (1789.20 kg /ha), closely followed by CSCN-23-03(1719.29 kg /ha) and CSCN-23-01 (1634.88 kg/ha).

- **Screening of elite varieties of pearl millet and mustard crops irrigated with poor quality water**

The salinity tolerance of selected pearl millet and mustard genotypes were tested at Hisar under saline water irrigation conditions (canal water, ECiw 2.5, 5.0 and 7.5 dS/m) in micro-plots (2 m × 2 m). During 2022–2024, pearl millet (HHB-67, HHB-197, HHB-226 and HHB-299) and mustard genotypes (CS-54 as check, CS-2020-10*, CS-60 as local Released; LR) and Kranti (National check; NC) were tested under saline irrigation (ECiw 2.5, 5.0, and 7.5 dS/m) following standard agronomic practices. In 2023, four improved pearl millet genotypes (HHB-67 Improved, HHB-67 Improved 2, HHB-344 and HHB-346) were evaluated for similar condition. In 2022, pearl millet genotypes HHB-299 (287.76 g/m²) recorded the highest yields at ECiw 7.5 dS/m, while HHB-67 yielded the least. Mean yield reductions were found as 3.74%, 12.55%, and 21.85% as salinity increased. In 2023, HHB-346 performed the best (212.53 g/m² at 7.5 dS/m), followed by HHB-67-Improved 2, whereas HHB-67-Improved produced the lowest yields, with reductions of 2.89%, 13.30%, and 22.48%. Among mustard genotypes (2022–23), CS-2020-10* yielded the highest (235.84 g/m² at 7.5 dS/m), followed by CS-54, while Kranti (NC) showing 2.16%, 14.76%, and 26.81% yield reductions. In 2023–24, CS-2020-10 again outperformed others (209.33 g/m² at 7.5 dS/m), followed by CS-60 (LR), with Kranti (NC) least tolerant, showing 3.31%, 13.08%, and 20.98% yield declines. Overall, HHB-299, HHB-346, and CS-2020-10 demonstrated superior salinity tolerance across years and crops.

- **Evaluation of Green gram varieties for sodicity tolerance**

Five greengram varieties *ie.,* VBN 5, CO 8, VBN 6, CO 9 and VBN 2 were evaluated at Tiruchirappalli under variable sodicity levels *viz.,* ESP 8, 16, 24, 32, 40 and 48 in 2023 under strip plot design with two replications. The results revealed that VBN 5, VBN 6, VBN 2, CO 8 and CO 9 verities of greengram can be recommended for the ESP level up to 24 to get reasonable yield (at least 50%).

- **Evaluation of traditional rice landraces for sodicity tolerance**

The traditional rice landraces *viz.,* Kaalanamak, Kuadai Vazhai, Mappilai Samba, Kichili Samba, Garudan Samba, Illuppaipoo Samba, Milagu Samba, Thuyamalli, Seeraga Samba, KaruppuKavuni, Rathasali, Kothamalli Samba, were evaluated at Tiruchirappalli for sodicity tolerance under variable levels of sodicity *viz.,* ESP 8, 16, 24, 32, 40 and 48. The results of that the study indicate that grain and straw yields of traditional rice landraces were gradually decreased with increasing ESP levels. The traditional rice landraces *viz.,* Karruppukavuni, Kaalanamak, Mappillai samba, Milagu samba, Kichili samba and Thuyamalli performed well up to the ESP level of 32 with yield loss of 50 % yield.

6. OPERATIONAL RESEARCH PROJECTS/ON-FARM TRIALS/SC SP ACTIVITIES

- **Operational research program on use of underground saline waters for irrigation at farmer's field**

During 2022–23 and 2023–24, twenty-five farmers were selected for operational research programme (ORP) by AICRP Agra centre. Improved technologies such as conjunctive use of saline and low-saline water, sowing with conserved rain moisture, saline water recharge, recommended agronomic practices, and forate with zinc application were implemented to enhance crop yields and profitability over traditional methods. In pearl millet, ORP farmers achieved 20.6–24.8 q/ha compared to 18.2–24.1 q/ha for others, with net profits of ₹31,920–36,675 and B:C ratios of 2.16–2.63. Sesame yields were 6.7–7.5 q/ha under ORP while it was 5.8–6.7 q/ha for others, which resulted returns of Rs. 42,020–51,680, B:C 2.82–3.31. Mustard yields also reached to 24.8-28.1 q/ha under ORP with profits of Rs 83,770-1,31,845, and B:C ratio of 3.50-4.93. Wheat yields under ORP were 44.2-47.7 q/ha as compared to 40.1-43.8 q/ha of others, with profits of Rs 1,04,650-1,22,210 and B:C ratio of 3.75-4.37. Green gram yields were 5.2–7.3 q/ha in ORP in comparison of 4.7–6.8 of others and profits recorded as 24,383-44,500, while B:C ratio was 2.10–3.28.

- **Operational research project on alkali soils with different reclamation technologies**

Alkali soil reclamation technology *i.e* in-situ incorporation of *dhaincha* at 50 per cent flowering stage + application of 50% of gypsum requirement+ 25% extra fertilizer was implemented in Konanki village, which indicated reduction of soil ECe and ESP to an extent of 24-43 and 30-45 per cent, respectively over a period of three years.

- **ORP on evaluation of green gram varieties for their tolerance to sodicity**

To confirm the results of field experiments and demonstration to the farmers, on farm trials were conducted by Tiruchirappalli centre of AICRP in sodic soils at different locations viz, ADAC&RI, Trichy, AC&RI, Kudumiyanmalai, CRS, Veppanthattai, RRS, Paiyur. From the trails, it was found that the VBN 5 green gram variety registered higher mean plant height (51.8 cm), no. of pods plant^{-1} (19), No. of seeds pod^{-1} (10.4) and grain yield (773 kg ha^{-1}) than VBN 6, VBN 2, Co 8 and Co 9 under sodicity. Hence, VBN 5 and VBN 6 green gram varieties can be recommended for getting higher productivity in sodic soil condition upto the ESP of 24.

7. IMPLEMENTATION OF SCHEDULED CASTE SUB PLAN (SC SP) ACTIVITIES

With the aim to improve farm productivity and economic development of SC farmers through dissemination of improved technologies, on campus and off campus trainings, frontline demonstrations, on-farm trials, skill development, input distribution and exposure visits to nearby universities and KVK's were organized.

- During kharif 2024, pearl millet seed was distributed to 10 Scheduled Caste (SC) farmers in Bhahai Barari, Kurkunda, and Anguthi villages. Further, mustard, maize, and wheat seeds, 14 spray machines, and 10 storage bins were also provided.
- In 2023–24 and 2024–25, under SCSP activities, agricultural inputs were distributed by Bikaner centre.
- At Gangawathi (2022–23), SC farmers received ferrous sulphate, a calcium-magnesium-sulphur soil conditioner, and Organic Magic.
- At Tiruchirappalli, activities were mainly focused on improving productivity and incomes of SC farmers through technology dissemination, training, demonstrations, trials, skill development, exposure visits, and input distribution.
- 15 SC farmers from Raigad, Maharashtra, were trained in agriculture and allied sectors at Khar Land Research Station, Panvel.
- Seeds of salinity-tolerant rice varieties (Vyttila 8 and Vyttila 10) were distributed to SC farmers in Kuzhuppilly and Ezhikkara panchayats by Vyttilac centre during kharif 2024.

INTRODUCTION

The All India Coordinated Research Project on "Use of Saline Water in Agriculture" was initiated during the Fourth Five-Year Plan under the umbrella of Indian Council of Agricultural Research, New Delhi. The Project Coordinating Unit (PCU) was established at ICAR-Central Soil Salinity Research Institute, Karnal. Initially, four centres (Agra, Bapatla, Dharwad, and Nagpur) were set up to address the use of saline water in distinct agro-ecological regions including semi-arid, black soil and coastal areas. The project at these centres was continued during Fifth Five Year Plan. In Sixth Five Year Plan, four centres from the AICRP on Water Management and Soil Salinity (Kanpur, Indore, Jobner, and Pali) were transferred to this AICRP, while the Nagpur centre was closed. Since, Kanpur and Indore looking reclamation and management of heavy textured alkali soils, the project was renamed as All India Coordinated Research Project on Management of Salt Affected Soils and Use of Saline Water in Agriculture (AICRP on SAS & USW). Further reorganization was occurred and Dharwad centre was shifted to Gangavathi in 1989 and Jobner centre to Bikaner in 1990 to conduct site-specific research in areas severely affected by salinity. During the Seventh Five-Year Plan, the AICRP continued at these locations. Two new centres at Hisar and Tiruchirappalli were added during the Eighth Five-Year Plan, which started operations in 1995 and 1997, respectively. Subsequently, during the Twelfth Five-Year Plan, four new volunteer centres (Bathinda, Port Blair, Panvel, and Vyttila) were established in 2014, expanding the network to eight cooperating centres and four volunteer units. Hence, by the mid-Twelfth Plan, the Sub-Scheme was operated at RBS College, Agra; Agriculture College, Bapatla (ANGRAU, Guntur); SKRAU, Bikaner; ARS, Gangavathi (UAS, Raichur); CCSHAU, Hisar; College of Agriculture, Indore (RVSKVV, Gwalior); CSAUA&T, Kanpur; and ADAC&RI, Tiruchirappalli (TNAU, Coimbatore). The Volunteer centres were functioned at Panvel, Vyttila, Bathinda, and Port Blair. Based on ICAR-CSSRI's QRT (2011–17) recommendation, Indore centre was converted in to a volunteer centre, while Kanpur and Port Blair centres were closed on 31st March 2020. Further, staff strength of the Sub-Scheme was reviewed during finalization of SFC 2017-20 and scheme's strength reduced from 103 to 33 with effect from 1-04-2018. As per SFC 2021-26, total sanctioned strength of the scheme is 26, which include 12 scientific staff sanctioned and 14 administrative and supporting staffs for 6 cooperating centres. For 5 volunteer centres (Bathinda, Panvel, Vyttila, Indore and Akola), provision of 2 SRF/ 2 JRF in relevant discipline was made based on fund availability. As per recommendation of QRT (2011-17), name of AICRP has been changed from "Management of Salt Affected Soils and Use of Saline Water in Agriculture" to "Management of Saline Water and Associated Salinization in Agriculture" with the revised mandate. The QRT (2018-2022) of ICAR-CSSRI also recommended strengthening the scientific position of AICRP centres by increasing the sanctioned scientific staff from two to three scientists at cooperating centres, and by providing office assistance at each centre. These measures aim to enhance research capacity and improve administrative support for the All India Coordinated Research Projects (AICRP), ensuring more efficient functioning and higher output from these multi-location research teams. AS per SFC (2021-26), the project continued at following 11 centres and Coordinating Unit at ICAR-CSSRI, Karnal with the total outlay of Rs. 3489.94 lakh which included ICAR and State share as Rs. 2651.40 lakh and Rs. 838.54 lakh, respectively.

Cooperating centres with addresses

1. Raja Balwant Singh College, Bichpuri, Agra (Uttar Pradesh)
2. Regional Research Station, ANG Ranga Agricultural University, Bapatla (Andhra Pradesh)
3. SK Rajasthan Agricultural University, Bikaner (Rajasthan)

4. Agricultural Research Station, University of Agricultural Sciences, Gangavathi (Karnataka)
5. Department of Soils, CCS Haryana Agricultural University, Hisar (Haryana)
6. AD Agricultural College and Research Institute, TN Agril. University, Tiruchirappalli (Tamil Nadu)

Volunteer Centres

1. Regional Research Station, Punjab Agril University, Bathinda (Punjab)
2. Khar Land Research Station, Dr. BS Konkan Krishi Vidyapeeth, Panvel (Maharashtra)
3. Rice Research Station, Kerala Agril. University, Vyttila, Kochi (Kerala)
4. Agriculture College, RVS Krishi Vishwa Vidyalaya, Indore (Madhya Pradesh)
5. Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola

Mandate of the scheme

- Survey, characterization and mapping of groundwater quality for irrigation purpose
- Evaluation of effects of poor-quality groundwater irrigation on soils and crops under different agro-climate conditions
- Development of management practices for irrigation induced salinization and guidelines for saline water irrigation (including micro irrigation) under different agro-climatic regions
- Screen crop cultivars and tree species appropriate to soil salinity and alkalinity conditions

Finance: As per approved SFC proposal for five years (2021-26), total fund of Rs. 3489.94 lakh was allocated to the scheme running at 11 centres, which included Rs. 2651.40 lakh and Rs. 838.54 lakh as ICAR and State share, respectively.

RESEARCH ACCOMPLISHMENTS

1. RESOURCE INVENTORIES FOR POOR QUALITY GROUNDWATER AND SALT AFFECTED SOILS

1.1 Resource Inventories of Poor-Quality Groundwater for Irrigation

- **Characterization of underground waters for irrigation purpose in different districts of U.P. (Agra)**

The groundwater quality for irrigation purpose of Uttar Pradesh depicts the spatial distribution of groundwater quality across the state different color codes represent categories such as good (blue), marginally saline (yellow), saline (orange), high SAR saline (brown), marginally alkali (light orange), alkali (green), and high alkali (dark green). The map (Fig 1.1) shows large tracts in the western, central, and some eastern districts affected by salinity or alkalinity problems, while good quality groundwater is prevalent in parts of northern, northeastern, and southeastern Uttar Pradesh. This spatial information is crucial for guiding irrigation water management, crop planning, and soil health preservation in the state.

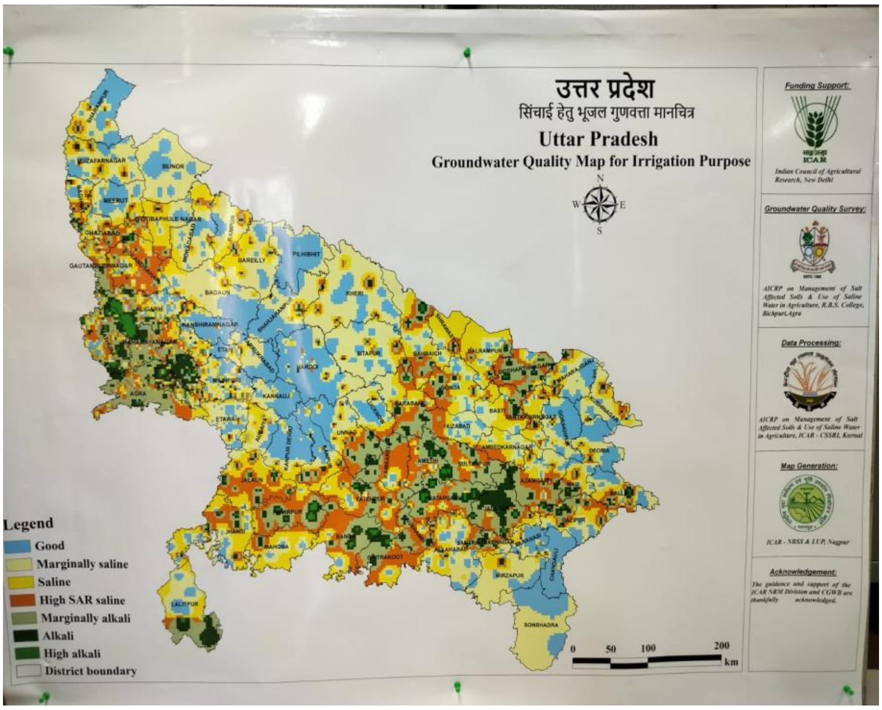


Figure 1.1 Groundwater quality map of Uttar Pradesh for irrigation purposes

- **Survey and characterization of underground irrigation water of districts of Andra Pradesh (Bapatla)**

Srikakulam district (Revisiting)

Ground water survey (Revisiting of sites) was carried out during the month of December, 2022 covering all the 38 mandals of erstwhile Guntur district. A total of 883 ground water samples were collected from available water resources. Different water quality parameters, including pH, EC, CO_3^{2-}, HCO_3^{-}, Cl^{-}, SO_4^{2-}, Ca^{2+}, Na^{+}, Mg^{2+}, RSC, and SAR, were analyzed using standard procedures to assess the suitability of groundwater for irrigation. Based on EC, SAR, and RSC values, and following the ICAR-CSSRI classification, the samples were categorized into seven classes: good water, marginally saline, saline, high SAR saline, marginally alkali, alkali, and high SAR alkali. The percentage distribution of samples in these categories is presented in Table 1.1. Percent distribution shows that about 79% of water samples belonged to good water category while ~12 % sample fell into marginal saline category. Using the analysed data, a groundwater quality map of the erstwhile Srikakulam district was developed (Fig. 1.2), illustrating spatial variability in water quality. The map depicts good quality groundwater from irrigation point of view for most of the area of the district. A temporal comparison with 2007–08 data (Fig. 1.3) revealed a slight reduction in good-quality water and a noticeable rise in marginally saline and alkali water classes, indicating gradual deterioration in groundwater quality for irrigation purposes, likely due to increasing salinity and alkalinity over time.

Table 1.1 Irrigation water quality of erstwhile Srikakulam district

Class	EC (dS m^{-1})	SAR	RSC (me L^{-1})	No. of samples	Per cent samples
A. Good water	<2	<10	<2.5	699	79.16
B. Saline water					
B1. Marginally saline	2.0 - 4.0	<10	<2.5	104	11.78
B2. Saline	>4	<10	<2.5	2	0.23
B3. High SAR saline	>4	>10	<2.5	2	0.23
C. Alkali water					
C1. Marginally alkali	<4	<10	2.5-4.0	34	3.85
C2. Alkali	<4	<10	>4	36	4.08
C3. High SAR alkali	Variable	>10	>4	6	0.68
	Total samples			**883**	

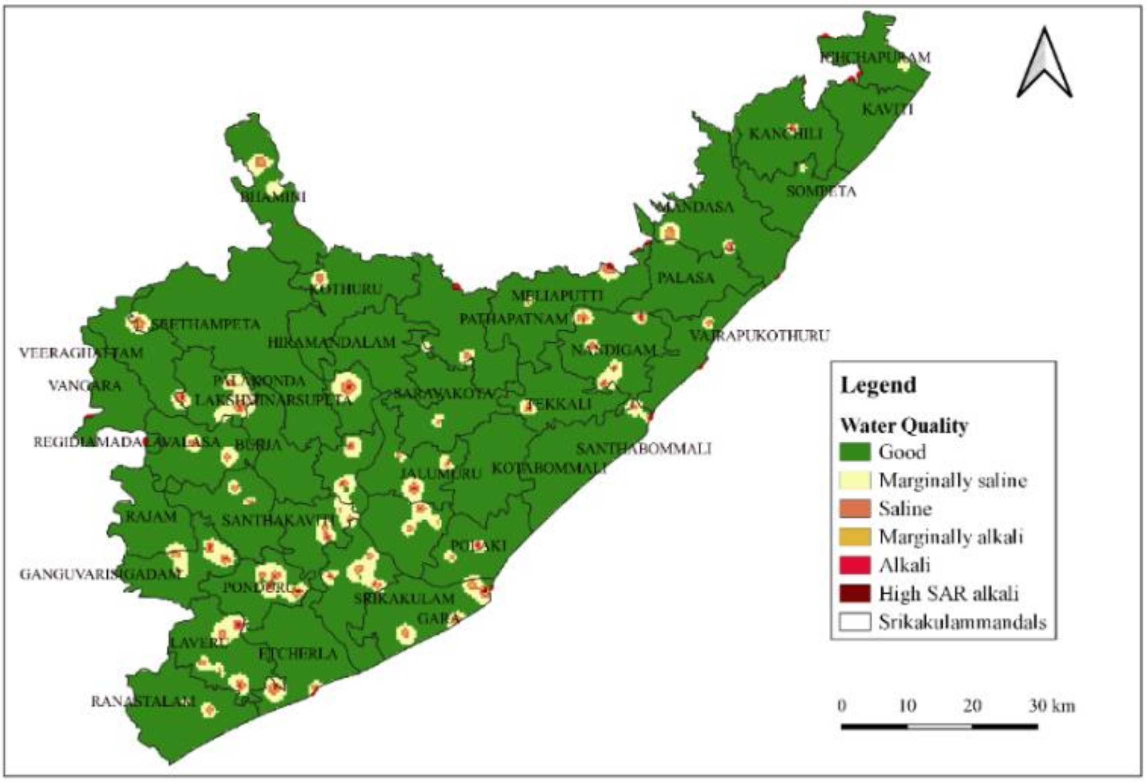
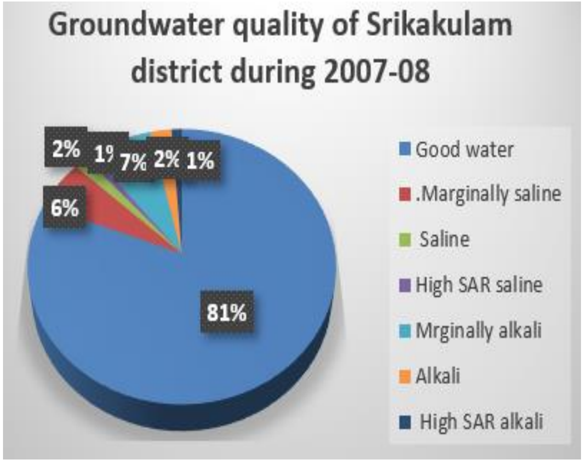


Fig 1.2 Groundwater quality map of erstwhile Srikakulam district



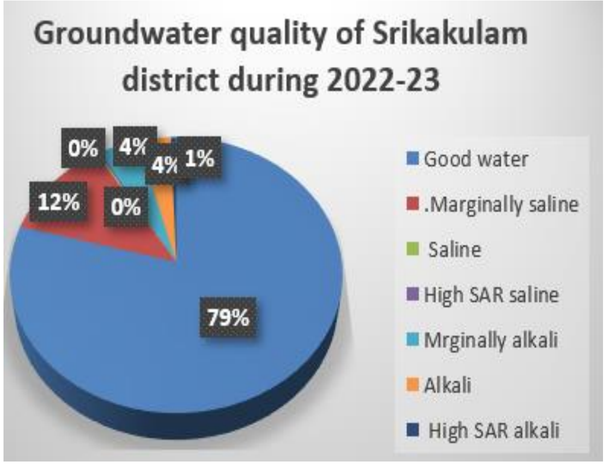


Fig. 1.3 Graphical representation of temporal variation in groundwater quality of Srikakulam district

Vizianagaram district (Revisiting)

Ground water survey (Revisiting of sites) in Vizianagaram district was carried out during the month of February 2023 736 groundwater samples were collected from 34 mandals of Vizianagaram. Based on quality parameters (EC, SAR and RSC) groundwater was grouped into seven classes (Table 1.2 & Fig. 1.4) by following the water classification standards. The number of samples under different classes was recorded as good water (85 %) > slightly saline (7.5 %) > marginally alkaline (3.8)> high SAR alkali (2.3) > alkali (0.95) > high SAR saline (0.27)> saline water (0.14 %). Majority of the samples collected from different mandals are good in quality except 2 or 3 samples.

Table 1.2 Irrigation water quality of erstwhile Vizianagaram district

Class	EC (dS m^{-1})	SAR	RSC (me L^{-1})	No. of samples	% samples	Recommended management practices
1. Good water	<2	<10	<2.5	625	84.92	Can be used for all types of soils and crops
2.Marginally saline	2.0 - 4.0	<10	<2.5	56	7.61	Can be used with slight salt tolerant crops and periodic monitoring
3. Saline	>4	<10	<2.5	1	0.14	For salt tolerant crops by conjunctive use or alternate use with good quality water and periodic monitoring of salts
4. High SAR saline	>4	>10	<2.5	2	0.27	Unsuitable for irrigation but can be diluted with good quality water and used for tolerant crops
5. Marginally alkali	<4	<10	2.5-4.0	28	3.80	Can be used by passing through gypsum bed and periodical monitoring
6. Alkali	<4	<10	>4	7	0.95	Can be used by passing through gypsum bed, green manuring and periodical monitoring
7. High SAR alkali	Variable	>10	>4	17	2.3	Unsuitable for irrigation for fine soils
Total samples				**736**		

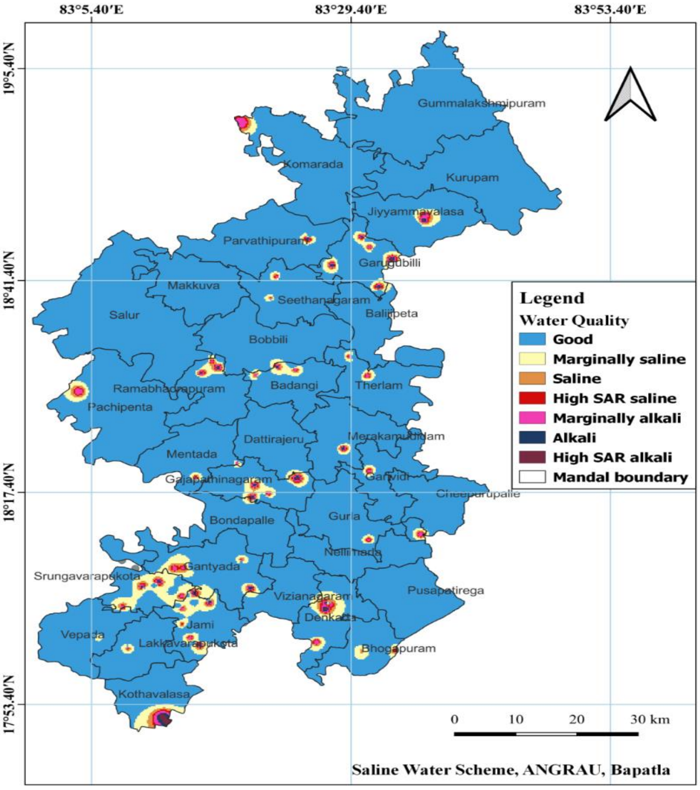


Fig 1.4 Groundwater quality map of erstwhile Vizianagaram district

Visakhapatnam district (Revisiting)

Groundwater survey in erstwhile Visakhapatnam district was carried out from 02-03-2024 to 02-03-2024. A total of 800 water samples covering all the 43 mandals of erstwhile Visakhapatnam district were collected. Chemical analysis of all samples was done for EC, pH, carbonates, bicarbonates, chloride, calcium, magnesium, sodium and potassium. The grouping of water samples based on various parameters (Table 1.3) indicates that about 70 % collected samples fell under good water category, while ~14% samples were found marginally saline. Under marginally alkali and high SAR alkali categories, 6.75 and 2.13 percent samples were found. The comparison of overall groundwater quality of years 2006-07 and 2024-25, indicates a noticeable decline in good water quality (Fig. 1.5). In 2006-07, 96.9 per cent of the total 636 water samples were classified as "Good," indicating a predominantly healthy water status. However, by 2024-25, the percentage was dropped to 85.63, reflecting a reduction in proportion of good-quality water. At the same time, there has been a significant increase in the share of "marginally saline" water samples from 3.77 per cent (19 samples) in 2006-07 to 13.88 per cent (111 samples) in 2024-25. Similarly, the proportion of saline water has increased from 0.63 per cent (4 samples) to 3.25 per cent (26 samples). These shifts indicate a clear trend of increasing groundwater salinity, which poses potential risks for agriculture, human consumption, and environmental sustainability. The data highlights the growing need for improved water management strategies to curb further deterioration in quality.

Table 1.3 Irrigation water quality of erstwhile Visakhapatnam district

Class	EC (dS m^{-1})	SAR	RSC (meq L^{-1})	No. of samples	% samples	Recommended management practices
1. Good water	<2	<10	<2.5	557	69.63	Can be used for all types of soils and crops
2. Marginally saline	2.0 - 4.0	<10	<2.5	114	13.88	Can be used with slight salt tolerant crops and periodic monitoring
3. Saline	>4	<10	<2.5	26	3.25	For salt tolerant crops by conjunctive use or alternate use with good quality water and periodic monitoring of salts
4. High SAR saline	>4	>10	<2.5	6	0.75	Unsuitable for irrigation but can be diluted with good quality water and used for tolerant crops
5. Marginally alkali	<4	<10	2.5-4.0	54	6.75	Can be used by passing through gypsum bed and periodical monitoring
6. Alkali	<4	<10	>4	29	3.63	Can be used by passing through gypsum bed, green manuring and periodical monitoring
7. High SAR alkali	Variable	>10	>4	17	2.13	Unsuitable for irrigation for fine soils
Total samples				**800**		

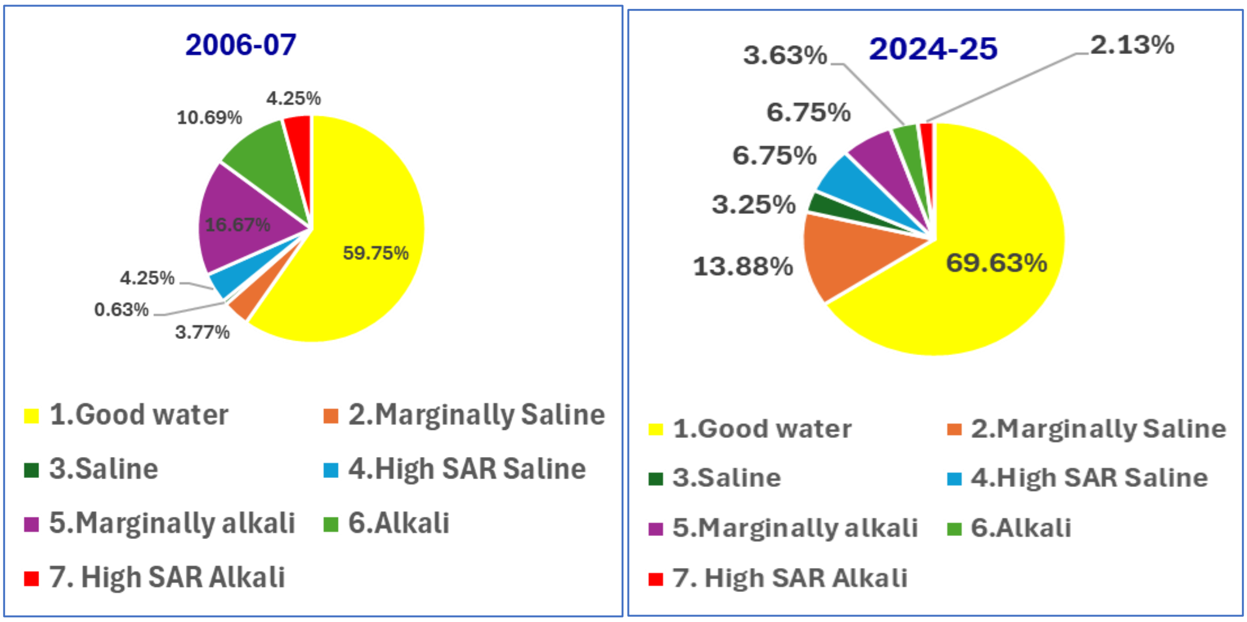


Fig 1.5 Comparison of ground water quality of Visakhapatnam district (Revisiting)

- **Compilation and mapping of groundwater quality of Andhra Pradesh using GIS (Bapatla)**

The water quality maps of all districts of Krishna zone (Krishna, Guntur and Prakasam) and Scarce rainfall zone were generated using QGIS. The data were cleaned and organized into required format for generation of thematic maps in QGIS. Initially the delimited text layer plotted and exported as shapefile. Further the shapefile containing groundwater location coordinates is clipped for the new district boundaries of the zone *viz*. Krishna, NTR, Bapatla, Guntur, Palnadu and Prakasam districts. Further data points were interpolated using IDW and thematic maps of pH, EC, chloride, sodium, RSC and SAR were generated in QGIS. Finally, considering all the data points, the water quality map was generated for Krishna Zone (Fig 1.6 to 1.10).

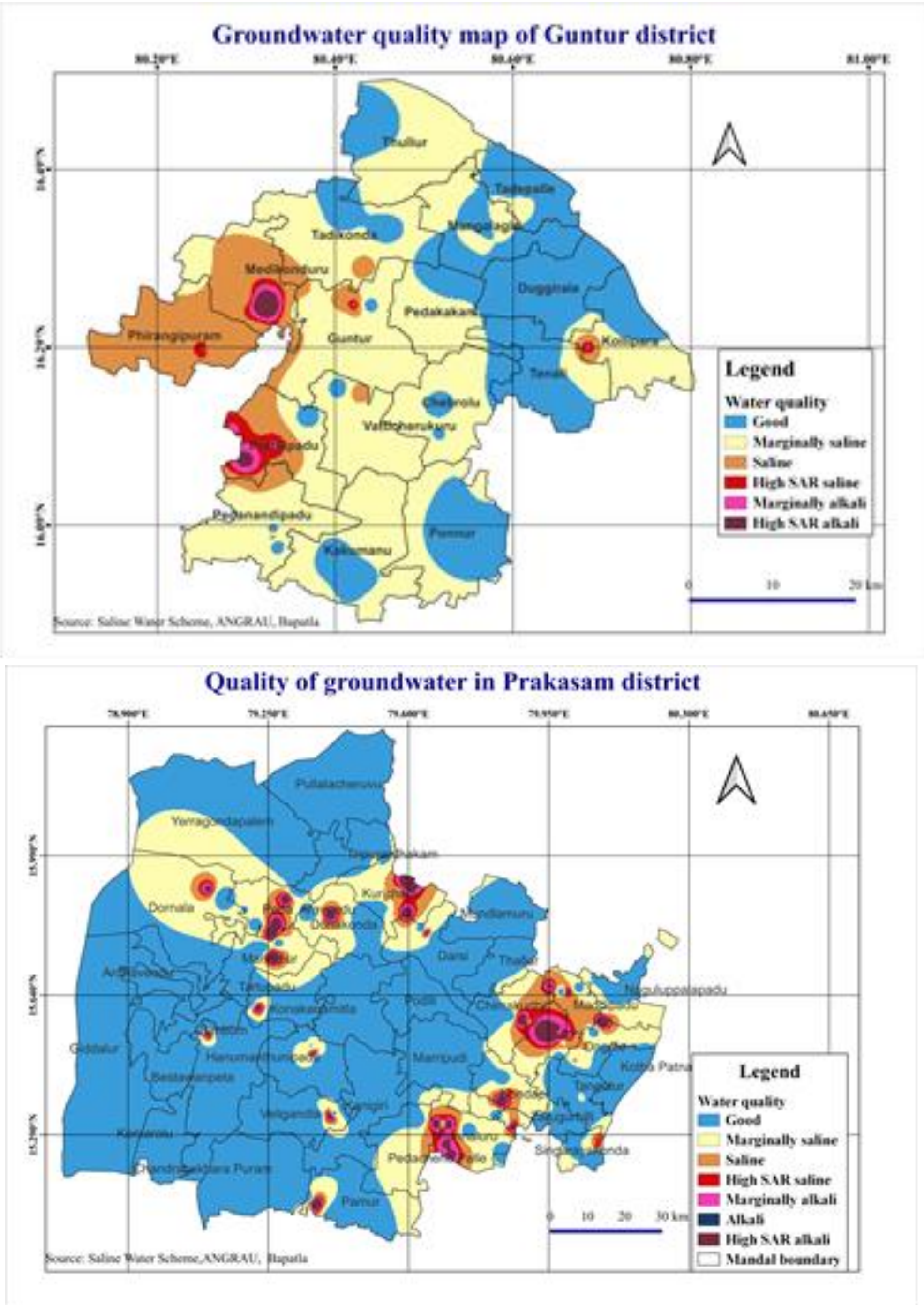
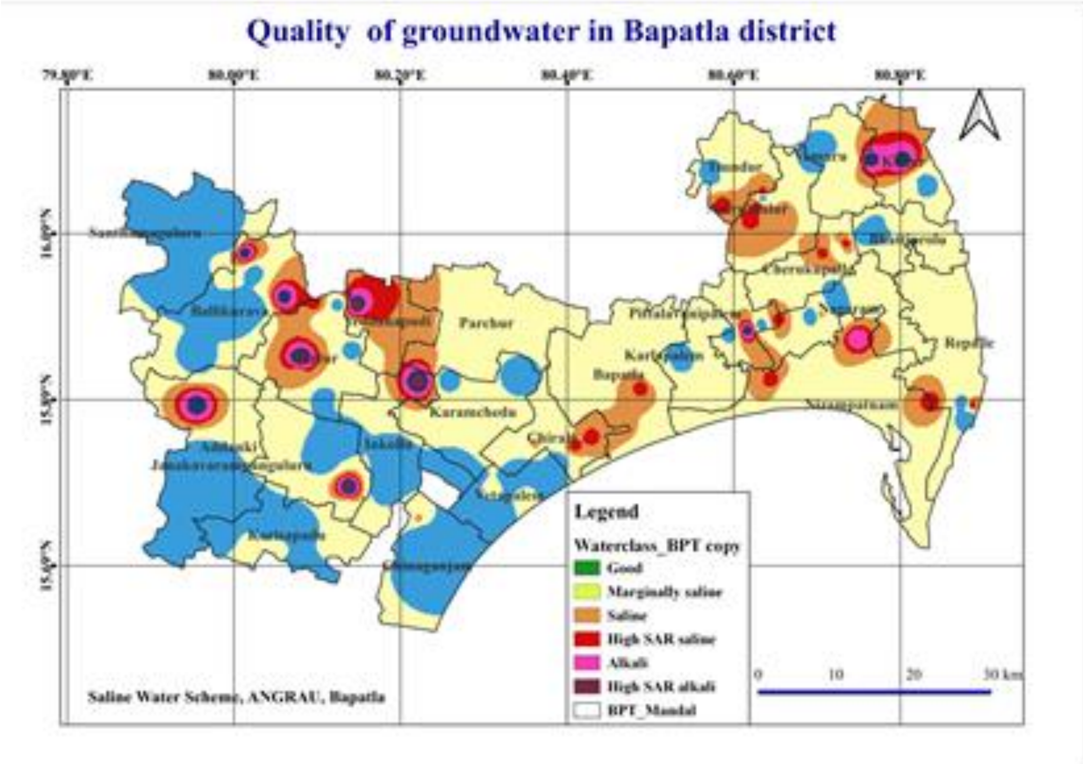


Fig 1.6 Groundwater quality maps of Guntur, Prakasam district



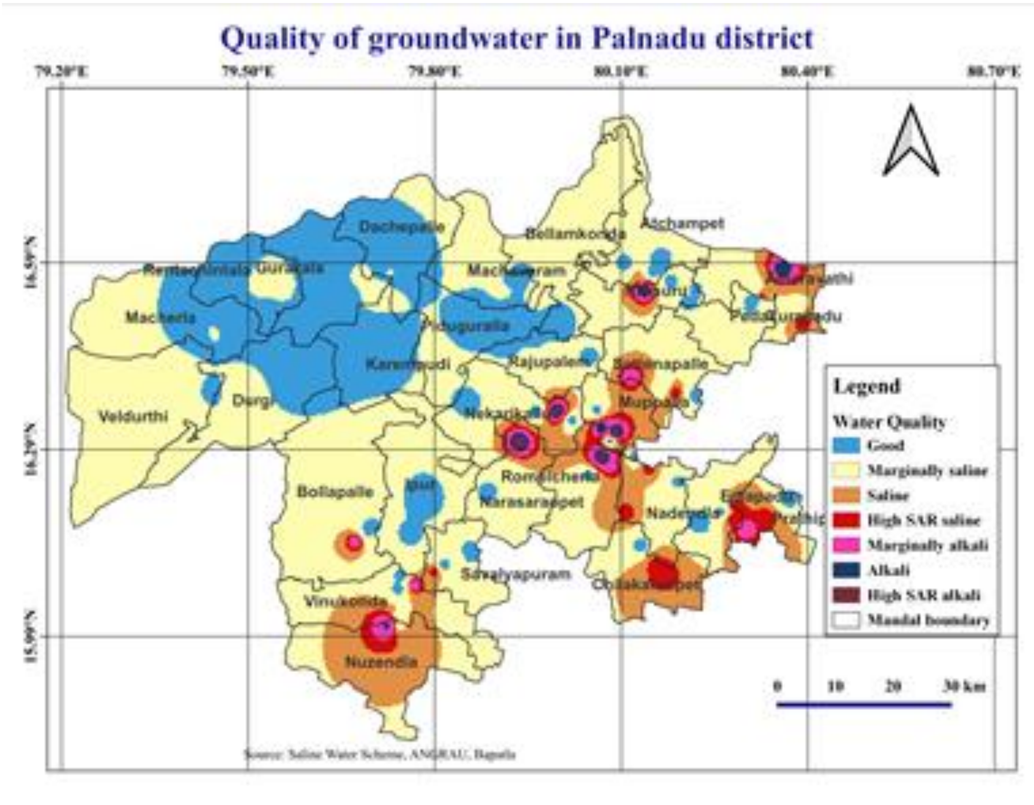


Fig 1.7 Groundwater quality maps of Bapatla and Palnadu districts

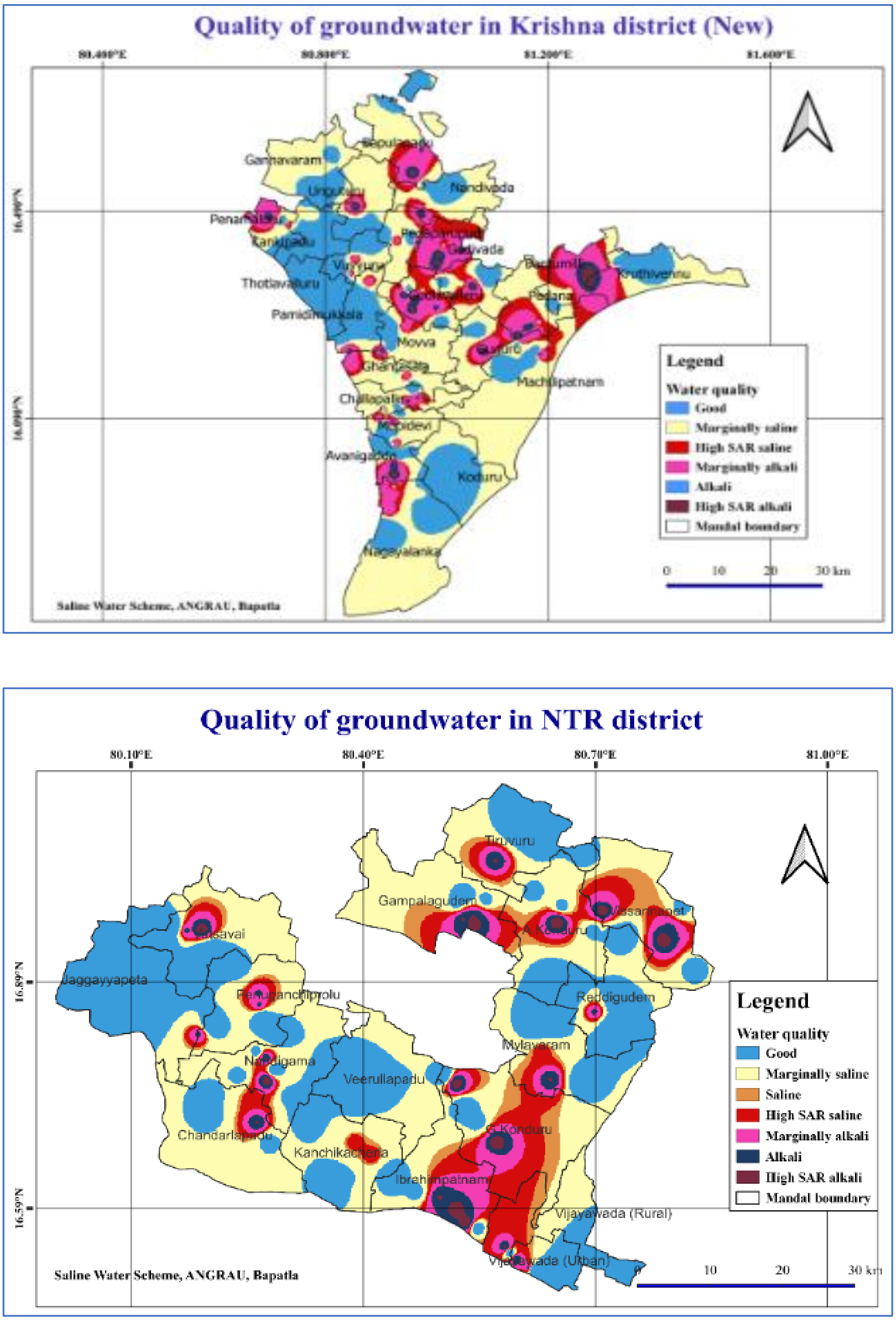
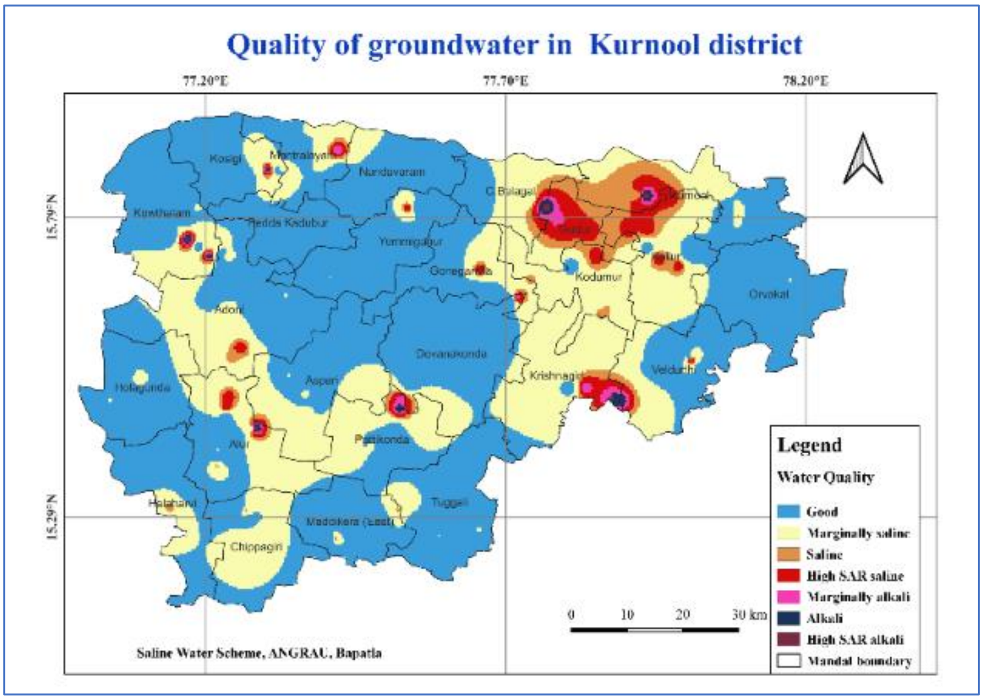


Fig 1.8 Groundwater quality maps of NTR and Krishna districts



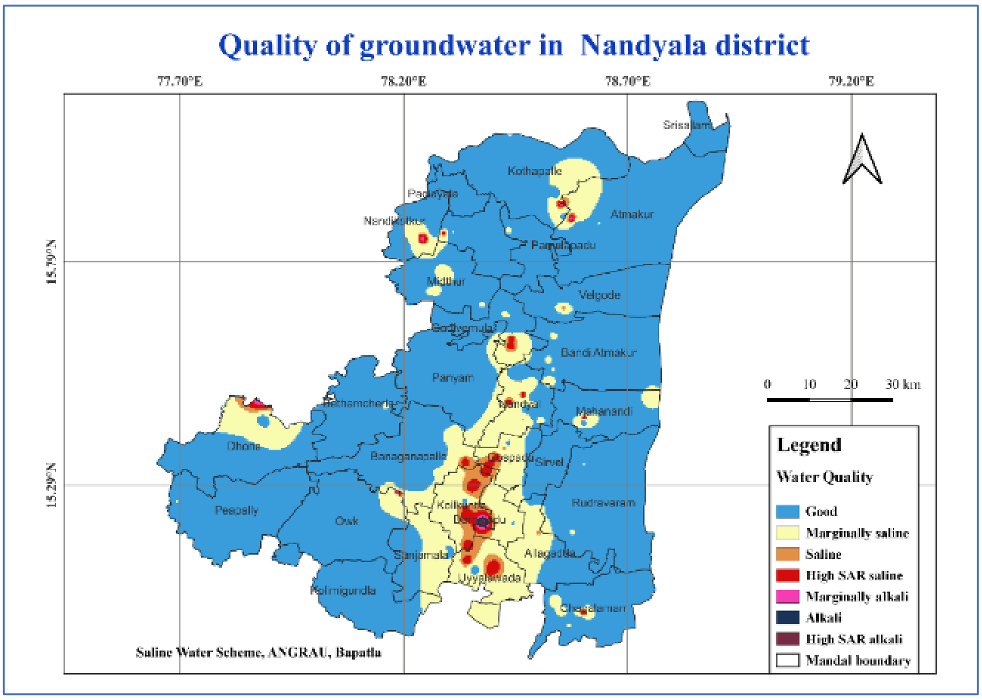
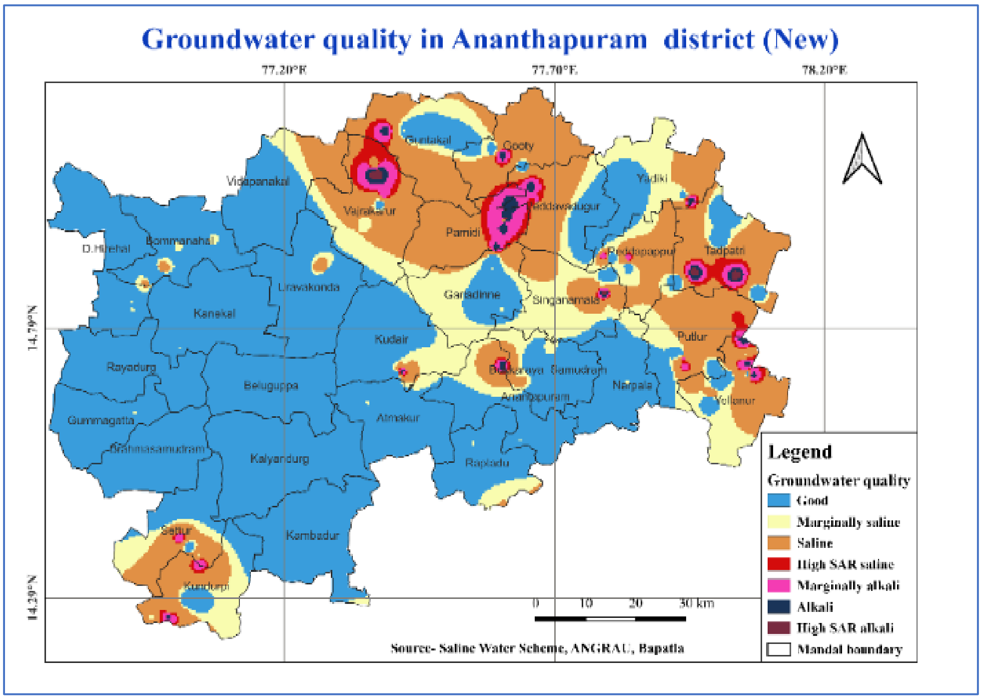


Fig 1.9 Groundwater quality maps of Kurnool and Nandyala districts



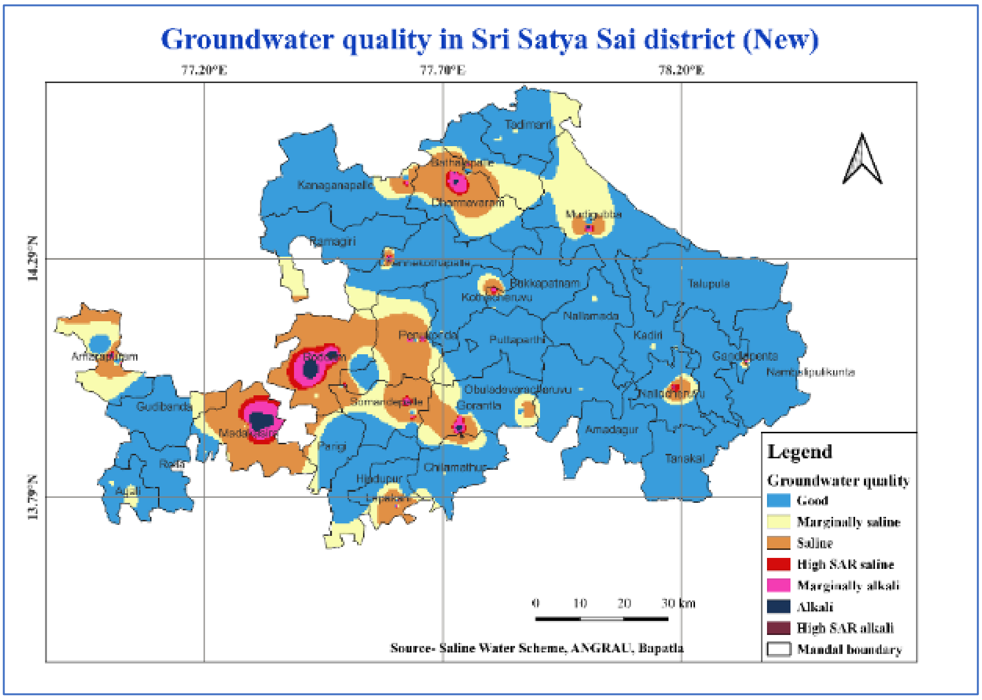


Fig 1.10 Groundwater quality maps of Ananthapuram and SriSatya Sai districts

- **Survey and Characterization of Underground Water for Irrigation of Barmer and Jalore districts (Bikaner)**

During 2022, underground water samples from 247 tube wells distributed in 141 villages in eight tehsils (15 Dhorimana, 15 Gudamalani, 12 Sindhari, 15 Siwana, 21 Baytu, 22 Sheo, 20 Barmer shahar and 21 Chohtan) of Barmer district were collected and analyzed for various chemical characteristics. Total 224 surface soil samples (0-15 cm depth) were also collected from the fields irrigated with underground water and analyzed to assess the effects of saline water use. All soil and water samples were analysed for EC, pH, water soluble cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}), anions (CO_3^{2-}, HCO_3^{-}, Cl^{-} and SO_4^{2-}).

Barmer district

The data range of chemical characteristics of tube well waters collected from 141 villages of Barmer district and analysed to prepare a map of groundwater quality suitable for irrigation. Based on EC, SAR, and RSC values, and following the ICAR-CSSRI classification, the samples were categorized into seven classes: good water, marginally saline, saline, high SAR saline, marginally alkali, alkali, and high SAR alkali and plotted to see the spatial variation (Fig. 1.11). The figure depicts that underground water in most parts of the districts is marginally saline to high SAR saline categories. High alkali water is also present in a sizable are. This geographic representation aids in identifying both favorable and problematic zones for agricultural water use, reflecting variations in groundwater quality across the districts.

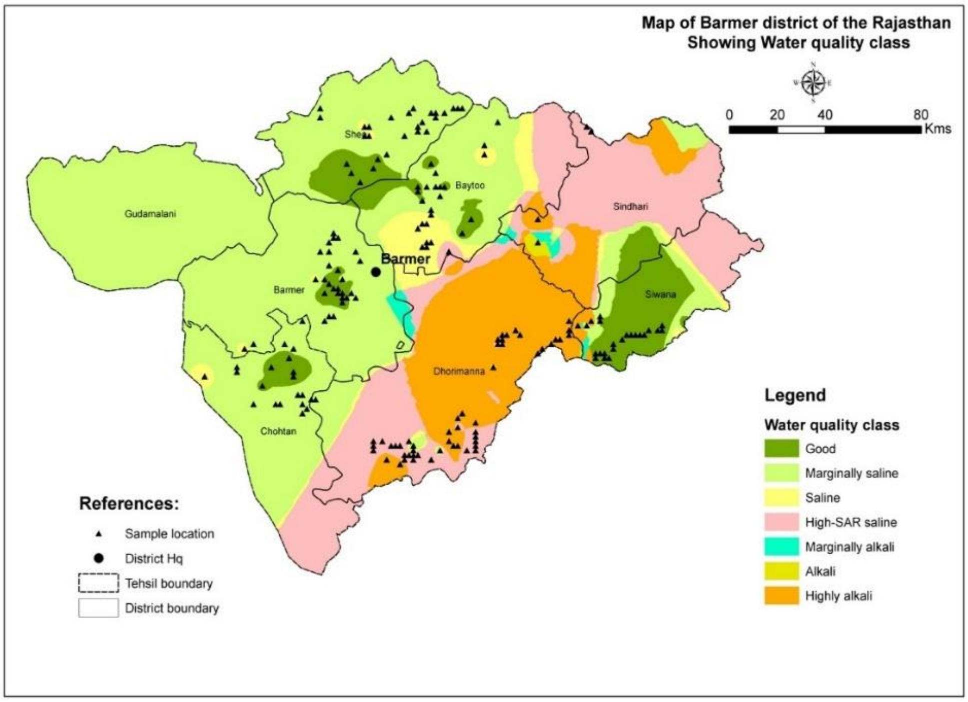


Fig. 1.11 Ground water quality map of Barmer District

Jalore district: The data on range of chemical characteristics of tube well water collected from 240 tube wells distributed in 141 villages Ahore, Bhadrajun, Bhinmal, Jalore, Jaswantpura Sayla, Bagora, Raniwara tehsils of Jalore district are presented in Table 1.4.

Perusal of the data presented in Table 1.4 indicate that EC ranged between 0.34 to 14.54 dSm^{-1}, whereas, pH varied from 7.0 to 8.42in different tahsils. Similarly, concentration of carbonates and bicarbonates varied between 0.01 -5.11 me/L and 0.7 0 -28.61 me/L, respectively in different tahsil.

Table 1.4 Range of characteristics of underground water for irrigation in tehsils of Jalore district

Parameter	Tehsils of Jalore district							
	Ahore (30)*	**Bhadrajun (29)***	**Bhinmal (18)***	**Jalore (31)***	**Jaswant-pura (35)***	**Sayla (30)***	**Bagora shahar (30)***	**Raniwara (37)***
pH	7.0 - 8.31 (7.77)	7.03 - 8.42 (7.64)	7.2 - 7.89 (7.62)	7.01-8.15 (7.70)	7.05-8.35 (7.60)	7.14 - 8.28 (7.77)	7.45 - 8.40 (7.94)	7.12 - 8.10 (7.63)
EC (dS/m)	0.34-13.9 (3.41)	0.56 - 14.5 (4.48)	0.64-7.24 (3.45)	0.46-10.7 (2.62)	0.33-7.59 (1.64)	0.59 - 6.90 (3.74)	0.49 - 6.81 (3.34)	0.28 - 6.28 (1.63)
RSC (me/L)	Nil - 0.31 (0.04)	Nil - 0.74 (0.03)	Nil - 2.77 (-0.92)	Nil - 5.46 (0.45)	Nil - 4.72 (0.80)	Nil - 2.97 (-0.92)	Nil - 1.55 (-0.75)	Nil - 1.89 (0.65)
SAR	4.03-21.6 (10.02)	5.07- 22.9 (11.93)	6.4 - 16.5 (11.74)	4.55- 26.0 (10.32)	3.5- 23.6 (9.95)	9.59- 18.9 (12.59)	8.91 - 16.9 (12.06)	5.42 - 15.8 (9.48)
Potential salinity (me/L)	2.32-94.4 (23.3)	3.8 - 99.3 (30.8)	3.76-50.6 (23.9)	2.83-73.2 (17.7)	2.20-53.2 (11.13)	3.36 - 48.2 (26.06)	3.00- 47.5 (23.3)	1.08 - 43.4 (11.1)
Adj. SAR	2.82-82.1 (24.6)	5.32- 87.2 (32.72)	6.45-51.4 (29.3)	4.77-77.7 (24.7)	1.78-60.1 (17.2)	6.27- 49.2 (31.9)	15.6-51.5 (30.9)	16.3-37.7 (16.8)
SSP	61.6-76.9 (71.3)	68.43- 78.3 (71.38)	70.1-86.3 (74.6)	65.2-89.4 (75.4)	70.4-95.3 (81.3)	70.48- 91.6 (74.82)	71.2- 95.4 (75.2)	70.5- 93.6 (79.41)
Water table depth (ft)	60 - 500 (236)	40 - 340 (198)	90-800 (436)	50-650 (305)	60-875 (220)	450-800 (640)	400-800 (635)	75-700 (360)

** No. of samples tested* *** Figures in parenthesis are th e average value*

The collected samples were categorized in into seven classes: good water, marginally saline, saline, high SAR saline, marginally alkali, alkali, and high SAR alkali and mapped to see the spatial variation (Fig 1.12). The figure depicts that underground water in most parts of the districts from where samples were collected, is marginally saline to saline categories. Good quality water is also present in a sizable are. Samples from 02 tehsils were not collected. This geographic representation will help in devising strategies for agricultural water use, reflecting variations in groundwater quality across the districts.

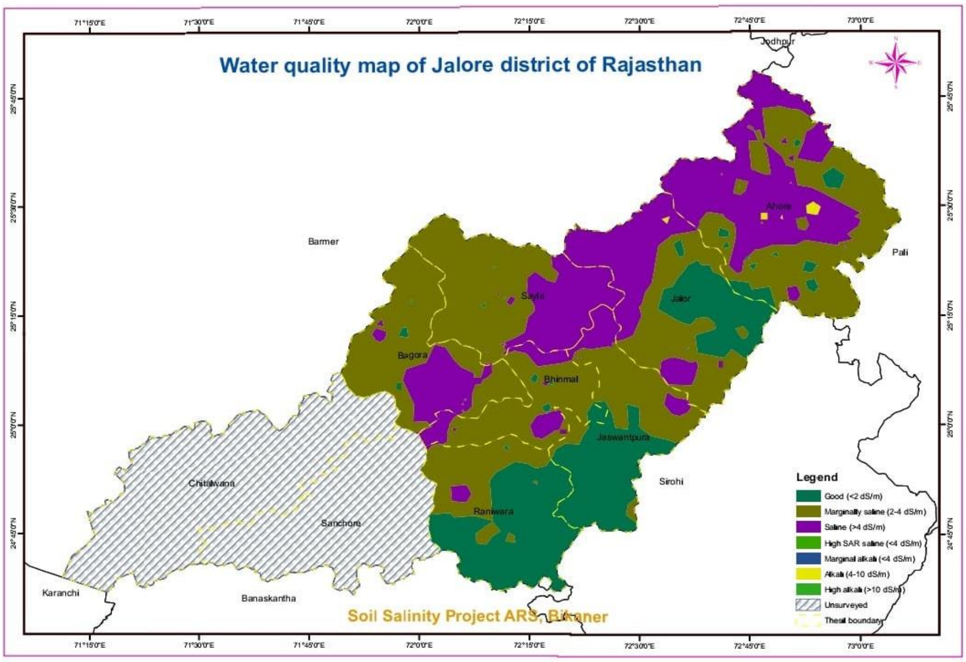


Fig 1.12 Ground water quality map of Jalore District

- **Survey and characterization of groundwater for irrigation of Panchkula Ambala, Charkhi Dadri and Yamuna Nagar district of Haryana (Hisar)**

The survey and characterization of groundwater for irrigation purpose in Panchkula district was carried out during 2022–23, while in Ambala, Yamuna Nagar, and Charkhi Dadri districts during 2023–24.

Panchkula

A total of 85 groundwater samples were collected from the Barwala (23), Morni (16), and Pinjaur (25 and 21 from two locations within the Pinjaur block) using GPS locations. These samples were analyzed for pH, electrical conductivity (EC), major cations (Na^+, Ca^{2+}, Mg^{2+}, K^+) and anions (CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}), and SAR and RSC values were calculated. Using estimated chemical parameters of collected samples, groundwater quality was classified for irrigation purposes using the standard classification adopted by AICRP. It was found that 97.7% of the samples in Panchkula district were of good quality, while 2.3% were marginally alkali (Fig 1.13). A groundwater quality map was also developed to depict spatial variability across the district (Fig 1.14).

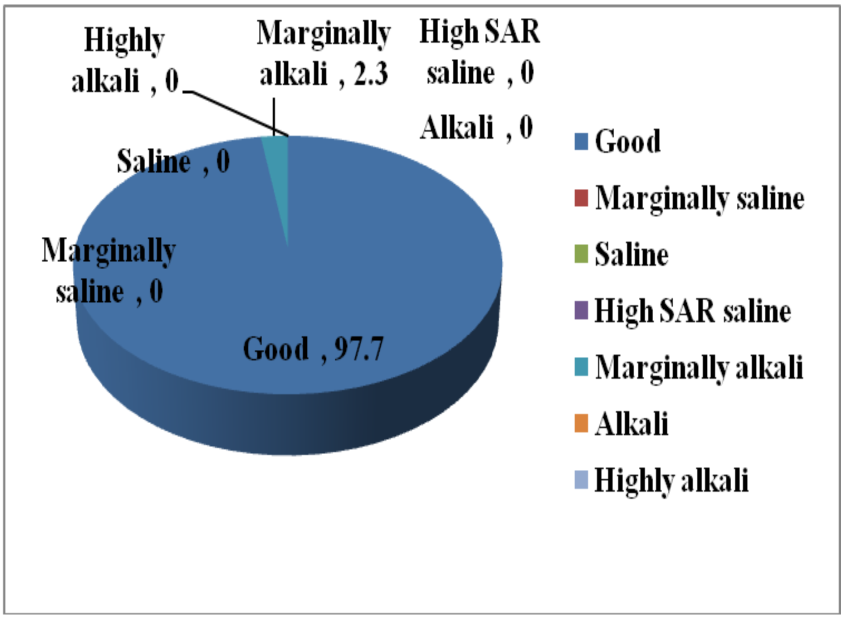


Fig 1.13 Quality of groundwater (percent) in Panchkula district

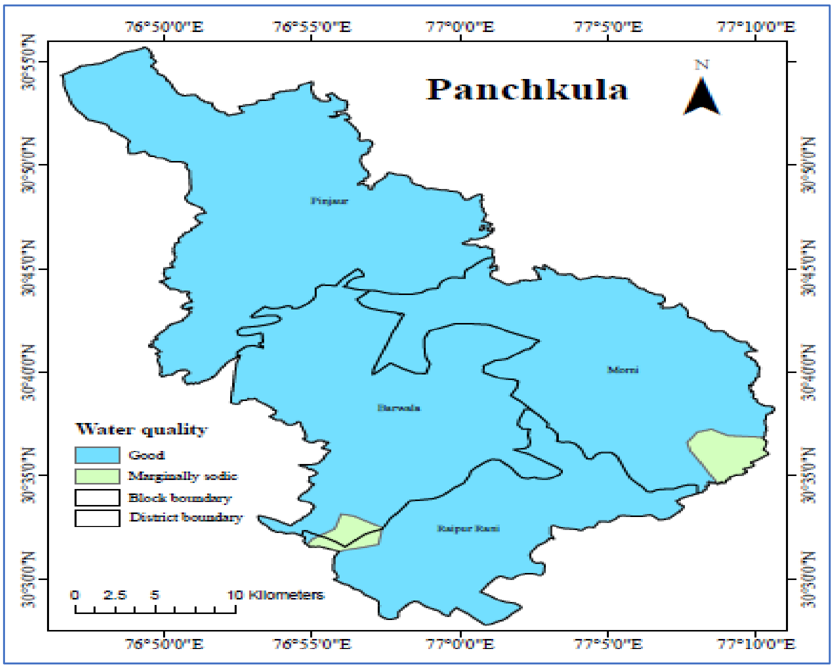


Fig 1.14 Groundwater quality map for Panchkula district according to AICRP criteria

Ambala

Total 86 groundwater samples were collected from different locations of the district using GPS location and analysed for EC, pH, major cations and anions. The SAR and RSC were also estimated for the collected samples. Based on chemical composition and standard criteria, samples were characterized for suitability of irrigation and spatial distribution of GW quality was presented in GIS environment to show he spatial variability in groundwater of the district (Fig 1.15). Study revealed that 90.48, 7.14, 1.19 and 1.19 per cent samples of the district were fall in good, marginally saline, High SAR saline and marginally alkali categories, respectively.

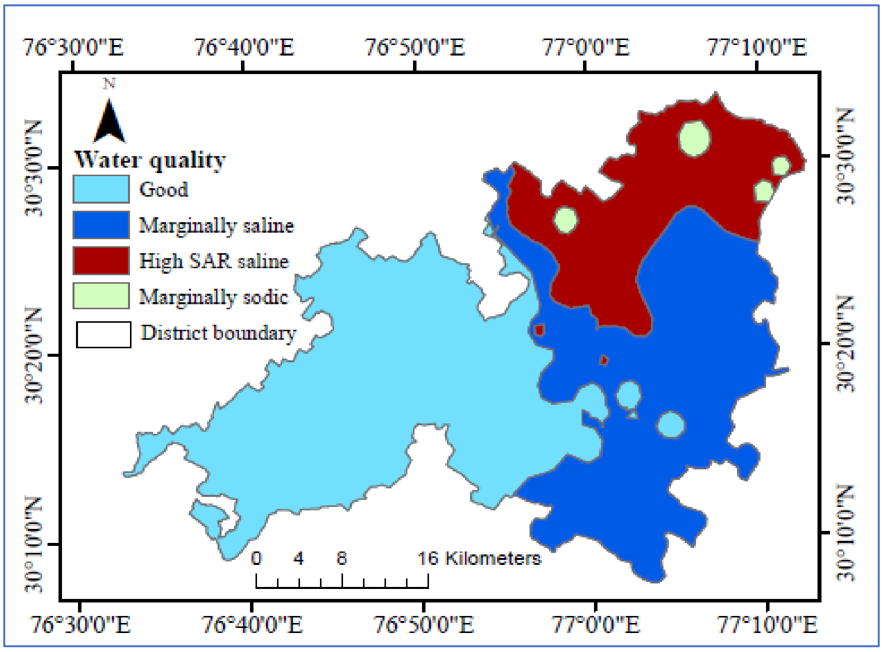


Fig 1.15 Groundwater quality map of Ambala district

Charkhi Dadri

Charkhi Dadri district consists of three blocks i.e. Dadri-I, Dadri II and Badhra. Total 226 groundwater samples were collected from three blocks to develop a groundwater quality map for the area. Based on chemical composition and standard criteria, samples were characterized (Table 1.5). Table depicts that 28.89% samples were of good quality, whereas, 22.22%, 0.44%, 30.67% and 15.56% samples were marginally saline, saline, high SAR saline and marginally alkali categories, respectively. Ver few samples were found under alkali (0.44%), and highly alkali (1.78%) categories. The groundwater quality map of the district presents through figure 1.16.

Table 1.5 Block wise Ground water quality distribution (%) in Charkhi Dadri district

Water quality	Dadri I	Dadri II	Badhra	Charkhi Dadri district
Good		15.97	54.10	28.89
Marginally saline		24.31	13.11	22.22
Saline		0.69	0.00	0.44
High SAR saline		42.36	8.20	30.67
Marginally alkali		13.89	22.95	15.56
Alkali		0.69	0.00	0.44
Highly alkali		2.08	1.64	1.78
Total samples	**20**	**146**	**61**	**227**

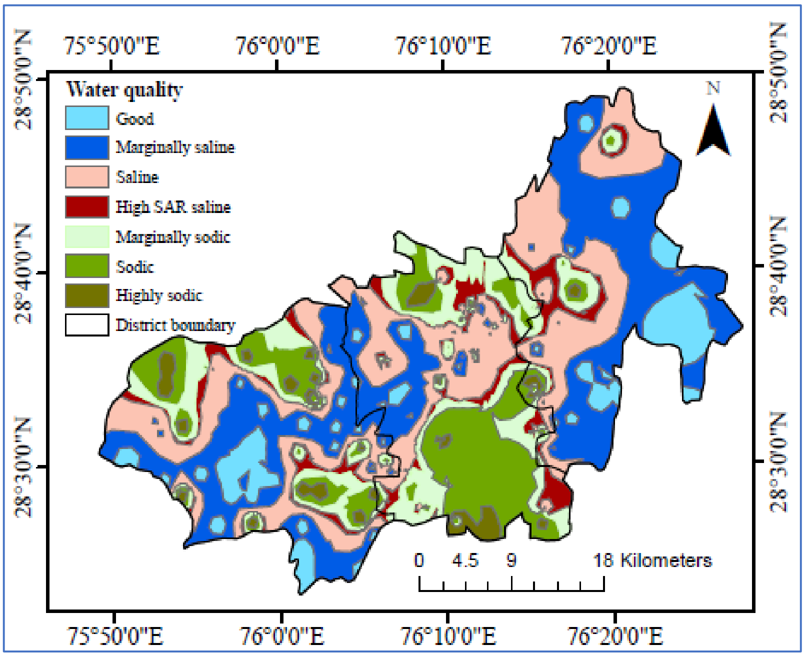


Fig 1.16 Groundwater quality map of Charkhi Dadri district

Yamuna Nagar

Total 82 samples were collected to study the suitability of groundwater for irrigation purposes. A spatial variability map was prepared by using ArcGIS through the interpolation by using the analysed values. Based on, pH, electrical conductivity (EC), major cations (Na^+, Ca^{2+}, Mg^{2+}, K^+) and anions (CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2-}), and calculated SAR and RSC values, category of the collected samples were decided using standard protocol. Results presented in Fig. 1.17 show that as such there is no limitation with available groundwater for crop production as all collected samples were found of good quality.

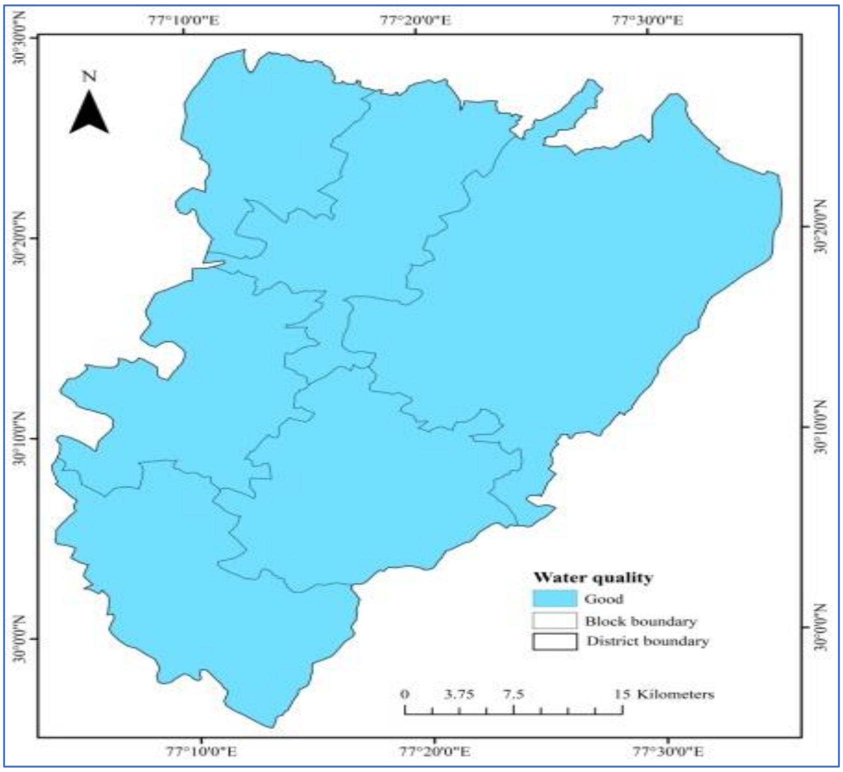


Fig 1.17 *Groundwater quality map of Yamuna Nagar district*

- **Survey and Characterization of Groundwater of Coastal districts of Tamil Nadu for Irrigation (Tiruchirappalli)**

Kanchipuram district: The Kanchipuram (77°28' to 78°50' E and 11°00' to 12°00' N) district is located in Tamil Nadu's Northeast**.** The district covers a total area of 4, 43,210 hectares. Total 150 groundwater samples were collected during 2023 and analyzed for pH, EC, cations *(*Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions *(*CO_3^{2-}, HCO_3^{-}, and Cl^{-} and SO_4^{2-}) using standard procedure. Sodium Absorption Ration (SAR) and Residual Sodium Carbonate (RSC) were calculated using determined anions and cations. The groundwater samples were classified for irrigation suitability based on EC, SAR, and RSC values using the classification given by ICAR- Central Soil Salinity Research Institute (CSSRI), Karnal and the Groundwater quality map of Kanchipuram district was prepared using Arc GIS software to represent spatial variability. The analysis of 150 groundwater samples collected across the Kanchipuram district indicated that 38% were of good quality, 25% alkali water, 15% marginally alkali, 17% highly alkali, 3% marginal saline, and 2% high SAR saline water (Table 1.6 and Fig. 1.18 & 1.19). Table 1.6 depicts the highest percentage of good quality water was found in Uthiramerur (59%), followed by Sriperumbudur (41%), Kundrathur (39%), Walajabad (32%), and Kanchipuram (19%) blocks. Spatial distribution data shown in Fig. 1.19 highlight that a majority (57%) of groundwater samples fall under the alkali water category, while 38% were classified as good quality. This assessment provides an essential baseline for irrigation water management and guides targeted interventions in Kanchipuram's agricultural areas.

Table 1.6 Water quality distribution (%) in Kanchipuram district

Blocks	No. of Samples	Good	MS	Saline	HSS	MA	Alkali	HA
Kundrathur	28	39	4	-	-	22	21	14
Sriperumbudur	32	41	6	-	3	9	16	25
Walajabad	34	32	-	-	6	18	29	15
Uthiramerur	29	59	3	-	-	7	24	7
Kanchipuram	27	19	-	-	-	22	37	22
Total (%)	**150**	**38**	**3**	**-**	**2**	**15**	**25**	**17**

Note : Marginal Saline (MS), High SAR Saline (HSS), Marginally Alkali (MA), Highly Alkali (HA)

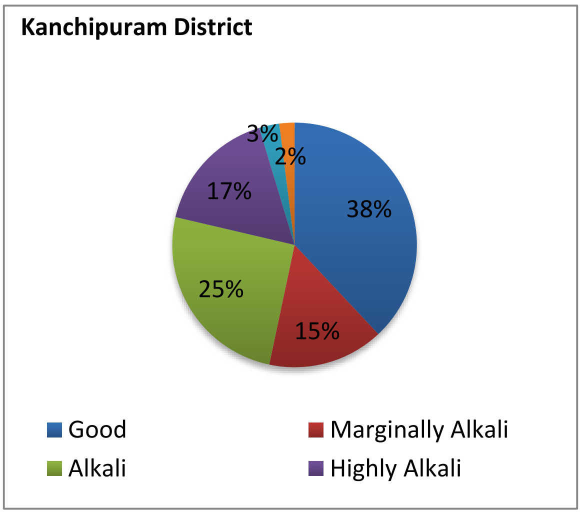


Fig 1.18 Overall Percentage distribution of groundwater quality in Kanchipuram district

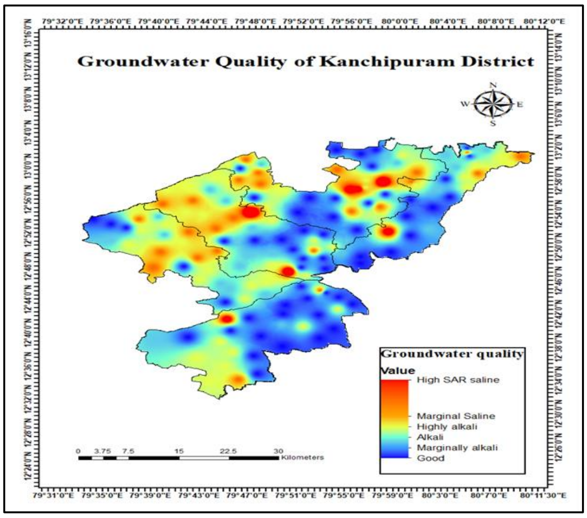


Fig 1.19 Groundwater quality map of Kanchipuram district

Salem District

The Salem district having 20 blocks is located between 11°14' and 12°53' North latitude and 77°44' and 78°50' East longitude. The district covers an area of 5, 20,530 hectares, with approximately 2,20,138 hectares designated as net cultivated land. To characterize groundwater suitability for irrigation, total 200 groundwater samples were collected in 2024 and analyzed for pH, EC, cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions (CO_3^{2-}, HCO_3^{-}, and Cl^{-} and SO_4^{2-}) using standard procedure. Sodium Absorption Ration (SAR) and Residual Sodium Carbonate (RSC) were also calculated.

Based on EC, SAR, and RSC values, collected samples were classified for irrigation suitability and groundwater quality thematic map was produced using Arc GIS software to assess the spatial variation. Study revealed that 66% of the collected groundwater samples were of good quality, 5% alkali water, 8% marginally alkali, and 21% were marginal saline water (Table 1.7, and Fig. 1.20 & 1.21). The Yercaud block

Table 1.7 Water Quality distribution (%) the Salem district

Blocks	No. of Samples	Good	MS	Saline	HSS	MA	Alkali	HA
Panamarathupatti	10	80	10	-	-	10	-	-
Salem	10	70	30	-	-	-	-	-
Omalur	10	50	40	-	-	10	-	-
Veerapandi	10	70	30	-	-	-	-	-
Tharamangalam	10	60	20	-	-	20	-	-
Edapaddi	10	60	20	-	-	10	10	-
Kadayampatty	10	80	10	-	-	10	-	-
Mecheri	10	30	20	-	-	20	30	-
Nangavalli	10	70	10	-	-	20	-	-
Kolathur	10	40	30	-	-	10	20	-
Sankari	10	70	20	-	-	10	-	-
Yercaud	10	100	-	-	-	-	-	-
Magudanchavadi	10	80	-	-	-	10	10	-
Gangavalli	10	70	20	-	-	10	-	-
Attur	10	70	10	-	-	10	10	-
Thalaivasal	10	70	30	-	-	-	-	-
Vallapady	10	70	10	-	-	10	10	-
Konganapuram	10	70	30	-	-	-	-	-
Ayodhipattinam	10	70	30	-	-	-	-	-
Pethanaickenpalayam	10	50	40	-	-	-	10	-
Total / Average	200	66	21	-	-	8	5	-

Note : Marginal Saline (MS), High SAR Saline (HSS), Marginally Alkali (MA), Highly Alkali (HA) recorded the highest proportion of good quality water (100%), followed by Panamarathupatti, Kadayampatty, and Magudanchavadi blocks at 80%, with several other blocks including Salem and Veerapandi ranging from 30% to 70%. The Mecheri block recorded the highest alkali water percentage at 30%, followed by Kolathur at 20%, and several blocks with 10%. Marginally alkali water was most prominent in Mecheri (30%), with 20% in Tharamangalam, Sankari, and Nangavalli blocks, and 10% in several others. Marginal saline water was prevalent in Omalur, Veerapandi, and Pethanaickenpalayam (40%), and ranged from 10% to 30% in other blocks. Fig. 1.21 depicts the spatial distribution of groundwater quality parameters, highlighting the variation in water quality across Salem district's blocks, crucial for irrigation and water resource management.

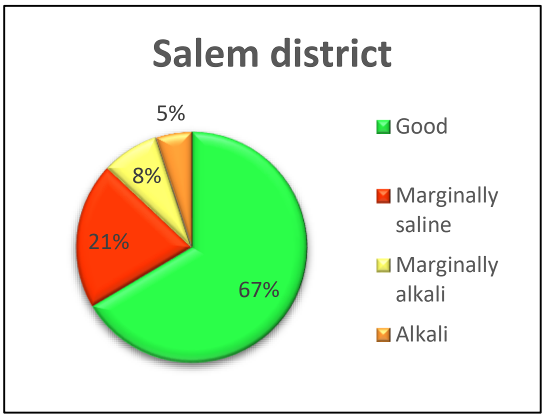


Fig 1.20 Overall Percentage distribution of groundwater quality in Salem district

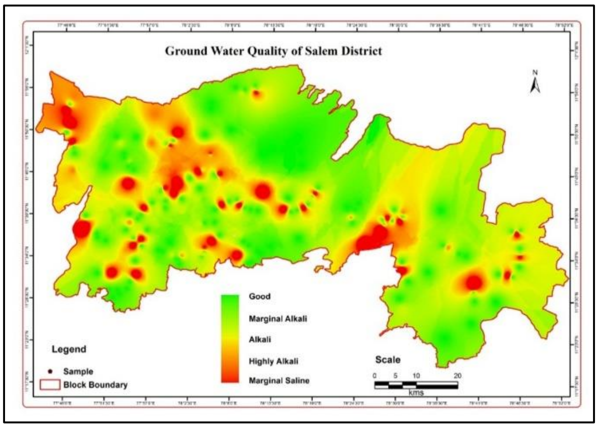


Fig 1.21 Groundwater quality map of Salem district

- **Survey and characterization of groundwater for irrigation of Barnala and Sangrur districts of Punjab (Bathinda)**

The Barnala district lies between 30º 30’52” N latitude and 75º15’ 75” E longitudes, whereas, Sangrur District falls in the southern part of the Punjab, bounded by latitudes 29°44'45'' and North latitudes and 75°14'45'' East longitudes. The groundwater samples for characterizing quality for irrigation were collected during 2023. The range of chemical constituents and average value of the collected samples are summarized in Table 1.8. The pH of GW in Barnala district varied between 6.74- 10.25, while RSC ranged from nil to 7.10 me/L. Among the anions, bicarbonate (2.0-12.0 meL^{-1}) was dominant ion followed by chloride (0.40-8.40 me L^{-1}) and carbonate (0.0 to 0.60 me L^{-1}). The Sulfur (S) in GW was found in the range of 62.50- 152 me L^{-1}, and Potassium (K) varied between 12.40- 45.50 me L^{-1}, whereas, Sodium (Na) content ranged between 0.07-109.39 me L^{-1} in the district. A critical view on Table 1.8 reveals that RSC in GW of Sangrur district varied between nil to 8.5 me L^{-1} with mean of 2.7 me L$^{-1,}$ which indicates that risk of soil sodicity while using for irrigation without adopting neutralization option. The K content in underground water of Sangrur district ranged between 11.0- 391.90 me L^{-1}, whereas, Na content varied from 2.3-152 me L^{-1} with a mean of 62.6 and 56.5 me L^{-1}, respectively. Based on irrigation water electrical conductivity, sodium absorption ratio, and residual sodium carbonate, GW of Barnala district was classified as 39% (good), 40% (High-SAR saline water), 14% marginally alkaline and remaining under alkaline and highly alkaline categories for irrigation (Table 1.9). In Sangrur district, only 3% GW samples were found under good category, while, 79% and 18% samples were classified as alkaline and highly-alkaline, respectively for irrigation.

Table 1.8 Range of chemical constituents and average value of groundwater in Barnala and Sangrur districts

Constituents	Minimum		Maximum		Average	
	Barnala	Sangrur	Barnala	Sangrur	Barnala	Sangrur
pH	6.74	-	10.25	-	8.42	-
EC (dSm^{-1})	0.16	0.10	2.60	1.80	1.07	0.80
Ca^{+2} +Mg^{+2} (me L^{-1})	0.20	1.00	10.00	9.20	5.35	4.60
Cl^{-1} (me L^{-1})	0.40	0.40	8.40	5.00	2.13	1.30
CO_3^{-2} (me L^{-1})	0.0	0.00	0.60	1.00	0.20	0.30
HCO_3^- (me L^{-1})	2.0	1.80	12.00	11.60	6.92	6.60
RSC (me L^{-1})	0.0	0.00	7.10	8.50	1.76	2.70
SAR (me L-1)	0.06	1.90	158.94	107.00	12.40	39.50
Potassium K (me L^{-1})	12.40	11.00	45.50	391.90	26.23	62.60
Sodium, Na (me L^{-1})	0.07	2.30	109.39	152.00	105.77	56.50
Sulfur, S (me L^{-1})	62.50	-	152.00	-	89.49	-

Table 1.9 Classification of irrigation water quality of Barnala and Sangrur districts

Category	Parameters	No. of Samples		Per cent (%)	
		Barnala	Sangrur	Barnala	Sangrur
A. **Good**	ECiw (ds/m) <2; RSC (meq/L) <2.5;SAR iw (m mol/l)<10	109	10	39	3
B. **Saline**					
I. Marginally Saline	ECiw (ds/m) <2-4; RSC (meq/L) <2.5; SAR iw (m ol/l)<10	05	0	02	-
II. Saline	ECiw (ds/m) >4; RSC (meq/L) <2.5; SAR iw (m mol/l)<10	0	0	-	-
III. High –SAR Saline	ECiw (ds/m) >4; RSC (meq/L) <2.5; SAR iw (m mol/l)>10	106	0	38	-
C. **Alkaline Water**					
I. Marginally alkaline	ECiw (ds/m) <4; RSC (meq/L) <2.5-4; SAR iw (m mol/l)<10	39	0	14	-
II. Alkaline	ECiw (ds/m) <4; RSC (meq/L) >4; SAR iw (m mol/l)<10	13	263	05	79
III. Highly alkaline	ECiw (ds/m) <variable; RSC (meq/L) >4; SAR iw (mmol/l)>10	06	59	02	18
	Total samples	**278**	**332**	**100**	**100**

Based on BIS limits, GW quality of Barnala and Sangrur district was classified as safe and unsafe categories and percent distribution is presented in Table 1.10. Fluoride content in different collected samples was ranged between 0.01 – 0.24 mg L^{-1} and 0.20 - 3.30 mg L^{-1} in Barnala and Sangrur districts, respectively. It was found that all the collected GW samples of Barnala district fall under safe category (≤ 1.0 mg L^{-1}) for fluoride concentration and are suitable for drinking purpose. However, based on nitrate concentration, only 12% samples of the district were found under safe category. In Sangrur district, about 94 % collected GW samples having fluoride concentration ≤ 1.0 mg L^{-1} i.e. under safe category. Nitrate concentration in 96% collected GW samples was recorded >45 mg L^{-1} (Unsafe).

Table 1.10 Range and percentage distribution of collected samples under different categories

Districts	Value (mg/L)		Percent (%) Samples under	
	Min.	Max	Safe category	Unsafe category
Fluoride				
Barnala	0.01	0.24	100	0.0
Sangrur	0.20	3.30	94	06
Nitrate				
Barnala	22.0	408.0	12	88
Sangrur	25.7	995.0	04	96

Note : As per BIS, limit is categorized as ≤1.0 mg/L (Safe) & >1.0 mg/L (unsafe) for Fluoride and ≤ 45 mg/L (Safe) & >45 mg/L (Unsafe) for Nitrate

- **Survey and characterization of underground irrigation waters, salinity associated problems in Shajapur district of Madhya Pradesh (Indore)**

The survey and characterization of groundwater for irrigation of Shajapur district (latitude 23° 06' to 24° 19' N, longitude 75° 41" to 77° 02' E) of Madhya Pradesh was undertaken during 2021. Two hundred fifteen ground water samples were collected from open wells and tube wells of different villages of Gulana tehsil and Sajapur tehsil of Shajapur district. The depth of wells/tube wells varied from 40 to 470 feet in Gulana tehsil and Sajapur tehsil. The frequency distribution of analysed groundwater samples across different quality categories is illustrated in Figure 1.22. Out of 101 groundwater samples collected from the tehsil, 94 were classified as good quality water (Category A), while 7 samples fell into Category B (marginally saline water). Notably, no samples from Sajapur Tehsil were categorized as alkali water (Category C).

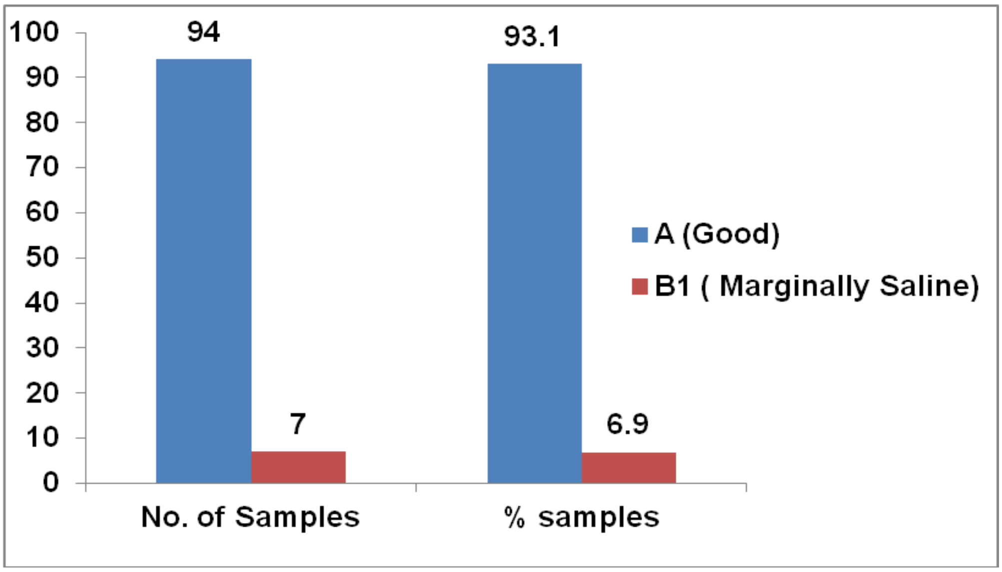


Fig 1.22 Frequency of ground water quality of Sajapur tehsil as per criteria given by CSSRI, Karnal

1.2 Resource Inventories of Salt Affected Soils

- **Characterization and delineation of salt affected soils using remotely sensed data and ground truth of Shajapur district of Madhya Pradesh (Indore)**

A detailed reconnaissance soil survey was conducted in Shajapur tehsil of Shajapur district, Madhya Pradesh, to identify the locations, extent, and characteristics of salt-affected soils. Soil samples were collected by traversing various locations, other than previously identified, and having salinity or alkalinity issues, and GPS coordinates and village names recorded. Based on salinity and alkalinity hazards, the soils were categorized into three levels: salinity as slight (ECe 4 to 8 dS m^{-1}), moderate (ECe 8 to 15 dS m^{-1}), and high (ECe >15 dS m^{-1}); and alkalinity as slight (ESP 15 to 25), moderate (ESP 25 to 40), and high (ESP > 40). Total 215 surface soil samples were collected from different villages of Gulana tehsil and Shajapur tehsil of Shajapur district. The analysis of soil samples indicated pHs ranged from 7.2 to 8.3 for different soil samples. The ECe values ranged from 0.8 to 3.8 dS^{m-1}. Among different cations, Na ranged from 0.6 to 3.4 meL^{-1}. The SAR values ranged between 0.21 and 2.59.

Based on chemical analysis of 114 surface soil samples collected from Shajapur tehsil, were classified (Table 1.11). The data indicate that all 114 samples (100%) fell within the very slight salinity category. Regarding sodicity, 108 samples (94.7%) were classified as very slight, while 5.3% exhibited slight sodicity.

Table 1.11 Frequency of soil samples with respect to EC and ESP of Shajpur tehsil of Shajpur district, Madhya Pradesh

Category		No. of samples
	Soil Salinity (dSm^{-1})	
Very slight	< 4	114 (100%)
Slight	4-8	
Moderate	8-15	
High	>15	
	Soil Alkalinity (ESP)	
Very slight	< 15	108 (94.7%)
Slight	15-25	6 (5.3%)
Moderate	25-40	
High	>40	

2 MANAGEMENT OF POOR-QUALITY WATERS

2.1 Management of Alkali Water

- **Conjunctive use of alkali and canal water for lentil and sesame cropping sequence (Agra)**

A field experiment was conducted during 2020–2024) with the aim to identify a suitable cyclic mode of conjunctive use of alkali and canal water for crop production The residual sodium carbonate (RSC) of water was 8 meq/l. Lentil (variety PDL-1) and sesame (local variety) was sown. Lentil was irrigated twice in 2022, while the sesame crop received one pre-sowing irrigation in 2023. The recommended dose of fertilizers (20:40:40 NPK) was applied to the crops in both years.

Crop yield of lentil:

Lentil grain and stover yields varied significantly in 2022–23 and 2023–24 season with different modes of canal and alkali water irrigation (Table 2.1). Crop irrigated with canal irrigation recorded the highest mean grain yield (9.16 q/ha) and stover yield (30.0 q/ha) with the highest net profit of Rs 43,250.37/ha. The mixing of one canal: one alkali water irrigation was found to be the second-best performer. The benefit–cost (B:C) ratio was also highest (2.82) under all canal water irrigation, followed by mixing and one canal: one alkali water irrigation (Table 2.2). The irrigation water treatments of one canal: one alkali water and mixing (1:1) were found to be statistically at par.

Table 2.1 Effect of alkali water irrigation to supplemental canal water irrigation on Yield of lentil crop (2020–21, 2021–22, 2022–23 & 2023–24)

Treatments	Grain yield (q/ha)	Stover yield (q/ha)	Grain yield (q/ha)	Stover yield (q/ha)	Grain yield (q/ha)	Stover yield (q/ha)	Grain yield (q/ha)	Stover yield (q/ha)	Grain yield (q/ha)	Stover yield (q/ha)
	2020–21		2021–22		2022–23		2023–24		Average 4 year	
All Canal Water	6.01	23.04	6.30	23.00	11.60	33.30	12.73	40.69	9.16	30.00
All alkali water	2.61	9.90	2.60	9.70	7.40	21.80	9.21	26.91	5.45	17.08
One Canal: One alkali	5.12	19.04	4.90	19.10	9.60	27.00	11.67	37.88	7.82	25.76
One Alkali: One Canal	4.10	15.58	4.00	15.50	9.30	24.00	10.75	35.98	7.04	22.76
Mixing (1:1)	5.20	20.50	5.10	20.40	10.70	29.90	12.25	35.88	8.31	26.67
CD at 5%	0.64	2.66	0.53	2.28	1.66	3.44	1.55	7.26	-	-

Table 2.2 Effect of alkali water irrigation to supplemental canal water irrigation on average Yield, Net profit and B: C of lentil (2020–21, 2021–22, 2022–23 and 2023–24)

Treatments	2020–21		2021–22		2022–23		2023–24		Average	
	Net profit (Rs.)	B: C ratio	Net profit (Rs.)	B: C ratio	Net profit (Rs.)	B: C ratio	Net profit (Rs.)	B: C ratio	Net profit (Rs.)	B: C ratio
All Canal Water	24,820	2.44	28,820	2.62	52,225	2.91	67,136.50	3.31	43,250.37	2.82
All alkali water	1,020	1.06	1,440	1.08	23,825	1.79	40,560.50	2.40	16,711.37	1.58
One Canal: One alkali	18,540	2.08	18,460	2.04	38,225	2.32	59,133.50	3.04	33,589.62	2.37
One Alkali: One Canal	19,450	1.66	11,800	1.66	65,100	2.25	52,187.50	2.80	37,156.87	2.09
Mixing (1:1)	19,150	2.11	19,940	2.12	45,925	2.58	63,512.50	3.19	37,131.87	2.50

Soil studies:

The initial soil status at the time of lentil sowing showed electrical conductivity of the saturation extract (ECe), pH, and organic carbon content as 2.3 dS/m, 7.9, and 0.27%, respectively, in the 0–15 cm soil depth. In the lower depth (60–90 cm), these values were 1.5 dS/m, 7.9, and 0.16%, with the ESP being 11.1 (as reported in the Biennial Report 2021–22). In general, at the harvest of the lentil crop, the ECe, pH, sodium adsorption ratio (SAR), and exchangeable sodium percentage (ESP) were lower under canal water irrigation compared to alkali water alone and other cyclic modes of canal and alkali water irrigation. The ECe, pH, SAR, and ESP were determined depth-wise at harvest of lentil under different treatments and are presented in Table 2.3.

Crop yield of sesame:

The grain and stover yields of sesame differed significantly among the modes of canal and alkali water irrigation (Table 2.4). In 2023, the highest grain yield (5.6 q/ha), stover yield (28.0 q/ha), net profit (₹53,200/ha), and benefit–cost (B:C) ratio (3.14) were recorded under all canal water irrigation, while the lowest grain yield (3.9 q/ha), stover yield (19.8 q/ha), net profit (₹29,400/ha), and B:C ratio (2.18) were observed under all alkali water irrigation. Among the cyclic modes, mixing canal and alkali water in a 1:1 ratio produced a grain yield of 4.6 q/ha, stover yield of 26.4 q/ha, net profit of ₹39,200/ha, and B:C ratio of 2.55, followed by one canal: one alkali irrigation (4.5 q/ha, 22.4 q/ha, ₹37,800/ha, and 2.50) and one alkali: one canal irrigation (4.2 q/ha, 21.2 q/ha, ₹33,600/ha, and 2.33). The critical difference (CD) at the 5% level was 0.96 for grain yield and 3.4 for stover yield.

Table 2.3 Soil analysis of lentil crop at sowing and after harvest (2022–23 and 2023–24)

Treatments	Soil Depth (cm)	At Sowing				At Harvest			
		ECe (dS/m)	pH	SARe $(mmol/l)^{1/2}$	ESP	ECe (dS/m)	pH	SARe $(mmol/l)^{1/2}$	ESP
2022−23									
All Canal Water	0-15	2.2	7.9	9.1	9.2	2.9	7.8	9.8	9.9
	15-30	2.2	7.9	8.5	10.0	2.7	7.9	9.6	10.3
	30-60	2.1	7.8	8.5	-	2.6	7.8	9.5	-
	60-90	2.0	7.7	8.8	-	2.3	7.8	9.3	-
All Alkali Water	0-15	2.6	8.2	12.8	12.5	3.8	8.2	14.7	14.8
	15-30	2.7	8.1	11.6	12.8	3.5	8.1	13.0	14.9
	30-60	2.5	8.0	11.3	-	3.5	8.0	12.2	-
	60-90	2.4	8.0	12.5	-	2.7	7.9	11.0	-
One Canal : One Alkali	0-15	2.3	7.9	10.4	11.4	3.7	8.1	12.9	13.2
	15-30	2.3	7.9	9.9	11.8	3.7	8.1	12.8	13.9
	30-60	2.4	7.9	10.2	-	3.5	8.0	11.0	-
	60-90	2.4	8.0	10.6	-	3.0	7.9	11.6	-
One Alkali : One Canal	0-15	2.3	7.9	10.9	11.5	3.5	8.1	12.8	13.5
	15-30	2.3	7.8	10.8	11.8	3.2	8.0	11.8	13.8
	30-60	2.4	7.9	10.0	-	3.0	8.0	11.2	-
	60-90	2.4	7.9	10.2	-	2.9	8.0	10.8	-
Mixing (1:1)	0-15	2.3	8.0	10.2	11.8	3.2	8.1	12.0	12.5
	15-30	2.4	7.9	10.4	12.0	3.2	8.1	11.9	13.2
	30-60	2.3	7.9	10.5	-	3.0	8.0	11.7	-
	60-90	2.3	7.9	11.0	-	2.9	8.0	10.2	-
2023−24									
All Canal Water	0-15	1.9	7.8	9.0	9.2	2.8	7.8	10.0	9.7
	15-30	2.1	7.9	8.6	9.9	2.7	7.8	9.9	10.1
	30-60	2.2	7.8	8.5	-	2.6	7.9	9.6	-
	60-90	2.3	7.8	8.9	-	2.4	7.8	9.2	-
All Alkali Water	0-15	2.5	8.2	12.8	12.8	3.8	8.2	14.9	15.2
	15-30	2.6	8.1	11.4	12.0	3.6	8.2	13.5	15.4
	30-60	2.6	8.0	11.5	-	3.4	8.1	12.7	-
	60-90	2.9	8.1	12.3	-	2.9	8.0	11.2	-
One Canal : One Alkali	0-15	2.5	8.0	11.4	11.7	3.5	8.1	12.9	13.6
	15-30	2.5	7.9	10.7	11.8	3.6	8.1	12.8	13.7
	30-60	2.6	8.0	10.9	-	3.4	8.1	11.0	-
	60-90	2.6	8.0	11.0	-	3.1	8.0	11.6	-
One Alkali : One Canal	0-15	2.3	7.9	11.9	11.4	3.5	8.1	12.8	13.6
	15-30	2.4	7.8	11.8	11.6	3.3	8.0	11.8	14.1
	30-60	2.5	7.9	10.6	-	3.1	8.0	11.2	-
	60-90	2.6	7.9	10.9	-	2.8	8.0	10.8	-
Mixing (1:1)	0-15	2.3	8.0	12.0	11.7	3.5	8.1	12.0	13.5
	15-30	2.5	8.1	11.9	12.0	3.2	8.1	11.9	13.6
	30-60	2.5	8.0	11.9	-	3.1	8.0	11.7	-
	60-90	2.6	8.1	12.4	-	3.0	8.0	10.2	-

Table 2.4 Effect of alkali and canal water irrigation on yield and yield attributes of sesame

Treatments	Grain yield (q/ha)	Stover yield (q/ha)	Net profit (Rs/ha)	B:C ratio
		2023		
All Canal Water	5.6	28.0	53,200	3.14
All alkali water	3.9	19.8	29,400	2.18
One Canal: One alkali	4.5	22.4	37,800	2.50
One Alkali: One Canal	4.2	21.2	33,600	2.33
Mixing (1:1)	4.6	26.4	39,200	2.55
CD at 5%	0.96	3.4	-	-

Soil studies: The EC_e, pH, SAR and ESP were analyzed at sowing and harvest of sesame under different modes of irrigation and was observed less in canal water as compared to alkali water alone and other modes of canal and alkali water (Table 2.5).

Table 2.5 Soil analysis at sowing and harvesting of sesame (2023)

Treatments	Soil Depth (cm)	at Sowing				at Harvest			
		ECe	pH	SAR	ESP	ECe	pH	SAR	ESP
All Canal	0-15	2.3	7.8	8.8	9.8	2.0	7.9	10.1	10.0
Water	15-30	2.2	7.8	8.5	10.3	1.8	7.8	9.9	10.3
	30-60	2.5	7.7	9.3	-	2.5	7.8	11.6	-
	60-90	2.6	7.8	9.3	-	2.5	7.7	12.4	-
All alkali Water	0-15	2.5	8.4	12.4	13.8	2.6	8.2	12.8	14.7
	15-30	2.8	8.3	13.0	13.4	2.5	8.1	14.9	15.8
	30-60	2.8	8.2	12.5	-	2.6	8.1	12.9	-
	60-90	3.1	8.2	12.8	-	2.9	8.0	14.9	-
1Canal:1Alkali	0-15	2.2	8.0	9.1	12.1	2.5	7.9	12.9	12.5
	15-30	2.4	8.2	9.8	12.4	2.3	8.1	11.9	12.5
	30-60	2.4	7.9	9.8	-	2.3	7.8	12.6	-
	60-90	2.6	7.9	9.8	-	2.5	7.8	11.8	-
1Alkali:1Canal	0-15	2.4	8.2	9.3	12.2	2.6	8.0	11.9	12.5
	15-30	2.5	8.1	9.4	11.9	2.5	8.0	12.6	12.3
	30-60	2.6	7.9	9.5	-	2.4	7.8	11.3	-
	60-90	2.7	7.9	9.5	-	2.4	7.8	11.5	-
Mixing 1:1)	0-15	2.4	8.1	9.5	12.3	2.5	8.0	10.9	12.8
	15-30	2.6	8.0	9.7	12.5	2.3	7.9	12.0	13.2
	30-60	2.6	7.9	9.9	-	2.3	7.9	12.9	-
	60-90	2.8	8.0	9.3	-	2.4	7.8	12.3	-

- **Management of Alkali water (High RSC) for enhancing the growth and yield of Sesame (Tiruchirappalli)**

An experiment was conducted at farmer's field with sesame (variety VRI 4) by treating the alkali water with gypsum for reducing the RSC of alkali water to different RSC levels *viz.*, RSC 4.0, 2.5, 1.25. The calculated quantity of gypsum for different RSC levels was also applied to soil as one-time basal dose. Influence of different levels of RSC water on soil properties, growth and yield of sesame were studied. The experiment was conducted in RBD with three replications. The pH of the soil was found as 8.9 (alkali) with the EC 1.21 dSm^{-1} and ESP of 26. The RSC of irrigation water was 6.7 meq L^{-1} with the EC of 1.8 dSm^{-1}. Growth and yield parameters were recorded at harvest stage. Soil and plant samples were collected. Seed samples were analyzed for oil content. Seed and plant samples were analyzed for Na and K uptake. Post-harvest soil samples were analyzed for pH, EC, exchangeable cations and ESP.

Higher reduction in ESP of soil was recorded in T_2 and T_5 which received gypsum. The results of plant analysis (Table 2.6) revealed that gypsum application considerably reduced the Na and K ratio both in seed and plant samples. The data on growth and yield parameters (Table 2.7) showed that application of gypsum either to soil or through irrigation water influenced performance of sesame. Highest yield was recorded in T_2 which involves gypsum bed treated irrigation water to the RSC level of 1.25 $meqL^{-1}$. T_3 (Gypsum bed treated water with RSC of 2.5 meL^{-1}) (B: C ratio of 2.41). It was also observed that, gypsum bed treatment of irrigation water (T_2, T_3, and T_4) performed better than soil application of gypsum (T_5, T_6, T_7) for the same quantity of gypsum applied. It can be concluded that treating high RSC alkali water with gypsum to the level of 2.5 $meqL^{-1}$ will be to be optimum for getting higher yield and B:C ratio of sesame under alkali soil environment.

Table 2.6 Influence of RSC levels of irrigation water and soil application of gypsum on chemical properties Na & K uptake and Na/K rates of sesame

Treatments	pH	EC dSm^{-1}	ESP	Na uptake (kg / ha)		K uptake (kg / ha)		Na / K ratio	
				Seed	Seed	Haulm	Seed	Haulm	Seed
T_1	9.2	1.24	27.3	0.23	0.071	0.139	0.401	1.18	0.23
T_2	8.7	1.25	22.5	0.44	0.053	0.112	0.45	1.29	0.44
T_3	8.8	1.25	23.2	0.50	0.060	0.117	0.432	1.25	0.50
T_4	8.9	1.26	23.8	0.44	0.065	0.121	0.421	1.23	0.44
T_5	8.8	1.25	22.1	0.45	0.060	0.123	0.433	1.23	0.45
T_6	8.8	1.25	23.1	0.46	0.065	0.125	0.431	1.2	0.46
T_7	9	1.25	23.7	0.41	0.067	0.129	0.425	1.2	0.41
S.Ed	0.10	0.025	0.56	0.01	0.001	0.002	0.008	0.02	0.01
CD (0.05)	0.2	NS	1.1	0.02	0.002	0.005	0.016	0.05	0.02

Table 2.7 Influence of RSC levels of irrigation water and soil application of gypsum on growth, yields & economics of sesame

Treatments	Plant Height (cm)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Oil content (%)	Cost (Rs / ha)	Gross income (Rs/ ha)	B: C ratio
T_1	72	320	675	49.8	31250	36800	1.18
T_2	87	838	1760	50.6	40970	96370	2.35
T_3	85	827	1756	50.9	39350	95105	2.41
T_4	84	680	1435	50.7	37730	78200	2.07
T_5	85	750	1575	50.5	40970	86250	2.1
T_6	83	700	1470	50.4	39350	80500	2.04
T_7	82	610	1281	50.4	37730	70150	1.86
S.Ed	1.59	13.2	28.6	0.45			
CD (0.05)	3.1	26	55	0.9			

- **Conjunctive use of rainwater and bore well water for maximizing Bhendi crop yield with effective alkali water management under drip irrigation system (Tiruchirappalli)**

Field experiment was conducted during 2024 with bhendi (CO H- 4) crop to fix the ratio of rainwater, high RSC bore well water and gypsum treated bore well water for irrigation drip system. The harvested rain water was mixed with high RSC (RSC 6) bore well water at 1:1 and 2: 1 ratio. The high RSC bore water also treated with gypsum to reduce the RSC to the level of < 1.25 meq L^{-1}. The gypsum treated bore well water was irrigated either alone or in combination with harvested rain water at 1: 1 ratio. High RSC Bore well water and harvested rain water were also applied alone as a check. The experiment was conducted in RBD and the treatments were replicated thrice. The irrigation water has the pH of 8.4, EC of 3.2 dSm^{-1} and RSC of 6.0 meq L^{-1}. The initial soil has the pH of 8.9, EC of 1.56 dSm^{-1} and ESP of 23.2.

The results of the field experiment revealed that maximum plant height (119.9 cm) and the highest number of branches per plant (3.4) and inter nodal length (5.4 cm) were recorded under irrigation with rain water alone (T_1), which was statistically superior to all other treatments (Table 2.8). This was followed by T_6 (mixing of rainwater and gypsum-treated bore well water in a 1:1 ratio), which recorded a plant height of 110.3 cm and 3.1 branches per plant and 4.7 cm inter nodal length. This was on par with T_3 (gypsum-treated bore well water) that recorded 108.3 cm plant height, 2.9 branches per plant and 4.7 cm intermodal length. Conversely, the lowest values for both plant height (76.3 cm) and number of branches (1.9) and inter nodal length (2.8 cm) were observed under T_2 (bore well water with RSC 6 meq L^{-1}), indicating a detrimental effect of untreated alkali water on vegetative growth. Intermediate growth parameters *viz.,* plant height and number of branches per plant and intermodal length was noted in treatments T_5 (99.2 cm, 2.7 and 4.5 cm) and T_4 (90.3 cm, 2.3 and 4.1 cm), which involved mixing rainwater with untreated borewell water in 2:1 and 1:1 ratio, respectively.

These findings demonstrate that the plant height and number of branches per plant were significantly influenced by the quality and management of irrigation water. Treatments involving rainwater and gypsum amendment resulted in improved chemical properties of soil after harvesting of crop (Table 2.9).

Table 2.8 Effect of conjunctive use of rainwater and borewell water on the growth parameters of drip irrigated bhendi

Treatments	Plant height (cm)	No. of branches plant^{-1}	Inter nodal length (cm)
T_1 - Rain water	119.9	3.4	5.3
T_2 - Borewell water (RSC 6 meq L^{-1})	76.3	1.9	2.8
T_3 - Gypsum treated borewell water	108.3	2.9	4.7
T_4 - Mixing of rain water + Borewell water @ 1:1 ratio	90.3	2.3	4.1
T_5 - Mixing of rain water + Borewell water @ 2:1 ratio	99.2	2.7	4.5
T_6 - Mixing of rain water + Gypsum treated borewell water @ 1:1 ratio	110.3	3.1	5.1
SEd	4.1	0.1	0.2
CD (0.05)	8.1	0.2	0.4

Table 2.9 Effect of conjunctive use of rainwater and bore well water on chemical properties after harvest of bhendi

Treatments	pH	EC	ESP
T_1 - Rain water	8.8	1.53	23.0
T_2 - Borewell water (RSC 6 meq L^{-1})	9.2	1.58	24.6
T_3 - Gypsum treated borewell water	8.7	1.57	22.6
T_4 - Mixing of rain water + Borewell water @ 1:1 ratio	8.9	1.57	24.2
T_5 - Mixing of rain water + Borewell water @ 2:1 ratio	8.9	1.56	23.9
T_6 - Mixing of rain water + Gypsum treated borewell water @ 1:1 ratio	8.7	1.57	22.9
SEd	0.18	0.02	0.4
CD (0.05)	0.37	0.04	0.8

Based on the experimental results, it could be concluded that the application of rainwater alone or in combination with gypsum-treated bore well water was effective in enhancing growth and yield of bhendi under drip irrigation, particularly under conditions of alkali water stress.

General view of the experimental field

2.2 Management of Saline Water

- **A case study on the functioning of doruvu technology and shallow bore wells in farmers' fields and its impact on coastal saline agricultural production systems (Bapatla)**

The functioning of doruvu technology and shallow bore wells was studied at n farmers' fields and its impact on coastal saline agricultural production systems was compared. Results indicate EC values fluctuated seasonally and inter-annually, reflecting influences rainfall, recharge, and water extraction. Peak EC values generally occur around June–July, and minimum EC values appear during October–December, coinciding with post-monsoon periods (Table 2.10 and Fig. 2.1). Over six years, no consistent improvement or deterioration was observed, however, EC values recorded higher during 2024–2025 than 2021–2023, indicating a need for closer monitoring.

Table 2.10 Output and water quality of bore wells before and after pumping

Bore well No.	Output (l/3sec)	Before pumping		After pumping	
		pH	ECiw (dSm^{-1})	pH	ECiw (dSm^{-1})
4	20.0	7.5	4.7	7.7	4.8
9	20.0	7.7	2.4	7.8	2.4
10	20.0	7.5	2.9	7.8	2.9

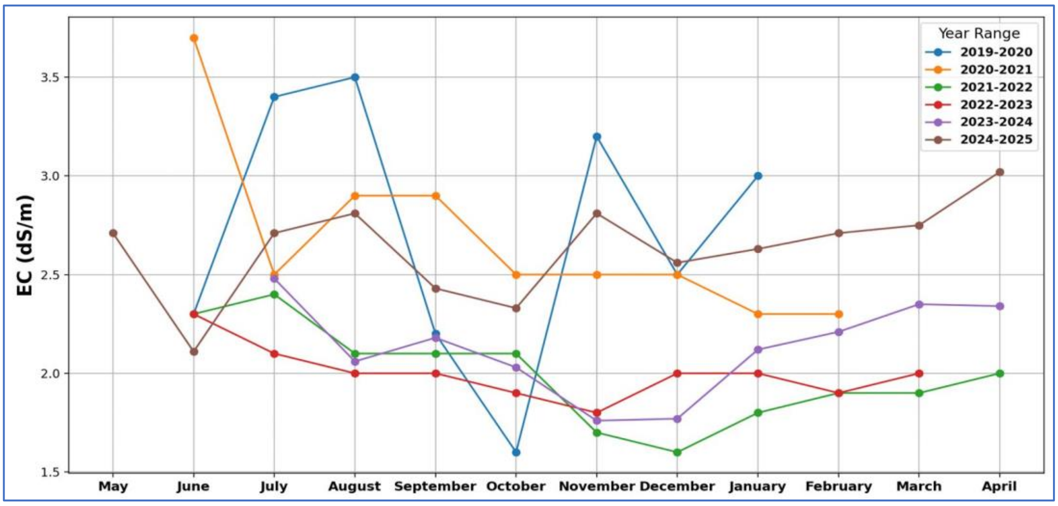


Fig 2.1 Temporal variation in EC of water in BWs

Field view of Improved Doruvu Technology and Bore wells

- **Effect of saline irrigation water on yield and fertilizer use efficiency of Maize crop under fertigation (Bapatla)**

The experiment was conducted during *rabi,* 2022-23 & 2023-24. The experimental soil had PH_2 and EC_2 7.3 & 0.3 dS m^{-1}, respectively. Nutrient status of the soil was low in available N (251 kg ha^{-1}), high in available phosphorus (27 kg ha^{-1}) and potassium (423 kg ha^{-1}). The experiment was laid out in a randomized block design with four replications. The experimental results revealed that plant height was significantly affected by different levels of salinity and fertilizer doses in maize crop. Significant difference among the treatments was observed in plant height, no of leaves, dry matter at harvest (Table 2.11). Among the treatments, T_4 and T_7 were observed superior to the others in growth and yield attributes, respectively signify highest test weight (28.0 g) was recorded with T_4 treatment which was on par with T_5, T_7 and T_8 treatments. The lowest test weight was observed with T_3 treatment (22.2g).

The data pertaining to the kernel yield revealed that salinity levels of irrigation water and fertilizer doses influenced maize kernel yield and stover yield. Among the treatments the highest production of kernel yield was observed with the T_4 treatment (5850 and 6123 kg ha^{-1}) which was at par with the T_5, T_7 and T_8 treatments, whereas it was significantly superior to the rest of the treatments. The lowest kernel yield (4135 and 4024 kg ha^{-1}) was observed with T_3 treatment *i.e.,* irrigation with 4 EC saline water through a drip system without fertilizer application (Table 2.12). Among the different treatments, the highest stover yield (9241 and 9102 kg ha^{-1}) was recorded under T_4 treatment and it was on par with T_5, T_7 and T_8 treatments whereas it was significantly superior to the rest of the treatments during the study period. The lowest stover yield (7417 and 6516 kg ha^{-1}) was found with T_3 treatment. The harvest index was not significantly affected by salinity levels and fertilizer doses.

The data pertaining to the water use efficiency revealed that salinity levels of irrigation water and fertilizer doses influenced water use efficiency of maize. Among the treatments the water use efficiency was observed with the T_4 treatment (18.5 kg ha mm^{-1}) which was at par with the T_5, T_7 and T_8 treatments, whereas it was significantly superior to the rest of the treatments (Table 2.13). The lowest water use efficiency (12.1 kg ha mm^{-1}) was observed with T_3 treatment *i.e.,* irrigation with 4 EC saline water through a drip system without fertilizer application. The economics of maize crop was influenced by different levels of saline water drip fertigation. The highest gross returns, net returns and BC ratio were observed in the T4 treatment (Table 2.13).

- **Performance of water melon irrigated with saline water through drip system (Bapatla)**

The experiment was conducted at SWS, Agricultural College Farm, Bapatla. The vine length was affected by salinity levels. The highest vine length of 213.3 and 245.8 cm was observed at a salinity level of 0.06 dS m^{-1} (BAW), which was significantly superior to 8 dS m^{-1}. The lowest plant height (166 and 132.3 cm) was observed at the salinity level of 8 dS m^{-1} (Table 2.14). The data on the number of branches per plant revealed that salinity levels had significantly influenced by each increment in salinity levels. The number of branches was highest in BAW treatment (3.8 and 4.2) which was on par with 2 dS m^{-1} and significantly superior to the rest of the salinity levels. The minimum number of branches was observed at the 8 dS m^{-1} treatment (2.1 and 1.3). The number of leaves per plant was significantly influenced by water salinity levels and it was observed that the highest no. of leaves was recorded in BAW 1.0 treatment. The number of fruits per plant was decreased with increasing salt concentration (Table 2.14). The highest number of fruits was recorded (1.5) at a salinity level of <1 dS m^{-1} (BAW) whereas, the lowest number of fruits was recorded (0.9) at a higher salinity level of 0.8 dS m^{-1} (BAW). At the age of 2 months, the crop was seriously affected by leaf miner, fusarium wilt and watermelon mosaic virus.

Table 2.11. Effect of saline water on growth and yield attributes of drip fertigated maize

Treatments	Plant height(cm)		No. of leaves/plant		Dry matter at harvest (kg ha-)		No. of cobs/plant		No. of kernel rows/cob		Cob weight (g)	
	2022-23	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
T1	171.1	217.9	12.9	15.8	13510	17250	1.0	1.1	13.8	15.1	78.4	81.9
T2	157.4	211.1	12.1	15.7	11410	16300	0.9	1.0	13.5	15.0	69.8	74.5
T3	132.8	177.8	12.2	15.6	10770	13800	0.9	0.8	13.4	14.9	54.7	67.6
T4	265.7	247.8	16.6	16.8	21230	25850	1.2	1.5	15.5	15.5	134.4	128.5
T5	211.1	241.1	14.0	16.3	19815	25700	1.1	1.4	14.3	15.4	120.8	105.8
T6	186.8	225.5	14.3	15.7	16815	24600	1.0	1.2	13.8	15.2	96.8	90.2
T7	252.0	240.0	15.8	15.9	18940	22650	1.1	1.2	14.9	15.3	114.8	98.3
T8	241.7	238.7	14.2	15.9	15040	23200	1.1	1.2	14.2	15.2	115.4	93.5
Sem +	7.6	9.8	0.5	0.3	401.3	1844	0.06	0.1	0.43	0.4	2.87	6.4
CD (0.05)	22.3	28.9	1.4	0.9	1180.3	5423	0.2	0.3	1.3	NS	8.5	18.8
CV (%)	10.5	12.7	11.8	13.1	10.5	13.4	10.9	14.4	9.0	9.6	10.2	14.4

Table 2.12. Effect of saline water on yield and harvest index of drip fertigated maize

Treatments	Cob length (cm)		No. of kernals/ row		Test weight (g)		Kernel yield (kg ha-1)		Stover yield (kg ha-1)		Harvest index (%)	
	2022-23	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**	**2022-23**	**2023-24**
T1	10.8	11.6	51	56	24.0	24.2	4580	4657	7855	7621	36.9	37.9
T2	10.6	11.4	46	55	23.1	23.1	4510	4362	7614	7043	37.2	38.5
T3	8.8	9.9	41	50	22.7	22.2	4135	4024	7417	6516	35.7	37.9
T4	16.2	16.0	76	73	28.0	28.0	5850	6123	9241	9102	38.8	40.2
T5	15.6	15.2	70	66	27.2	27.4	5600	5720	8954	8819	38.5	39.2
T6	13.0	13.2	55	58	24.2	24.4	4920	4840	8396	8258	36.8	37.5
T7	14.9	14.8	66	64	26.8	27.0	5440	5472	8650	8590	38.8	38.6
T8	14.5	14.0	62	61	25.4	26.5	5300	5071	8524	8312	38.8	38.0
Sem +	0.46	0.5	6.0	4.4	0.80	1.05	292.5	362	403.2	293	1.7	1.7
CD (0.05)	1.3	1.5	18.0	13.0	2.4	3.1	860	1064	1189	862	NS	NS
CV (%)	11.1	10.8	10.3	14.5	9.3	12.3	11.6	14.4	11.7	12.3	9.1	9.0

Table 2.13. Effect of saline water levels on water use efficiency and economics of drip fertigated maize

Treatments	Water use efficiency (kg ha mm^{-1})	Gross Returns (Rs. ha^{-1})	Cost of cultivation	Net Returns (Rs. ha-1)	BC Ratio
T1	14.8	82350	47394	34956	1.7
T2	13.9	81180	47394	33786	1.7
T3	12.1	74430	47394	27036	1.6
T4	18.5	105300	59106	46194	1.8
T5	17.9	100800	59106	41694	1.7
T6	15.3	88560	59106	29454	1.5
T7	17.3	97920	59106	38814	1.7
T8	16.9	97200	59106	38094	1.6

Table 2.14: Growth and yield attributes of water melon crop irrigated with saline water through drip system

Treatment	Vine length (cm)		No. of branches/ plant		No. of leaves/ plant		No. of fruits/ Plant	
	2022	2023	2022	2023	2022	2023	2022	2023
T1-BAW (1.0)	213.6	245.8	3.8	4.2	73.2	84.3	1.5	-
T2-2E	208.1	228.2	3.4	3.7	64.2	77.4	1.4	-
T3-4EC	203.3	213.2	2.9	2.9	56.4	68.4	1.2	-
T4-6EC	192.8	184.6	2.3	2.0	55.3	55.3	1.2	-
T5-8EC	166.0	132.3	2.1	1.3	53.4	43.2	0.9	-
SEm+	11.6	10.6	0.15	0.16	3.21	2.7	0.06	-

- **Influence of Nitrogen and *Azospirellum* on rice crop in saline soils (Bapatla)**

This experiment was conducted in the farmer's field of Kothapalem village. The initial soil pH and EC were 7.8 and 6.0 dS m^{-1} respectively. Soil salinity was significantly influenced by nitrogen levels and *Azospirillum* doses in rice crop during the crop growth period. Results showed significantly higher plant height (111 cm) for Leaching+green manure incorporation+25% extra RDN+750 mL/ac *Azosprillum* treatment which was significantly superior to T_1 treatment *i.e* Leaching+ green manure incorporation + RDN whereas, at par with all other treatments. Data on productive tiller number also indicates that soil salinity had significant influence (Table 2.15). Among the treatments, the highest number of tillers (13.5) was observed with Leaching+ green manure incorporation+ 25% extra RDN+750mL/ac *Azosprillum* treatment which was statistically on par with all other treatments it was significantly superior to T_1 and T_2 treatments. The highest panicle length (27.1 cm) was observed with Leaching+ green manure incorporation+25% extra RDN+750 mL/ac *Azosprillum* treatment which was on par with rest of the treatments, further, it was significantly superior compared to T_1 treatment. Grain yield was maximum with the T_7 treatment (6117 kg ha^{-1}) which was found to be on par with T_8, T_3, T_4, T_5 and T_6 treatments and it was significantly superior to the rest of the treatments. The minimum grain yield was observed (Table 2.15) unde control treatment (4067 kg ha^{-1}). The data further indicated that the straw yield with T_7 treatment was significantly superior to T_1 and T_2 treatments but was at par with all other treatments.

Table 2.15: Influence of nitrogen levels and *Azospirillum* doses on growth and yield of rice

Treatments	Plant height(cm)	Productive tillers/m2	Panicle length (cm)	Grain Yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T1- Leaching+ green manure incorporation + RDN	83.4	7.7	21.5	4067	5717
T2- Leaching+ green manure incorporation+RDN+500mL/ac Azosprillum	99.2	12.1	25.6	5283	7333
T3- Leaching+ green manure incorporation+RDN+750mL/ac Azosprillum	102.9	12.4	25.8	5367	7717
T4- Leaching+ green manure incorporation+RDN+1000mL/ac Azosprillum	102.3	12.6	26.0	5400	7633
T5- Leaching+ green manure incorporation+ 25% extra RDN	106.9	12.7	26.2	5583	7900
T6- Leaching+ green manure incorporation+ 25% extra RDN+500mL/ac Azosprillum	105.5	12.8	26.4	5483	7683
T7- Leaching+ green manure incorporation+ 25% extra RDN+750mL/ac Azosprillum	111.0	13.5	27.1	6117	8683
T8- Leaching+ green manure incorporation+ 25% extra RDN+1000mL/ac Azosprillum	110.1	13.0	26.8	5867	8117
Sem +	4.9	0.4	0.7	301	437
CD (0.05)	14.9	1.1	2.0	913	1325
CV (%)	10.7	6.7	5.9	12.6	12.9

- **Effect of saline water irrigation on growth, yield attributes and yields of Fennel through drip system (Bikaner)**

This experiment was initiated during rabi 2021-22 to study the effect of saline irrigation water on performance of different varieties of fennel under drip. The treatments comprised of four levels of water salinity 0.25 (BAW), 4, 6 and 8 dS/m) and four fennel varieties (AF-1, RF-157, RF-281 and RF-290) in split plot design with 5 replications. Results indicated that water salinity and varieties had significant effect on yield and economics of fennel (Table 2.16). Increase in ECiw beyond 6 dS/m caused significant reduction in seed yield. A progressive decline in yield with increasing salinity levels was also observed, which shows adverse impact of saline irrigation on crop productivity, particularly at higher salinity concentrations. Economic analysis showed that increasing in salinity reduce net returns by Rs. 5093, 13620 and 28212 /ha by ECiw 4 dS/m, ECiw 6 dS/m and ECiw 8 dS/m over BAW (ECiw 0.25 dS/m).

- **Effect of nitrogen fertigation utilizing good and saline water under drip irrigation system in vegetable crops (Hisar)**

A field experiment was initiated during 2017–18 at Hisar to evaluate response of garlic and onion to nitrogen fertigation and to assess the salt and water dynamics in drip-irrigated soil. The experiment involved three qualities of irrigation water, namely canal water (ECiw 0.3 dS/m), saline water (ECiw 2.5 dS/m), and saline water (ECiw 5.0 dS/m), along with three nitrogen fertigation levels: 75% of recommended dose of nitrogen (RDN), 100% RDN, and 125% RDN. The trial was conducted in plots of 2.0 × 2.0 m with a plant-to-plant and row-to-row spacing of 45 cm.

Table 2.16 Yield and economics of drip irrigated fennel as influenced by irrigation salinity levels and crop variety

Treatments	Seed yield (q/ha)	Net returns (Rs./ha)	B:C ratio
Salinity level			
BAW (ECiw 0.25 dS/m	11.17	45652	2.34
Saline irrigation water (ECiw 4 dS/m)	10.46	40559	2.18
Saline irrigation water (ECiw 6 dS/m)	9.26	32032	1.94
Saline irrigation water (ECiw 8 dS/m)	7.23	17440	1.51
SEm ±	0.26	-	-
CD (P= 0.05)	0.74	-	-
Variety			
AF-1	8.57	27020	1.79
RF-157	7.43	18820	1.56
RF-281	10.55	41287	2.20
RF-290	11.57	48556	2.41
SEm ±	0.19	-	-
CD (P= 0.05)	0.52	-	-

Garlic :

Results of season 2022-23 showed that under drip irrigation with 75% of the recommended nitrogen dose (RDN), garlic plant height decreased by 8.00% and 23.59% when irrigated with saline water of 2.5 dS $m^{-1}$and 5.0 dS m^{-1}, respectively, compared to canal water irrigation (Table 2.17). With 100% RDN, plant height reduction was 6.82% at 2.5 dS m^{-1} and 19.81% at 5.0 dS m^{-1} salinity. At 125% RDN, reductions were lower. significant decline in plant height was recorded at ECiw 5.0 dS m^{-1} compared to canal water irrigation. For the average number of leaves per plant, a similar trend was observed. At 75% RDN, the number of leaves decreased compared to canal water. With 100% RDN, the reductions were 7.25% and 19.61%, while with 125% RDN, the reductions were 7.92% and 17.70% at 2.5 and 5.0 dS m^{-1}, respectively.

Table 2.17. Effect of nitrogen fertigation under different saline water in drip irrigation system on plant height (cm) at harvest and average number of leaves per plant of garlic

Nitrogen Level	Plant height (cm) at harvest				Average number of leaves per plant			
	Canal (0.3 dS m^{-1})	2.5 dS m^{-1}	5.0 dS m^{-1}	Mean	Canal (0.3 dS m^{-1})	2.5 dS m^{-1}	5.0 dS m^{-1}	Mean
75% RDN	72.83	67.00	55.65	65.16	9.65	8.75	7.31	8.57
RDN	80.44	74.95	64.50	73.30	10.35	9.60	8.32	9.42
125% RDN	81.61	78.76	68.19	76.19	10.73	9.88	8.83	9.82
Mean	78.29	73.57	63.09		10.24	9.41	8.16	
CD (p=0.05)	Nitrogen (N)- 2.36, Salinity (S) -3.42 N x S - NS				Nitrogen (N)- 0.52, Salinity (S)-1.85 N x S -NS			

The number of cloves per bulb and yield of garlic was found to be minimum at 75% of the recommended dose of nitrogen (RDN). Further, a significant decline in the average number of cloves per bulb was recorded at ECiw 5.0 dS m^{-1} compared to canal water irrigation (Table 2.18). For garlic yield, at 75% RDN, the reduction was 10.43% and 27.08 % under saline water of 2.5 and 5.0 dS m^{-1}, respectively, while 125% RDN 7.67% and 20.04% under the same salinity levels. On an average, the reduction in garlic yield was 8.62% at 2.5 dS/m and 22.78% at 5.0 dS/m, as compared to canal water irrigation.

Table 2.18. Effect of nitrogen fertigation under different saline water in drip irrigation system on number of cloves per bulb and yield (q/ha) of garlic

Nitrogen Level	Number of cloves per bulb				Yield (q/ha)			
	Canal (0.3 dS/m)	2.5 dS/m	5.0 dS/m	Mean	Canal (0.3 dS/m)	2.5 dS/m	5.0 dS/m	Mean
75% RDN	22.25	20.85	17.59	20.23	81.30	72.82	59.28	71.13
RDN	25.92	25.03	21.32	24.09	102.10	93.77	79.47	91.78
125% RDN	27.09	26.18	22.88	25.38	104.33	96.33	83.42	94.69
Mean	25.09	24.02	20.60		95.91	87.64	74.06	
CD (p=0.05)	Nitrogen (N)- 2.41, Salinity (S) -1.05 N x S - NS				Nitrogen (N)- 2.12, Salinity (S)-3.65 N x S -NS			

Soil Data: The data on soil ECe under nitrogen and salinity levels with drip irrigation (Table 2.19) revealed that the highest mean value of 3.85 dS m^{-1}, followed by 2.28 dS m^{-1} 0–15 cm soil. Among nitrogen levels, the minimum mean ECe value of 2.08 dS m^{-1} was observed 125% RDN, while the maximum of 2.27 dS m^{-1} was recorded at 75% RDN. Regarding available nitrogen after garlic harvest, the highest value (138.23 kg/ha) was obtained at 125% RDN with canal water irrigation under drip system, whereas the lowest (117.20 kg/ha) was recorded at 75% RDN with saline water of ECiw 5.0 dS m^{-1}. The mean available nitrogen decreased with increasing salinity of irrigation water. The highest mean value (130.47 kg/ha) was observed under canal water irrigation, which declined by 4.63% and 9.44% at ECiw 2.5 and 5.0 dS m^{-1}, respectively.

Table 2.19 Effect of nitrogen fertigation and different saline water irrigation on ECe and available nitrogen in surface soil (0-15 cm depth) under garlic crop

Nitrogen Level	Soil ECe (dS/m)				Available nitrogen (kg/ha)			
	Canal (0.3 dS/m)	2.5 dS/m	5.0 dS/m	Mean	Canal (0.3 dS/m)	2.5 dS/m	5.0 dS/m	Mean
75% RDN	0.50	2.36	3.95	2.27	117.20	111.38	108.33	112.30
RDN	0.41	2.28	3.89	2.19	135.98	129.95	120.53	128.82
125% RDN	0.35	2.19	3.71	2.08	138.23	131.93	125.59	131.91
Mean	0.42	2.28	3.85	2.18	130.47	124.42	118.15	124.35
CD (p=0.05)	Nitrogen (N)- 0.08, Salinity (S) -0.11 N x S - NS				Nitrogen (N)- 2.69, Salinity (S)-4.21 N x S -NS			

Onion:

The data on plant height and yield of onion under different nitrogen and salinity levels drip irrigation (Table 2.20) showed that both parameters were adversely affected by saline water irrigation. For plant 75% of the recommended dose of nitrogen (RDN), the reduction was 8.67% and 25.53% with saline water of 2.5 and 5.0 dS/m, respectively, compared to canal water irrigation. At 100% RDN, the reduction was 6.82% and 20.54%, while at 125% RDN, the reduction was 5.68% and 17.47% under the same salinity levels. A significant decline in average plant height was observed at ECiw 5.0 dS/m compared to canal water irrigation. The reduction at 75% RDN was found to be 5.48% and 27.26% under saline water of 2.5 and 5.0 dS/m, respectively. At 100% RDN, the yield reduction was 5.13% and 22.62%, whereas at 125% RDN, it was 4.59% and 20.68% under 2.5 and 5.0 dS/m ECiw, respectively. On an average basis, yield reduction was 5.05% at 2.5 dS/m and 23.36% at 5.0 dS/m as compared to canal water irrigation.

Table 2.20 Effect of nitrogen fertigation under different saline water in drip irrigation system on plant height (cm) at harvest and yield (q/ha) of onion

Nitrogen Level	Plant height (cm)				Onion yield (q/ha)			
	Canal (0.3 dS m^{-1})	2.5 dS m^{-1}	5.0 dS m^{-1}	Mean	Canal (0.3 dS m^{-1})	2.5 dS m^{-1}	5.0 dS m^{-1}	Mean
75% RDN	55.1	50.3	41.0	48.8	268.5	253.8	195.3	239.2
RDN	58.2	54.2	46.3	52.9	298.5	283.2	231.0	270.9
125% RDN	60.0	56.6	49.5	55.4	309.3	295.1	245.3	283.3
Mean	57.8	53.7	45.6		292.1	277.4	223.9	
CD (p=0.05)	Nitrogen (N)- 1.34, Salinity (S) -1.56 N x S - NS				Nitrogen (N)- 12.02, Salinity (S)- 13.78 N x S -NS			

The reduction in onion growth and yield under saline irrigation was mainly due to osmotic stress and ion toxicity caused by higher concentrations of salts in the root zone (Table 2.21). This stress reduces water uptake, disturbs nutrient absorption (particularly nitrogen and potassium), and led to reduced photosynthesis and poor bulb development. Consequently, onion plants irrigated with higher salinity water (ECiw 5.0 dS m^{-1}) exhibited the maximum reduction in both plant height and yield.

Table 2.21 Effect of nitrogen fertigation and different saline water irrigation on soil ECe (0-15 cm) depth under onion crop

Nitrogen Level	Canal (0.3 dS m^{-1})	2.5 dS m^{-1}	5.0 dS m^{-1}	Mean
75% RDN	0.56	2.64	4.15	2.45
RDN	0.44	2.44	4.06	2.31
125% RDN	0.39	2.38	3.86	2.21
Mean	0.46	2.49	4.02	

The average soil ECe was found maximum (4.15 dS m^{-1}) in ECiw 5.0 dSm^{-1} under drip irrigation at 75% RDF followed by ECe of 4.06 in saline water irrigated plots at RDN. The minimum mean ECe value 2.21 dS m^{-1} was found at 15% of RDN (Table 2.21).

- **Performance of mycorrhizal (*Glomus mosseae*) inoculation in cotton-wheat under saline water irrigation (Hisar)**

A pot experiment was initiated during *kharif* 2022 at the Soil Science Screen House, CCS HAU, Hisar to evaluate the performance of mycorrhizal inoculation (*Glomus mosseae*) on the cotton-wheat cropping system under saline water irrigation. The study aimed to assess the effect of mycorrhiza on crop yield, soil physico-chemical properties, physiological parameters, and mycorrhizal colonization in the rhizosphere. The experiment was conducted in a completely randomized design (CRD) with 10 treatment combinations involving control, FYM (10 t/ha), mycorrhiza, RDF, 75% RDF, and their different integrated combinations with mycorrhiza and FYM. Irrigation water qualities comprised two levels: canal water (ECiw 0.3 dS m^{-1}) and saline water (ECiw 8.0 dS m^{-1}). Mycorrhizal inoculation was done at the time of sowing by applying 400-500 sporocarps/kg soil. Both cotton and wheat crops were raised with recommended cultural practices and nutrient management as per treatment details. Observations were recorded on yield and yield attributes, soil physico-chemical properties, physiological parameters, and mycorrhizal colonization and sporocarp numbers.

Cotton: The performance of cotton during 2022 and 2023 under saline water irrigation (ECiw 8.0 dS m^{-1}) showed a significant reduction in yield, growth, and physiological parameters compared with canal water irrigation (ECiw 0.3 dS m^{-1}). The mean seed cotton yield was declined by 20.01% in 2022 and 21.53% in 2023 (Table 2.22). The lowest yield was observed in the control (35.75 g/pot in 2022 and 33.33 g/pot in 2023) plot, while the highest yield was recorded under RDF+FYM+*Mycorrhiza* (64.18 g/pot in 2022 and 63.05 g/pot in 2023), which remained statistically at par with RDF+*Mycorrhiza* and RDF alone. This indicates that mycorrhizal inoculation, especially in combination with RDF and FYM, plays a crucial role in mitigating salinity-induced yield losses. This demonstrates the synergistic effect of FYM and mycorrhiza with RDF in sustaining crop growth under salinity stress.

Physiological traits were also affected by saline irrigation (Tables 2.23). Chlorophyll content declined from 28.02 to 23.60 SPAD units in 2022 and 29.02 to 24.26 in 2023, while photochemical efficiency (Fv/Fm) reduced from 0.696 to 0.648 in 2022 and 0.713 to 0.649 in 2023. The highest chlorophyll content and Fv/Fm were recorded in RDF+FYM+*Mycorrhiza* (28.88 and 0.716 in 2022; 29.52 and 0.716 in 2023), followed by RDF+*Mycorrhiza*. This indicates that mycorrhizal association enhanced photosynthetic efficiency even under saline conditions.

On the other hand, anthocyanin and flavonoid contents (known indicators of stress defense) showed an increasing trend with salinity. Anthocyanin ranged from 0.084 to 0.092 in 2022 and 0.082 to 0.093 in 2023, while flavonoids increased from 0.33 to 0.46 during 2022 and 0.32 to 0.47 in 2023. This suggests activation of plant defense mechanisms under saline irrigation.

The salinity susceptibility index (SSI) further confirmed treatment differences. The lowest SSI values were recorded in RDF+FYM+*Mycorrhiza* (0.89) followed by RDF+*Mycorrhiza* (0.92), indicating greater tolerance to salinity stress compared with other treatments.

Table 2.22. Effect of mycorrhizal (*Glomus mosseae*) inoculation on seed cotton yield (g/plant) under saline water irrigation

Treatments	2022			2023		
	Canal	**EC 8 dS/m**	**Mean**	**Canal**	**EC 8 dS/m**	**Mean**
Control	40.58	30.91	35.75	39.09	27.57	33.33
FYM	43.82	33.95	38.89	42.68	32.29	37.49
Mycorrhiza	41.14	31.69	36.42	39.99	30.24	35.12
RDF	69.28	56.14	62.71	68.17	54.58	61.37
75%RDF	59.82	47.73	53.77	58.63	45.54	52.08
75%RDF+*Mycorrhiza*	60.05	48.10	54.08	59.26	46.51	52.89
75%RDF+FYM	62.57	50.17	56.37	60.99	47.64	54.32
75%RDF+FYM+*Mycorrhiza*	63.93	51.53	57.73	62.09	50.19	56.14
RDF+FYM+*Mycorrhiza*	70.46	57.90	64.18	69.60	56.50	63.05
RDF+*Mycorrhiza*	69.47	56.65	63.06	68.62	55.48	62.05
Mean	**58.11**	**46.48**		**56.91**	**44.65**	
CD (p=0.05)	Treatment (T) = 4.15, Salinity (S)= 1.85, T x S = NS			Treatment (T) = 5.31, Salinity (S) = 2.37, T x S = NS		

Table 2.23 Effect of mycorrhizal (*Glomus mosseae*) inoculation on chlorophyll content (SPAD units) in cotton under saline water irrigation

Treatments	2022			2023		
	Canal	**EC 8 dS/m**	**Mean**	**Canal**	**EC 8 dS/m**	**Mean**
Control	27.67	23.47	25.57	29.67	24.37	27.02
FYM	25.87	21.97	23.92	27.20	22.60	24.90
Mycorrhiza	26.20	23.90	25.05	27.53	24.57	26.05
RDF	27.97	25.37	26.67	28.97	25.17	27.07
75%RDF	29.97	18.17	24.07	30.63	18.53	24.58
75%RDF+*Mycorrhiza*	26.50	22.93	24.72	27.83	23.70	25.77
75%RDF+FYM	27.07	25.80	26.43	27.07	27.13	27.10
75%RDF+FYM+*Mycorrhiza*	27.77	20.83	24.30	28.93	21.47	25.20
RDF+FYM+*Mycorrhiza*	30.77	27.00	28.88	31.20	27.83	29.52
RDF+*Mycorrhiza*	30.43	26.60	28.52	31.20	27.27	29.23
Mean	**28.02**	**23.60**		**29.02**	**24.26**	
CD (p=0.05)	Treatment (T) = 2.91, Salinity (S)= 1.30, T xS = 4.11			Treatment (T) = 1.49, Salinity (S)= 0.66, Tx S = 2.10		

Overall, results from both years clearly indicate that saline irrigation (ECiw 8.0 dS m^{-1}) adversely affects cotton yield, and physiology. However, integration of RDF with FYM and mycorrhiza significantly alleviated salinity stress by improving yield, growth attributes, photosynthetic efficiency, and reducing susceptibility index. Thus, RDF+FYM+*Mycorrhiza* emerges as the most effective treatment for sustaining cotton productivity under saline water irrigation.

Wheat: The performance of wheat during 2022–23 and 2023–24 under saline irrigation (ECiw 8.0 dS m^{-1}) revealed a significant decline in yield and physiological attributes compared with canal water irrigation (ECiw 0.3 dS m^{-1}). The mean wheat yield decreased by 20.28% during 2022–23 and 28.76% in 2023–24 (Table 2.24). However, the lowest yield was recorded in control (25.92 g/pot in 2022–23 and 24.65 g/pot in 2023–24) plot. RDF+FYM+*Mycorrhiza* recorded the highest yield (51.86 g/pot during 2022–23 and 52.27 g/pot in 2023–24). These yields were statistically at par with RDF+*Mycorrhiza* (50.98 g/pot and 51.39 g/pot) and RDF (49.95 g/pot and 49.60 g/pot), indicating the strong role of nutrient integration with mycorrhiza in sustaining productivity under salinity stress.

Physiological parameters also exhibited salinity-induced reductions (Tables 2.25). In 2022–23, chlorophyll content decreased from 31.36 to 26.91 SPAD units under saline irrigation. In 2023–24, the respective value declined from 25.90 to 22.66 SPAD units. Maximum values for chlorophyll content consistently observed in RDF+FYM+*Mycorrhiza* followed by RDF+*Mycorrhiza*, highlighting the beneficial role of mycorrhizal association in maintaining photosynthetic efficiency under saline conditions.

The results from both years clearly demonstrate that saline irrigation (ECiw 8.0 dS m^{-1}) significantly reduces wheat yield and physiological performance. However, the integration of RDF+FYM+Mycorrhiza consistently produced the highest yield, improved chlorophyll. Thus, RDF+FYM+Mycorrhiza emerge as the most effective treatment for sustaining wheat productivity under saline water irrigation conditions.

Table 2.24 Effect of mycorrhizal (*Glomus mosseae*) inoculation on wheat yield (g/plant) under saline water irrigation

Treatments	2022–23			2023–24		
	Canal	EC 8 dS/m	Mean	Canal	EC 8 dS/m	Mean
Control	29.55	22.29	25.92	28.79	20.51	24.65
FYM	33.04	25.32	29.18	33.26	25.02	29.14
Mycorrhiza	30.64	23.77	27.21	31.37	23.81	27.59
RDF	55.45	44.44	49.95	55.10	44.10	49.60
75%RDF	44.98	35.94	40.46	44.67	35.38	40.03
75%RDF+*Mycorrhiza*	46.03	36.60	41.32	46.79	36.83	41.81
75%RDF+FYM	48.21	38.57	43.39	48.85	38.69	43.77
75%RDF+FYM+*Mycorrhiza*	49.32	39.93	44.63	49.68	39.75	44.71
RDF+FYM+*Mycorrhiza*	56.99	46.73	51.86	57.40	47.15	52.27
RDF+*Mycorrhiza*	56.34	45.62	50.98	56.80	45.97	51.39
Mean	45.06	35.92		28.79	20.51	
CD (p=0.05)	Treatment (T) = 2.28, Salinity (S)= 5.09, T x S = NS			Treatment (T) = 5.62, Salinity (S)= 2.54, T x S = NS		

Table 2.25 Effect of mycorrhizal (*Glomus mosseae*) inoculation on chlorophyll content (SPAD units) in wheat under saline water irrigation

Treatments	2022–23			2023–24		
	Canal	EC 8 dS/m	Mean	Canal	EC 8 dS/m	Mean
Control	25.53	22.10	23.82	24.40	20.93	22.67
FYM	26.73	18.73	22.73	27.83	21.53	24.68
Mycorrhiza	27.10	16.60	21.85	24.13	22.60	23.37
RDF	33.70	32.03	32.87	27.23	23.83	25.53
75%RDF	30.87	29.73	30.30	24.23	23.13	23.68
75%RDF+Mycorrhiza	29.77	26.17	27.97	27.33	21.53	24.43
75%RDF+FYM	30.07	29.37	29.72	24.83	23.17	24.00
75%RDF+FYM+*Mycorrhiza*	31.70	30.83	31.27	25.67	23.13	24.40
RDF+FYM+*Mycorrhiza*	42.27	33.67	37.97	27.40	24.07	25.73
RDF+*Mycorrhiza*	35.90	29.90	32.90	25.70	24.60	25.15
Mean	31.36	26.91		25.90	22.66	
CD (p=0.05)	Treatment (T) = 6.72, Salinity (S)= 3.01, T x S = NS			Treatment (T) = NS, Salinity (S)= 1.83, T x S = NS		

Soil Fertility: The Soil pH was non-significantly affected by saline irrigation as well as by different fertilizer treatments. However, slightly lower pH values were recorded in treatments where FYM was applied, indicating the buffering effect of organic manure. In contrast, soil EC was significantly influenced by saline water irrigation (Table 2.26). The mean EC increased from 0.26 dS m^{-1} under canal irrigation to 1.88 dS m^{-1}under saline irrigation (ECiw 8 dS m^{-1}), while the effect of mycorrhiza and fertilizers on EC was statistically non-significant. Like EC, the application of saline water irrigation reduced available soil nitrogen by 7.52% compared with canal irrigation, with higher nitrogen availability in canal-irrigated treatments. Among fertilizer treatments, the significantly available nitrogen (85.20 kg/ha) was recorded in RDF+FYM+*Mycorrhiza*, which was superior to RDF alone (79.28 kg/ha) but statistically at par with RDF+Mycorrhiza and 75% RDF+FYM+*Mycorrhiza*. The lowest available nitrogen was observed in the control, where no fertilizers were applied. This clearly demonstrates the synergistic effect of FYM and mycorrhiza in improving soil fertility under saline conditions.

Mycorrhizal colonization: Mycorrhizal colonization and sporocarp production were found to decline with increasing salinity. The mean colonization percentage decreased from 8.90 under canal irrigation to 7.06 under saline irrigation, while sporocarp number decreased from 11.40 to 9.10, respectively. However, among fertilizer treatments, the highest colonization (17.20%) and sporocarp number (23.00) were obtained in 75% RDF+FYM+*Mycorrhiza* under saline water irrigation, indicating that organic manure and mycorrhizal inoculation together provide a favorable environment for mycorrhizal growth even under saline stress.

Table 2.26 Effect of mycorrhizal (*Glomus mosseae*) inoculation on electrical conductivity ($EC_{1:2}$) after harvest of wheat under saline water irrigation

Treatments	2022–23			2023–24		
	Canal	EC 8 dS/m	Mean	Canal	EC 8 dS/m	Mean
Control	0.25	1.71	0.98	0.40	2.13	1.26
FYM	0.22	1.68	0.95	0.35	2.10	1.22
Mycorrhiza	0.21	1.54	0.88	0.23	2.06	1.14
RDF	0.20	1.29	0.75	0.16	1.77	0.97
75%RDF	0.24	1.70	0.97	0.28	1.97	1.12
75%RDF+*Mycorrhiza*	0.21	1.35	0.78	0.21	1.82	1.02
75%RDF+FYM	0.23	1.55	0.89	0.22	1.93	1.08
75%RDF+FYM+*Mycorrhiza*	0.22	1.25	0.74	0.27	1.67	0.97
RDF+FYM+*Mycorrhiza*	0.23	1.28	0.76	0.28	1.62	0.95
RDF+*Mycorrhiza*	0.21	1.20	0.71	0.23	1.73	0.98
Mean	0.22	1.45		0.26	1.88	
CD (p=0.05)	Salinity (S) = 0.18, Treatment(T)= NS, T x S = NS			Salinity (S) = 0.12, Treatment (T) = NS, TxS = NS		

Overall, saline water irrigation adversely affected soil EC, nitrogen availability, while pH remained stable. Integrated nutrient management, particularly RDF+FYM+*Mycorrhiza*, not only improved soil nitrogen availability but also enhanced mycorrhizal colonization and sporocarp production, thereby sustaining soil health and microbial activity under saline conditions.

- **Performance of vegetable guar with different doses of sulphur and potassium under different water quality (Bathinda)**

The experiment was conducted during 2023 and 2024 to assess the doses of sulphur (0, 30 and 45 kg/ ha) and 3 doses of potassium (0, 30 and 45 kg/ ha) on response vegetable guar under two qualities of water (canal water Tube well water). The quality of water used in field experiment is given in Table 2.27. The Recommended doses of 22.5 kg N/ha and 60 kg P_2O_5 /ha were applied uniformly in all treatments. Sulphur addition significantly influenced plant growth attributes and green pod yield (Table 2.28). It was recorded that sulphur application @ 30 kg/ha and 45 kg/ha improved germination by 7.9 and 13.9%, plant height by 9.7 and 13.6%, leaves/ plant by 17.7 and 32.4%, cluster/ plant by 16.8 and 23.3%, pod/plant by 49.3 and 71.6%, pod length by 5.3and 7.8%, green pod yield by 103 and 179%, respectively as compared to control (S_0). Similarly, in comparison of control (K_0), potassium application @ 30 kg/ha and 45 kg/ha enhanced germination by 5.4 and 8.7%, plant height by 6.0 and 8.0%, leaves/ plant by 10.1 and 18.6%,

Table 2.27: Composition of canal and tube well water used for irrigation

Particulars	Canal water Mean	Tube well water Mean
EC (dS m^{-1})	0.33	4.34
Na^{+}(me l^{-1})	0.88	33.92
Ca^{+2}+ Mg^{+2} (me l^{-1})	2.06	7.44
Cl^{-1} (mel^{-1})	0.55	8.45
CO_3^{-2} (mel^{-1})	Nil	Nil
HCO_3^{-} (mel^{-1})	1.64	7.22
K (mg l^{-1})	0.68	7.62
RSC (mel^{-1})	Nil	Nil
SAR	0.87	17.59

Table 2.28 Effect of irrigation water quality (IWQ), Sulphur levels (S) and potassium levels (K) on germination, plant growth, yield and its contributing traits in vegetable cluster bean during (pooled of 2023–24)

	Germination (%)	Plant height (cm) 120 DAS	Leaves/ plant 120 DAS	Cluster /plant	Pod/ plant	Pod length (cm)	Green Pod yield per plant (g)	Estimated Pod yield (t/ha)
				IWQ				
CW	86.66	144.76	111.05	18.56	95.06	5.79	98.43	12.49
TW	58.71	108.36	90.71	17.94	88.83	5.67	76.33	6.58
LSD (IWQ) ($p \leq 0.05$)	0.34	1.02	0.81	0.22	1.23	0.10	1.19	0.19
				Sulphur levels				
S_0	67.75	117.46	86.45	16.10	65.53	5.49	48.36	4.91
S_{12}	73.13	128.81	101.76	18.81	97.85	5.78	92.74	9.98
S_{18}	77.18	133.42	114.45	19.85	112.47	5.92	121.02	13.71
LSD (S) ($p \leq 0.05$)	0.86	1.93	1.18	0.48	1.26	0.10	1.83	0.30
				Potassium levels				
K_0	69.41	120.89	92.06	17.15	78.04	5.58	64.24	6.63
K_{12}	73.17	128.18	101.39	18.46	93.63	5.77	90.77	9.91
K_{18}	75.48	130.62	109.20	19.15	104.17	5.83	107.13	12.06
LSD (K) ($p \leq 0.05$)	0.86	1.93	1.18	0.48	1.26	0.10	1.83	0.30
LSD (IWQ x S) ($p \leq 0.05$)	1.22	2.72	1.67	NS	NS	NS	2.59	0.42
LSD (IWQ x K) ($p \leq 0.05$)	1.22	NS	1.67	NS	NS	NS	2.59	0.42
LSD (S x K) ($p \leq 0.05$)	1.49	NS	2.04	0.83	2.18	NS	3.17	0.51
LSD (IWQ x S x K) ($p \leq 0.05$)			2.89	NS	NS	NS	4.48	0.72

cluster/ plant by 7.6 and 11.7%, pod/plant by 20.0 and 33.5%, pod length by 3.0 and 4.5%, green pod yield by 49.5 and 81.9%, respectively. The Interaction effect between irrigation water quality x sulphur doses and irrigation water quality x potassium doses influenced germination, plant height, leaves/plant and green pod yield significantly. The Sulphur and potassium together also had significant effect on studied parameters except plant height and pod length. Interestingly, green pod yield increased significantly with Sulphur and potassium doses under saline water irrigation.

Canal water irrigation increased seeds/pod by 13.4%, 100-seed weight by 25.3%, seed yield by 89.7% as compared to saline water (Table 2.29). However, K and S content in seed and straw were found higher by 8.1 and 2.1 %, and 15.7% and 7.5% as compared to canal water. It was also recorded that Sulphur application @ 30 kg/ha and @ 45 kg/ha, improved seed/pod by 14.3 and 21.1%, 100-seed weight by 15.9 and 28.0% and seed yield by 95.5 and 181.8%. Likewise, as compared to control (K_0), potassium @ 30 kg/ha and potassium @ 45 kg/ha increased seed/pod by 8.1 and 12.7%, 100-seed weight by 15.0 and 18.7%, seed yield by 50.5 and 81.6 %. Interaction effect between irrigation water quality x sulphur doses and significantly irrigation water quality x potassium doses influenced seed/pod, 100-seed weight, seed yield and straw S content.

Table 2.29 Effect of irrigation water quality (IWQ), sulphur levels (S) and potassium levels (K) on seed attributes and seed and straw nutrient content of vegetable cluster bean seeds (pooled of 2023-24)

Traetment	No. seed/ pod	100 seed wt (g)	Seed yield/ plant (g)	Estimated yield (t/ha)	Seed K content (%)	Straw K content (%)	Seed S content (%)	Straw S content (%)
			IWQ					
CW	7.60	2.93	21.91	2.77	2.47	1.03	3.89	1.60
TW	6.70	2.54	16.77	1.46	2.66	1.15	4.00	1.75
LSD (IWQ) (p≤ 0.05)	0.20	0.083	1.04	0.13	0.009	0.021	0.070	0.036
			Sulphur levels					
S0	6.39	2.39	10.60	1.10	2.53	1.07	3.61	1.49
S12	7.32	2.77	20.06	2.15	2.56	1.08	4.04	1.70
S18	7.74	3.06	27.36	3.10	2.60	1.13	4.18	1.83
LSD (S) (p≤ 0.05)	0.12	0.054	0.76	0.11	0.038	0.016	0.065	0.024
			Potassium levels					
K0	6.69	2.46	13.91	1.47	2.41	1.03	3.90	1.65
K12	7.23	2.83	20.16	2.21	2.59	1.10	3.95	1.68
K18	7.54	2.92	23.95	2.67	2.69	1.15	3.99	1.70
LSD (K) (p≤ 0.05)	0.12	0.054	0.76	0.11	0.038	0.016	0.065	0.024
LSD (IWQ x S) (p≤ 0.05)	0.17	0.077	NS	0.15	NS	NS	NS	0.034
LSD (IWQ x K) (p≤ 0.05)	0.17	0.077	1.08	NS	NS	NS	NS	NS
LSD (S x K) (p≤ 0.05)	NS	0.094	1.32	0.19	NS	0.028	NS	NS
LSD (IWQ x S x K) (p≤ 0.05)	NS	0.13	1.87	NS	NS	NS	NS	NS

The soil parameters recorded after harvesting the crop are presented in Table 2.30. Interestingly, higher soil pH, soil EC and available P and S content were recorded with saline irrigation as compared to canal water irrigation, but canal water irrigated soil recorded significantly higher organic carbon (OC). However, effect of sulphur doses on soil pH was found non-significant, whereas soil EC, OC and available P, K and S, were influenced significantly. The K doses had significant effect only on soil available P, K and S as potassium @ 30 kg/ha and 45 kg/ha increased available soil P by 5.3 and 9.0%, soil K by 2.0 and 4.4%, soil S by 1.9 and 4.3%, respectively as compared to control (K_0).

Table 2.30: **Effect of irrigation water quality (IWQ), sulphur levels (S) and potassium levels (K) on soil parameters**

Traetment	Soil pH(1:2)	Soil EC (1:2) dS/m	SOC (%)	Soil P_2O_5(kg/ha)	Soil K_2O (kg/ha)	Soil S (kg/ha)
IWQ						
CW	8.32	0.19	0.24	13.38	231.24	20.99
TW	8.61	0.44	0.20	14.62	238.00	27.25
LSD (IWQ) ($p \leq 0.05$)	0.15	0.022	0.008	0.58	NS	0.88
Sulphur levels						
S0	8.51	0.35	0.20	12.49	231.14	21.11
S12	8.46	0.31	0.22	14.00	235.27	24.71
S18	8.42	0.28	0.24	15.50	237.44	26.54
LSD (S) ($p \leq 0.05$)	NS	0.015	0.015	0.37	4.93	0.51
Potassium levels						
K0	8.48	0.33	0.22	13.36	229.69	23.63
K12	8.45	0.31	0.22	14.07	234.36	24.08
K18	8.45	0.31	0.23	14.56	239.80	24.64
LSD (K) ($p \leq 0.05$)	NS	NS	NS	0.37	4.93	0.51
LSD (IWQ x S) ($p \leq 0.05$)	NS	NS	NS	NS	NS	0.72
LSD (IWQ x K) ($p \leq 0.05$)	NS	NS	NS	NS	NS	NS
LSD (S x K) ($p \leq 0.05$)	NS	NS	NS	NS	NS	NS
LSD (IWQ x S x K) ($p \leq 0.05$)	NS	NS	NS	NS	NS	NS

2.3 Management of Waste Water

- **Effect of treated sewage water as a source of irrigation and nutrient supply for Marigold-chrysanthemum rotation (Agra)**

A field experiment was conducted during 2020-21 and 2023-24 to evaluate the effects of sewage water (SW), tube well water (TW), and the recommended dose of fertilizer (RDF) in a marigold-chrysanthemum crop rotation. Eight treatments were tested: T_1 – SW, T_2 – SW + RDF, T_3 – SW + 50% RDF, T_4 – SW + 75% RDF, T_5 – TW + RDF, T_6 – TW + 75% RDF, T_7 – TW + 125% RDF, and T_8 – 1SW:1TW + RDF, laid out in a randomized block design. The data presented in Table 2.31 revealed that marigold flower yield was influenced by the various combinations of SW, TW, and RDF. In 2022–23, due to intermittent heavy rains

Table 2.31 Effect of different treatments on marigold flower yield, net profit and BC ratio

Treatments	Flower yield (q/ha)				Net profit (Rs/ha)				B:C ratio			
	20-21	21-22	22-23	23-24	20-21	21-22	22-23	23-24	20-21	21-22	22-23	23-24
T_1-SW	185	187	192	195	1,28,660	1,67,640	1,73,090	1,76,030	3.26	3.93	4.01	4.02
T_2-SW+RDF	224	227	235	239	1,54,817	2,02.438	2,18,160	2,22,170	3.22	3.86	4.42	4.45
T_3-SW+50%RDF	194	197	202	206	1,31,238	1,74,172	1,80,860	1,84,930	3.08	3.79	3.92	3.95
T_4-SW+75%RDF	205	209	222	227	1,39,028	1,82,980	2,00,810	2,05,850	3.09	3.67	4.05	4.10
T5-TW+RDF	187	191	196	201	1,17,817	1,57,520	1,65,230	1,69,130	2.69	3.21	3.35	3.36
T_6-TW+75%RDF	175	178	183	187	1,08,938	1,45,740	1,52,080	1,55,690	2.65	3.16	3.26	3.26
T_7-TW+125%RDF	199	202	207	211	1,25,907	1,68.940	1,78,049	1,80,870	2.72	3.31	3.54	3.50
T_8-1SW:1TW+RDF	192	195	203	208	1,35,360	1,75,420	1,86,160	1,90,090	3.38	4.01	4.25	4.16
CD at 5%	8.4	8.3	8.5	8.8	-	-	-	-	-	-	-	-

on several nights, soil-borne stem root rot disease developed; despite drainage and repeated replanting efforts, the marigold crop could not survive that year. During 2021–22 and 2023–24, application of T_2 (SW + RDF) resulted in higher flower yields by 8.04–19.31% and 11.19–26.87%, respectively, over other treatments. Treatment T_4 (SW + 75% RDF) was statistically at par with T_7 (TW + 125% RDF) but produced significantly higher flower yield compared to the other treatments. Application of T_7 (TW + 125% RDF) was statistically comparable to T_3 (SW + 50% RDF) and T_8 (1SW:1TW + RDF). The lowest flower yields (100.3 q/ha and 65.3 q/ha) were recorded under T_6 (TW + 75% RDF) in 2021–22 and 2022–23, respectively. Net profit from marigold was highest under T_2 – SW + RDF (₹1,13,820 and ₹1,17,330) and lowest under T_6 – TW + 75% RDF (₹85,120 and ₹68,290) in 2022–23 and 2023–24, respectively. The benefit-cost (B:C) ratio of marigold was maximum under T_2 – SW + RDF (2.97 and 2.92) and minimum under T_6 – TW + 75% RDF (2.30 and 2.10) in the respective years. Treatments include saline water (SW), tube well water (TW), mixed water (1SW:1TW), and various recommended fertilizer dose (RDF) levels. Across all years, T2 (SW + RDF) consistently recorded the highest flower yield (224.4 to 238.7 q/ha) and maximum net profit (₹1,54,817 to ₹2,22,170), with high B:C ratios (3.22–4.45), indicating its superior profitability. Conversely, T6 (TW + 75% RDF) yielded the lowest net returns and B:C ratio in most years. Mixed water with RDF (T8) also performed well, especially in terms of B:C ratio (up to 4.25 in 2022–23).

- **Soil analysis at sowing and after harvest of marigold- chrysanthemum crop rotation**

The pH recorded at the time of sowing was within the normal range in all the treatments. Sodium adsorption ratio (SAR) was also present in all the collected soil samples, with values ranging between 5.9 and 10.8 $(mmol/l)^{1/2}$, whereas residual sodium carbonate (RSC) was not detected in any sample at sowing After the harvest of the crop, soil samples were collected and analyzed. The pH at harvest remained within the normal range (Table 2.32). SAR were present in all soil samples, but RSC was not detected in any sample.

Table 2.32 Soil analysis at harvest of chrysanthemum crop (2023-24)

Treatment	Soil Depth (cm)	ECe (dS m^{-1})	pH	Na (me/l)	Ca+Mg (me/l)	HCO_3 (me/l)	Cl (me/l)	SO_4(me/l)	SAR $(mmol/l)^{1/2}$
T_1-SW	0-15	4.1	7.8	24.2	16.8	8.7	16.2	16.1	8.4
	15-30	3.9	7.8	23.5	15.5	7.9	17.3	13.8	8.5
	30-60	3.7	7.8	23.3	13.7	9.8	11.8	15.4	8.5
	60-90	3.6	7.8	22.7	13.3	9.5	12.2	14.3	8.8
T_2-SW+RDF	0-15	4.2	7.8	27.1	14.9	10.5	10.6	18.9	9.9
	15-30	4.0	7.8	22.6	17.4	9.8	15.2	15.0	7.7
	30-60	3.6	7.8	21.7	14.3	10.0	13.6	12.4	8.1
	60-90	3.8	7.7	21.5	14.5	9.5	11.9	16.6	7.5
T_3-SW +50%RDF	0-15	4.1	7.8	24.1	16.1	9.6	13.2	18.2	8.3
	15-30	4.0	7.8	23.9	16.9	10.1	12.9	17.0	9.4
	30-60	4.2	7.8	26.2	15.8	10.7	10.8	20.5	9.3
	60-90	3.8	7.0	22.7	15.3	9.9	12.8	15.3	8.2
T_4-SW+75% RDF	0-15	3.8	7.8	25.6	12.4	10.5	11.8	13.7	9.9
	15-30	3.7	7.8	22.7	14.3	10.2	15.8	11.0	8.5
	30-60	4.0	7.8	22.8	13.2	10.0	15.5	14.5	7.8
	60-90	4.1	7.9	23.6	7.4	9.0	10.1	19.9	8.0
T_5-TW+RDF	0-15	4.3	7.9	31.7	11.3	9.8	12.8	20.4	13.3
	15-30	5.2	7.8	34.1	17.9	10.0	13.6	28.4	11.4
	30-60	4.0	7.8	31.2	8.8	9.8	11.9	18.3	14.9
	60-90	3.7	7.8	30.9	6.1	9.9	12.2	14.9	17.6
T_6-TW+ 75%RDF	0-15	4.3	7.8	32.1	10.9	10.9	15.5	16.6	13.8
	15-30	5.4	7.8	33.9	20.1	12.9	17.8	23.3	10.2
	30-60	4.2	7.8	32.7	9.3	12.7	18.2	13.1	15.2
	60-90	3.8	7.8	28.2	9.8	10.1	14.9	13.0	12.7
T_7-TW+125%RDF	0-15	4.2	7.8	30.5	11.5	10.2	14.1	17.7	12.8
	15-30	5.3	7.8	31.3	21.1	10.8	12.7	29.5	9.5
	30-60	4.1	7.8	30.8	10.2	10.1	15.3	15.6	13.6
	60-90	3.9	7.8	23.5	15.5	10.9	14.3	13.8	8.5
T_8-1SW:1TW +RDF	0.-15	3.8	7.8	28.6	9.4	10.7	12.2	15.1	13.2
	15-30	3.7	7.8	27.2	9.8	9.8	10.7	14.5	12.2
	30-60	4.0	7.7	31.2	8.8	10.9	11.1	18.1	15.4
	60-90	3.8	7.8	30.5	7.5	9.6	11.8	16.6	15.7

After harvesting of the chrysanthemum crop soil samples were collected at different depths (0-15, 15-30, 30-60, 60-90 cm) from all treatments and analyzed for different parameters. Soil EC_e was ranged between 3.8-4.3 dS m^{-1} at surface layer, pH was normal, Na ranged between 24.1-32.1 meq L^{-1}, Ca+Mg ranged between 9.4-16.9 meq/l, CO_3 was absent, chloride was ranged between 10.6-16.2 meq L^{-1}, sulphate ranged between 13.70-20.4 meq L^{-1}, and SAR was calculated and ranged between 8.3-13.8 $(mmol/l)^{1/2}$ at surface layer).

Irrigation water analysis

Sewage water samples were collected from the inlet of the sewage treatment plant at Bichpuri, Agra, during the pre-sowing irrigation period of marigold and chrysanthemum. The electrical conductivity of irrigation water (ECiw) was high in all samples, while the pH value was within the normal range (Table 2.33). The biochemical oxygen demand (BOD) was 172 mg L^{-1}. Bicarbonate levels increased in the winter season sample. Calcium was the dominant cation, while nitrate and sodium concentrations were higher in the chrysanthemum crop period sample. Residual sodium carbonate (RSC) was not detected, but the sodium adsorption ratio (SAR) was 14.6 $(mmol/L)^{1/2}$.

Treated sewage water samples were also collected from the outlet of the same sewage treatment plant during the chrysanthemum crop period. The ECiw remained high, and pH was within the normal range (Table 2.33). The BOD was 65.0 mg L^{-1}. Bicarbonate levels increased during the summer season. Calcium remained the dominant cation, and nitrate and sodium levels were higher during the crop growth period. RSC was not detected in any sample, while SAR was 13.8 $(mmol/L)^{1/2}$.

Table 2.33 Irrigation water analysis of sewage and tube well water (2023-24)

Parameters	Sewage water inlet		Sewage water outlet		Tube well water	
	Marigold	Chrysanthemum	Marigold	Chrysanthemum	Marigold	Chrysanthemum
pH	8	8	8	8	8	8
EC_{iw} (dS/m)	2	2	2	3	3	3
BOD (mgL^{-1})	169	172	50	65	-	-
COD (mgL^{-1})	210	215	99	122	-	-
CO_3 (mgL^{-1})	17.8	22	12	18	-	-
HCO_3 (mgl-^{1})	516	535	490	586	1109	1109
Cl (mgL^{-1})	481	493	412	421	507	507
SO_4 (mgL^{-1})	508	566	471	508	710	710
NO^3 (mgL^{-1})	13	16	14	13	-	-
Ca (mgL^{-1})	294	293	275	290	337	337
Mg (mgL^{-1})	202	211	189	198	165	165
Na (mgL^{-1})	212	220	179	205	343	343
K (mgL^{-1})	13	13	15	13	-	-
SAR$(mmol/L)^{1/2}$	13	15	13	14	15	15

- **Effects of fluoride in irrigation water on yield and quality of brinjal (Poly house study) (Bathinda)**

In order to study the effects of fluoride concentrations in irrigation water on yield and quality of brinjal, an experiment was conducted during 2023 and 2024 in poly house, with two varieties namely PBH-4 (Long Fruited) and PBHR-42 (Oblong fruited). The plants established in pots (10 kg capacity) were irrigated with water having 0.12, 2.0, 4.0, 6.0, 8.0 and 10.0 mg L^{-1} concentration of fluoride. However, during the plant establishment, tap water (0.12 mg F/L) was used. After establishment, pots were irrigated twice in a week and provided one litre water/ pot in each irrigation. A total of 24 liters water per pot were applied during entire crop growing period. The observation on yield/plant and fluoride content in leaf and fruit were recorded, whereas, soil parameters were recorded after uprooting the plants (Table 2.34).

Table 2.34 Yield and fluoride content in brinjal leaf and fruit under varying fluoride concentration in irrigation water (Polled of 2023–2024)

A-Variety	Yield (kg/plant)	leaf-F (mg/kg)	fruit-F (mg/kg)
PBH-4	1.13	0.041	0.40
PBHR-42	1.25	0.033	0.33
CD ($p \leq 0.05$)	0.03	0.001	0.012
F content (mg F/l)			
0.12	1.28	0.031	0.31
2.0	1.25	0.032	0.32
4 .0	1.22	0.033	0.34
6.0	1.19	0.036	0.36
8.0	1.13	0.040	0.40
10.0	1.09	0.051	0.49
CD ($p \leq 0.05$)	0.05	0.002	0.021
A×B ($p \leq 0.05$)		0.003	0.029

Among the variety, PBHR-42 produced significantly higher yield as compared to PBH-4, which was varieties attributes of the crop (Table 2.35). However, PBH-4 contained significantly higher fluoride content in leaf as well as in fruit, but the accumulated concentration was found within the safe limit (≤ 1.0 ppm).

Table 2.35 Effect of soil parameters irrigated with varying amount of fluoride content in irrigation water.

A- Variety	pH (1:2)	EC (1:2)	OC (%)	P_2O_5 (kg/ha)	K_2O (kg/ha)	DWEF* (kg/ha)
PBH-4	8.38	0.43	0.39	13.17	283.66	2.20
PBHR-42	8.38	0.38	0.39	13.93	283.87	1.77
CD ($p \leq 0.05$)	NS	0.13	NS	0.33	NS	0.064
F content (mg F/l)						
0.12	8.22	0.32	0.34	14.86	307.26	1.04
2.0	8.29	0.35	0.35	14.72	301.44	1.18
4 .0	8.37	0.39	0.39	13.97	289.13	1.81
6.0	8.42	0.42	0.41	13.22	183.24	2.21
8.0	8.47	0.45	0.41	12.54	263.49	2.68
10.0	8.49	0.48	0.41	11.97	258.04	2.97
CD ($p \leq 0.05$)	NS	0.22	0.02	0.57	12.71	0.11
A×B ($p \leq 0.05$)			0.22			0.16

**DWEF- Distilled water extractable fluoride*

Results also indicate that increasing F concentration in irrigation water reduced yield significantly as compared to control. The F content in leaf and fruits was also higher in the treatments having increasing level of F in irrigation as compared to the control. The F content in brinjal leaf and fruit significantly affected due to interaction of variety and F concentration in irrigation water. Table 2.30 indicates that fluoride content in irrigation water influenced significantly to studied parameters except pH of soil as compared to control (0.12 mgF/L). The distilled water extractable fluoride content in soil was found significantly higher in variable F concentrated irrigation as compared to control.

3. MANAGEMENT OF IRRIGATION INDUCED SALINIZATION AND ALKALINIZATION

3.1 Management of Irrigation Induced Alkali Soils

- **Management of Sodic Vertisols through Conjunctive use of Gypsum and Gliricidia sepium under Paddy-Wheat Cropping System (Indore)**

A field investigation was started with aim to study the effect of gypsum and Gliricidia green leaves on physico-chemical properties of sodic Vertisols and rice performance. The experiment was initiated during 2023-24 with paddy as test crop (CSR-10) followed by wheat (HI-1544). The initial pH, EC and ESP of the experimental soils were 8.62 ,1.96 dSm^{-1} and 31.2, respectively. Three doses (Gyp 0%, Control; Gyp 50%: Gypsum 50% GR and Gyp 75%: Gypsum 75% GR) of gypsum was taken in main plots and three levels of *Gliricidia sepium* leaves (Gly 0 t/ha: Control, Gly 5 t/ha*: Gliricidia sepium@* 5 t/ha and Gly 10 t/ha: *Gliricidia sepium@* 10 t/ha) were taken in subplot. The experiment was laid in split plot design in a plot size of 10 x 5.5 m. The different doses of gypsum and *Gliricidia sepium* leaves were applied in *kharif* season at 15 days before paddy transplanting. Growth and yield parameters of paddy and wheat were recorded and soil samples were also taken to know the soil properties before and after paddy.

The data presented in Table 3.1 indicate that neither gypsum nor Gliricidia sepium leaves had a significant effect on soil pH and electrical conductivity (ECe). The highest soil pH (8.25) was observed in the treatment without gypsum (GR 0%), followed by the GR 50% treatment (8.16). however, Soil pH reduced significantly under Gyp 75% treatment. No significant different in soil pHs was recorded with different levels of Gliricidia sepium leaves. The maximum ECe value (1.27 dS/m) was recorded under the treatment with no gypsum and no Gliricidia application (0 t/ha). The lowest ECe (1.09 dS/m) occurred with the combined application of Gliricidia at 10 t/ha and GR at 75%. Exchangeable Sodium Percentage (ESP) was significantly affected by gypsum application. The lowest mean ESP value (27.4) was found in GR 75% treatment, whereas the highest mean ESP (31.62) was observed in the control treatment. ESP decreased as gypsum rates increased in combination with Gliricidia application. Organic carbon content (%) was significantly influenced by Gliricidia application and the highest organic carbon (0.50%) was recorded with the combined use of Gliricidia at 10 t/ha and gypsum at 75%.

The data on growth parameters and yield attributed are presented in Table 3.2. The results indicated that plant height, panicle length, as well as grain and straw yields of paddy were significantly influenced by the application of different levels of gypsum and Gliricidia sepium leaves during the experiment. The highest plant height (78.7 cm), number of tillers per plant (12.5), panicle length (19.8 cm), paddy yield (4088 kg ha^{-1}), and straw yield (5060 kg ha^{-1}) were observed with the combined treatment of 75% gypsum rate (GR 75%) and Gliricidia at 10 t/ha. This was followed by the treatment with 50% gypsum rate (GR 50%) and Gliricidia at 10 t/ha. The lowest values for all parameters were recorded in the control treatment.

Table 3.1 Effect of different treatments on soil pH, ECe, ESP and organic carbon (OC)

Treatments	**Gypsum application**			
	GR 0%	**GR 50%**	**GR 75%**	Mean
pHs				
Gliricidia– 0 t/ha	8.28	8.19	8.02	8.16
Gliricidia– 5 t/ha	8.27	8.13	7.98	8.12
Gliricidia– 10 t/ha	8.19	8.15	8.00	8.11
Mean	**8.25**	**8.16**	**8.00**	
	GYP	***GLY***	***GYP x GLY***	
SEm (±)	0.03	0.03	0.05	
CD 5%	0.11	NS	NS	
ECe (dS/m)				
Gliricidia– 0 t/ha	1.36	1.22	1.19	1.25
Gliricidia– 5 t/ha	1.23	1.17	1.12	1.17
Gliricidia– 10 t/ha	1.21	1.14	1.09	1.14
Mean	**1.27**	**1.17**	**1.13**	
	GYP	***GLY***	***GYP x GLY***	
SEm (±)	0.02	0.01	0.02	
CD 5%	0.06	0.04	NS	
ESP				
Gliricidia– 0 t/ha	32.15	28.89	26.78	29.27
Gliricidia– 5 t/ha	31.60	29.37	26.46	29.14
Gliricidia– 10 t/ha	31.11	28.36	26.34	28.60
Mean	31.62	28.87	26.53	
	GYP	***GLY***	***GYP x GLY***	
SEm (±)	0.01	0.01	0.01	
CD 5%	0.02	0.02	0.04	
Organic carbon (%)				
Gliricidia– 0 t/ha	0.32	0.35	0.33	0.33
Gliricidia– 5 t/ha	0.40	0.41	0.40	0.40
Gliricidia– 10 t/ha	0.45	0.49	0.50	0.48
Mean	**0.39**	**0.42**	**0.41**	
	GYP	**GLY**	**GYP x GLY**	
SEm (±)	0.00	0.01	0.01	
CD 5%	0.02	0.02	NS	

Table 3.2 Growth yield and yield attributes of paddy as influenced by different doses of Gypsum and Gliricidia sepium leaves

Treatments	Gypsum application			
	GR 0%	**GR 50%**	**GR 75%**	**Mean**
Plant height (cm)				
Gliricidia– 0 t/ha	61.2	65.3	76.1	67.5
Gliricidia– 5 t/ha	63.9	65.9	79.1	69.6
Gliricidia– 10 t/ha	65.1	67.2	80.8	71.1
Mean	63.4	66.1	78.7	
	GYP	GLY	GYP x GLY	
SEm (±)	0.26	0.31	0.53	
CD 5%	1.01	0.95	NS	
SEm (±)	0.01	0.01	0.02	
CD 5%	0.03	0.04	0.07	
Panicle length (cm)				
Gliricidia– 0 t/ha	15.8	17.7	19.5	17.7
Gliricidia– 5 t/ha	16.5	17.8	19.8	18.1
Gliricidia– 10 t/ha	16.8	17.9	20.0	18.3
Mean	16.4	17.8	19.8	
	GYP	GLY	GYP x GLY	
SEm (±)	0.02	0.02	0.04	
CD 5%	0.07	0.07	0.11	
Paddy yield (kg/ha)				
Gliricidia– 0 t/ha	3265	3826	4079	3723
Gliricidia– 5 t/ha	3567	3868	4122	3852
Gliricidia– 10 t/ha	3608	3925	4063	3865
Mean	3480	3873	4088	
	GYP	GLY	GYP x GLY	
Straw yield (kg/ha)				
Gliricidia– 0 t/ha	4555	4904	5011	4824
Gliricidia– 5 t/ha	4300	4967	5166	4811
Gliricidia– 10 t/ha	4632	5152	5004	4929
Mean	4496	5008	5060	
	GYP	GLY	GYP x GLY	
SEm (±)	20.27	6.61	11.45	
CD 5%	79.58	20.37	35.29	

3.2 Management of Induced Waterlogged Saline Soils and Coastal Saline Soils

- **Evaluation of different depth (head) of controlled drainage system in vertisols of TBP command (Gangawathi)**

The field experiment on controlled drainage system with different operating depth (head) was continued till *kharif* 2023 season and the observations pertaining to drainage discharge, drainage water salinity, salt output, irrigation water applied, paddy grain yield etc. were recorded. The experimental treatments were Conventional SSD (CNV_SSD), Controlled SSD with 0.3 m height (CSSD_0.3), Controlled SSD with 0.6 m height (CSSD_0.6) and Controlled SSD with root zone 0.7m height (CSSD_RZ_0.7)

Temporal changes in drainage discharge and drainage water salinity: The drain discharge was collected from the outlet of each treatment during *Kharif*-2023 and its volume as well as salinity was measured. The average drain discharge was highest (1.35 mm d^{-1}) for the CNV_SSD and continuously decreased in controlled CSSD with increase in height of raiser pipe. In case of drainage water salinity, average of four-season data indicated that, salinity of the effluent was higher with higher rate of drainage discharge under CNV_SSD as compared to other three variable CSSD systems. Based on drainage water outflow and drainage water salinity, salt removal patterns for CNV_SSD and variable CSSD system were calculated. Due to higher discharge and salinity, salt removal was highest (6.62 t ha^{-1}) for CNV_SSD and continuously decreased in CSSD with increase in height of raiser pipe.

Nitrate-Nitrogen (NO_3-N) losses through drainage system: The NO_3-N losses in drainage effluent were estimated in mg L^{-1} as well as kg ha^{-1} and it was highest for the CNV_SSD (average value of 7.56 mg L^{-1} and 6.97 kg ha^{-1}) and continuously decreased in CSSD with increase in height of raiser pipe.

Grain yield

Slightly higher grain yields (Table 3.3) were observed under CNV_SSD as compared to CSSD with 0.3 m height. However, grain yield was considerably lower in other CSSD system with lower salt removal.

Table 3.3 Grain yield (t ha^{-1}) under conventional and other variable controlled SSD systems

Season	CNV_SSD	CSSD_0.3	CSSD_0.6	CSSD_RZ_0.7)
Initial	3.15	3.04	3.18	3.31
Kharif-2020	4.53	4.35	4.15	3.87
Kharif-2021	6.35	6.02	5.67	5.51
Kharif-2022	5.54	5.03	4.85	4.31
Kharif-2023	6.36	5.48	5.31	5.10
% Increase over initial	102.0	80.3	67.0	54.0

- **Enhancing water use efficiency in reclaimed waterlogged saline Vertisols by implementation of subsurface drainage system (Gangavathi)**

The experiment consisted of the following treatments

i) T_1: Conventional drainage (CNV) during *kharif* season with continuous flooding (CF) irrigation

ii) T_2: Conventional drainage (CNV) during *kharif* season with Alternative wetting and drying (AWD)

iii) T_3: T_{-1} + Apply Controlled SSD during fertilizer application (for 12-15 days) only

iv) T_4: T-$_2$ + Apply Controlled SSD during fertilizer application (for 12-15 days) only

During the cropping season, observations were made on drain discharge (mm/day), drainage water salinity, salt output, and irrigation water applied in these systems.

Temporal changes in soil salinity

The soil salinity (Table 3.4) at the end of season revealed that in general, it is within the threshold level (< 4 dS m^{-1} for non-saline and 6-8 dS m^{-1} for puddle transplanted condition) for paddy except slightly higher EC levels at lower depths during *Rabi/summer* season could be due to accumulation of salts at lower depths due alternate wet and dry method of irrigation.

Table 3.4 Soil salinity (ECe, dSm^{-1}) at different soil depths as influenced by different irrigation regimes under conventional and controlled SSD system

Season	Continuous flooding (CF)				Alternative wetting and drying method (AWD)			
	Depth (cm)				Depth (cm)			
	0-15	15-30	30-60	60-90	0-15	15-30	30-60	60-90
Initial	2.78	2.32	4.41	3.26	1.65	2.20	5.11	8.25
Kharif-20	1.36	1.91	2.58	2.45	1.53	2.56	5.63	7.73
R/S-20-21	1.80	2.48	3.07	3.52	1.66	2.41	4.84	6.82
Kharif-21	1.92	2.27	3.31	4.01	1.45	1.37	3.99	6.80
R/S-21-22	2.55	2.96	6.43	6.47	1.79	2.28	3.97	3.19
Kharif-22	2.22	2.70	4.70	5.69	2.09	2.12	2.69	1.99
R/S-22-23	2.67	2.61	8.05	8.50	2.23	3.53	5.05	3.54
Kharif-23	1.84	2.42	3.24	2.75	2.40	3.70	7.48	5.93

Temporal changes in drainage discharge, drainage water salinity, salt removed, and nitrate-nitrogen losses

The drainage discharge, drainage water salinity, salt removal, and nitrate-nitrogen losses of seven seasons from *Kharif*-20 to *Kharif*-23 is given in Table 3.5. The data indicated that the drain discharge was higher in case of conventional SSD with CF method of irrigation as compared to AWD method of irrigation system. In case of drainage salinity, under conventional SSD with CF method of irrigation gave higher salinity effluent concentration than conventional SSD with AWD. However, in both the treatment during fertiliser application adopting controlled SSD gave higher salinity effluent concentration than another period. During R/S season, not much variation was observed with CF or AWD method of irrigation when both the plots had controlled SSD system and the values were like that of kharif seasons. It was observed that, conventional SSD with CF method of irrigation removed higher salt than conventional SSD with AWD. Also, under conventional SSD with CF method of irrigation higher nutrient loss was observed than conventional SSD with AWD. Shallow water table was maintained under conventional SSD with AWD method of irrigation maintain than conventional SSD with CF.

Table 3.5 Drainage discharge (D_D), drainage water salinity (D_{WS}), Salt removes, nitrate-nitrogen (NO_3-N) loss and depth to water table as influenced by different irrigation regime under conventional and controlled SSD system.

Season	Parameter	Treatment					
		CF	CF-CDF	CF-CD	AWD	AWD-CDF	AWD-CD
Kharif-2020	D_D, mm d^{-1}	1.03	0.64	-	1.89	1.77	-
	D_{WS}, dS m^{-1}	0.68	0.46	-	1.74	1.73	-
	Salt Removed, t ha^{-1}	1.35	0.44	-	1.04	0.29	-
	NO_3-N, kg ha^{-1}	4.30	1.40	-	3.80	0.87	-
	Water table, cm	12.40	6.70	-	13.4	8.00	-
R-S-2020/21	D_D, mm d^{-1}	-	-	0.58	-	-	0.44
	D_{WS}, dS m^{-1}	-	-	2.38	-	-	2.08
	Salt Removed, t ha^{-1}	-	-	0.35	-	-	0.20
	NO_3-N, kg ha^{-1}	-	-	3.30	-	-	2.60
	Water table, cm	-	-	7.50	-	-	9.00
Kharif-2021	D_D, mm d^{-1}	1.11	0.25	-	2.47	2.66	-
	D_{WS}, dS m^{-1}	0.62	0.12	-	2.41	2.79	-
	Salt Removed, t ha^{-1}	1.80	0.35	-	1.10	0.20	-
	NO_3-N, kg ha^{-1}	3.90	1.21	-	3.05	0.53	-
	Water table, cm	13.90	5.40	-	12.80	6.10	
R-S-2021/22	D_D, mm d^{-1}	-	-	0.61	-	-	0.56
	D_{WS}, dS m^{-1}	-	-	2.40	-	-	2.44
	Salt Removed, t ha^{-1}	-	-	0.49	-	-	0.50
	NO_3-N, kg ha^{-1}	-	-	2.30	-	-	2.13
	Water table, cm	-	-	7.00	-	-	7.50
Kharif-2022	D_D, mm d^{-1}	1.41	0.73	-	2.54	2.80	-
	D_{WS}, dS m^{-1}	1.26	0.64	-	2.10	2.43	-
	Salt Removed, t ha^{-1}	0.95	0.34	-	0.71	0.26	-
	NO_3-N, kg ha^{-1}	4.16	1.56	-	1.56	1.14	-
	Water table, cm	14.90	6.40		13.60	5.80	
R-S-2022/23	D_D, mm d^{-1}	-	-	0.26	-	-	0.24
	D_{WS}, dS m^{-1}	-	-	2.67	-	-	2.93
	Salt Removed, t ha^{-1}	-	-	0.19	-	-	0.24
	NO_3-N, kg ha^{-1}	-	-	1.20	-	-	1.08
	Water table, cm	-	-	7.40	-	-	7.90
Kharif-2023	D_D, mm d^{-1}	1.34	0.58	-	1.15	0.49	-
	D_{WS}, dS m^{-1}	2.38	2.74	-	2.23	2.18	-
	Salt Removed, t ha^{-1}	1.65	0.43	-	0.98	0.37	-
	NO_3-N, kg ha^{-1}	5.40	1.15	-	4.15	0.98	-
	Water table, cm	14.80	7.20	-	13.90	6.40	

Crop Yield and Irrigation water applied

The grain yield was increased from 5.80 to 6.8 t ha^{-1} under CF method of irrigation (Table 3.6). Similarly, under AWD method of irrigation system grain yield was increased from 5.04 to 5.90 t ha^{-1}. The per cent increase was slightly higher under CF (16%) compared to AWD (14%). Seasonal water balance of the study area worked out during both Rabi-summer 2022-23 and Kharif-23 by considering the quantity of irrigation water applied for paddy crop including rainfall under CF method of irrigation was 103 and 97 cm and under AWD method of irrigation system it was 132 and 107 cm. The results indicated that, during both Rabi-summer and Kharif, AWD method of irrigation system could save 17.8 (13%) and 19.9 cm (14%) of irrigation than CF method of irrigation.

Table 3.6 Crop yield (t ha^{-1}) as influenced by different irrigation regime under conventional and controlled SSD system over the seasons

Season	CF		AWD		Saving of water, cm
	Grain yield (t ha^{-1})	Depth of irrigation (cm)	Grain yield (t ha^{-1})	Depth of irrigation (cm)	
Initial (*Kharif*-19)	5.80	147.5	5.04	129.5	18.0
Kharif-2020	6.15	138.4	5.46	110.5	27.9
R/S-20-21	6.40	154.1	5.61	132.4	21.7
Kharif-21	6.70	125.0	5.75	105.0	15.0
R/S-21-22	6.60	115.0	5.70	100.0	10.0
Kharif-22	6.90	102.8	5.87	97.2	5.60
Kharif-23	6.80	132	5.90	107.0	25.0

- **Feasibility of drip irrigation in puddled transplanted rice (PTR) under saline vertisols of TBP Command Area, Karnataka (Gangawathi)**

Traditionally, paddy-paddy cropping system is a common practice followed in TBP command area over the decades and grown under puddled transplanted conditions Cultivation of puddle transplanted rice (PTR) in up-reach (close to reservoir) areas of the command over the years has led to water logging and secondary salinization problems and simultaneously shortage of irrigation water for mid-and tail-end areas of TBP command. Drip irrigation can reduce irrigation application losses drastically and help in controlling waterlogging and soil salinity, particularly in mid and down-stream areas of the command in the long term, if adopted on a large scale. Hence, field experiment on “Feasibility of drip irrigation in puddled transplanted rice (PTR) under saline Vertisols of TBP command area, Karnataka” for the assessment of drip irrigation induced changes in soil moisture content, soil salinity and their influence on growth and yield of transplanted paddy was continued during *kharif*-2023 at Agricultural Research Station, Gangavathi.

The experiment consisted of treatments *viz.,* paddy varieties (Gangavathi sona-M_1 and Tungabhadra sona-M_2) as main plot and different ET based irrigation levels as sub-plot treatments (I_1: 1.2, I_2:1.4, I_3:1.6 and I_4:1.8 ET) in a split-plot design with four replications each. During *kharif*-2023, the total rainfall received was 332.0 mm which was about 39% less than the long-term average rainfall of the station and about 104.0 mm was received over the cropping season. Hence, to meet the crop water requirement the total number of drip events as and when required was 14 times over the cropping season during *kharif*-2023.

Depth of irrigation and total crop water consumption under different ET levels over the cropping season

The amount of irrigation water applied under different irrigation levels (ET level) during *kharif-2023* is presented in Table 3.7. The total crop water consumption includes depth of irrigation through drip irrigation under different ET levels, water requirement for land preparation for transplanting and the actual rainfall received during the cropping season. The depth of irrigation given under different ET levels and total crop water consumption during *kharif*-2023 varied from 25.31(I_1) to 37.96 cm(I_4) and 65.71 (I_1)

to 78.36 cm(I_4) respectively with saving of nearly 45.24(I_1) to 34.70%(I_4) of total crop water consumed at different ET levels compared farmers' practice (120 cm). The potential water saving under drip irrigation was mainly due to ET based irrigation scheduling which leads to reducing seepage, percolation, less water evaporation losses thus increasing the capacity to capture rainfall.

Table 3.7 : Depth of irrigation and total crop water consumption under different ET levels during *Kharif*-2023

Irrigation Levels(ET)	Depth of irrigation based on ET levels (cm)	Water requirement for Puddling operations (cm)	Rainfall during cropping season (cm)	Total water consumed (cm)	Total water Saving over farmers' practice (%)
1	2	3	4	5 (2+3+4)	6
I_1-1.2 ET	25.31			65.71	45.24
I_2-1.4 ET	29.52	30.00	10.40	69.92	41.73
I_3-1.6 ET	33.74			74.14	38.22
I_4-1.8 ET	37.96			78.36	34.70

Note: *Total crop water requirement under traditional farmers' practice is about120 cm.*

Measurements on depth to water table was done by using observation wells installed in each of the plots, over six times at about 7- 10 days interval during the cropping season *kharif*-2023 (Table 3.8). Data indicated that, there was no significant difference between the two paddy varieties and the depth to the water table varied from 5.29 to 18.25. With respect to sub-plot treatments, significant differences were observed among different ET levels at all the dates of sampling. The average depth to water table was significantly shallower under 1.8 ET (8.92 cm) compared rest of the ET levels. Interaction effect was non-significant. Compared to experimental plots, the depth to water table measurement over the cropping season was much shallower in the general paddy fields around the experimental field. There were fluctuations in depth to water table over the cropping season at all the treatments with respect to drip irrigation events and amount of rainfall received. Depth to the water table was shallower when the drip irrigation events were performed or rainfall received and it was deepened when there was no rainfall or drip events were performed due to high evaporation coupled with lower rainfall. In terms of different ET levels, applied irrigation at 1.8 ET levels had a shallow water table and deeper water table in the case of applied irrigation at 1.2 ET level. This might be seen as a local impact caused by minimal percolation losses. This indicates that drip irrigation at different ET levels has the potential to influence water table behavior to a certain extent by enhancing the effectiveness of irrigation water utilization. It is generally known fact that shallower the depth to water table, greater will be chance that soils could become salinized in due course of time. Thus, deeper depth to water table under different ET levels compared to the general surrounding paddy fields could help to minimize or prevent waterlogging followed by secondary salinization in TBP command area provided large area is put in to drip irrigation for paddy cultivation as in the case of present investigation. It is noteworthy to understand that in the process of reclamation of waterlogged saline soils, lowering of depth to water table through either surface and/or subsurface drainage system are the common approach practiced in the irrigation command areas.

Table 3.8 Temporal variations in depth to water table (cm) as influenced by paddy varieties and different ET levels during *Kharif*-2023

Treatment	Depth to water table, cm (bgl)						Avg. depth to Water table(cm) over the season
	26.09.23	05.10.23	12.10.23	19.10.23	30.10.23	06.11.23	
	Main plot(M)						
M_1	18.25	15.18	11.24	7.49	6.94	5.67	10.77
M_2	16.75	14.93	10.82	7.19	6.39	5.29	10.20
S.Em.±	0.37	0.45	0.55	0.36	0.31	0.16	0.19
C.D.at 5%	NS	NS	NS	NS	NS	NS	NS
	Subplot (I)						
I_1	18.25	16.53	14.70	9.10	8.19	6.84	12.14
I_2	17.74	15.40	11.24	7.74	6.84	6.21	10.81
I_3	17.09	14.85	9.76	6.78	6.65	5.20	10.06
I_4	16.93	13.43	8.41	5.74	5.00	3.68	8.92
S.Em.±	0.34	0.50	0.47	0.40	0.31	0.28	0.12
C.D.at 5%	1.00	1.50	1.41	1.19	0.91	0.82	0.35
	Interaction(M×I)						
M_1I_1	18.96	16.40	14.78	9.50	8.50	7.33	12.39
M_1I_2	18.20	15.38	11.23	7.73	7.03	6.25	11.00
M_1I_3	18.00	14.95	10.23	6.90	7.20	5.43	10.48
M_1I_4	17.83	13.98	8.73	5.83	5.05	3.68	9.21
M_2I_1	17.53	16.65	14.63	8.70	7.88	6.35	11.89
M_2I_2	17.27	15.43	11.25	7.75	6.65	6.18	10.63
M_2I_3	16.17	14.75	9.30	6.65	6.10	4.98	9.64
M2I4	16.03	12.88	8.10	5.65	4.95	3.68	8.64
S.Em.±	0.48	0.71	0.67	0.56	0.43	0.39	0.17
C.D.at 5%	NS	NS	NS	NS	NS	NS	NS
General plot	1.0	2.0	2.8	3.0	33.8	2.6	2.53

Note: Main plot (M): Paddy varieties: M1: GVT-05-01 and M2: GNV - 1801; Subplot (I): Drip irrigation levels (Based on ET): I1:1.20, I2:1.40, I3:1.60 and I4:1.80 ; Bgl- Below ground level

Temporal changes in pH and EC of perched and irrigation water over the growing season as influenced by paddy varieties and different ET levels in different cropping seasons

Water samples from each of the observation wells (perched water) and irrigation water (canal water) were collected six times at 7-11 days intervals over the cropping season *kharif*-2023 revealed that the pH of canal water ranged from 7.90 -8.12 with average value of 8.00 (Table 3.9). Within the variety at different ET levels, pH of perched water varied from 6.98 to 7.66, 7.06 to 7.77, 7.07 to 7.72 and 6.96 to7.78 with an average of 7.32, 7.38, 7.36 and 7.35 at I_1, I_2, I_3 and I_4 under M_1 variety (Table 3.9). Similarly, 7.06 to 7.77, 7.18 to7.74, 6.96 to 7.71 and 7.05 to 7.83 with an average of 7.39, 7.39, 7.34 and 7.39 at I_1, I_2, I_3 and I_4 under M_2 variety, respectively. Irrespective of levels of irrigation and varieties, pH showed a declining trend with the progress of the season. However, the average pH of perched water reveals that the values did not vary much between the varieties and among different irrigation levels. The soluble salt content (EC) of canal water (irrigation water) ranged from 0.23-0.41dS m^{-1} with an average value of 0.30 dS m^{-1} over the cropping season. Irrespective of levels of irrigation and varieties, generally no specific trend was observed over the cropping season. As per the classification of irrigation water by Richards (1968), salinity of perched water analyzed over the season fall under category C3 (EC 0.75 to 2.25 dS m^{-1}) *i.e.,* high salinity and C4 (EC >2.25 dS m^{-1}) *i.e.,* very high salinity.

Table 3.9. Temporal variations in perched water pH and EC (dS m^{-1}) over the growing season as influenced by paddy varieties and different ET levels during *Kharif*-2023

Treatm-ent	26.09.23		05.10.23		12.10.23		19.10.23		30.10.23		06.11.23		Average over the season	
	pH	EC	pH	EC	pH	EC	p	EC	pH	EC	pH	EC	pH	EC
M_1I_1	7.66	2.2	7.4	2.0	7.1	1.7	7.4	2.7	7.2	2.5	6.9	2.15	7.32	2.2
M_1I_2	7.77	2.2	7.5	2.1	7.3	1.7	7.3	2.51	7.21	2.33	7.06	1.98	7.38	2.1
M_1I_3	7.72	2.43	7.44	2.40	7.26	1.80	7.40	2.83	7.31	2.57	7.07	2.43	7.36	2.41
M_1I_4	7.78	2.11	7.48	1.65	7.28	1.80	7.48	2.57	7.15	2.46	6.96	2.06	7.35	2.11
M_2I_1	7.77	1.90	7.52	1.71	7.31	1.51	7.50	2.83	7.21	2.40	7.06	2.01	7.39	2.06
M_2I_2	7.74	1.84	7.45	2.13	7.32	1.73	7.41	2.49	7.26	2.29	7.18	2.06	7.39	2.09
M_2I_3	7.71	1.72	7.42	1.66	7.32	1.51	7.45	2.41	7.20	2.38	6.96	2.12	7.34	1.96
M_2I_4	7.83	2.48	7.44	1.83	7.29	1.32	7.43	2.14	7.33	2.14	7.05	2.03	7.39	1.99
Canal water	8.12	0.23	7.96	0.24	8.07	0.23	7.98	0.41	7.96	0.32	7.90	0.35	8.00	0.30

Soil moisture content at different crop growth stages as influenced by paddy varieties and different ET levels in different cropping seasons

Surface (0-15 cm) and subsurface (15-30 cm) soil samples were collected at active tillering, panicle initiation and at crop harvest and analyzed gravimetrically for changes in soil moisture content as influenced by paddy varieties and different irrigation levels during *kharif*-2023. The data (Table 3.10) revealed that paddy varieties didn't differ significantly with respect to percent soil moisture content. However, soil moisture content was slightly higher under paddy variety GNV-1801(M_2) with values of 45.2,45.9 and 12.70 (%) in surface (0-15 cm) soil and 45.1, 50.1 and16.2(%) in sub-surface (15-30 cm) soil at active tillering, panicle initiation and harvest stage respectively compared to GVT- 05-01 (M_1) wherein soil moisture content was 41.1, 40.5 and 11.5 (%) in surface soil and 43.3,46.4 and13.5(%) in sub-surface soil at active tillering, panicle initiation and harvest stage, respectively.

Understanding how to control soil moisture is crucial for maximizing irrigation effectiveness because it enables the delivery of water in the correct amount and at the right time which intern helps in reducing soil salinity. Irrespective of the paddy varieties and levels of irrigation applied at different ET's, percent soil moisture content showed an increasing trend up to panicle initiation stage and thereafter decreased towards harvest of the crop during the cropping season.

Table 3.10 Influence of paddy varieties and different ET levels on soil moisture content at different crop growth stages during *Kharif*-2023

Treatment	Soil moisture content (%)					
	Active tillering stage		Panicle Stage		Harvest	
	0-15	15-30	0-15	15-30	0-15	15-30
			Main-plots (M)			
M_1	41.08	43.28	40.49	46.36	11.54	13.55
M_2	45.18	45.08	45.92	50.11	12.70	16.19
S.Em.±	2.76	1.21	2.01	3.06	0.37	0.59
C.D.at 5%	NS	NS	NS	NS	NS	NS
			Sub-plots (I)			
I_1	39.72	39.20	38.69	43.31	9.98	12.79
I_2	42.04	43.06	42.35	46.85	11.63	14.23
I_3	43.37	45.68	44.37	49.00	13.02	15.77
I_4	47.39	48.79	47.42	53.79	13.85	16.70
S.Em.±	1.81	2.17	1.93	2.41	0.61	0.96
C.D.at 5%	5.37	6.44	5.72	7.16	1.80	2.84
			Interaction (M X I)			
M_1I_1	36.69	38.66	37.93	42.18	9.85	12.14
M_1I_2	39.69	41.78	39.20	44.20	11.00	13.25
M_1I_3	41.58	45.24	41.37	46.87	12.11	14.11
M_1I_4	46.38	47.44	43.47	52.21	13.21	14.71
M_2I_1	42.74	39.74	39.45	44.45	10.11	13.44
M_2I_2	44.40	44.34	45.49	49.49	12.26	15.22
M_2I_3	45.16	46.11	47.38	51.13	13.93	17.43
M_2I_4	48.41	50.14	51.38	55.38	14.50	18.70
S.Em.±	2.56	3.07	2.72	3.41	0.86	1.35
C.D.at 5%	NS	NS	NS	NS	NS	NS

Temporal changes in soil pH and soil salinity at different crop growth stages as influenced by paddy varieties and different ET levels in different cropping seasons

Surface (0-15 cm) and subsurface (15-30 cm) soil samples collected at active tillering and panicle initiation and harvest stages of the crop were analyzed for changes in pH, ECe and time weighted mean salinity (TWMS) as influenced by different paddy varieties and different ET levels during *kharif*-2023. The data revealed that irrespective of the paddy varieties and irrigation treatments, soil pH decreased slightly from initial (8.30) up to panicle initiation stage and then increased slightly towards harvest both at surface soil (0-15 cm) and sub-surface (15-30 cm) soil (Table 3.11). Soil pH was generally higher at sub-surface soil compared to surface soil. Similar to varieties, there was no significant differences among the irrigation levels (ET) levels in soil pH. Interaction effect between paddy varieties and irrigation at different ET levels was non- significant on soil pH. The relevant data on soil salinity (ECe) across the growth stages of paddy as influenced by paddy varieties and irrigation at different ET levels during *kharif*-2023 revealed that irrespective of paddy varieties and drip irrigation at different ET levels, ECe values declined from its initial level (5.90 at 0-15 cm and 6.78 dS m^{-1} at 15-30cm) to active tillering, from active tillering to panicle initiation stage and increased from panicle initiation stage to harvest stage both at surface (0-15 cm) and sub-surface (15-30 cm) depths respectively. The capillary flux from the shallow and saline water table seems to have to evaporation and re-salinization of soils at harvest thus increasing soil salinity levels compared to earlier crop growth stages as there will be withdrawal of irrigation water 10-15 days prior to harvest.

Table 3.11 Influence of paddy varieties and different ET levels on soil pH and salinity (ECe) at different crop growth stages during *Kharif*-2023

Treatment	Soil pH and ECe (dSm^{-1}) Active tillering stage				Panicle Initiation Stage				Harvest			
	Depth (cm)				Depth (cm)				Depth (cm)			
	0-15		15-30		0-15		15-30		0-15		15-30	
	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC	pH	EC
	Main-plot (M)											
M_1	7.77	2.74	7.92	5.80	7.74	1.78	7.88	5.57	7.93	3.64	8.11	6.13
M_2	7.72	2.61	7.89	5.67	7.62	1.62	7.86	5.50	7.89	3.59	8.04	6.09
S.Em.±	0.10	0.11	0.07	0.18	0.03	0.08	0.05	0.17	0.03	0.07	0.02	0.13
C.D.at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Sub-plot (I)											
I_1	7.78	2.97	7.96	5.90	7.73	1.91	7.93	5.71	8.00	3.85	8.11	6.16
I_2	7.72	2.35	7.88	5.56	7.66	1.50	7.84	5.33	7.89	3.36	8.05	6.06
I_3	7.71	2.56	7.86	5.69	7.60	1.63	7.80	5.50	7.86	3.53	8.04	6.09
I_4	7.76	2.81	7.92	5.80	7.72	1.76	7.90	5.60	7.91	3.73	8.09	6.12
S.Em.±	0.06	0.08	0.07	0.12	0.14	0.10	0.07	0.19	0.06	0.08	0.08	0.25
C.D.at 5%	NS	0.24	NS	NS	NS	0.29	NS	NS	NS	0.23	NS	NS
	Interaction (M X I)											
M_1I_1	7.80	3.02	7.98	5.98	7.78	1.95	7.93	5.72	8.01	3.87	8.14	6.19
M_1I_2	7.76	2.35	7.91	5.64	7.76	1.55	7.89	5.36	7.92	3.38	8.09	6.08
M_1I_3	7.73	2.63	7.88	5.75	7.64	1.76	7.81	5.53	7.86	3.53	8.08	6.11
M_1I_4	7.78	2.95	7.93	5.84	7.76	1.86	7.90	5.66	7.94	3.80	8.12	6.15
M_2I_1	7.77	2.93	7.94	5.82	7.69	1.88	7.93	5.69	7.98	3.82	8.09	6.13
M_2I_2	7.69	2.34	7.86	5.47	7.56	1.45	7.80	5.30	7.86	3.33	8.02	6.05
M_2I_3	7.69	2.50	7.84	5.63	7.55	1.51	7.79	5.47	7.85	3.54	8.00	6.07
M_2I_4	7.75	2.67	7.91	5.77	7.68	1.65	7.91	5.54	7.89	3.67	8.06	6.10
S.Em.±	0.08	0.12	0.10	0.17	0.19	0.14	0.10	0.26	0.08	0.11	0.12	0.35
C.D.at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

There was no significant difference in soil salinity (ECe) between paddy verities in both surface (0-15 cm) and sub-surface (15-30cm) soil at active tillering, panicle initiation, and harvest stage. Further, generally the values at surface and sub- surface soil depths were found to be within the threshold limit of 4 dS m^{-1} and above the threshold limit of 4 dS m^{-1} respectively. With respect to different irrigation levels (ETs), though the soil salinity differed significantly numerically among different levels in surface soil at all the three crop stages *i.e.,* AT, PI and harvest, the soil salinity was within the threshold salinity level *i.e.*, < 4 dSm^{-1}indicating that the effective root zone was free from excessive soluble salt content (non-saline soil conditions). Unlike surface soil, there were no significant differences among different ET levels during AT, PI and at harvest at sub-surface soil. Interaction effect of paddy varieties and irrigation levels was non-significant at all the three crop growth stages (Table 3.11).

The mean soil salinity data of kharif-2023 season revealed that paddy varieties did not differ significantly with respect to TWMS in both surface (0- 15 cm) and sub-surface (15-30 cm) soil depths. The TWMS was 1.42 and 1.50 dS m^{-1}in surface soil (0-15 cm) and 3.22 and 3.27dSm^{-1} in sub-surface soil under GNV-

1801(M_2) and GVT-05-01(M_1) respectively. With respect to irrigation levels, numerically significant differences were observed at surface soil only but the values were within the threshold levels *i.e.,* < 4dS m^{-1}. The TWMS varied from1.30 (I_2) to1.61 (I_1) at surface (0-15cm) and 3.16 (I_2) to 3.33 (I_1) at sub-surface(15-30cm) soil respectively. Both between the varieties and among different ET levels, TWMS was generally within the threshold limit (< 4 dS m^{-1}) both at surface and subsurface soil. Slightly higher TWMS both surface and subsurface soil under 1.2 ET could be attributed to lesser depth of irrigation water though relatively deeper water table (average 13.06-12.14 cm) were maintained. The interaction of main plot and sub-plot treatments were non-significant and the TWMS values were also within the threshold limit. The TWMS values were lower at surface compared to sub-surface soil.

Plant growth, yield and yield attributes as influenced by paddy varieties and different irrigation levels

Paddy varieties differed significantly with respect to plant height and significantly higher plant height (94.55 cm) was observed in M_2 *i.e.,* GNV-1801 as compared to M_1*i.e.,* GVT-05-01 (91.26 cm) at harvest stage (Table 3.12), respectively which could be attributed to the differences in genetic characteristics of these varieties wherein GNV-1801 claimed to be a moderately salt stress tolerant variety with better root proliferation could intern help in anchor for water and nutrients thus there was better physiological growth compared to GNV-05-01. Irrigation levels also differed significantly with respect to plant height. Significantly higher plant height (98.90 cm) was observed in (I_3) *i.e.,*1.6 ET as compared to rest of the ET levels except 1.4 ET. The lowest plant height (86.29 cm) was observed in (I_1) *i.e.,* 1.2 ET followed by irrigation at 1.8 ET level. Interaction effect was non- significant. Significantly higher number of tillers per hill (22.0) was recorded in M_2 *i.e.,* GNV-1801 paddy variety as compared to M_1*i.e.,* GVT-05-01(20.45). Significantly highest number of tillers per hill (23.48) was observed at 1.6ET level as compared to rest of the treatments but was on par with1.4ET level among the different irrigation levels. The lowest number of tillers per hill (18.72) was recorded in 1.2 ET. The interaction effect was non-significant. Paddy verities differed significantly with respect to number of panicles at crop harvest. Significantly higher number of panicles (11.53) was recorded in GNV-1801(M_2) as compared to M_1 *i.e*., GVT- 05-01 (10.32). Significant differences were also observed in number of panicles at crop harvest due to different irrigation levels. Significantly higher number of panicles was registered at 1.6 ET (12.11) as compared to rest of the treatments but was on par with 1.4 ET (11.46). The lowest number of panicles (9.50) was registered at 1.2ET. The interaction effect was non-significant.

Similar number of panicles per hill, significant differences were observed in panicle length at crop harvest between paddy varieties. Variety GNV-1801 (M_2) registered significantly higher panicle length (22.64 cm) as compared to variety GVT- 05-01 (21.48 cm). Further, significant differences were also observed due to different ET levels. Significantly higher panicle length (23.85 cm) was recorded at1.6 ET level as compared to rest of the treatments but was on par with 1.4 ET (22.62 cm). The lowest panicle length (20.35 cm) was recorded in irrigation at 1.2ET. The interaction effect was non- significant. Paddy varieties differed significantly with respect to grain yield with significantly higher grain yield (6165 kg ha^{-1}) was recorded in variety GNV-1801(M_2) as compared to GVT-05-01(5938 kg ha^{-1}). Similarly, irrigation levels differed significantly with respect to grain yield. Significantly higher grain yield was obtained under 1.6 ET level (6592 kg ha^{-1}) as compared to ET 1.2 (5449 kg ha^{-1}) but was on par with 1.4 ET (6237 kg ha^{-1}) and 1.8 ET (5927 kg ha^{-1}). Like grain yield, paddy varieties differed significantly with significantly higher straw yield (6843 kg ha^{-1}) was recorded in variety GNV-1801(M_2) as compared to variety GVT-05-01(M_1) (6605 kg ha^{-1}). Further, irrigation levels also differed significantly with respect to straw yield wherein significantly higher straw yield (7300 kg ha^{-1}) was obtained under 1.6 ET level which was on par with 1.4 ET (6903 kg ha^{-1}) and 1.8ET levels (6328 kg ha^{-1}). Like grain yield, the lowest straw yield (6158.0 kg ha^{-1}) was obtained under 1.2 ET level.

Table 3.12 Plant height, number of tillers/hill, number of panicles/hill, panicle length at harvest and grain and straw yield

Treatment	Plant Height (cm)	Tillers/ hill	Panicle Initiation	Panicle length (cm)	Yield (kg/ha)		WUE(Kg (ha-cm)$^{-1}$)
					Grain	Straw	
Main-plot (M)							
M_1	91.26	20.45	10.32	21.48	5938	6605	76.34
M_2	94.55	22.00	11.53	22.64	6165	6843	78.83
S.Em.±	0.48	0.32	0.27	0.06	34.46	26.31	0.22
C.D.at 5%	2.17	1.46	1.2	0.29	155	118	1.00
Sub-plot (I)							
I_1	86.29	18.72	9.50	20.35	5449	6158	74.01
I_2	95.68	21.92	11.46	22.62	6237	6903	79.55
I_3	98.90	23.48	12.11	23.85	6592	7300	80.56
I_4	90.75	20.78	10.63	21.42	5927	6535	76.22
S.Em.±	2.74	0.78	0.43	0.47	205	249	1.67
C.D.at 5%	8.13	2.33	1.27	1.4	609	740	4.96
Interaction (MXI)							
M_1I_1	85.92	18.64	9.20	19.86	5376	6105	72.30
M_1I_2	92.88	20.90	10.40	22.14	6150	6857	78.55
M_1I_3	98.06	22.53	11.45	23.52	6310	7124	79.52
M_1I_4	88.17	19.71	10.25	20.42	5917	6332	75.01
M_2I_1	86.65	18.80	9.80	20.85	5522	6211	75.73
M_2I_2	98.48	22.94	12.52	23.11	6325	6949	80.55
M_2I_3	99.75	24.43	12.78	24.18	6875	7475	81.61
M_2I_4	93.32	21.86	11.00	22.42	5937	6737	77.44
S.Em.±	3.87	1.11	0.60	0.67	290	352	2.36
C.D.at 5%	NS	NS	NS	NS	NS	NS	NS

With respect to WUE, significantly higher water use efficiency (78.83 kg ha.cm^{-1}) was noticed in GNV-1801 as compared to variety GNV-05-01(76.34 kg ha.cm^{-1}). With respect to irrigation levels, significantly higher water use efficiency (80.56 kg ha.cm^{-1}) was noticed under1.6ET which was on par with 1.4 and1.8ET levels (79.55 and 76.22 kg ha.cm^{-1}respectively). The lowest water use efficiency was noticed under 1.2ET level (74.01 kg ha.cm^{-1}).

Influence of paddy varieties and different ET levels on economics of rice cultivation

The cost of cultivation (COC) was slightly higher under GNV-1801 (₹ 79,360 ha^{-1}) as compared to GVT-05-01 (₹79,240 ha^{-1}) (Table 3.13). Among different ET levels, COC was in the order of ET1.8 (Rs. 79,575 ha^{-1})>1.6(Rs.79,375 ha^{-1})>1.4(Rs.79,275 ha^{-1})>1.2(Rs.78,975 ha^{-1}) (Table 3.13). The cost of cultivation was less than the previous seasons which is due to exclusion of cost incurred for drip irrigation system as well as depreciation cost of the unit. The gross returns obtained differed significantly between paddy varieties due to variations in yield levels. Significantly higher gross returns (₹1,51,654 ha^{-1}) were obtained under M_2*i.e.,* variety GNV-1801 as compared to variety GVT-05-01 (M_1) (₹1,38,286 ha^{-1}). Different irrigation levels also differed significantly with respect to gross returns. Irrigation at 1.6ET recorded the highest gross returns

(₹1,57,989 ha^{-1}) as compared to rest of the treatments but was on par with 1.4ET level ₹1,49,757 ha^{-1}). The lowest gross return (₹1,31,117 ha^{-1}) was observed at 1.2 ET level. The interaction effect was non-significant.

Like gross returns, higher net returns were obtained in variety GNV-1801 (₹71,869 ha^{-1}) as compared to variety GVT-05-01(₹58,621 ha^{-1}). Among different irrigation levels, ET 1.6 recorded significantly higher net return (₹ 78,264 ha^{-1}) as compared to rest of the treatments but was on par with ET1.4 (₹70,032 ha^{-1}). The lowest net return (₹51,392 ha^{-1}) was recorded at 1.2 ET level. The interaction effect was non-significant. Paddy varieties differed significantly with respect to BC ratio wherein the variety GNV-1801 recorded significantly higher BC ratio of 1.91 as compared to GVT-05-01(1.75). Among different irrigation levels, significantly the highest BC ratio (1.99) was obtained under 1.6 ET as compared to rest of the treatments but was on par with 1.4 ET level (1.89). The lowest BC ratio (1.66) was obtained under 1.2 ET level. The interaction effect was non-significant.

Table 3.13 Influence of paddy varieties and different ET levels on economics

Treatment	Cost of cultivation (₹ha^{-1})	Gross returns (₹ha^{-1})	Net returns (₹ha^{-1})	B:C
Main-plot (M)				
M_1	79240	138286	58621	1.75
M_2	79360	151654	71869	1.91
S.Em.±	-	854	854	0.01
C.D.at 5%	-	3841	3841	0.05
Sub-plot (I)				
I_1	78975	131117	51392	1.66
I_2	79275	149757	70032	1.89
I_3	79375	157989	78264	1.99
I_4	79575	141019	61293	1.77
S.Em.±	-	4631	4631	0.06
C.D.at 5%	-	13757	13757	0.17
Interaction (M X I)				
M_1I_1	78915	126116	46451	1.60
M_1I_2	79215	143715	64050	1.81
M_1I_3	79315	147577	67912	1.86
M_1I_4	79515	135736	56071	1.71
M_2I_1	79035	136117	56332	1.72
M_2I_2	79335	155799	76014	1.96
M_2I_3	79435	168400	88615	2.12
M_2I_4	79635	146300	66515	1.84
S.Em.±	-	6549	6549	0.08
C.D.at 5%	-	NS	NS	NS

- **Comparative efficacy of nano and conventional urea on growth and yield of rice (*Oryza sativa* L.) under waterlogged saline soil in Tungabhadra Command Area, Karnataka (Gangawathi)**

Fertilizers have a crucial role in enhancing food production and quality particularly with the introduction of high-yielding and fertilizer-responsive varieties of different crops. Paddy yield mostly relies on soil conditions and furthermore on the supply of essential nutrients. In general, paddy requires large amounts of nitrogen for their growth, development, and grain production. Soil N supply is often limited, which forces farmers to increase the amount of N fertilizers to accomplish better crop yield and it is more so in case of salt affected soils. Under non-saline soils, generally farmers in the TBP command are applying nitrogen to the extent of 35 to 40% over and above the recommended rate of application i.e., @150 kg ha^{-1}. This entails unnecessary expenditure on the part of farmers. Nonetheless, nitrogen management in lowland paddy crop is very difficult because it leads to nitrogen losses through ammonia volatilization, nitrification, denitrification, leaching and runoff which not only decrease the availability of nitrogen for rice plants but also contribute to environmental pollution i.e., land and groundwater pollution and so also greenhouse gas (GHG) emissions. Thus, the N use efficiency remains low *i.e.*, 30 to 35% only.

Nano fertilizers are known to improve crop growth, yield and quality parameters with increased nutrient use efficiency, reduce wastage of fertilizers and cost of cultivation. There are reports wherein increased efficiency of nano urea could save nitrogen fertilizer to the extent of 25-34% and serve to protect plants from various biotic and abiotic stresses. With this background, this project was undertaken to assess the Comparative efficacy of nano and conventional urea on growth and yield of rice (*Oryza sativa* L.) under waterlogged saline soil in Tungabhadra Command Area, Karnataka. The experiment was conducted during *kharif*-2024 at Agricultural Research Station, Gangavathi comprised of ten treatments, replicated thrice in RBD design. Initial soil $pH_{1:2.5}$ of the experimental site varied from 8.20 to 8.56 and 8.30 to 8.70 at 0-15 and 15-30 cm depth, respectively whereas ECe varied from 5.10 to 8.70 and 5.30 to 9.80 dS/m at 0-15 and 15-30 cm depth respectively.

As shown in Table 3.14, the T_5 (125% RDN + Foliar spray of conventional urea fertilizer @1% at AT and PI) had significantly higher plant height (81.10 cm), number of tillers per hill (15.1) and number of panicles per hill (13.2) at crop harvest compared to rest of the treatments except the treatments T_1(100% RDF), T_2, (100% RDN + Foliar spray of urea at AT and PI), T_9 (125% RDN through conventional urea + Foliar spray of conventional urea fertilizer @ 1% at AT & PI) and T_{10} (125% RDN through conventional urea).

Further, paddy grain yield (5995 kg ha^{-1}) was also significantly higher under the treatment T_5 compared to rest of the treatments except T_2, T_9 and T_{10} whereas the straw yield (6388 kg ha^{-1}) was significantly superior over rest of the treatment except T_1, T_2, T_6 (100% RDN + Foliar spray of conventional urea fertilizer @1% at AT & PI), T_9 and T_{10} (Table 3.14).

Table 3.14 Plant height, No. of tillers/hill, No. of panicles/hill, panicle length (cm), grain and straw yields (kg ha^{-1}) of paddy as influenced by different treatments during K-2024

Treatments	Plant Height (cm)	tillers/ hill	panicles/ hill	Panicle length (cm)	Yield (kg ha^{-1}) Grain	Straw
T1	82.1	15.7	12.7	19.1	5574	5672
T_2	81.3	15.7	12.8	19.2	5700	5798
T_3	78.1	12.6	10.7	18.6	5361	5438
T_4	75.8	12.8	10.6	19.0	5013	4972
T_5	81.1	15.1	13.2	18.4	5995	6388
T_6	81.1	14.9	12.3	18.9	5581	5638
T_7	76.5	14.5	10.9	18.8	5321	5588
T_8	75.8	14.7	10.3	17.8	5209	5055
T_9	81.5	15.3	13.0	19.1	6082	6138
T_{10}	81.1	15.9	12.7	18.5	5961	6215
SEm	1.10	0.70	0.30	0.49	103.6	257.2
$C.D._{0.05}$	3.20	1.90	1.00	1.40	308	752

Soil $pH_{1:2.5}$ and ECe declined at panicle initiation (PI) stage compared to prior to transplanting and varied from 7.71 to 7.99 and 1.31 to 1.60 dS/m at 0-15 cm depth, respectively. Similarly, soil $pH_{1:2.5}$ and ECe varied from 7.89 to 8.07 and 2.99 to 4.11 dS/m at 15-30 cm depth respectively. Towards the crop harvest, both soil pH and ECe showed an increasing trend from the PI stage. The soil $pH_{1:2.5}$ and ECe varied from 7.89 to 8.15 and 1.75 to 3.13 dS/m at 0-15 cm depth, respectively. Similarly, soil $pH_{1:2.5}$ and ECe varied from 7.94 to 8.22 and 2.56 to 5.23 dS m^{-1} at 15-30 cm depth respectively (Table 3.15). The soil salinity was within the threshold limit of 4.0 dS m^{-1} at surface soil (0-15 cm) i.e., in the crop effective root zone at both the sampling dates though there was slightly higher soil salinity at sub-surface (15-30 cm) soil.

Table 3.15 Soil $pH_{1:2.5}$ and ECe (dS m^{-1}) at different crop growth stages as influenced by different treatments under waterlogged saline soil during *kharif*-2024

Treatments	At PI stage				At harvest			
	0-15 cm		15-30 cm		0-15 cm		15-30 cm	
	pH	ECe	pH	ECe	pH	ECe	pH	ECe
T1	7.86	1.57	8.06	4.03	8.15	1.93	8.11	3.44
T_2	7.80	1.33	7.99	3.28	8.00	1.93	7.94	4.74
T_3	7.71	1.31	8.00	3.43	8.00	1.75	8.10	2.56
T_4	7.84	1.60	7.98	4.54	7.99	2.10	8.05	4.79
T_5	7.69	1.39	8.01	3.27	8.01	2.02	7.94	3.54
T_6	7.89	1.48	8.06	2.99	8.06	1.88	8.22	2.78
T_7	7.93	1.46	8.02	3.26	8.02	2.37	8.08	2.63
T_8	7.93	1.47	8.07	3.80	8.07	2.24	8.07	5.23
T_9	7.99	1.45	7.97	3.66	7.97	1.96	8.05	2.78
T_{10}	7.81	1.37	7.89	4.11	7.89	3.13	8.08	3.05

- **Effect of different levels of organic manures and mulching on vegetables (Brinjal, Chilli, and Tomato) under drip irrigation (Panvel)**

An experiment was conducted to study the effect of different levels of organic manures and mulching on brinjal, chilli, and tomato under drip irrigation in the coastal saline soils of Konkan. The main objectives were to evaluate how organic manures and mulching influence the performance of these vegetables and to examine their impact on soil properties. Using a factorial randomized block design with three replications, total 36 different treatment combinations were implemented in the field. The plot size was 4.20 m x 1.2 m. The field experiment included three vegetable crops i.e. brinjal (Mahyco MEBH 10), chilli (Seminis hybrid SHP 4884), and tomato (Sungro F_1 hybrid 3618), three mulching treatments (black plastic mulch , M_1; paddy straw , M_2; and no mulch, M_3) and four organic manure application treatments (FYM @ 15 t ha^{-1},F_1; Vermicompost @ 5 t ha^{-1}, F_2; FYM @ 7.5 t ha^{-1}+ Vermicompost @ 2.5 t ha^{-1}, F_3 and no organic manure, F_4). The data collection focused on soil properties-such as pH, electrical conductivity, organic carbon, available nitrogen, phosphorus, and potassium at both the initial and harvest stages, as well as soil moisture, and crop yield. The design also detailed the experimental layout, including paired row planting, plot size, and precise mulch/manure applications, thereby enabling assessment of the effectiveness of these treatments in improving both crop yield and soil health in challenging saline conditions.

<u>Brinjal</u>

Soil Electrical conductivity and pH

The data recorded from the experiment evaluating effect of different levels of organic manures and mulching on electrical conductivity and soil pH in the plots where brinjal crop was grown with drip irrigation system in saline coastal soils are presented in Table 3.16. Results shoes that application of plastic mulch (M_1) consistently led to the lowest soil electrical conductivity (EC1:2.5), recording values of 2.68 dS m^{-1} at 30 days and 1.16 dS m^{-1} at 90 days after planting, which were both statistically significant improvements as compared to paddy straw mulch and no mulching treatments. Among the organic manure treatments, the combination of FYM at 7.5 t ha^{-1} with vermicompost at 2.5 t ha^{-1} (F_3) also resulted in the lowest EC values (3.15 dS m^{-1} at 30 days, 2.11 dS m^{-1} at 90 days), outperforming higher rates of manures. The interaction between plastic mulch and F_3 manure (M_1F_3) proved most effective, recorded the lowest EC readings (2.54 dS m^{-1} at 30 days, 0.97 dS m^{-1} at 90 days).

The plastic mulch (M_1) treatment recorded significantly higher pH values as compared to other mulch options. The pH levels of 7.18 was recorded at 30 days and 7.13 at 90 days. Similarly, the F_3 organic manure treatment recorded higher pH values than the other rates and control. pH was found 7.02 at 30 days and 6.96 at 90 days. The positive effect was most pronounced in the M_1F_3 interaction, which reached a pH of 7.25 at 30 days and 7.20 at 90 days.

Soil moisture content and brinjal yield

The data presented on soil moisture dynamics revealed that the use of plastic mulch (M_1) significantly enhanced soil moisture compared to paddy straw mulch (M_2) and no mulch (M_3). At 30 days after sowing, M_1 recorded the highest soil moisture (41.26%), while the organic manure treatment F_3 (FYM @ 7.5 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1}) maintained higher moisture retention (36.53%) compared to F_1, F_2, and F_4 (Table 3.17). The interaction M_1F_3 proved most effective, achieving 43.75% soil moisture and outperforming all other combinations. Similarly, at 90 days after planting brinjal, M_1 continued to maintain significantly higher soil moisture (35.12%), followed by M_2 (27.09%) and M_3 (19.33%). Among organic manures, F_3 again recorded the maximum soil moisture (30.15%). The interaction of M_1 with F_3 resulted in the highest soil moisture content (39.51%), demonstrating the synergistic benefit of combining plastic mulch with integrated organic manure application. The yield data of brinjal revealed that paddy straw mulch (M_2) significantly outperformed plastic mulch (M_1) and no mulch (M_3), recording the highest yield of 245.14 q ha^{-1} compared to 226.52 q ha^{-1} and 176.97 q ha^{-1}, respectively (Table 3.17). Among organic manures, the combined application of FYM @ 7.5 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} (F_3) produced the highest yield of 240.19 q ha^{-1}, surpassing F1 (232.39 q ha^{-1}), F2 (228.96 q ha^{-1}), and F4 (163.31 q ha^{-1}). The interaction M_2F_3 exhibited maximum productivity, achieving 275.43 q ha^{-1}, significantly superior to other treatment combinations (Table 3.17).

<u>Chilli</u>

Soil Electrical conductivity and pH

The data recorded at 30 days after planting indicates that soil electrical conductivity (EC) under plastic mulch (M_1) was the lowest (2.95 dS m^{-1}) as compared to paddy straw mulch (M_2) at 4.00 dS m^{-1} and no mulch (M_3) at 4.73 dS m^{-1} (Table 3.18). Among organic manure treatments, FYM @ 7.5 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} (F_3) recorded the lowest EC value of 3.43 dS m^{-1}, followed by F_1 (3.88 dS m^{-1}), F_2 (4.03 dS m^{-1}), and F_4 (4.23 dS m^{-1}), respectively (Table 3.18). The interaction of M_1F_3 resulted in the lowest EC value of 2.13 dS m^{-1}. At 90 days after planting, the lowest EC value of 1.49 dS m^{-1} was again recorded under plastic mulch (M_1), was statistically significant, compared to paddy straw mulch (M_2) at 2.10 dS m^{-1}. In organic manure treatments, F_3 showed the lowest EC value of 2.49 dS m^{-1}, better to F_1, F_2, and F_4. Notably, the interaction of plastic mulch and F_3 (M_1F_3) yielded the minimum EC value of 0.98 dS m^{-1}, the lowest among all combinations.

For soil pH at 30 days after planting, plastic mulch (M_1) treatment recorded higher pH value of 6.78, followed by paddy straw mulch (6.73) and no mulch (6.68). In organic manure treatments, F_4 (no organic manures) recorded the lowest pH (6.71). The interaction M_1F_3 reached a higher pH of 6.81 (Table 3.18). At 90 days, no mulch (M_3) produced the lowest pH (6.65), while plastic mulch (M_1) and paddy straw mulch (M_2) recorded pH values of 6.77 and 6.73, respectively. The M_1F_3 interaction was statistically significant, recording a higher pH of 6.79.

Table 3.16 Effect of different levels of organic manures and mulching on electrical conductivity (dS m^{-1}) and soil pH in 1:2.5; soil:water suspension at 30 and 90 days after planting in brinjal plots under drip irrigation (Year-2023)

Treatment	Electrical conductivity (dS m^{-1})										Soil pH									
	30 DAP					90 DAP					30 DAP					90 DAP				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
M_1	2.62	2.71	2.54	2.86	**2.68**	1.19	1.23	0.97	1.25	**1.16**	7.22	7.16	7.25	7.09	**7.18**	7.18	7.10	7.20	7.04	**7.13**
M_2	3.44	3.65	3.14	3.39	**3.41**	1.84	2.33	1.45	2.52	**2.04**	6.90	6.88	7.01	6.84	**6.91**	6.87	6.88	6.89	6.82	**6.86**
M_3	4.03	4.12	3.78	4.18	**4.03**	4.18	4.30	3.91	4.80	**4.30**	6.80	6.78	6.81	6.76	**6.79**	6.76	6.73	6.78	6.70	**6.74**
Mean	**3.36**	**3.50**	**3.15**	**3.48**	-	**2.40**	**2.62**	**2.11**	**2.86**	-	6.97	6.94	7.02	6.90	-	6.94	6.90	6.96	6.86	-
SE±m	Mulch (M): 0.05; F: 0.06; MxF: 0.10					Mulch (M): 0.005; F: 0.006; MxF: .010					Mulch (M): 0.002; F: 0.002; MXF: 0.004					Mulch (M): 0.002; F: 0.002; MXF: 0.004				
CD (5%)	Mulch (M): 0.14; F: 0.16; MxF: 0.28					Mulch (M): 0.014; F: 0.017; MxF: 0.029					Mulch (M): 0.006; F: 0.006;MXF: 0.011					Mulch (M): 0.005; F: 0.006; MXF:0.011				

Treatments-M_1: plastic mulch; M_2: paddy straw mulch @ 4 t ha^{-1}; M_3: no mulch; F_1: organic manures FYM @ 15 t ha^{-1}; F_2: Vermicompost @ 5 t ha^{-1}; F_3: FYM @ 7.5 t ha^{-1}+ Vermicompost @ 2.5 t $ha^{-1}$and F_4: no organic manures; DAP-Days after planting

Table 3.17 Effect of different levels of organic manures and mulching on soil moisture (%) at 30 and 90 days after planting and yield of brinjal under drip irrigation (Year-2023)

Treatment	Soil moisture content (%)										Yield of Brinjal (q ha-1)				
	30 DAP					90 DAP									
	F_1	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**	**F_1**	**F_2**	**F_3**	**F_4**	**Mean**
M_1	41.68	40.86	43.75	38.74	41.68	36.81	32.14	39.51	32.03	**35.12**	244.27	235.57	251.56	174.70	**226.52**
M_2	34.52	33.93	37.51	30.37	34.52	29.13	26.52	30.63	22.08	**27.09**	268.88	270.74	275.43	165.51	**245.14**
M_3	26.16	24.53	28.34	23.75	26.16	19.62	19.05	20.31	18.34	**19.33**	184.03	180.58	193.57	149.71	**176.97**
Mean	**34.12**	**33.11**	**36.53**	**30.95**	**34.12**	**28.52**	**25.91**	**30.15**	**24.15**	-	**232.39**	**228.96**	**240.19**	**163.31**	-
SE±m	Mulch (M): 0.02; F: 0.03;MxF:0.05					Mulch (M): 0.01; F: 0.01; MxF:0.02					Mulch (M): 1.28; F: 1.48; MxF: 2.57				
CD (5%)	Mulch (M): 0.07; F: 0.08;MxF:0.14					Mulch (M): 0.03; F: 0.03; MxF:0.06					Mulch (M): 3.76; F: 4.35;MxF:7.53				

Treatments-M_1: plastic mulch; M_2: paddy straw mulch @ 4 t ha^{-1}; M_3: no mulch; F_1: organic manures FYM @ 15 t ha^{-1}; F_2: Vermicompost @ 5 t ha^{-1}; F_3: FYM @ 7.5 t ha^{-1}+ Vermicompost @ 2.5 t $ha^{-1}$and F_4: no organic manures; DAP-Days after planting

Table 3.18: Effect of different organic manures and mulching on electrical conductivity (dS m-1) and soil pH in 1:2.5; soil:water suspension at 30 and 90 days after planting of chilli under drip irrigation plots (Year-2023)

Treatment	Electrical conductivity (dS m^{-1})										Soil pH									
	30 DAP					90 DAP					30 DAP					90 DAP				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
M_1	2.99	3.19	2.13	3.50	**2.95**	1.40	1.67	0.98	1.91	**1.49**	6.79	6.77	6.81	6.75	6.78	6.77	6.74	6.79	6.76	**6.77**
M_2	3.91	4.04	3.80	4.24	**4.00**	1.81	2.35	1.73	2.52	**2.10**	6.74	6.70	6.76	6.71	6.73	6.75	6.74	6.74	6.70	**6.73**
M_3	4.75	4.86	4.36	4.96	**4.73**	4.83	5.01	4.75	5.30	**4.98**	6.68	6.66	6.70	6.66	6.68	6.65	6.64	6.68	6.60	**6.65**
Mean	**3.88**	**4.03**	**3.43**	**4.23**	-	**2.68**	**3.01**	**2.49**	**3.24**	-	**6.74**	**6.71**	**6.75**	**6.71**	**-**	**6.73**	**6.71**	**6.74**	**6.69**	-
SE±m	Mulch (M): 0.04; F: 0.05; MxF: 0.09					Mulch (M): 0.04; F: 0.05; MxF: 0.08					Mulch (M): 0.007; F: 0.008; MxF: 0.013					Mulch (M): 0.005; F: 0.005; MxF: 0.009				
CD (5%)	Mulch (M): 0.13; F: 0.15; MxF: 0.26					Mulch (M): 0.12; F: 0.13; MxF: 0.23					Mulch (M): 0.019; F: 0.028;MxF: 0.039					Mulch (M): 0.014; F: 0.016; MxF:0.027				

Treatments-M_1: plastic mulch; M_2: paddy straw mulch @ 4 t ha^{-1}; M_3: no mulch; F_1: organic manures FYM @ 15 t ha^{-1}; F_2: Vermicompost @ 5 t ha^{-1}; F_3: FYM @ 7.5 t ha^{-1}+ Vermicompost @ 2.5 t $ha^{-1}$and F_4: no organic manures; DAP-Days after planting

Table 3.19. Effect of different organic manures and mulching on soil moisture (%) and yield of Chilli under drip irrigation (Year-2023)

Treatment	Soil moisture content (%)										Yield of chilli (q ha-1)				
	30 DAP					90 DAP									
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
M_1	40.63	38.42	41.23	37.48	**39.44**	35.56	33.45	38.86	32.43	**35.08**	72.57	68.61	78.95	43.11	**65.81**
M_2	34.69	32.29	36.34	30.05	**33.34**	28.81	27.69	29.84	27.30	**28.41**	90.63	88.57	94.52	37.48	**77.80**
M_3	23.61	22.30	26.13	20.34	**23.10**	20.05	19.76	23.84	18.30	**20.49**	56.61	50.94	58.82	35.09	**50.36**
Mean	**32.98**	**31.00**	**34.57**	**29.29**	-	**28.14**	**26.97**	**30.85**	**26.01**	-	**73.27**	**69.37**	**77.43**	**38.56**	**-**
SE±m	Mulch (M): 0.002; F: 0.002; MxF:0.003					Mulch (M): 0.002; F: 0.002; MXF:0.003					Mulch (M): 0.17; F: 0.20; MxF: 0.35				
CD (5%)	Mulch (M): 0.005; F: 0.005; MxF:0.009					Mulch (M): 0.005; F: 0.005; MXF:0.010					Mulch (M): 0.51; F: 0.59;MxF:1.02				

Treatments-M_1: plastic mulch; M_2: paddy straw mulch @ 4 t ha^{-1}; M_3: no mulch; F_1: organic manures FYM @ 15 t ha^{-1}; F_2: Vermicompost @ 5 t ha^{-1}; F_3: FYM @ 7.5 t ha^{-1}+ Vermicompost @ 2.5 t $ha^{-1}$and F_4: no organic manures; DAP-Days after planting

Soil moisture content and chilli yield

At 30 days after planting, plastic mulch (M_1) resulted in a significantly higher soil moisture content (39.44%) than paddy straw mulch (M_2) of 33.34% and no mulch (M_3) of 23.10% (Table 3.19). Application of organic manures, specifically FYM @ 7.5 t ha^{-1} combined with Vermicompost @ 2.5 t ha^{-1} (F_3), further enhanced moisture content to 34.57. Notably, the interaction between plastic mulch and the combined organic manure treatment (M_1F_3) yielded the highest soil moisture content of 41.23% among all treatment interactions. At 90 days after planting also, similar effects were found. Plastic mulch (M_1) recorded higher soil moisture value of 35.08% than paddy straw mulch (M_2) and no mulch (M_3). The F_3 treatment also retained the highest moisture content (30.85%), followed by F_1, F_2, and F_4 with soil moisture content of 28.14%, 26.97%, and 26.01%, respectively. The interaction plastic mulch and F_3 (M_1F_3) recorded the highest moisture at 38.86% in soil, significantly higher than the other treatment combinations. These results highlight the efficiency of combining plastic mulch with organic manures to maximize soil moisture conservation in brinjal cultivation under varying growth periods.

Among various mulching treatments, paddy straw mulch (M_2) recorded significantly higher chilli yield (77.80 q ha^{-1}) as compared to plastic mulch (M_1) which yielded 65.81 q ha^{-1}, and no mulch (M_3) which yielded 50.36 q ha^{-1}. Regarding organic manures, the combined application of FYM @ 7.5 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} (F_3) resulted in 77.43 q ha^{-1} yield as compared to FYM @ 15 t ha^{-1} (F_1) at 73.27 q ha^{-1}, Vermicompost @ 5 t ha^{-1} (F_2) at 69.37 q ha^{-1}, and no organic manure (F_4) at 38.56 q ha^{-1} (Table 3.19). Notably, the interaction effect of paddy straw mulching combined with FYM and vermicompost (M_2F_3) produced the highest yield of 94.52 q ha^{-1} and outperformed all other treatment interactions. Results show the effectiveness of integrating paddy straw mulch with organic manure treatment to maximize chilli yield (Table 3.19).

Tomato crop

Soil Electrical conductivity and pH

The data describing effects of plastic mulch and organic manure applications on soil electrical conductivity (EC) and pH at different stages after planting is presented in Table 3.20. This is clear from the table that EC values consistently lower under plastic mulching (M_1) as compare to other mulching treatments. At 30 days after planting, the combination of plastic mulch (M_1) and the application of farmyard manure (FYM) at 7.5 t ha^{-1} plus vermicompost at 2.5 t ha^{-1} (F_3) recorded the lowest EC value of 1.94 dS m^{-1}, which was statistically significant over all other combinations. Similarly, at 90 days, EC of 1.24 dS m^{-1} was recorded in plastic mulched plot, which was significantly lower than paddy straw mulch (M_2) and no mulch (M_3), with values of 2.82 and 4.66 dS m^{-1}, respectively. Among organic manure treatments, F_3 recorded the lowest EC value of 2.40 dS m^{-1} compared to other manure treatments.

The soil pH was also found higher in plastic mulch (M_1) with mean pH of 6.90 at 30 days after planting as compared to other mulching treatments (Table 3.20). Organic manure application F_3 also recorded a statistically higher mean pH of 6.85 at the same time point. The combined treatment of plastic mulch with FYM and vermicompost (M_1F_3) showed a significant increase in pH, reaching 6.93. At 90 days after planting also, plastic mulch (M_1) treatment recorded higher pH (6.85), while the F_1 treatment had a pH of 6.75, higher than other treatments. In contrast, the M_1F_3 interaction treatment maintained a significantly higher pH of 6.90 at this stage.

Table 3.20 Effect of different organic manures and mulching on electrical conductivity (dS m-1) and soil pH in 1:2.5; soil:water suspension at 30 and 90 days after planting in drip irrigated tomato plots (Year-2023)

Treatment	Electrical conductivity (dS m^{-1})										Soil pH									
	30 DAP					90 DAP					30 DAP					90 DAP				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
M_1	2.05	2.45	1.94	2.63	**2.27**	1.09	1.30	1.06	1.51	**1.24**	6.92	6.90	6.93	6.86	**6.90**	6.88	6.82	6.90	6.81	**6.85**
M_2	3.41	3.47	3.20	3.83	**3.48**	2.27	3.28	1.99	3.75	**2.82**	6.80	6.78	6.85	6.80	**6.81**	6.72	6.70	6.80	6.70	**6.73**
M_3	4.15	4.33	4.05	4.61	**4.29**	4.68	4.80	4.16	5.01	**4.66**	6.75	6.70	6.76	6.60	**6.70**	6.65	6.68	6.65	6.62	**6.65**
Mean	**3.21**	**3.42**	**3.06**	**3.69**	-	**2.68**	**3.13**	**2.40**	**3.43**	-	**6.82**	**6.80**	**6.85**	**6.75**	-	**6.75**	**6.73**	**6.78**	**6.71**	-
SE±m	Mulch (M): 0.002; F: 0.002; MxF: 0.003					Mulch (M): 0.002; F: 0.002; MxF: 0.004					Mulch (M): 0.002; F: 0.002; M xF: 0.003					Mulch (M): 0.002; F: 0.002; MXF: 0.003				
CD (5%)	Mulch (M): 0.005; F: 0.006; MxF: 0.010					Mulch (M): 0.005; F: 0.006; MxF: 0.011z					Mulch (M): 0.005; F: 0.006; MxF: 0.010					Mulch (M): 0.005; F: 0.006; MxF:0.010				

Treatments-M1: plastic mulch; M2: paddy straw mulch @ 4 t ha-1; M3: no mulch; F1: organic manures FYM @ 15 t ha-1; F2: Vermicompost @ 5 t ha-1; F3: FYM @ 7.5 t ha-1+ Vermicompost @ 2.5 t ha-1and F4: no organic manures; DAP-Days after planting

Table 3.21 Effect of different organic manures and mulching on soil moisture (%) at 30 and 90 days after planting and yield of tomato under drip irrigation (Year-2023)

Treatment	Soil moisture content (%)										Yield of Tomato (q ha^{-1})				
	30 DAP					90 DAP									
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
M_1	41.48	38.45	43.92	38.33	**40.55**	38.53	35.64	40.62	33.15	**36.98**	228.70	220.33	233.07	210.22	**223.08**
M_2	37.09	35.96	38.00	30.48	**35.39**	29.69	25.66	31.66	25.03	**28.01**	248.77	236.30	**251.34**	165.57	**225.49**
M_3	23.49	22.20	24.64	20.86	**22.80**	21.56	19.58	23.38	17.90	**20.60**	185.03	177.23	191.17	163.83	**179.32**
Mean	**34.02**	**32.21**	**35.52**	**29.89**	-	**29.92**	**26.96**	**31.88**	**25.36**	-	**220.83**	**211.29**	**225.19**	**179.87**	-
SE±m	Mulch (M): 0.04; F: 0.05; MXF:0.09					Mulch (M): 0.05; F: 0.06; MXF:0.11					Mulch (M): 0.96; F: 1.11; MxF: 1.93				
CD (5%)	Mulch (M): 0.13; F: 0.14; MXF:0.25					Mulch (M): 0.15; F: 0.18; MXF:0.31					Mulch (M): 2.82; F: 3.26; MxF:5.65				

Treatments-M_1: plastic mulch; M_2: paddy straw mulch @ 4 t ha^{-1}; M_3: no mulch; F_1: organic manures FYM @ 15 t ha^{-1}; F_2: Vermicompost @ 5 t ha^{-1}; F_3: FYM @ 7.5 t ha^{-1}+ Vermicompost @ 2.5 t ha^{-1} and F_4: no organic manures; DAP-Days after planting

Soil moisture content and tomato yield

Plastic mulch treatment (M_1) recorded higher soil moisture content (40.55%) at 30 days after planting than paddy straw mulch and no mulch treatments. Among organic manure treatments, application of farmyard manure (FYM) at 7.5 t ha^{-1} combined with vermicompost at 2.5 t ha^{-1} (F_3) resulted in improved soil moisture (35.52%) compared to treatments with FYM at 15 t ha^{-1} (F_1), vermicompost at 5 t ha^{-1} (F_2), and no organic manure (F_4). The interaction between plastic mulch and this manure combination (M_1F_3) recorded the highest soil moisture level of 43.92%, significantly higher than all other treatment combinations at 30 days (Table 3.21). Similar trend for soil moisture content was found at 90 days after planting as soil moisture was relatively higher under plastic mulch (36.98%) compared to other mulching treatments. The F_3 organic manure treatment also maintained superior soil moisture content of 31.88% compared to other manure applications. The combined M_1F_3 treatment again exhibited the highest soil moisture (40.62%), which was statistically significant over other interaction treatments.

The yield data presented in Table 3.21 indicates that among mulching treatments, paddy straw mulch (M_2) produced the highest tomato yield of 225.49 q ha^{-1}, which was statistically better than no mulch and comparable to plastic mulch (M_1) at 223.08 q ha^{-1} (Table 3.21). Among organic manure treatments, the combination of FYM at 7.5 t ha^{-1} and vermicompost at 2.5 t ha^{-1} (F_3) resulted in the highest yield of 225.19 q ha^{-1}, outperformed F_1 (220.83 q ha^{-1}), F_2 (211.29 q ha^{-1}), F_4 (179.87 q ha^{-1}). The interaction between paddy straw mulch and F_3 (M_2F_3) was found the best which produced the highest tomato yield of 251.34 q ha^{-1}.

Overall, results indicated that plastic mulching combined with organic manure application effectively reduced soil salinity as indicated by lowered EC and improved soil pH levels, contributing to better soil health conditions throughout the growth period after planting. However, the treatment receiving FYM @ 7.5 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} under paddy straw mulch (M_2F_3) was the best combination to achieve the higher yield of vegetables *viz.,* brinjal, chilli and tomato crops.

General view of experimental plot

- **Effect of planting windows and irrigation on dibbling of wal (Field bean) grown under zero tillage in coastal saline soils of Konkan (Panvel)**

A field experiment was conducted to investigated the effects of sowing dates and irrigation levels on Wal (field bean) cultivation using zero tillage in coastal saline soils of Konkan. The crop (variety - Konkan wal-2) was sown on three sowing dates i.e. 18/11/2022 (P1), 28/11/2022 (P2), and 08/12/2022 (P3). Three irrigation treatments viz. no irrigation (I0), one irrigation at flowering (I1), and two irrigations at flowering and pod formation stages (I2) were tested. Hence, the study tested nine treatment combinations across three sowing windows (immediately after rice harvest, 10 days later, and 20 days later) and three irrigation frequency. Experiment was laid out in factorial randomized block design included four replications. The observations focused on key soil properties-pH, organic carbon, available nitrogen, phosphorus (P_2O_5), and potassium (K_2O)-at the initial stage and after harvest, along with soil moisture and electrical conductivity measurements at 30 and 90 days after sowing. Seed yield was recorded to evaluate productive outcomes. At initial stage, the soil pH, electrical conductivity (EC), soil organic carbon and available nitrogen were recorded ~6.74; 2.89 dS m^{-1}, 3.30 g kg^{-1} and 216.15 kg ha^{-1}, respectively.

Soil electrical conductivity and pH as influenced by planting windows and irrigation

The data on Soil pH and electrical conductivity recorded at 30 and 90 days after planting under different treatments are presented in Table 3.22, It is clear from the table that the highest electrical conductivity (EC) values of 1.91 dS m^{-1} at 30 days and 4.73 dS m^{-1} at 90 days after planting it was observed in no irrigation treatment (I_0). The lowest and statistically significant EC values-1.04 dS m^{-1} and 3.30 dS m^{-1} were found under two irrigations treatment (I_2), indicating better salt management at flowering and pod formation stage. Among planting windows, sowing 20 days after rice harvest (P_3) resulted in significantly higher EC i.e. 1.53 dS m^{-1} at 30 days and 4.17 dS m^{-1} at 90 days. Notably, the interaction of no irrigation and P_3 (I_0P_3) recorded the highest EC values (2.08 dS m^{-1} and 4.83 dS m^{-1} at 90 days, i.e. post-planting), demonstrating the compounded negative effect of delayed sowing and no irrigation on soil salinity.

The soil pH (7.40) in the plots planting immediately after rice harvest (P_1) was statistically at par with planting 10 days later (P_2, 7.38), and both were higher than planting 20 days after harvest (P_3, 7.36). Treatments with two irrigations at flowering and pod formation (I2) exhibited higher pH values (7.44) for soil as compared to no irrigation (I_0, 7.33) and one irrigation at flowering (I_1, 7.35) at 30 days after planting. The interaction effect revealed that I_2P_1 recorded the highest pH value (7.46). After 90 days, immediate planting after rice harvest continued to show a higher pH (7.37), however, it was statistically similar with P_2 and P_3 (Table 3.22).

Soil moisture content and wal seed yield

The soil moisture content (%) at 30 and 90 days after planting of wal under different planting windows and irrigation treatments reveal that irrigation treatment I2 (two irrigations) resulted in significantly higher soil moisture (30.11%) as compared to one irrigation at flowering (I_1) and no irrigation (I_0) (Table 3.23). Planting immediately after rice harvest (P_1) also recorded significantly higher soil moisture content (27.12%), than 10 days later (P_2, 25.41%) and 20 days later (P_3, 23.06%). The interaction effect showed that I_2P_1 treatment had a significantly higher soil moisture content (32.55%) than other combinations. Similarly, at 90 days after sowing, I_2 (two irrigations) again resulted in significantly higher soil moisture (28.32%), followed by no irrigation (I_0, 19.12%) and one irrigation (I_1, 21.71%). Similarly, P_1 exhibited superior soil moisture (24.40%) over other planting times. The interaction of planting immediately after rice harvest with two irrigations (I_2P_1) produced the highest soil moisture content (30.44%) compared to all other treatment interactions. These results highlight the importance of early planting and adequate irrigation for improved soil moisture retention for better crop growth of field bean cultivation.

Table 3.22 Effect of planting windows and irrigation on electrical conductivity (dS m^{-1}; 1:2.5; soil:water suspension) and pH (1:2.5; soil: water suspension) at 30 and 90 days after planting of wal (Year-2023)

Treatment	Electrical conductivity (dS m^{-1})								Soil pH							
	30 DAP				90 DAP				30 DAP				90 DAP			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
I_0	1.64	2.02	2.08	**1.91**	4.56	4.81	4.83	**4.73**	7.35	7.34	7.32	7.33	7.32	7.31	7.30	**7.31**
I_1	1.21	1.33	1.36	**1.30**	3.78	3.80	4.09	**3.89**	7.38	7.37	7.35	7.37	7.35	7.37	7.34	**7.35**
I_2	0.92	1.04	1.17	**1.04**	2.79	3.50	3.60	**3.30**	7.46	7.44	7.41	7.44	7.43	7.42	7.40	**7.41**
Mean	**1.26**	**1.46**	**1.53**	-	**3.71**	**4.03**	**4.17**	-	**7.40**	**7.38**	**7.36**	-	**7.37**	**7.37**	**7.35**	-
SE±m	Irrigation (I): 0.01; P: 0.01; I x P: 0.01				Irrigation (I): 0.003; P: 0.03; I x P: 0.006				Irrigation (I): 0.01; P: 0.01; IxP: 0.01				Irrigation (I): 0.005; P: 0.005; IXP: 0.009			
CD (5%)	Irrigation (I): 0.02; P: 0.02; I x P: 0.03				Irrigation (I): 0.10; P: 0.10; I x P: 0.17				Irrigation (I): 0.02; P: 0.02; IxP: 0.03				Irrigation (I): 0.014; P: 0.014; IXP: 0.025			

I_0- No Irrigation; I_1- One irrigation at flowering , I_2- Two irrigations (1 each at flowering and pod formation; P_1- Immediate after harvest of rice ; P_2 -10 days after harvest of rice ; P_3 - 20 days after harvest of rice

Table 3.23 Effect of planting windows and irrigation on soil moisture content and seed yield of wal (q ha^{-1}) (Year-2023)

Treatment	Soil moisture content (%)								Seed yield of wal (q ha^{-1})			
	30 DAP				90 DAP							
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
I_0	21.10	20.96	19.92	20.66	19.30	19.22	18.85	**19.12**	7.60	6.58	5.29	6.49
I_1	27.71	25.08	21.70	24.83	23.46	21.47	20.20	**21.71**	9.72	7.91	8.11	8.58
I_2	32.55	30.20	27.57	30.11	30.44	29.41	25.12	**28.32**	8.32	7.66	7.78	7.92
Mean	**27.12**	**25.41**	**23.06**	-	**24.40**	**23.37**	**21.39**	-	8.55	7.38	7.06	-
SE±m	Irrigation (I): 0.20; P: 0.20; IXP: 0.34				Irrigation (I): 0.12; P: 0.12; IXP: 0.20				Irrigation (I): 0.10; P: 0.10; IXP: 0.18			
CD (5%)	Irrigation (I): 0.57; P: 0.57; IXP: 0.99				Irrigation (I): 0.34; P: 0.34; IXP: 0.59				Irrigation (I): 0.30; P: 0.30; IXP: 0.52			

I_0- No Irrigation; I_1- One irrigation at flowering , I_2- Two irrigations (1 each at flowering and pod formation; P_1- Immediate after harvest of rice ; P_2 -10 days after harvest of rice ; P_3 - 20 days after harvest of rice

Among the various treatments of irrigations (Table 3.23), the treatment received water at the time of flowering (I_1) recorded highest wal yield (8.58q ha$^{-1)}$ which was statistically superior over I_2 (7.92 q ha^{-1}) and I_0 (6.49 q ha^{-1}). Planting of wal immediately after harvest of rice (P_1) produced statistically higher yield (8.55q ha^{-1}) over the treatments of P_2 (7.38 q ha^{-1}) and P_3 (7.06 q ha^{-1}). Interaction effect of I_1P_1 produced statistically significant and superior with higher yield of (9.72 q ha^{-1}) over remaining interactions.

A view of experimental plot

3.3 Management of Saline-Acidic Soils

- **Effect of method of planting in the establishment of rice seedlings in high salinity (Vyttila)**

The present investigation was initiated with the aim to compare the different methods of planting in seedling establishment in saline soils. Effort was also made to find out the best method of planting for seedling establishment with the minimum land preparation and to reduce the mortality of seedlings caused by non-insect pests. The experiment evaluated different land preparation methods (mounding, ridging, and raking with a tiller) and planting techniques (sowing or transplanting on mounds, ridges, and using a transplanter), wherein the saline-tolerant Pokkali rice variety Vyttila- 10 (KAU Lavanya) was cultivated organically with zero external inputs. Treatment details are presented in Table 3.24. The field was drained and dried in April-May and prepared as per the treatments. Seeds were sown or seedlings were transplanted in the respective treatment plots during June month. After one-month ridges/ mounds were dismantled and the seedlings were uniformly transplanted in the field. However, heavy rainfall occurred in July, 2023 led to complete crop loss.

- **Table 3.24 Details of Treatments**

Treatments	Description
T_1	Control- No land preparation and drainage. Direct sowing
T_2	Draining, drying, mound preparation (1m base) and sowing on mounds
T_3	Draining, drying, mound preparation (1m base) and transplanting on mounds
T_4	Draining, drying and ridge preparation and sowing
T_5	Draining, drying and ridge preparation and transplanting
T_6	Draining, drying and raking with garden tiller and sowing
T_7	Draining, drying, raking with garden tiller and transplanting manually
T_8	Draining, drying, raking with garden tiller and transplanting with transplanter

Different land preparation methods evaluated for rice seedling establishment in high salinity conditions: (i) Raking with garden tiller(ii) Mound preparation (iii) Ridge preparation (iv) Sowing on mounds (v) Machine transplanting in prepared land and (vi) Manual transplanting in prepared land

Results indicate that there was 100% germination for sowing and transplanting on mounds and tiller + manual transplanting (treatments, T_2, T_3 and T_7). Moderate performance was observed in T_4 and T_6, both achieving 75% germination in sowing on ridges and sowing after raking with tiller. Treatment T_8 showed 50% germination in machine transplanting. Treatments T_5 and T_1 performed poorest with only 35% and 25% germination, respectively. Due to heavy flooding, the entire crop was lost one week after germination. These early establishment data highlighted the superior performance of raised planting methods and proper land preparation techniques in high-salinity conditions. Unfortunately, unprecedented heavy rainfall later completely flooded the experimental fields preventing the collection of yield data.

Flooded field due to heavy rainfall

The same experimental set-up was repeated in June 2024 with eight distinct land preparation and planting techniques. Initial and final soil samples were analyzed to study the changes in soil properties.

Soil characteristics

The soil pH and electrical conductivity data recorded under different treatments are presented in Table 3.25. Recorded data revealed a significant shift from very strongly acidic (pH 4.59) to more favorable levels across all treatments. However, soil electrical conductivity was below 4 ds m^{-1} in all the treatments probably due to high rainfall received during the season. The data on organic carbon (OC) also indicates that OC improved from the initial 2.25% across most treatments, with mound preparation and transplanting (T_3: 3.27%) and raking with direct sowing (T_6: 3.23%) showing the highest increases (Table 3.2). The significant variation in organic carbon between treatments indicates that different land preparation methods influence organic matter dynamics in saline soils.

Availability of Nutrient

The available nutrients in soil recorded under different treatments are presented in Table 3.25. The obtained data shows that nitrogen availability declined from the initial level (345.0 kg ha^{-1}) in most treatments. However, phosphorus level increased substantially across treatments compared to the initial 25.70 kg ha^{-1}, and the highest values was found in T_8 (146.8 kg ha^{-1}). Potassium showed remarkable increases from the initial 121.0 kg ha^{-1} across all treatments, particularly in T_1 (276.3 kg ha^{-1}) and T_4 (286.2 kg ha^{-1}). Similarly, secondary nutrients (Ca, Mg and S) also increased across all treatments from their initial values (Ca: 351.8; Mg: 192.1 kg ha^{-1} and S: 0.63 mg kg^{-1}). The mound preparation treatment T_2 demonstrated extremely high Ca levels (9385.3

kg ha^{-1}) and Mg (3437.5 kg ha^{-1}) and treatment T_7 exhibited the highest S content with 3.51 mg kg^{-1}. Micronutrients showed variations but generally increased availability across treatments, with iron, manganese and zinc showing notable improvements compared to initial values.

Sodium dynamics and salinity stress

It is clear from the Table 3.25 that Na accumulation (1080.2 kg ha^{-1}) was higher in control treatment (T_1). The mound preparation treatments (T_2 and T_3) demonstrated lower sodium levels (961.96 and 947.02 kg ha^{-1}, respectively) than the control. Particularly, T_3 (mound preparation with transplanting) showed approximately 12.3% less Na accumulation than T_1. Similarly, ridge formation treatments (T_4 and T_5) exhibited lower Na concentrations (976.9 and 955.7 kg ha^{-1}), representing about 9.6% and 11.5% reductions as compared to the control. The mechanical transplanting (T_8) exhibited even higher sodium concentration (1106.9 kg ha^{-1}) than the control.

Rice growth parameters and yield

The effect of different treatments on growth and yield parameters of Pokkali rice is presented in Table 3.26. It is clear from the table that treatments T_3, T_5, T_6 resulted in significantly higher plant height (> 112 cm), whereas T_1, T_2, and T_4 had plant heights around 37 cm. The number of tillers ranged from 6.44 in T_1 to 23 in T_3, and productive tillers followed the similar trend. Grain yield was found highest in T_5 (34.88 q ha^{-1}), closely followed by T_7 (33.35 q ha^{-1}), T_8 (31.97 q ha^{-1}), and T_3 (30.94 q ha^{-1}). The lowest grain yield was recorded in T_4 (1.16 q ha^{-1}). Straw yield also showed a similar pattern, with T_3 produced the highest (51.40 q ha^{-1}) and T_4 the lowest (1.31 kg ha^{-1}). The data indicate that treatments involving mound and ridge planting significantly enhance both vegetative growth and yield compared to direct sowing or less intensive methods.

Nutrient composition in rice plant

The nutrient composition of the Pokkali rice plants was significantly affected by the different planting methods (Table 3.27). Nitrogen (N) content showed considerable variation, with Treatment T_2 exhibiting the highest accumulation at 2.60%. In contrast, treatments involving garden tiller raking (T_6 to T_8) had substantially lower nitrogen levels, ranging from 1.67% to 1.87%, representing a 24–32% reduction as compared to the control. Phosphorus (P) levels remained relatively consistent across treatments, with only slight increases was observed in T_4 and T_6. Potassium (K) varied notably, with T_2 recording the highest concentration of 22.25%, marking a 42.6% increase over T_1. Other treatments showed lower K levels than the control, with T6 having the lowest at 9.10%, a 41.7% decrease. Secondary nutrients including calcium (Ca) and magnesium (Mg) were also influenced by treatments; Ca was higher in T_1 and T_2, but significantly reduced in ridge and garden tiller treatments, with T_7 showing the lowest Ca content (63.1% decrease from T_1). Magnesium peaked in T_2 (24.9% more than control) but declined in T_6 to T_8, with T_8 being 36.3% lower. Sulfur (S) remained stable across treatments, implying limited impact by planting methods. Micronutrient concentrations varied as Fe increased in T_2 and T_8, but dropped in T_6 (84.5% reduction). Mn nearly doubled in T_2 but decreased drastically in T_3 to T_6. Zn saw slight increases in T_7 and T_8, whereas Cu was highest in T_1 and decreased in other treatments. Boron (B) was highest in T_1. Sodium (Na), critical for saline soils, was significantly reduced in T_3, T_4, and T_5, suggesting better sodium exclusion. Aluminum (Al) concentration was lowest in T_5, with an 82.5% reduction from T_1. These findings demonstrate that planting methods substantially affect nutrient dynamics and soil ion balance in Pokkali rice cultivation.

Table 3.25 Soil characteristics recorded under different treatments

Treatment	pHs	ECe (dS m^{-1})	OC (%)	Available nutrients												
				kg ha^{-1}				mg kg^{-1}								
				N	P	K	Na	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Al
Initial	4.59	1.40	2.25	345.0	25.70	121.0	1082.5	351.8	192.1	0.63	139.8	0.18	1.5	1.02	0.47	105.60
T_1	6.63	3.63	3.26	143.7	141.2	276.3	1080.2	8804.0	3510.0	3.40	351.8	5.58	4.28	6.19	0.42	55.97
T_2	5.95	1.33	3.04	122.8	145.1	267.6	961.96	9385.3	3437.5	3.35	356.6	3.57	2.71	5.20	0.41	38.70
T_3	5.99	1.4	3.27	122.8	141.2	232.1	947.02	8704.0	3390.1	3.41	347.3	4.17	3.35	5.50	0.44	42.89
T_4	6.53	1.32	2.71	109.8	142.9	286.2	976.9	8890.7	3458.8	3.24	338.2	2.31	3.05	5.05	0.42	43.69
T_5	6.13	1.35	2.91	120.7	139.7	288.7	955.7	6858.7	3400.5	3.27	321.7	1.31	1.59	3.85	0.43	73.74
T_6	5.45	1.38	3.23	139.0	150.8	230.8	967.6	7044.0	3338.8	3.29	351.1	2.11	2.47	4.87	0.43	111.35
T_7	5.62	2.89	3.25	144.78	132.9	182.9	899.1	4131.2	3114.0	3.51	350.6	1.42	2.08	4.77	0.43	130.60
T_8	5.38	2.88	2.82	127.53	146.8	222.8	1106.9	5454.7	3241.9	3.37	344.2	1.68	2.44	3.47	0.41	137.54

Table 3.26 Rice crop growth parameters and yield under different treatments

Treatments	Height (cm)	No of tillers	No of productive tillers	Grain yield (kg ha^{-1})	Straw yield (Kg ha^{-1})
T_1	37.11^{b}	6.44	6.44	285.36^{b}	268.71^{d}
T_2	37.33^{b}	11.17	7.44	754.60^{b}	592.43^{d}
T_3	115.78^{a}	23.00	23.00	3094.46^{a}	5140.77^{a}
T_4	37.00^{b}	13.00	13.00	116.10^{b}	131.71^{d}
T_5	115.00^{a}	13.33	13.33	3488.43^{a}	4384.92^{ab}
T_6	112.89^{a}	11.56	11.56	2340.08^{a}	2895.95^{c}
T_7	108.89^{a}	10.78	10.78	3335.84^{a}	4051.18^{abc}
T_8	107.78^{a}	12.33	12.33	3197.53^{a}	3364.45^{bc}
CD (0.05)	58.98	NA	NA	1228.33	1171.09

Table 3.27 Effect of method of planting on total plant nutrient content

Treatments	Total nutrient												
	N	**P**	**K**	**Na**	**Ca**	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**Cu**	**B**	**Al**
	%			mg kg^{-1}									
T_1	2.45	0.0173	15.60	12.00	46480	89900	45.90	564.00	16.47	76.40	55.64	111.74	29.00
T_2	2.60	0.0173	22.25	10.95	43505	112250	46.75	614.60	32.12	65.24	43.52	74.22	24.94
T_3	2.31	0.0173	11.17	5.20	23510	60260	46.30	162.09	4.73	49.37	43.93	79.41	6.71
T_4	2.31	0.0174	11.10	5.70	21350	66610	46.16	220.32	0.13	48.16	44.64	80.66	14.33
T_5	2.09	0.0173	10.70	6.20	25352	68120	46.11	224.15	9.60	67.23	46.01	82.14	5.07
T_6	1.87	0.0174	9.10	4.93	13323	52363	45.34	87.36	0.15	65.47	47.31	79.77	6.71
T_7	1.67	0.0173	11.13	7.30	17133	59793	45.50	193.57	2.27	77.25	48.07	78.77	23.08
T_8	1.75	0.0173	9.80	9.37	19387	57293	45.53	606.08	10.67	79.69	49.37	79.92	61.76

This study highlights the critical impact of planting methods and land preparation on rice productivity and nutrient dynamics in acidic saline Pokkali soils. Using the salt-tolerant variety Vyttila 10 (KAU Lavanya), eight different treatments were evaluated, demonstrating that customized planting strategies can effectively mitigate salinity stress, improve seedling establishment, and enhance soil health. Key findings revealed improved soil pH, increased organic carbon content, and better macronutrient and micronutrient availability in treatments involving mound and ridge preparation. Ridge transplanting (T_5) yielded the highest rice productivity, while ridge preparation and sowing (T_4) led to poor germination and low yields. The correlation between planting techniques and nutrient uptake indicate the benefits of tailored agronomic practices for sustainable rice cultivation in saline environments. These insights offer valuable guidance for developing climate-resilient rice farming systems in coastal saline agroecosystems, though further experimentation is required to confirm these findings.

Plot with maximum tillering *Machine transplanting and manual transplanting*

- **Management of salinity and acidity of *Pokkali* soils using suitable amendments (Vytilla)**

The present study was conducted to evaluate the effects of calcium salts and silica on managing soil acidity and salinity, and to identify a suitable ameliorant for achieving economic rice yield for integrated farming systems in the Pokkali ecosystem. Experiment was conducted in a randomized block design with eight treatments (T_1-control; T_2-Calcium nitrate @1000kg/ha, T_3-Calcium chloride @1000 kg/ha, T_4-Gypsum@1000 kg/ha, T_5-Rock phosphate@1000 kg/ha, T_6-Dolomite @1000 kg/ha, T_7-Lime@1000kg/ha and T_8-Rice husk ash @1000kg/ha) and three replications. The experiment involved organic cultivation of the salt-tolerant rice variety (Vyttila 11, KAU Jyotsna) without using any fertilizers or pesticides. Field preparation included mound formation during April-May, which was dismantled following monsoon showers along with the application of respective treatments. Seedlings were transplanted in July in treated plots. Unfortunately, in 2023, after one week of planting, the entire crop was lost due to flooding.

Land preparation *Treatment application*

The experiment was repeated in June 2024 under same set of treatments and field preparation. After the receipt of monsoon showers, the mounds were dismantled along with the treatment application. Seedlings were transplanted in the treatment plots in July. The biometric observations were recorded and the crop was harvested in October 2024. Initial and final soil chemical properties were analyzed using samples collected from the field.

Soil characteristics

The data on soil characteristics presented in Table 3.28 shows that control treatment (T_1) recorded the lowest pHs of 4.57. Interestingly, all calcium amendments increased soil pH, with calcium nitrate treatment (T_2) raised to 5.69, calcium chloride treatment (T_3) to 5.00, gypsum treatment (T_4) to 5.06, rock phosphate treatment (T_5) to 4.91, dolomite treatment (T_6) to 5.90 and lime treatment (T_7) to 4.90. Table also indicates that ECe was below 4 dsm^{-1} throughout the crop growing period probably due to adequate rain fall received. ECe was the highest in the control treatment (3.83). However, ECe was below 3.0 dsm^{-1} in other treatments.

Available Nutrient

The data on available macronutrients (N, P and K) in soil is presented in Table 3.28. Table depicts that application of amendments increased available N compared to the control treatment. The highest N availability was observed with T_5 (Rock Phosphate) followed by T_6 (Dolomite)treatment. The treatment, T_1(Control) recorded 74.95 kg ha^{-1} of available P, while, in T_5 and T_6. P availability was recorded as 75.84 and 80.91 kg ha^{-1}, respectively. Rock phosphate treatment (T_5) and dolomite treatment (T_6) also enhanced K availability. Similarly, treatments influenced availability of secondary nutrients (Ca, Mg and S) in soil. All calcium amendments significantly increased available Ca compared to the control treatment. The highest Ca was found in treatment, T_3 and T_6. This is directly related to the presence of calcium in these amendments. Dolomite treatment (T_6) recorded the highest Mg compared to the control. Gypsum treatment (T_4) significantly increased S availability compared to control treatment (T_1). Micronutrient (Fe, Mn, Zn, Cu, B) were also influenced by different treatments. Higher Fe content was recorded in T_3 and T_5 as compared to the control treatment. Results of the study also that T_5 treatment recorded the highest Mn availability. In general, all treatments enhanced Zn availability, however, maximum enhancement was found in T_5 and T_7. All calcium amendments increased Cu availability also in comparison to control. The Boron content increased slightly in most of the treatments. However, all treatments showed below detection limit (BDL), including control treatment (T_1).

Total nutrient content in rice shoot and roots

The results presented in Table 3.29 demonstrate significant variations in total nutrient content in rice shoots under different treatments. Treatment T_7(lime) recorded the highest calcium content (28070 mg kg^{-1}) among all treatments, representing a 65.7% increase compared to the absolute control. Whereas, treatment T_6 (dolomite) resulted in the highest Mg concentration (52100 mg kg^{-1}) in rice shoots, likely due to dolomite's composition as calcium magnesium carbonate. An elevated potassium (K) and sodium (Na) values (13.70% and 23.05%, respectively) were also recorded under T_6. For micronutrients in rice shoots, T_7 demonstrated the highest Zn (65.33 mg kg^{-1}) and Cu (77.06 mg kg^{-1}) contents, while T_3 recorded the highest Fe content (458.67 mg kg^{-1}). T_4 and T_5 treatments resulted in moderate increase in most nutrients in rice shoots but were found effective in enhancing S content (56.87 and 63.30 mg kg^{-1} respectively compared to the control.

Table 3.28 Soil chemical properties measured under different treatments

Treatments	pHs	ECe (dS m^{-1})	OC (%)	Available nutrients												
				kg ha^{-1}			mg kg^{-1}									
				N	P	K	Na	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Al
T1	4.57	3.83	3.19	91.47	74.95	331.64	1201.51	14030	24993	1.03	277.67	0.68	2.26	2.30	0.47	BDL
T2	5.69	1.46	3.15	112.90	79.25	345.96	1003.64	18240	28860	1.00	273.50	2.01	2.55	2.57	0.45	BDL
T3	5.00	2.35	3.29	90.42	73.68	244.53	990.58	14787	20247	1.01	280.13	1.37	2.07	2.16	0.47	BDL
T4	5.06	2.46	3.70	113.94	73.92	271.91	1049.07	16680	24157	0.96	279.73	4.42	1.68	2.19	0.47	BDL
T5	4.91	2.92	3.65	160.46	75.84	332.27	1083.91	15900	25223	1.03	285.03	2.91	2.15	2.79	0.49	BDL
T6	5.56	1.41	3.32	114.46	80.91	336.00	1204.00	16270	28337	0.99	282.43	1.78	1.92	2.34	0.46	BDL
T7	4.90	2.61	2.89	94.08	73.44	290.58	1131.82	14660	23407	1.00	282.30	1.20	2.34	3.07	0.46	BDL
T8	5.53	2.84	3.24	112.90	78.09	357.16	1294.22	15787	28250	1.03	273.87	1.89	1.93	2.39	0.48	BDL

Table 3.29 Total nutrient content in rice shoots under various treatments

Treatments	Total nutrient												
	N	P	K	Na	Ca	Mg	S	Fe	Mn	Zn	Cu	B	Al
	%			mg kg^{-1}									
T_1	1.78	0.0173	11.45	10.45	18705	50495	57.81	787.60	15.13	7.73	32.29	90.08	24.84
T_2	1.35	0.0172	10.00	6.60	18440	50000	51.08	380.66	0.13	4.92	35.85	78.71	25.04
T_3	1.46	0.0173	10.33	8.43	21477	45017	58.51	458.67	BDL	17.33	36.73	81.48	23.59
T_4	2.00	0.0172	10.15	7.15	18230	45685	56.87	778.00	2.67	46.27	38.95	81.39	9.14
T_5	1.80	0.0173	11.93	9.67	34797	55430	63.30	942.67	17.33	53.72	39.84	81.26	6.32
T_6	1.53	0.0172	13.70	23.05	26230	52100	46.81	24.00	BDL	75.41	41.98	80.74	1.00
T_7	1.60	0.0172	18.50	13.25	28070	61460	52.18	160.00	26.67	67.53	77.06	80.83	66.92
T_8	1.67	0.0172	8.70	6.53	18720	46750	54.93	565.20	2.67	51.52	41.50	83.38	6.64

The Ca:Mg ratios varied considerably across the treatments, with T_7 recorded the highest ratio of 0.46 (28070:61460), followed by T_6 at 0.38 (26230:52100). The optimal Ca:Mg ratio for most crops typically ranges from 3:1 to 5:1, but the observed lower ratio and increased calcium content under treatments T_6 and T_7 appear beneficial for overall plant nutrition. The difference in K:Na ratios was also observed between the treatments. T_1 recorded a K:Na ratio of 1.10 (11.45:10.45), while T_7 showed a more favorable K:Na ratio of 1.44(18.50:13.25).

Nutrient content in rice roots under different treatments are presented in Table 3.30. Results indicate significant increase over control as treatment T_5 achieved the highest calcium concentration in roots (46,793 mg kg^{-1}), representing a 40.3% increase over the control. The Ca:Mg ratios in roots ranged from 0.60 (T_1) to 0.77 (T_2), exceeding shoot ratios but remaining below the ideal 3:1 to 5:1 range, however T_2 recorded the highest. All treatments had K:Na ratios below 1.0 in roots, indicating sodium dominance. It is clear from the table that the lowest (0.24) and highest (0.28) ratio was under T_7 and T_5, respectively. Treatment T_6 registered the highest sodium content (29.70%) with moderate potassium (5.33%) resulted in a low K:Na ratio (0.18). Nitrogen content in roots varied less, from 0.99% (T_3) to 1.31% (T_2), while phosphorus remained stable. T_5 also exhibited the highest magnesium (60,857 mg kg^{-1}) and potassium (6.03%) contents in roots. Overall, calcium amendments significantly altered nutrient distribution between roots and shoots; lime (T_7) benefited shoot nutrients, whereas rock phosphate (T_5) enhanced root calcium and overall nutrient status.

Table 3. 30 Total nutrient content in rice roots under various amendments

Treatments	Total nutrients					
	N	P	K	Na	Ca	Mg
	%				mg kg^{-1}	
T_1	1.19	0.0173	5.47	26.37	33350	55523
T_2	1.31	0.0173	4.47	23.80	45673	56203
T_3	0.99	0.0173	4.67	22.13	33487	48510
T_4	1.21	0.0173	5.27	21.73	33630	55323
T_5	1.02	0.0174	6.03	21.73	46793	60857
T_6	1.09	0.0173	5.33	29.70	33750	57980
T_7	1.12	0.0174	4.30	18.10	35520	52820
T_8	1.09	0.0173	4.97	23.23	35737	57157

Conclusion

Though, crop lost to severe flooding in 2023, but the field experiment completed successfully in 2024. Results reveal that all calcium amendments enhanced soil pH value from the acidic baseline of 4.57, while dolomite and calcium nitrate had the strongest effects as pH raised to 5.56 and 5.69, respectively. Most treatments reduced soil electrical conductivity, thereby mitigating salinity. Nutrient availability varied by amendment; rock phosphate and dolomite notably increased nitrogen, phosphorus, and potassium, while all treatments reduced aluminium solubility below detectable levels. Rice husk ash emerged as the best ameliorant, delivering the highest grain yield (2749.37 kg ha^{-1}) and raised soil pH to 5.53. Dolomite was second most effective, with higher grain (2651.50 kg ha^{-1}) and straw yield (3528.09 kg ha^{-1}).

Based on the holistic assessment dolomite (T_6) and rice husk ash (T_8) emerged as the most effective amendments for managing acidity and salinity in Pokkali soils under organic conditions. However, experiment must be repeated for confirming the results.

4 ALTERNATE LAND USE

- **Development of Horticulture Based Agri-horti System under Saline Water Conditions (Bikaner)**

An experiment initiated during 2018-2023 evaluated the impact of saline water irrigation on horticulture-based agri-horti systems, using three levels of electrical conductivity (EC_{iw}): BAW (0.25 dS/m), 2.4 dS/m, and 6.0 dS/m, with cluster bean as an intercrop during kharif and mustard, taramira, oat, and barley during rabi. Results showed significant decreases in seed and straw yields with increased water salinity, particularly in cluster bean, with seed yield reductions of 13.02% and 40.72% at ECiw 2.4 dS/m and 6.0 dS/m, respectively, compared to BAW (Table 4.1 and 4.2). Pooled data analysis confirmed these findings, with cluster bean seed yield decreasing by 13.41% and 45.92% at ECiw 2.4 dS/m and 6.0 dS/m, respectively, and oat yield reducing by 3.25% and 11.36% at ECiw 6.0 dS/m compared to BAW and ECiw 2.4 dS/m, respectively (Table 4.3 and 4.4)

Table 4.1 Effect of irrigation water salinity on seed yield (q/ha) of cluster bean crop

Treatments	2018	2019	2020	2021	2022	2023	pooled
BAW (EC 0.25 dsm^{-1})	5.71	5.75	12.50	10.83	10.83	10.30	9.32
Tube-well (TW) water (EC 2.4 dsm^{-1})	4.48	4.80	10.94	9.42	9.42	9.35	8.07
Saline irrigation water (EC 6 dsm^{-1})	2.55	2.65	6.58	6.42	6.42	5.65	5.04
SEm±	0.28	0.21	0.45	0.30	0.30	0.41	0.31
CD (P= 0.05)	0.98	0.72	1.55	1.03	1.03	1.43	0.89

Table 4.2 Effect of irrigation water salinity on straw yield (q/ha) of cluster bean crop

Treatments	2018	2019	2020	2021	2022	2023	pooled
BAW (EC 0.25 dsm^{-1})	22.37	24.13	27.85	23.62	23.62	26.66	24.71
Tube-well water (EC 2.4 dsm^{-1})	16.13	18.50	22.73	17.13	17.14	24.04	19.28
Saline irrigation water (EC 6 dsm^{-1})	8.15	8.70	11.77	9.50	9.50	14.41	10.34
SEm±	0.90	0.40	0.91	0.56	0.56	1.06	0.73
CD (P= 0.05)	3.12	1.39	3.14	1.94	1.94	3.68	2.11

<u>Bael</u>

The data presented in Table 4.2 highlights the impact of irrigation water salinity on the fruit yield of bael over a six-year period (2018 to 2023). For the initial four years (2018–2021), no fruit yield was recorded under any treatment, indicating that bael trees had not reached fruit-bearing maturity during this period. However, from 2022 onwards, significant differences in fruit yield were observed across treatments with varying salinity levels. In 2022, the highest yield was recorded with BAW (EC 0.25 dsm^{-1}) at 38.01 q/ha (Table 4.5), followed by 35.30 q/ha under tube-well water (EC 2.4 dsm^{-1}), and the lowest at 31.62 q/ha under saline irrigation water (EC 6 dsm^{-1}).

Table 4.3 Effect of irrigation water salinity on seed yields (q/ha) of rabi crops

Treatments	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	pooled
Mustard							
BAW (EC 0.25 dS/m)	17.58	25.38	15.31	18.11	16.11	21.15	18.94
TW water (EC 2.4 dS/m)	17.25	24.26	14.51	17.82	15.14	20.29	18.21
Irrigation water (EC 6 dS/m)	16.58	23.58	12.25	17.09	13.97	17.98	16.91
SEm±	0.34	0.59	0.70	0.71	0.89	1.32	0.73
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS
Taramira							
BAW (EC 0.25 dS/m)	12.68	16.35	12.34	14.95	12.04	13.18	13.59
TW water (EC 2.4 dS/m)	12.43	15.76	11.19	14.16	11.80	12.93	13.04
Irrigation water (EC 6 dS/m)	11.95	14.80	10.74	13.93	10.20	11.73	12.23
SEm±	0.32	0.77	0.51	0.65	0.68	0.30	0.50
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS
Oat							
BAW (EC 0.25 dS/m)	21.06	21.98	21.92	17.06	20.06	17.81	19.98
TW water (EC 2.4 dS/m)	20.68	21.56	20.72	16.68	19.41	16.93	19.33
Irrigation water (EC 6 dS/m)	19.44	20.55	18.75	15.08	17.15	15.31	17.71
SEm±	0.37	0.31	0.42	0.46	0.40	0.36	0.35
CD (P= 0.05)	1.27	1.06	1.44	1.60	1.39	1.26	1.01
Barley							
BAW (EC 0.25 dS/m)	37.46	48.76	52.12	44.97	47.28	49.87	46.74
TW water (EC 2.4 dS/m)	36.80	47.70	49.22	44.04	46.88	48.22	45.48
Irrigation water (EC 6 dS/m)	36.01	45.84	48.85	42.26	44.14	45.60	43.78
SEm±	0.81	0.92	0.95	2.02	2.09	1.88	1.29
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	4.26

Table 4.4: Effect of irrigation water salinity on straw yields (q/ha) of crops

Treatments	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24	pooled
			Mustard				
BAW (EC 0.25 dS/m)	52.49	58.70	46.24	41.00	41.24	51.20	48.48
TW water (EC 2.4 dS/m)	51.43	57.99	44.26	39.56	34.82	47.24	45.88
Irrigation water (EC 6 dS/m)	51.19	55.40	37.48	38.84	31.71	44.90	43.26
SEm±	0.40	1.48	2.15	2.38	2.04	2.03	1.67
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS
			Taramira				
BAW (EC 0.25 dS/m)	75.15	54.03	49.59	45.14	40.33	49.05	52.21
TW water (EC 2.4 dS/m)	74.98	53.17	49.22	43.20	38.94	46.99	51.08
Irrigation water (EC 6 dS/m)	73.25	49.16	46.74	42.62	34.27	41.41	47.91
SEm±	0.55	1.46	2.16	1.98	2.27	2.34	1.66
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	4.76
			Oat				
BAW (EC 0.25 dS/m)	47.85	52.08	50.86	39.00	56.17	55.67	50.27
Tube-well water (EC 2.4 dS/m)	47.07	50.70	50.14	38.91	46.58	46.33	46.62
Irrigation water (EC 6 dS/m)	46.34	49.20	46.12	35.10	41.50	40.90	43.19
SEm±	0.28	0.58	1.00	0.98	1.14	0.97	0.74
CD (P= 0.05)	0.97	2.01	3.45	3.39	3.94	3.35	2.13
			Barley				
BAW (EC 0.25 dS/m)	51.20	66.75	78.70	61.31	66.19	65.73	64.98
TW water (EC 2.4 dS/m)	51.02	66.50	76.78	60.74	66.57	63.29	64.15
Irrigation water (EC 6 dS/m)	50.11	64.50	75.72	57.75	63.12	61.36	62.09
SEm±	0.37	1.15	1.46	2.54	2.95	2.61	1.68
CD (P= 0.05)	NS	NS	NS	NS	NS	NS	NS

A similar trend was noted in 2023, with yields increasing across all treatments due to the advancing age of the bael plants, but still showing a clear negative impact of increasing salinity. In that year, BAW irrigation recorded 86.46 q/ha, tube-well water produced 82.82 q/ha, and saline water resulted in the lowest yield of 74.60 q/ha. The mean fruit yield over the two bearing years (2022–2023) was highest with BAW (62.23 q/ha), followed by 59.06 q/ha with tube-well water, and the lowest with saline water at 53.11 q/ha (Table 4.5). The yield differences in both 2022 and 2023 were statistically significant, with the critical difference (CD) at 5% probability level being 5.35 q/ha in 2022 and 10.35 q/ha in 2023, confirming the adverse effect of saline irrigation on fruit production. These results clearly indicate that higher salinity in irrigation water reduces bael fruit yield, although the crop still maintained some productivity under moderate salinity (EC 2.4 dS/m). This suggests that bael can tolerate low to moderate salinity but performs best under high-quality irrigation water.

Table 4.5 Effect of irrigation water salinity on fruit yield of bael

Treatments	Fruit yield (q/ha)						
	2018	2019	2020	2021	2022	2023	Mean
BAW (EC 0.25 dS/m)	0.00	0.00	0.00	0.00	38.01	86.46	62.23
Tube-well water (EC 2.4 dS/m)	0.00	0.00	0.00	0.00	35.30	82.82	59.06
Saline irrigation water (EC 6 dS/m)	0.00	0.00	0.00	0.00	31.62	74.60	53.11
SEm±	-	-	-	-	1.55	2.99	-
CD (P= 0.05)	-	-	-	-	5.35	10.35	-

Economics of cropping system

The net return data clearly indicate that irrigation water salinity had a pronounced negative impact on the economic performance of all Bael-based cropping systems (Table 4.6). Among the four systems, the Cluster bean–Bael–Mustard combination proved to be the most profitable, achieving the highest pooled net return of Rs. 1,30,492/ha under good-quality canal water (BAW, EC 0.25 dS/m). However, with an increase in irrigation water salinity, net returns declined progressively to Rs. 1,16,472/ha under tube-well water (EC 2.4 dS/m) and Rs. 88,101/ha under saline water (EC 6.0 dS/m), representing reductions of Rs. 14,020 and Rs. 42,391/ha, respectively, compared to BAW. A similar decreasing trend was observed in the Cluster bean–Bael–Taramira system, where pooled net returns dropped from Rs. 1,03,352/ha under BAW to Rs. 91,035/ha and Rs. 65,745/ha under tube-well and saline irrigation, respectively. The Cluster bean–Bael–Oat system was more sensitive to salinity, with pooled net returns of Rs. 80,192/ha under BAW declining to Rs. 68,488/ha and Rs. 43,880/ha under tube-well and saline irrigation, respectively; in fact, it recorded negative returns during initial years under saline and tube-well water, indicating poor adaptability to salinity. The Cluster bean–Bael–Barley sequence also exhibited a similar pattern, with net returns decreasing from Rs. 1,17,696/ha (BAW) to Rs. 1,05,556/ha (tube-well) and Rs. 81,042/ha (saline water). Overall, the results revealed that net returns decreased sharply with increasing salinity levels, and the use of high-quality irrigation water significantly enhanced economic returns and system profitability in Bael-based cropping systems.

The Benefit: Cost (B:C) ratio showed a clear declining trend with increasing salinity of irrigation water across all cropping sequences, indicating that profitability was adversely affected by saline conditions (Table 4.6). Among the crop sequences, the Cluster bean–Bael–Mustard system recorded the highest pooled B:C ratio (2.83) under good-quality irrigation water (BAW, EC 0.25 dS/m), followed by tube-well water (2.63) and the lowest under saline water (2.23, EC 6 dS/m). Similarly, in the Cluster bean–Bael–Taramira system, the pooled B:C ratios were 2.63, 2.44, and 2.04 under BAW, tube-well, and saline irrigation, respectively. The Cluster bean–Bael–Oat sequence exhibited relatively lower profitability with pooled B:C ratios of 2.26, 2.08, and 1.69, while the Cluster bean–Bael–Barley sequence recorded moderate values of 2.65, 2.48, and 2.14 under respective water qualities. Over the years, a consistent increase in B:C ratio was observed under all treatments, particularly with good-quality water, reaching maximum values (above 5.0) during 2023–24 in most sequences. Overall, the results clearly demonstrate that the use of good-quality irrigation water (EC ≤ 0.25 dS/m) considerably enhanced economic returns, whereas saline irrigation (EC 6 dS/m) substantially reduced profitability of Bael-based cropping systems.

Table 4.6 Effect of irrigation water salinity on economics of crops

Treatments	Net returns (Rs./ha)						
	2018-19	**2019-20**	**2020-21**	**2021-22**	**2022-23**	**2023-24**	**Pooled**
Cluster bean–Bael–Mustard							
BAW (EC 0.25 dS/m)	26694	90672	77022	85976	175862	326725	130492
Tube-well water (EC 2.4 dS/m)	17744	79623	64382	75922	154226	306935	116472
Saline irrigation water (EC 6 dS/m)	3760	63415	29585	56290	122268	253291	88101
SEm±	1484	2956	4795	2837	9100	14794	6593
CD (P= 0.05)	5135	10228	16591	9817	31491	51193	18911
Cluster bean–Bael–Taramira							
BAW (EC0.25 dS/m)	16328	51550	65842	66643	146653	273099	103352
Tube-well water (EC 2.4 dS/m)	7976	43174	52639	54726	130277	257419	91035
Saline irrigation water (EC 6 dS/m)	-5228	26102	27453	37846	97503	210794	65745
SEm±	898	3354	3582	3693	4999	8080	4160
CD (P= 0.05)	3107	11607	12396	12780	17300	27959	11930
Cluster bean–Bael–Oat system							
BAW (EC0.25 dS/m)	-4466	23198	51826	30278	133150	247167	80192
Tube-well wate (EC 2.4 dS/m)	-12572	16303	41230	21317	115063	229584	68488
Saline irrigation wate (EC 6 dS/m)	-25665	1737	14349	2126	85244	185486	43880
SEm±	954	810	2333	1030	4357	7349	3216
CD (P= 0.05)	3301	2802	8074	3565	15076	25430	9225
Cluster bean–Bael–Barley							
BAW (EC 0.25 dS/m)	6557	54326	95712	72115	175083	302382	117696
Tube-well water (EC 2.4 dS/m)	-1809	46700	82158	62177	159400	284713	105556
Saline irrigation water (EC 6 dS/m)	-14224	30814	58431	42858	128996	239379	81042
SEm±	1862	1246	3392	2587	4187	6237	3218
CD (P= 0.05)	6444	4313	11739	8951	14487	21584	9229

5. SCREENING FOR SALINITY/SODICITY TOLERANCE

- **Screening of mustard cultivars for saline water irrigation (Agra)**

This experiment was conducted in micro-plots. Irrigation water was synthetically prepared for desired water salinity (EC_{iw} 10 dS m^{-1}) for screening of four IVT cultivars during 2022-23 and five cultivars during 2023-24 in RBD with 4 replications. RDF (120:60:60 NPK) and 2-3 irrigations were applied.

Seed yield: During 2022-23, the yield of different mustard genotypes (IVT) was significantly affected in saline water irrigation. The statistically significant higher yield was produced in genotype CSCN 22-02 (2252.15 kg/ha) and lowest was in genotype CSCN 22-01 (1808.63 kg/ha). During 2023-24, significantly higher yield of AVT genotype was produced in CSCN 23-02 (1987.65 kg/ha) and lowest was in genotype CSCN 23-01 (1423.76 kg/ha) (Table 5.1).

Table 5.1 Effect of saline water irrigation on yield and yield attributing characters of mustard genotype

Genotype (IVT)	Grain yield (kg/ha)	Genotype (AVT)	Grain yield (kg/ha)
2022-23		2023-24	
CSCN 22-01	1808.63	CSCN 23-01	1423.76
CSCN 22-02	2252.15	CSCN 23-02	1987.65
CSCN 22-03	1982.70	CSCN 23-03	1651.23
CSCN 22-04	1883.32	CSCN 23-04	1563.26
		CSCN 23-05	1628.69

- **Screening of Mungbean entries under alkali water irrigation (Agra)**

During 2024, thirteen Mungbean genotypes were evaluated under alkali water irrigation (RSC_{iw} 4 meq/l) in randomized block design and replicated 3 times. The genotypes were sown on 19 April 2024 and RDF (NPK 20:40:20) were applied, total 4 irrigations were given and harvested on 03 July 2024. The variable grain yield of Mungbean was found for different genotypes. The maximum grain yield was recorded in SAS-24-12(641.68 kg/ha) and lowest yield (434.45 kg/ha) was recorded with SAS-24-02 entry (Table 5.2).

Table 5.2 Yield and yield attributing characters of Mungbean with alkali water

Name of Entry	No. of pods/ plant	Days to Flower	Pod length (cm)	No. of seeds/ pod	Days to maturity	100 Grain Weight (gm)	Biological yield (kg/ha)	Grain Yield (kg/ha)
SAS-24-01	17.7	37.3	6.8	7.5	67.6	6.26	1343	454
SAS-24-02	17.3	42.7	6.3	7.5	68.0	5.86	1328	434
SAS-24-03	18.0	37.3	7.3	7.5	67.0	6.83	1451	494
SAS-24-04	20.0	35.6	7.2	7.7	66.7	5.96	1573	517
SAS-24-05	19.3	39.7	7.0	7.6	66.0	5.86	1884	589
SAS-24-06	19.7	36.7	7.3	7.7	66.7	6.30	1675	541
SAS-24-07	19.6	39.6	7.5	8.1	68.3	5.83	1892	616
SAS-24-08	20.0	42.6	7.2	7.6	68.6	6.10	1837	609
SAS-24-09	19.0	42.7	7.6	8.0	68.7	6.50	1667	546
SAS-24-10	18.7	41.6	6.7	7.8	67.3	6.06	1807	522
SAS-24-11	21.3	41.6	7.2	8.3	67.3	6.07	1903	621
SAS-24-12	22.0	36.6	7.7	8.8	66.3	6.03	1953	642
SAS-24-13	18.0	39.7	6.8	7.3	67.6	6.50	1710	551
SEm±	0.90	0.39	0.27	0.7	0.70	0.23	29.1	28.58
CD at 5%	1.97	0.80	0.61	1.6	1.41	0.50	63.4	62.29

- **Screening of Mungbean entries under saline water irrigation (Agra)**

During 2024, thirteen mungbean genotypes were evaluated under saline water irrigation (ECiw 5 dS m^{-1}) in a randomized block design with three replications. The genotypes were sown on 19 April 2024, and the recommended dose of fertilizers (NPK 20:40:20) was applied. A total of four irrigations were given, and the crop was harvested on 03 July 2024. Under saline water irrigation, the grain yield of mungbean varied significantly among the genotypes. The highest grain yield was recorded in SAS-24-12 (598.90 kg/ha), while the lowest yield was observed in SAS-24-06 (447.23 kg/ha) during 2024 (Table 5.3).

Table 5.3 Yield and yield attributing characters of Mungbean with saline water

Name of Entry	No. of pods/ plant	Days to Flower	Pod length (cm)	No. of seeds/ pod	Days to maturity	100 Grain weight (gm)	Biological yield (kg/ha)	Grain Yield (kg/ha)
SAS-24-01	15.7	43.7	6.1	5.7	68.3	5.73	1369.7	447.8
SAS-24-02	16.3	45.6	6.8	6.3	68.6	5.43	1486.7	479.4
SAS-24-03	19.7	42.6	7.0	7.0	66.6	5.63	1493.3	479.4
SAS-24-04	19.0	42.7	6.7	7.0	66.7	5.63	1519.3	491.1
SAS-24-05	18.3	43.6	6.6	7.8	66.3	5.80	1451.7	468.9
SAS-24-06	19.0	41.7	6.0	7.3	67.0	6.00	1385.0	447.2
SAS-24-07	19.7	44.6	6.5	7.7	68.3	5.40	1488.3	494.4
SAS-24-08	19.3	39.7	6.8	7.5	68.0	6.00	1508.3	495.5
SAS-24-09	18.0	41.6	6.8	7.7	68.3	6.03	1501.7	493.3
SAS-24-10	19.7	39.7	7.0	8.0	66.7	5.86	1495.0	496.7
SAS-24-11	19.3	41.6	7.1	8.2	67.6	5.60	1646.7	543.9
SAS-24-12	21.3	41.6	7.3	8.3	65.6	5.83	1806.7	598.9
SAS-24-13	18.3	37.6	7.1	8.0	68.3	6.20	1636.7	501.1
SEm$\pm$	1.02	0.39	0.25	0.55	0.86	0.17	43.1	24.9
CD at 5%	2.23	0.79	0.55	1.20	1.73	0.38	86.9	54.28

- **Screening of newly released rice varieties for salinity tolerance (Bapatla)**

This experiment was conducted at the farmer's field of Kothapalem village. The initial soil pH and EC were 7.8 and 8.0 dS m^{-1} respectively. The data indicated that soil salinity significantly influenced the yield, and Na/K ratio of rice crop (Table 5.4). Grain yield was maximum with MCM 100 variety (5205 and 4917 kg ha^{-1}) which was found to be on par with MTU 1290, MCM 125, CSR56 and CSR 60 varieties and it was significantly superior to the rest of the varieties during both the years 2023 and 2024. The minimum grain yield was observed with MTU 1293 variety (3220 and 3300 kg ha^{-1}). The data further indicated that the straw yield with MCM 100 variety was significantly superior to MTU 1293 variety but was at par with all other varieties during both the years of study but except MTU 1061 during 2024.

Sodium uptake and potassium uptake in grain and sodium / potassium ratio was significantly influenced by soil salinity. The lowest sodium uptake in grain was observed in MTU 1293 variety whereas it was on par with all other varieties further it was significantly superior to CSR56 variety during 2023 and it was significantly superior MCM 100, MCM 125, CSR 56 and CSR 60 treatments during 2024. Among the varieties, significantly the highest K uptake in grain was recorded with CSR 60 variety (34) during 2023 and 31.4 with MTU 1061 variety during 2024 and it was significantly superior to MTU 1293 and MTU 1061 during 2023 and significantly superior to rest of the varieties during 2024. The lowest Na/K ratio in grain was recorded with MCM variety and in straw with MTU 1293 variety during both the years of study.

Table 5.4 Yield, Na/K ratio in grain and Na/K ratio in straw of salinity tolerance rice varieties

Treatments	Grain Yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Na/K ratio in grain		Na/K ratio in straw	
	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
T1-MTU1293	3220	3300	4133	4833	0.15	0.18	0.70	3.17
T2-MTU1290	4534	4400	6367	6283	0.14	0.20	1.09	4.00
T3-MTU1061	3729	3667	5200	5367	0.14	0.30	0.54	3.70
T4-MCM100	5205	4917	6827	7050	0.13	0.27	0.63	4.72
T5-MCM125	4848	4733	6263	6833	0.14	0.34	0.69	4.42
T6-CSR56	4308	4150	5700	6167	0.15	0.58	0.82	4.16
T7-CSR60	4744	4517	5817	6633	0.14	0.44	0.97	4.54
Sem +	364	368.8	641	338.8	-	-	-	-
CD (0.05)	1122	1136	1975	1044	-	-	-	-
CV (%)	14.4	15.1	13.3	9.5	-	-	-	-

From the data, it can be inferred that there was no significant effect on soil available pH by different varieties in saline soils. Significantly the maximum soil available nitrogen was 311 kg ha^{-1} was recorded with MCM 100 followed by MTU 1290, MCM 125 and CSR 60 varieties. The lowest available nitrogen was recorded with MTU 1293 variety (234 kg ha^{-1}). The soil available phosphorus was not significantly affected by different varieties in saline soils. At harvest the highest available phosphorous 33kg ha^{-1} was recorded with MCM 100 and MCM 125 varieties (Table 5.5). The soil available potassium was not significantly influenced by different varieties in saline soils. The highest available potassium was observed with CSR 60 variety (1032 kg ha^{-1}) whereas the lowest available potassium was recorded with MTU 1293 variety (942 kg ha^{-1}).

- **Table 5.5 Soil characters after harvest of rice crop**

Treatments	pH	EC (dS m^{-1})	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
T1-MTU1293	7.7	3.2	234	26	942
T2-MTU1290	7.7	3.4	280	29	983
T3-MTU1061	7.7	3.8	250	27	953
T4-MCM100	7.7	4.6	311	33	1076
T5-MCM125	7.7	3.9	301	33	1061
T6-CSR56	7.8	3.9	261	28	965
T7-CSR60	7.6	4.0	293	30	1032
Sem $\pm$	0.07	0.3	12.8	1.8	48.8
CD (0.05)	0.22	0.8	39.4	NS	NS
CV (%)	1.6	11.8	8	10	8

Field view of experimental plot

- **Screening of Summer Mustard Genotypes under Saline/Alkaline Conditions (Bikaner)**

During rabi 2023-24 in AVT of mustard, five entries were evaluated in randomized block design with four replications under saline conditions (ECiw 13 dS m^{-1}). The differences among the genotypes for seed yield was found significant. Highest seed yield was recorded in entry CSCN-23-04 (1789.20 kg/ha) closely followed by CSCN-23-03(1719.29 kg/ha) and CSCN-23-01 (1634.88 kg/ha) (Table 5.6).

Table 5.6 Advanced varietal trial (AVT) of mustard under saline/ alkaline conditions

S. No.	Treatments	Plant population per plot	Days to 50% Flowering	Plant height (cm)	Main shoot length (cm)	No. of Siliqua on Main shoot	Days to maturity	1000-seed wt. (gm)	Seed Yeld (kg/ha)
1	CSCN-23-01	199.50	52.50	135.65	50.90	51.15	127.00	4.80	1634.88
2	CSCN-23-02	205.00	48.75	178.05	55.30	50.45	145.00	5.14	1128.24
3	CSCN-23-03	203.00	49.25	177.70	60.30	59.00	145.75	5.54	1719.29
4	CSCN-23-04	209.25	51.25	165.55	61.20	60.00	144.75	5.82	1789.20
5	CSCN-23-05	196.50	47.50	179.00	57.70	46.20	145.25	5.08	1279.48
	SEm ±	7.24	2.04	6.76	2.21	3.11	3.70	0.19	69.07
	CD (P= 0.05)	22.32	6.28	20.84	6.79	9.58	11.41	0.60	212.81

Soil test value of experimental area: Organic carbon 0.14%, Available phosphorus (P2O5) 22.6 kg/ha and available potassium (K2O) 299 kg/ha.

- **Screening of elite varities of different crop irrigated with poor quality water (Hisar)**

Experiments were conducted during 2022-24 to evaluate the tolerance of pearl millet and mustard genotypes to poor-quality irrigation water. Four water qualities (canal water and saline waters with ECiw of 2.5, 5.0, and 7.5 dS m^{-1}) were tested using lined micro-plots with sandy loam soil. The study assessed the performance of various genotypes of pearl millet and mustard under different irrigation water salinity levels, with standard agronomic practices followed. Soil samples were analyzed for electrical conductivity to determine salt build-up in the soil profile.

Pearl millet (2022): Among the pearl millet genotype, HHB-299 (287.76 g/m^2) performed best at EC_{iw} (7.5 dS m^{-1}) followed by HHB-226 (276.27 g/m^2) whereas among all the genotypes HHB-67 (203.31 g/m^2) was the lowest yielder (Table 5.7). The mean grain yield (327.49 g/m^2) of HHB-299 was higher than other genotypes followed by HHB-226 (317.487 g/m^2). The overall mean reduction in pearl millet yield at 2.5, 5.0 and 7.5 dS m^{-1} was 3.74, 12.55 and 21.85 per cent, respectively as compared to canal water (Table 5.7). The data showed that the stover yield, plant height, number of effective tillers per plant and earhead length of different genotypes of pearl millet decreased with an increase in EC of the irrigation water. In pearl millet genotype HHB-299 gave the highest stover yield (627.85 g/m^2), plant height (169.00 cm), number of effective tillers per plant (2.78) and earhead length (19.17 cm) at ECiw 7.5 dS m^{-1} and the lowest stover yield (438.78 g/m^2), plant height (167.70 cm), number of effective tillers per plant (2.33) and earhead length (17.57 cm) were obtained in HHB-67. All the genotypes of pearl millet showed decreasing trend of yield with the increasing levels of salinity (canal to 7.5 dS m^{-1}).

Pearl millet (2022-23): Among the pearl millet genotype, HHB-346 (212.53 g/m^2) performed best at EC_{iw} (7.5 dS m^{-1}) followed by HHB-67 Improved 2 (201.58 g/m^2) whereas among all the genotypes HHB-67 Improved (183.45 g/m^2) was the lowest yielder. The mean grain yield (244.03 g/m^2) of HHB-346 was higher

Table 5.7 Grain yield (g/m^2) of pearl millet genotypes as affected by different saline waters

Genotype	EC_{iw} (dS m^{-1})				Mean
	Canal (0.3)	2.5	5.0	7.5	
			2022		
HHB-67	270.80	256.70	230.50	203.31	240.33
HHB-197	313.97	298.64	269.50	239.77	280.47
HHB-226	347.91	337.44	308.28	276.27	317.48
HHB-299	355.97	347.66	318.58	287.76	327.49
Mean	322.16	310.11	281.72	251.78	
CD (p=0.05)	Variety (V) = 16.84, Salinity (S) = 16.84, V x S =NS				
			2023		
HHB-67 Improved	243.24	234.36	206.66	183.45	216.93
HHB-67 Improved 2	258.51	251.27	226.75	201.58	234.53
HHB-344	250.33	242.47	214.54	192.20	224.89
HHB-346	266.83	261.35	235.42	212.53	244.03
Mean	**254.72**	**247.36**	**220.84**	**197.44**	
CD (p=0.05)	Variety (V) = 16.42, Salinity (S) = 16.42, V x S =NS				

than other genotypes followed by HHB-67 Improved 2 (234.53 g/m^2). The overall mean reduction in pearl millet yield at 2.5, 5.0 and 7.5 dS m^{-1} was 2.89, 13.30 and 22.48 per cent, respectively as compared to canal water (Table 5.7). The data showed that the plant height, number of effective tillers per plant and earhead length and 1000 grain weight of different genotypes of pearl millet decreased with an increase in EC of the irrigation water. All the genotypes of pearl millet showed decreasing trend with the increasing levels of salinity (canal to 7.5 dS m^{-1}).

Mustard (2022-23)*:* During 2022–23, four mustard genotypes under AVT-1 were evaluated under varying irrigation salinity levels. Results indicated that seed yield decreased with increasing EC of irrigation water

(Table 5.8). Among the genotypes, CS-2020-10* produced the highest seed yield (235.84 g/m²), followed by CS-54 (Check) (218.38 g/m²) at ECiw 7.5 dS m^{-1}, while Kranti (NC) recorded the lowest yield (172.36 g/m²). The overall mean yield reduction at ECiw 2.5, 5.0, and 7.5 dS $m^{-1}$was 2.16%, 14.76%, and 26.81%, respectively, compared to canal water. Number of siliqua per plant, and 1000-grain weight also decreased with increasing salinity (Tables 5.9-5.10). The highest siliqua per plant (278.70), and 1000-grain weight (4.67 g) were recorded in CS-2020-10*, whereas Kranti (NC) showed the lowest values (226.41, and 4.21 g, respectively). Chlorophyll content and photochemical quantum yield (Fv/Fm) declined from 28.75 to 24.12 and 0.718 to 0.679, respectively, with increasing salinity (Table 5.11). CS-54 (28.23 and 0.710) and CS-2020-10* (27.18 and 0.702) maintained higher chlorophyll and Fv/Fm values under 7.5 dS/m salinity. Conversely, anthocyanin and flavonoid content increased from 0.45 to 0.64 and 0.12 to 0.16, respectively, with rising salinity (Tables 5.12-5.13), indicating enhanced stress defense mechanisms. Soil salinity at harvest increased from 2.05 dS/m (canal water) to 10.36 dS m^{-1}under ECiw 7.5 dS m^{-1}irrigation. Overall, CS-2020-10* and CS-54 demonstrated better tolerance to saline irrigation conditions.

Table 5.8 Seed yield (g/m^2) of mustard genotypes under AVT-I as affected by waters of different salinities

Genotype	EC_{iw} (dS/m)				Mean
	Canal (0.3)	2.5	5.0	7.5	
		2022-23			
CS-54 (Check)	295.45	286.68	252.65	218.38	263.29
CS-2020-10*	314.90	306.44	272.35	235.84	282.38
CS 60 (LR)	250.45	241.39	212.42	180.27	221.13
Kranti (NC)	241.59	232.31	202.23	172.36	212.12
Mean	275.60	266.70	234.91	201.71	
CD (p=0.05)	Salinity (S) = 9.89,	Variety (V) = 9.89,	SxV= NS		
		2023-24			
Kranti (NC)	202.96	194.97	172.33	150.23	180.12
CS 2020-10	250.32	243.22	221.43	209.33	231.07
CS 60 (Filler)	211.56	203.70	182.67	173.20	192.78
CS-54 (Check)	225.84	218.44	196.36	179.54	205.04
CS 60 (LR)	240.38	233.22	210.35	181.42	216.34
Mean	226.21	218.71	196.63	178.74	
CD (p=0.05)	Salinity (S) = 15.32,	Variety (V) = 17.12,	SxV= NS		

Table 5.9 Number of siliqua per plant of mustard genotypes under AVT-1 as affected by waters of different salinities

Genotype	EC_{iw} (dS/m)				Mean
	Canal (0.3)	2.5	5.0	7.5	
		2022-23			
CS-54 (Check)	334.16	321.49	295.48	242.75	298.47
CS-2020-10*	375.00	361.24	334.13	278.70	337.27
CS 60 (LR)	328.78	314.40	282.43	234.23	289.60
Kranti (NC)	323.33	307.85	272.19	226.41	282.44
Mean	340.32	326.25	296.06	245.52	
CD (p=0.05)	Salinity (S) = 28.16,	Variety (V) = 28.16,	SxV = NS		
		2023-24			
Kranti (NC)	170.4	161.3	149.3	137.4	154.6
CS 2020-10	206.6	198.3	182.4	169.2	189.1
CS 60 (Filler)	184.3	175.4	161.4	148.3	167.4
CS-54 (Check)	175.5	167.6	155.0	143.5	160.4
CS 60 (LR)	190.5	182.0	167.0	155.0	173.6
Mean	185.5	176.9	163.0	150.7	
CD (p=0.05)	Salinity (S) = 3.15,	Variety (V) = 3.52,	SxV= NS		

Mustard (2023-24)*:* A study on five mustard genotypes under AVT-1 tested the impact of increasing irrigation water salinity (ECiw) on seed yield and growth parameters (Table 5.8-5.14. Results showed that seed yield decreased with increasing ECiw, with a mean reduction of 3.31%, 13.08%, and 20.98% at ECiw 2.5, 5.0, and 7.5 dS m^{-1}, respectively. The genotype CS 2020-10 performed best, with the highest seed yield

Table 5.10 1000 seed weight (g) of mustard genotypes under AVT-1 as affected by waters of different salinities

Genotype	EC_{iw} (dS m^{-1})				Mean
	Canal (0.3)	2.5	5.0	7.5	
		2022-23			
CS-54 (Check)	5.60	5.47	5.00	4.47	5.14
CS-2020-10*	5.77	5.64	5.17	4.67	5.31
CS 60 (LR)	5.50	5.31	4.87	4.34	5.00
Kranti (NC)	5.43	5.17	4.76	4.21	4.89
Mean	5.58	5.40	4.95	4.42	
CD (p=0.05)	Salinity (S) = 0.29,	Variety (V) = 0.29,	SxV = NS		
		2023-24			
Kranti (NC)	4.27	4.23	4.15	4.03	4.17
CS 2020-10	5.40	5.38	5.29	5.12	5.30
CS 60 (Filler)	5.46	5.43	5.32	5.17	5.35
CS-54 (Check)	5.43	5.38	5.27	5.13	5.30
CS 60 (LR)	5.41	5.37	5.22	5.11	5.28
Mean	5.19	5.16	5.05	4.91	
CD (p=0.05)	Salinity (S) = 0.12,	Variety (V) = 0.14,	SxV = NS		

(209.33 g/m²) and growth parameters, while Kranti (NC) showed the lowest yields. Increasing salinity also decreased chlorophyll content, photochemical quantum yield, and other growth parameters, but increased anthocyanin and flavonoids. The soil salinity after harvest ranged from 2.10 dS/m (canal water) to 10.42 dS m^{-1} (ECiw 7.5 dS m^{-1}).

Table 5.11 Chlorophyll content (SPAD units) of mustard genotypes underAVT-1 as affected by waters of different salinities (2022-23)

Genotype	EC_{iw} (dS m^{-1})				Mean
	Canal (0.3)	2.5	5.0	7.5	
		2022-23			
CS-54 (Check)	32.95	30.68	30.45	28.23	30.58
CS-2020-10*	29.10	28.65	28.13	27.18	28.26
CS 60 (LR)	27.85	26.75	22.75	20.65	24.30
Kranti (NC)	27.00	25.38	22.55	20.43	23.84
Mean	28.75	28.14	25.97	24.12	
CD (p=0.05)	Salinity (S) = 1.06,	Variety (V) = 1.07,	SxV= 2.12		
		2023-24			
Kranti (NC)	28.47	25.27	24.73	23.83	25.58
CS 2020-1	38.53	37.87	33.40	32.43	35.56
CS 60 (Filler)	34.70	29.83	29.53	23.37	29.36
CS-54 (Check)	32.20	30.97	31.87	28.80	30.96
CS 60 (LR)	38.30	33.90	31.60	29.90	33.43
Mean	34.44	31.57	30.23	27.67	
CD (p=0.05)	Salinity (S) = 1.96,	Variety (V) = 2.19,	S X V = NS		

Table 5.12 Anthocyanin content (%) of mustard genotypes underAVT-1 as affected by waters of different salinities (2022-23)

Genotype	EC_{iw} (dS m^{-1})				Mean
	Canal (0.3)	2.5	5.0	7.5	
		2022-23			
CS-54 (Check)	0.49	0.63	0.63	0.70	0.725
CS-2020-10*	0.50	0.57	0.58	0.59	0.715
CS 60 (LR)	0.41	0.41	0.51	0.55	0.688
Kranti (NC)	0.42	0.54	0.55	0.71	0.693
Mean	0.45	0.54	0.56	0.64	
CD (p=0.05)	Salinity (S) = 0.18,	Variety (V) = 0.20,	SxV = 0.05		
		2023-24			
Kranti (NC)	0.43	0.58	0.63	0.71	0.61
CS 2020-10	0.38	0.41	0.51	0.54	0.46
CS 60 (Filler)	0.42	0.57	0.58	0.58	0.54
CS-54 (Check)	0.40	0.55	0.56	0.65	0.54
CS 60 (LR)	0.40	0.51	0.54	0.60	0.51
Mean	0.40	0.52	0.56	0.62	
CD (p=0.05)	Salinity (S) = 0.02,	Variety (V) = 0.02,	SxV= 0.05		

Table 5.13 Flavonoids (%) of mustard genotypes underAVT-1 as affected by waters of different salinities (2022-23)

Genotype	EC_{iw} (dS m^{-1})				Mean
	Canal (0.3)	2.5	5.0	7.5	
	2022-23				
CS-54 (Check)	0.10	0.11	0.13	0.15	0.12
CS-2020-10*	0.11	0.13	0.14	0.15	0.13
CS 60 (LR)	0.12	0.13	0.13	0.17	0.14
Kranti (NC)	0.13	0.13	0.14	0.17	0.14
Mean	0.12	0.13	0.14	0.16	
CD (p=0.05)	Salinity (S) = 0.007,	Variety (V) = 0.006,	SxV = 0.013		
	2023-24				
Kranti (NC)	0.12	0.13	0.14	0.17	0.14
CS 2020-10	0.10	0.10	0.12	0.12	0.11
CS 60 (Filler)	0.12	0.12	0.12	0.15	0.13
CS-54 (Check)	0.11	0.12	0.12	0.16	0.13
CS 60 (LR)	0.11	0.12	0.12	0.13	0.12
Mean	0.11	0.12	0.13	0.15	
CD (p=0.05)	Salinity (S) = 0.005,	Variety (V) = 0.006,	S xV = 0.012		

Table 5.14 Salinity at different soil depths after the mustard harvest

Depth (cm)	EC_e (dS m^{-1})							
	2022-23				2023-24			
	Canal	2.5	5.0	7.5	Canal	2.5	5.0	7.5
0-15	2.10	4.63	7.91	10.43	2.14	4.7	7.99	10.47
15-30	1.99	4.23	7.41	10.30	2.05	4.34	7.56	10.36
Mean	**2.05**	**4.43**	**7.66**	**10.36**	**2.10**	**4.52**	**7.78**	**10.42**

- **Evaluation of Green gram varieties for their tolerance to sodicity (Tiruchirappalli)**

A field experiment was conducted at the permanent ESP gradient field of Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, to evaluate the performance of five greengram varieties (VBN 5, CO 8, VBN 6, CO 9, and VBN 2) under graded levels of sodicity (ESP 8, 16, 24, 32, 40, and 48). The experiment followed a strip plot design with two replications. Yield parameters and Na and K accumulation were studied (Table 5.15-5.18). All growth and yield attributes significantly declined with increasing ESP. Among the varieties, VBN 5 recorded the highest plant height and pod number at all ESP levels. Up to ESP 24, VBN 5, VBN 6, and VBN 2 maintained about 50% yield, which drastically reduced beyond that. At ESP 40, yield dropped to 11.0, 8.7, 8.0, 6.5, and 6.1% of the yield at ESP 8 for VBN 5, VBN 6, VBN 2, CO 8, and CO 9, respectively, while no survival was recorded at ESP 48. The Na/K ratio increased with sodicity (Table 5.17-5.18), but tolerant varieties (VBN 5, VBN 6, VBN 2) maintained lower ratios. Soil analysis (Table 5.19-5.21) showed that soil pH and EC increased with sodicity, reaching 10.1 and 1.42 dS m^{-1}, respectively, at ESP 48. The ESP values remained close to target levels with slight declines post-harvest. Overall, VBN 5 and VBN 6 performed best under sodic conditions and could be recommended up to ESP 24 for maintaining reasonable yield (≈50%).

Table 5.15 Effect of ESP levels on grain yield of green gram

ESP	Grain yield (kg ha^{-1})					
	VBN 5	**CO 8**	**VBN 6**	**CO 9**	**VBN 2**	**Mean**
8	770	690	700	650	696	701
16	610	490	580	460	540	536
24	480	380	450	340	420	414
32	306	210	260	200	240	243
40	85	45	61	40	56	57
48	-	-	-	-	-	-
Mean	**450**	**363**	**410**	**338**	**390**	
	M	S	MXS			
SEd	9.0	6.7	12.8			
CD (0.05)	20.4	13.6	26.1			

Table 5.16 Effect of ESP levels on Stover yield of green gram

ESP	Stover yield (kg ha^{-1})					
	VBN 5	**CO 8**	**VBN 6**	**CO 9**	**VBN 2**	**Mean**
8	1717	1553	1561	1450	1552	1566
16	1354	1107	1282	1017	1199	1192
24	1075	851	1004	751	928	922
32	679	470	580	442	530	540
40	191	100	136	90	124	128
48	79	41	54	37	51	52
Mean	**849**	**687**	**769**	**631**	**731**	
	M	S	MxS			
SE d	19	8	28			
CD (0.05)	38	18	59			

Table 5.17 Effect of ESP levels on Na/K ratio of green gram (Grain)

	Grain					
ESP	**VBN 5**	**CO 8**	**VBN 6**	**CO 9**	**VBN 2**	**Mean**
8	0.17	0.2	0.18	0.21	0.19	0.19
16	0.50	0.57	0.50	0.59	0.52	0.54
24	0.66	0.73	0.68	0.76	0.71	0.71
32	0.74	0.81	0.75	0.83	0.78	0.78
40	0.85	0.92	0.87	0.93	0.91	0.90
48	-	-	-	-	-	-
Mean	**0.584**	**0.646**	**0.596**	**0.664**	**0.622**	
	M	S	MXS			
SE d	0.011	0.005	0.020			
CD (0.05)	0.032	0.013	0.041			

Table 5.18 Effect of ESP levels on Na/K ratio of green gram (Stover)

	Stover					
ESP	**VBN 5**	**CO 8**	**VBN 6**	**CO 9**	**VBN 2**	**Mean**
8	0.42	0.42	0.47	0.40	0.40	0.42
16	0.72	0.76	0.75	0.80	0.74	0.75
24	0.85	1.02	0.97	0.98	1.00	0.96
32	0.95	1.00	0.96	1.08	0.97	0.99
40	1.07	1.13	1.09	1.14	1.16	1.12
48	1.40	1.53	1.44	1.55	1.55	1.49
Mean	**0.90**	**0.98**	**0.95**	**0.99**	**0.97**	
	M	S	MxS			
SE d	0.020	0.017	0.027			
CD (0.05)	0.041	0.032	0.056			

Table 5.19 Effect of ESP levels on pH, EC and ESP of soil at post-harvest stage of greengram

ESP Levels	pH					
	VBN 5	**CO 8**	**VBN 6**	**CO 9**	**VBN 2**	**Mean**
8	8.11	8.1	8.13	8.15	8.12	8.12
16	8.59	8.53	8.6	8.59	8.52	8.57
24	8.61	8.56	8.6	8.57	8.56	8.58
32	9.53	9.42	9.51	9.54	9.52	9.50
40	9.9	9.92	9.89	9.91	9.88	9.90
48	10.2	10.2	10.1	10	10.1	10.12
Mean	**9.16**	**9.12**	**9.14**	**9.13**	**9.12**	
		M	S	MXS		
SE d		0.14	0.05	0.18		
CD (0.05)		0.33	NS	NS		

Table 5.20 Effect of ESP levels on EC of soil at post-harvest stage of greengram

ESP	EC (dS m^{-1})					
Levels	**VBN 5**	**CO 8**	**VBN 6**	**CO 9**	**VBN 2**	**Mean**
8	0.63	0.6	0.64	0.61	0.59	0.61
16	0.89	0.85	0.9	0.88	0.91	0.89
24	0.95	0.97	0.98	0.95	0.99	0.97
32	1.12	1.08	1.15	1.16	1.14	1.13
40	1.15	1.17	1.16	1.21	1.18	1.17
48	1.41	1.45	1.41	1.46	1.38	1.42
Mean	**1.03**	**1.02**	**1.04**	**1.05**	**1.03**	
		M	S	MXS		
SE d		0.019	0.007	0.026		
CD (0.05)		0.04	NS	NS		

Table 5.21 Effect of ESP levels on ESP of soil at post-harvest stage of greengram

ESP	ESP (%)					
Levels	**VBN 5**	**CO 8**	**VBN 6**	**CO 9**	**VBN 2**	**Mean**
8	8.13	8.17	8.28	8.31	8.33	8.24
16	15.9	16.2	15.7	15.5	15.8	15.82
24	23.5	22.8	23.1	23.4	22.9	23.14
32	31.7	31.3	31.5	31.9	32.3	31.74
40	39.5	39.1	40.2	39.8	39.4	39.60
48	45.3	45.9	44.9	46.2	49.5	46.36
Mean	**27.3**	**27.2**	**27.3**	**27.5**	**28.0**	
		M	S	MxS		
SE d		0.65	0.45	0.87		
CD (0.05)		1.38	NS	NS		

- **Evaluation of traditional rice landraces for their sodicity tolerance (Tiruchirappalli)**

Field experiment was conducted at permanent ESP gradient field at the Anbil Dharmalingam Agricultural College and Research Institute, NavalurKuttapattu, Tiruchirappalli using traditional rice landraces *viz.,* Kaalanamak, KuadaiVazhai, Mappilai Samba, Kichili Samba, Garudan Samba, Illuppaipoo Samba, Milagu Samba, Thuyamalli, Seeraga Samba, KaruppuKavuni, Rathasali, Kothamalli Samba, TRY 3 (Check) to evaluate its performance under graded level of sodicity *viz.,* ESP 8, 16, 24, 32, 40 and 48. The experiment was laid out in split plot design with two replications. The rice varieties were screened based on grain and straw yield under graded levels of sodicity stresses.

The different ESP level had significant effect on grain yield of rice (Table 5.22). Among the different ESP levels *viz.,* ESP 8 (M_1), ESP 16 (M_2), ESP 24 (M_3), ESP 32 (M_4), ESP 40 (M_5) and ESP 48 (M_6), the highest grain yield (3358 kg/ha) was recorded at ESP 8 and gradually decreased with increasing ESP levels. Comparing grain yield at ESP 8 (M_1) with other ESP levels *ie.,* ESP 16 (M_2), ESP 24 (M_3), ESP 32 (M_4), ESP 40 (M_5) and ESP 48 (M_6) a decreased trend was observed to the tune of 2850, 2260, 1830, 1339 and 976 kg ha^{-1}, respectively.

In case of traditional rice landraces, the grain yield was found to be significantly different. The highest grain yield was recorded in Karruppukavuni followed by Kaalanamak, Mappillai samba, Milagu samba, Kichili samba, Thuyamalli, KuadaiVazhai, Seeraga samba, Garudan samba, Kothamalli samba, Illuppaipoo Samba and Rathasali. The lowest grain yield recorded in susceptible variety Rathasali (886 kg ha^{-1}). Interaction between different sodicity levels and rice varieties was found to be significantly different.

Table 5.22 Effect of graded levels of ESP on grain yield of traditional rice landraces

ESP level / Traditional rice land races	Grain yield (kg/ha)						
	ESP 8	**ESP 16**	**ESP 24**	**ESP 32**	**ESP 40**	**ESP 48**	**Mean**
Kaalanamak	3764	3285	2356	2185	1892	1317	2467
KuadaiVazhai	3503	2786	2465	1773	1152	991	2112
Seeraga Samba	3148	2802	1654	1171	806	365	1658
MappilaiSamba	3825	3424	2590	2016	1636	1473	2494
Kichili Samba	3617	3072	2329	2250	1566	1068	2317
Garudan Samba	2511	2080	1813	1244	1079	706	1572
Rathasali	1712	1193	832	694	525	358	886
Illuppaipoo Samba	2234	1226	850	738	589	431	1011
Kothamalli Samba	2471	1431	1131	1018	984	428	1244
Milagu Samba	3683	3353	2547	1826	1508	1119	2339
Thuyamalli	3278	2916	2614	2219	1541	1084	2275
KaruppuKavuni	4353	4170	3629	2809	1712	1406	3013
TRY 3 (Check)	5560	5314	4358	3648	2344	1944	3861
Mean	**3358**	**2850**	**2260**	**1830**	**1339**	**976**	
	M	V	MxV				
SEd	76	57	83				
CD (0.05)	153	116	165				

Under increasing ESP levels, Karruppukavuni, Kaalanamak, Mappillai samba, Milagu samba, Kichili samba and Thuyamalli recorded reasonable yield of 50 % at ESP 32 and thereafter drastically decreased. This 50 % yield in Karruppukavuni, Kaalanamak, Mappillai samba, Milagu samba, Kichili samba and Thuyamalli traditional rice variety was due to higher number of tillers per square meter, productive tillers, efficient nutrient uptake, increased biochemical mechanism and extended degree of tolerance. In case of KudaiVazhai, Seeraga samba and Garudan samba 50 % of grain yield was recorded upto ESP 24 and thereafter decreases. In case of Kothamalli samba, Illuppaipoo Samba and Rathasali 50 % yield was achieved only upto ESP 16 and thereafter decreases drastically. Similar trend was observed in straw yield.

Statistically significant difference was also observed in straw yield at different ESP levels (Table 5.23). The mean straw yield at different sodicity levels recorded higher at ESP 8 - M_1 (5016 kg ha^{-1}) followed by ESP 16 (M_2), ESP 24 (M_3), ESP 32 (M_4) and ESP 40 (M_5) *viz.,* 3911, 3132, 2438 and 1632 kg ha^{-1}, respectively. The lowest straw yield was recorded at ESP 48 (1203 kg ha^{-1}). The traditional rice landraces showed significant difference in straw yield *ie.,* Karruppukavuni followed by Kaalanamak, Mappillai samba, Milagu samba, Kichili samba, Thuyamalli, KudaiVazhai, Seeraga samba, Garudan samba, Kothamalli samba, Illuppaipoo Samba and Rathasalirecorded straw yield of 4194, 3442, 3359, 3205, 3081, 2875, 2785, 2273, 2158, 1969, 1461, and 1433 kg ha^{-1}, respectively. Interaction between rice varieties and ESP levels was also found to be significantly different. At ESP 8 (M_1), the lowest straw yield (2568 kg ha^{-1}) was recorded by Rathasali, while at ESP 48 (M_6), the lowest straw yield was recorded by Rathasali (508 kg/ha).

Table 5.23 Effect of graded levels of ESP on straw yield of traditional rice landraces

ESP level / Traditional rice land races	Straw yield (kg/ha)						
	ESP 8	**ESP 16**	**ESP 24**	**ESP 32**	**ESP 40**	**ESP 48**	**Mean**
Kaalanamak	5758	4088	3570	2937	2188	1612	3359
KuadaiVazhai	5254	4256	2785	1997	1314	1103	2785
Mappilai Samba	5486	4444	3922	2962	1975	1865	3442
Kichili Samba	5389	3880	3449	2802	1886	1078	3081
Garudan Samba	3721	2679	2493	1674	1414	967	2158
Illuppaipoo Samba	3283	1740	1248	1018	788	689	1461
Milagu Samba	5590	4360	3857	2907	1733	783	3205
Thuyamalli	5015	3561	2959	2558	1755	1404	2875
Seeraga Samba	4753	3042	2467	1521	1046	808	2273
KaruppuKavuni	6675	6275	5006	3471	2069	1669	4194
Rathasali	2568	2440	1310	1053	719	508	1433
Kothamalli Samba	3658	3548	1610	1317	1024	658	1969
TRY 3 (Check)	8062	6530	6047	5482	3305	2499	5321
Mean	**5016**	**3911**	**3132**	**2438**	**1632**	**1203**	
	M	V	MxV				
SEd	103	81	114				
CD (0.05)	205	162	229				

Na/K ratio : The Na: K ratio in both rice grain and straw was significantly influenced by ESP levels, varietal differences, and their interaction, with a clear trend of increasing Na/K ratio as sodicity increased from M_1 to M_6 (Table 5.24 and 5.25). This reflects the enhanced uptake or accumulation of sodium relative to potassium under increasing soil sodicity stress.

In grain, the Na: K ratio increased from 0.64 at M_1 to 0.87 at M_6, and the differences among ESP levels, varieties, and their interaction were all statistically significant. Varieties such as Kalanamak, Mappillai Samba, and Milagu Samba, which maintained higher grain yields (>3200 kg/ha), showed lower grain Na/K ratios across the ESP gradient, especially at M_5 and M_6. In contrast, varieties such as Illuppaipoo Samba, Garudan Samba, and Kothamalli Samba, with lower grain yields (<2200 kg/ha), exhibited higher Na/K ratios, particularly under higher sodicity. This again suggests that the ability to regulate sodium and potassium homeostasis at the cellular level is closely linked with yield stability under sodic conditions.

In straw, a similar trend was evident. The mean Na/K ratio increased progressively from 0.93 at M_1 to 1.26 at M_6, with significant differences across ESP levels, varieties, and their interaction. The interaction effect revealed that some varieties maintained relatively lower Na/K ratio even under high ESP levels. Notably, high-yielding varieties such as TRY 3 and Karuppu Kavuni, which produced mean straw yields of 5321 kg/ha and 4194 kg/ha, respectively, were associated with comparatively lower Na/K ratio than lower-yielding varieties like Illuppaipoo Samba and Rathasali, which exhibited higher Na/K ratios and produced 1461 kg/ha and 1433 kg/ha, respectively. This inverse relationship suggests that genotypes able to restrict sodium accumulation or sustain potassium uptake are better adapted to sodic conditions, thereby supporting greater biomass production. The M × S interaction revealed that while Na/K ratio generally increased with ESP, the magnitude of increase varied by traditional varieties. For instance, TRY 3 showed a modest increase in Na/K ratio from M_1 to M_6, maintaining ionic balance despite elevated ESP levels. Conversely, sensitive traditional landraces such as Rathasali and Illuppaipoo Samba showed a sharper rise in Na/K ratio under the same conditions, indicating their lower physiological tolerance to sodicity.

Table 5.24 Effect of graded levels of ESP on grain Na/Kratio of traditional rice landraces

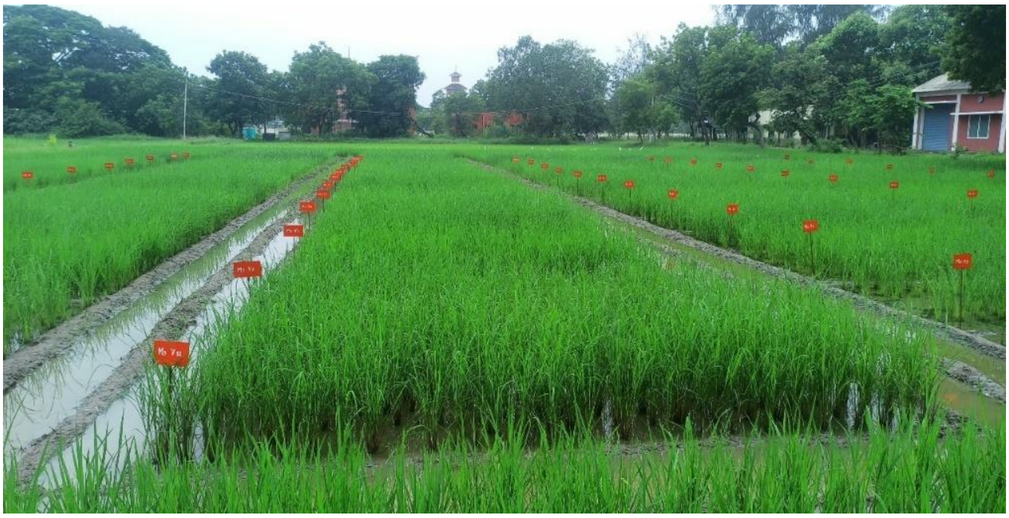
ESP level / Traditional rice land races	Grain Na/K ratio						
	ESP 8	**ESP 16**	**ESP 24**	**ESP 32**	**ESP 40**	**ESP 48**	**Mean**
Kaalanamak	0.59	0.63	0.67	0.71	0.73	0.76	0.68
KuadaiVazhai	0.62	0.65	0.72	0.75	0.91	1.01	0.78
Mappilai Samba	0.57	0.66	0.69	0.71	0.73	0.79	0.69
Kichili Samba	0.66	0.7	0.72	0.75	0.76	0.78	0.73
Garudan Samba	0.66	0.75	0.77	0.81	0.88	1.01	0.81
Illuppaipoo Samba	0.68	0.76	0.88	0.85	0.94	0.99	0.85
Milagu Samba	0.66	0.69	0.71	0.73	0.75	0.78	0.72
Thuyamalli	0.72	0.76	0.71	0.72	0.76	0.79	0.74
Seeraga Samba	0.67	0.71	0.76	0.78	0.9	0.92	0.79
KaruppuKavuni	0.58	0.62	0.63	0.68	0.72	0.75	0.66
Rathasali	0.71	0.77	0.89	0.91	0.95	1.03	0.88
Kothamalli Samba	0.66	0.75	0.77	0.86	0.92	1.01	0.83
TRY 3 (Check)	0.52	0.53	0.57	0.63	0.69	0.7	0.61
Mean	**0.64**	**0.69**	**0.73**	**0.76**	**0.82**	**0.87**	
	M	V	MXV				
SEd	0.00	0.00	0.01				
CD (0.05)	0.01	0.01	0.04				

Table 5.25 Effect of graded levels of ESP on straw Na/K ratio of traditional rice landraces

ESP level / Traditional rice land races	Straw Na/K ratio						
	ESP 8	ESP 16	ESP 24	ESP 32	ESP 40	ESP 48	Mean
Kaalanamak	0.91	0.93	1.01	1.03	1.09	1.11	1.01
KuadaiVazhai	0.93	0.99	1.04	1.14	1.23	1.29	1.10
Mappilai Samba	0.91	1.02	1.05	1.07	1.09	1.03	1.03
Kichili Samba	0.92	0.94	1.07	1.13	1.17	1.22	1.08
Garudan Samba	1.05	1.02	1.07	1.15	1.19	1.3	1.13
Illuppaipoo Samba	1.06	1.07	1.17	1.19	1.3	1.39	1.20
Milagu Samba	0.91	1.04	1.05	1.07	1.13	1.17	1.06
Thuyamalli	0.92	1.02	1.03	1.05	1.12	1.38	1.09
Seeraga Samba	1.02	1.04	1.06	1.16	1.18	1.27	1.12
KaruppuKavuni	0.66	0.84	0.99	1.05	1.08	1.13	0.96
Rathasali	1.06	1.14	1.15	1.17	1.37	1.42	1.22
Kothamalli Samba	1.04	1.02	1.15	1.17	1.25	1.47	1.18
TRY 3 (Check)	0.66	0.68	0.69	0.89	1.02	1.18	0.85
Mean	**0.93**	**0.98**	**1.04**	**1.10**	**1.17**	**1.26**	
	M	V	MxV				
SEd	0.02	0.04	0.11				
CD (0.05)	0.05	0.08	0.21				

The results of the field experiment revealed that the grain and straw yields of traditional rice landraces were gradually decreased with increasing ESP levels. The traditional rice landraces *viz.* Karruppukavuni, Kaalanamak, Mappillai samba, Milagu samba, Kichili samba and Thuyamalli were performed better upto the ESP level of 32 to get reasonable 50 % yield. KudaiVazhai, Seeraga samba and Garudan samba were tolerant upto ESP 24. Kothamalli samba, Illuppaipoo Samba and Rathasali were tolerant upto ESP 16. At increasing sodicity levels, Na/K ratio increased in all traditional rice landraces. But the tolerant traditional rice landraces recorded lower Na/K ratio and susceptible traditional rice landraces recorded higher Na/K ratio.

Traditional rice landraces



General view of the experimental field at tillering stage

6. OPERATIONAL RESEARCH PROJECTS/ON-FARM TRIALS/SC SP ACTIVITIES

- **ORP on use of underground saline water for irrigation at farmer's field (Agra)**

In Operational Research project (ORP), field demonstrations on use of poor-quality water for irrigation was conducted. The pH was normal in all tube well water samples, Na ranged between 28.9 to 110.7 meq L^{-1}, Ca+Mg ranged between 9.1 to 22.3 meq L^{-1}. The CO_3 was absent and HCO_3 was present. The chloride and sulphate were present in all the samples. The SAR ranged from 13.6 to 36.9, but RSC was absent in all samples. The pearl millet yield obtained from ORP and farmers field indicates that grain yield was higher a ORP fields (24.9 - 28.6 q/ha) as compared to farmers yield (22.8 to 25.7 q/ha). At harvest of pearl millet, EC_e ranged from 4.5 to 5.4 dS m^{-1} and pH ranged from 7.7 to 7.9 (Table 6.1).

Table 6.1 Grain yield of pearl millet under ORP and farmer's field and soil EC_e and pH at harvest (2022-23 and 2023-24)

Farmer name	ORP yield (q/ha)	Farmer yield (q/ha)	Increase over farmer yield (%)	EC_e (dS/m) (0-30cm)	pH (0-30cm)
Mr. Deepak	26.5	24.0	10.6	4.5	7.8
Mr. Nand Ram	26.0	23.5	10.7	4.6	7.8
Mr. Subhash	24.9	22.8	9.2	4.5	7.9
Mr. Mahesh	25.6	22.9	11.8	5.0	7.8
Mr. Vijay Pal	25.7	23.3	10.1	4.8	7.8
Mr. Sanjay	25.3	23.1	9.5	4.7	7.7
Mr. Kishan Gopal	26.0	23.3	11.4	4.8	7.8
Mr. Lokendra	26.3	23.9	10.0	4.9	7.9
Mr. Ram Prakash	25.6	23.3	9.8	4.8	7.8
Mr. Natthi Lal	28.6	25.7	11.2	5.4	7.9
Mr. Mukesh	25.9	23.7	9.3	4.8	7.7
Mr. Bhanwar Singh	26.2	23.9	9.6	4.6	7.8

The cost of cultivation, gross income, net profit (Rs/ha) and B:C ratio of pearl millet crop was calculated and presented in Table 6.2 which indicated that the cost of cultivation in ORP field was less as compare to farmer's practice. The gross income (Rs/ha) was higher in ORP field as compared to farmer's field. The net profit (Rs/ha) and B: C ratio was higher in ORP as compared to farmer's field.

Table 6.2 Cost of cultivation, gross income, net profit and B:C ratio of pearl millet in ORP and farmer's field (2022-23 and 2023-24)

Farmer name	ORP Field				Farmer field			
	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net profit (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	Gross income (Rs/ha))	Net profit (Rs/ha)	B:C ratio
Mr. Deepak	21,965	58,305	34,840	2.65	23,005	52,745	29,740	2.29
Mr. Nand Ram	21,910	57,245	35,335	2.61	22980	51,922	28,942	2.26
Mr. Subhash	21,420	55,002	33,582	2.57	23,190	50,545	27,355	2.17
Mr. Mahesh	22,490	56,402	33,912	2.50	23,050	50,660	27,610	2.20
Mr. Vijay Pal	22,235	56,627	34,392	2.54	22,800	50,562	27,762	2.22
Mr. Sanjay	22,290	55,880	33,885	2.54	23,130	51,200	28,070	2.21
Mr. Kishan Gopal	22,220	57,132	35,002	2.57	22,745	51,340	28,594	2.25
Mr. Lokendra	22,730	59,405	36,675	2.61	22,940	53,170	30,230	2.32
Mr. Ram Prakash	22,155	57,572	34,417	2.60	22,580	51,385	28,805	2.27
Mr. Natthi Lal	22,292	56,180	33,958	2.53	22,650	51,020	28,370	2.25
Mr. Mukesh	22,275	56,390	34,115	2.53	23,270	51,270	28,000	2.20
Mr. Bhanwar Singh	22,615	57,020	34,405	2.52	23,290	51,690	28,400	2.22

The sesame yield obtained under ORP and farmer's practice presented in Table 6.3 clearly showed that grain yield of sesame under ORP was ranged between 6.7 to 7.2 q/ha which was higher as compared to farmers' yield (6.0 to 6.4 q/ha). At harvest of crop, EC_e ranged from 4.2 to 5.0 dS/m and pH ranged from 7.7 to 7.9.

Table 6.3 Grain yield of sesame in ORP and farmer's field and soil EC_e and pH at harvest (2022-23 and 2023-24)

Farmer name	ORP yield (q/ha)	Farmers' yield (q/ha)	Increase over Farmers' yield (%)	EC_e (dS/m) (0-30cm)	pH (0-30cm)
Mr. Saudan Singh	6.7	6.0	12.3	4.6	7.8
Mr. Kishan Gopal	7.2	6.1	14.3	5.0	7.8
Mr. Lakhan Singh	7.0	6.4	9.2	4.5	7.8
Mr. Vijay Pal	6.9	6.2	11.3	5.0	7.7
Mr Nand Ram	6.8	6.1	12.3	4.8	7.8
Mr. Deepak Singh	7.1	6.2	13.5	4.4	7.7
Mr. Nando	7.1	6.1	16.4	4.2	7.9

The cost of cultivation, gross income, net profit (Rs/ha) and B:C ratio of sesame crop was estimated. Results indicate that the cost of cultivation in ORP field was less as compared to farmer field. The gross income

(Rs/ha) was higher in ORP field as compared to farmer's field. The net profit (Rs/ha) and B: C ratio was also higher in ORP as compared to farmers (Table 6.4).

Table 6.4 Cost of cultivation, gross income, net profit and B: C ratio of sesame crop in ORP and farmers field (2022-23 and 2023-24)

Farmer name	ORP field				Farmers field			
	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net profit (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	Gross income (Rs/ha))	Net profit (Rs /ha)	B:C ratio
Mr. Saudan Singh	22,910	67,500	44,590	2.94	23,175	60,000	36,825	2.59
Mr. Kishan Gopal	23,215	72,000	48,785	3.09	23,585	63,000	39,415	2.67
Mr. Lakhan Singh	23,370	70,000	46,630	2.99	23,540	64,000	40,460	2.71
Mr. Vijay Pal	22,950	69,000	46,050	3.00	23,290	62,250	38,960	2.66
Mr Nand Ram	23,340	68,500	45,160	2.92	23,545	61,000	37,455	2.59
Mr. Deepak Singh	22,210	71,000	48,790	3.19	23,135	62,500	39,365	2.70
Mr. Nando	22,800	71,000	48,200	3.11	23,210	61,000	37,790	2.63

Perusal of ORP and farmers' mustard yield in Table 6.5 showed that mustard grain yield under ORP ranged between 21.8-23.8 q/ha which was higher as compared to farmers' yield (19.2-21.0 q/ha). At harvest, soil EC_e ranged from 5.0 to 5.5 dS/m and pH from 7.7-7.9.

The cost of cultivation, gross income, net profit (Rs/ha) and B:C ratio for mustard crop presented in Table 6.6 indicate that cost of cultivation in ORP was found less as compared to farmer's practice. The gross income (Rs/ha) was higher in ORP field as compared to farmer's field. The net profit (Rs/ha) and B:C ratio was higher in ORP as compared to farmers.

Table 6.5 Grain yield of mustard in ORP and farmers' field and soil EC_e and pH at harvest (2022-23 and 2023-24)

Farmer name	ORP yield (q/ha)	Farmers' yield (q/ha)	Increase over Farmers' yield (%)	EC_e (dS/m) (0-30cm)	pH (0-30cm)
Mr. Nand Ram	22.9	20.5	11.9	5.3	7.8
Mr. Kalicharan	22.3	19.4	12.8	5.5	7.8
Mr. Natthi Lal	22.2	19.8	11.9	5.1	7.9
Mr. Netra Pal	23.2	20.9	10.7	5.1	7.8
Mr. Nand Kishore	22.4	20.0	11.3	5.0	7.9
Mr. Mando	23.0	20.7	10.8	5.3	7.7
Mr. Hari Sharma	23.3	20.4	14.3	5.2	7.8
Mr. Bhanwar Singh	23.7	21.0	13.0	5.2	7.8
Mr. Mahesh	23.6	20.8	13.4	5.5	7.9
Mr. Lokendra Singh	23.8	20.9	13.9	5.3	7.8
Mr. Kanchan Singh	21.8	19.2	11.3	5.4	7.9

Table 6.6 Cost of cultivation, gross income, net profit and B:C ratio of mustard on ORP and farmer's field (2022-23 and 2023-24)

Farmer name	ORP field				Farmers field			
	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net profit (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)	Gross income (Rs/ha))	Net profit (Rs/ha)	B:C ratio
Mr. Nand Ram	26,805	1,25,077	98,272	4.66	27,255	1,11,725	84770	3.75
Mr. Kalicharan	26,750	1,21,807	95,057	4.55	27,200	1,00,552	73352	3.69
Mr. Natthi Lal	27,805	1,20,990	93,185	4.35	28,425	1,02,732	74307	3.61
Mr. Netra Pal	27,625	1,26,440	98,815	4.57	27,900	1,14,177	86277	4.08
Mr. Nand Kishore	26,770	1,22,352	94,782	4.45	28,011	1,09,272	81261	3.91
Mr. Mando	26,940	1,25,350	98,410	4.65	27,460	1,13,087	85627	4.11
Mr. Hari Sharma	27,895	1,27,257	99,362	4.56	28,245	1,11,180	82935	3.93
Mr. Bhanwar Singh	27,725	1,29,437	1,14,212	4.67	27,940	1,14,450	86510	4.09
Mr. Mahesh	27,650	1,28,620	1,00,970	4.65	28,205	1,13,360	85,155	4.01
Mr. Lokendra Singh	26,970	1,29,710	1,02,740	4.80	27,110	1,13,905	86,795	4.20
Mr. Kanchan Singh	26,950	1,18,810	91,860	4.40	27,250	1,04,640	77,390	3.84

Grain yield of wheat: Data presented in Table 6.7 showed that grain yield of wheat in ORP ranged between 45.2-47.2 q/ha which was higher than farmers yield ranged from 40.8 to 42.9 q/ha. The average increase of ORP yield was 10.6 % more over farmers' grain yield. At harvest EC_e ranged from 7.2 to 7.9 dS/m, pH was 7.7 - 7.9.

Table 6.7 Grain yield of wheat in ORP and farmers' field and soil EC_e and pH at harvest (2022-23 and 2023-24)

Farmer name	ORP yield (q/ha)	Farmer's yield (q/ha)	Increase over Farmer yield (%)	EC_e (dS/m) (0-30cm)	pH (0-30cm)
Mr. Babu Lal	46.2	41.6	11.1	7.5	7.9
Mr. Lokendra	45.8	40.8	12.2	7.4	7.8
Mr. Bahadur	46.9	42.7	9.8	7.7	7.8
Mr. Om Prakash	45.2	41.1	9.9	7.8	7.9
Mr. Tejveer	45.7	41.1	11.2	7.6	7.8
Mr. Hemant	47.2	42.1	12.1	7.9	7.7
Mr. Ram Ratan	45.6	41.2	10.5	7.9	7.8
Mr. Subhash	45.6	41.1	10.7	7.8	7.8
Mr. Satish Sharma	46.7	41.3	13.1	7.6	7.9
Mr. Tara Chand	45.9	40.9	10.8	7.8	7.7
Mr. Sher Singh	45.6	41.8	9.1	7.3	7.8
Mr. Ravi	46.8	42.7	9.6	7.2	7.8
Mr. Surendra	46.3	42.9	7.9	7.6	7.8

- **ORP on vegetable cultivation (Agra)**

For Cauliflower, yield of 285.35 q/ha was recorded at the field of Mr. Tufan Singh and Mr. Kishan Gopal. The crop earned Rs 2,18,190/ha as net profit and 3.27 benefit cost ratio (B:C) ratio (Table 6.8). In Cabbage crop, yield of 376.35 q/ha was recorded in field of Mr. Kishan Gopal. The crop earned Rs 1,80,845/ ha as net profit and 3.84 benefit cost ratio. In tomato, fruit yield of 223.35 q/ha was recorded in the field of Mr. Tufan Singh. The crop earned Rs 2,49,252/ha as net profit and 3.91 benefit cost ratio.

In okra crop yield of 107.5 q/ha was recorded in the field of Mr. Tufan Singh. The crop earned Rs 1,19,210/ha as net profit and 2.39 benefit cost ratio. In brinjal crop yield of 380.0 q/ha was recorded in the field of Mr. Kishan Gopal. The crop earned Rs 2,97,800/ha as net profit and 4.62 benefit cost ratio. (Table 6.8).

Table 6.8 Yield, cost of cultivation, gross income, net profit and B:C ratio of vegetable crops in ORP field (Av. 2022-23&2023-24)

Farmer name	Vegetable crop	Yield q/ha)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net profit (Rs/ha)	B:C ratio
Mr Tufan Singh& Mr Kishan Gopal	Cauliflower	285.35	96,150	3,09,320	2,18,190	3.27
Mr. Kishan Gopal	Cabbage	376.35	63,235	2,44,080	1,80,845	3.84
Mr. Tufan Singh	Tomato	223.35	85,773	3,35,025	2,49,252	3.91
Mr. Tufan Singh	Okra	107.5	85,290	2,04,950	1,19,210	2.39
Mr. Kishan Gopal	Brinjal	380.0	82,200	3,80,000	2,97,800	4.62

- **ORP on alkali soil with different Reclamation Technologies (Bapatla)**

This experiment was carried out at five farmer's fields in Konanki village during *kharif* 2021 in soil having pH, ECe and ESP values ranging from 9.0 to 10, 2.3 to 8.3 and 37.0 to 55.4%, respectively (Table 6.9). Recommended reclamation practices viz., leaching, *in-situ* incorporation of dhaincha at 50% flowering stage and application of 50 per cent SS quantity of gypsum requirement and 25% extra fertilizer application were practiced to reduce the adverse effect of alkali soils. These package of practices were carried out during the study period of three revealed that from the first year on wards ECe, exchangeable ESP was reduced by adopting the package of practices like leaching, green manure incorporation, gypsum application and 25% extra fertilizer application. During 2023 after harvest of the crop pH, ECe, ESP ranges from 8.4 to 9.1, 1.6 to 7.2 and 28.5 to 38.1%. By adopting the alkali soil reclamation package of practices, the soil ECe and ESP reduced 24-43% and 30-45% during the study period 2021 to 2023 in farmers' fields of Konaki village.

Experimental data revealed that recommended reclamation practices of alkali soil adopted by the farmers increased the crop yield of rice from 4270 to 5780 kg ha^{-1}. An increase in rice yields of 8-33% was recorded in treated plots as compared to untreated plots 8-16% during the study period 2021-2023 (Table 6.10).

Table 6.9 Final soil characteristics during 2022-23

S.No	Name of the farmer	ECe (dS/m)	pH	CEC (c.mol(p+)/ kg-1))	Exch. Na (c.mol(p+)/ kg-1))	ESP (%)
			2020-21			
1.	Sri T. Koteswara Rao	2.3	8.7	46.9	17.2	36.7
2.	Sri T. Yerra Kotaiah	1.9	8.8	44.3	13.5	30.5
3.	Sri J. Yakobu	3.0	8.7	39.5	17.7	44.8
4.	Sri K. Babu Rao	4.1	9.5	20.4	7.8	38.2
5.	Sri T. Yesu	7.4	9.0	24.9	10.3	41.3
			2021-22			
1.	Sri T. Koteswara Rao	2.1	8.6	46.1	16.8	36.4
2.	Sri T. Yerra Kotaiah	1.8	8.7	43.5	12.4	28.5
3.	Sri J. Yakobu	2.8	8.6	37.3	16.2	43.4
4.	Sri K. Babu Rao	4.0	9.4	19.9	7.5	37.6
5.	Sri T. Yesu	7.7	8.9	23.4	9.1	38.8
			2022-23			
1.	Sri T. Koteswara Rao	1.9	8.6	44.8	14.2	31.6
2.	Sri T. Yerra Kotaiah	1.6	8.5	39.6	11.3	28.5
3.	Sri J. Yakobu	2.5	8.4	34.4	13.1	38.1
4.	Sri K. Babu Rao	3.6	9.1	17.7	6.4	36.2
5.	Sri T. Yesu	7.2	8.7	22.5	7.2	32.0

Table 6.10 Rice crop yields during 2022-23

S. No	Name of the farmer	Grain yield (kg/ha)					
		2020-21		2021-22		2022-23	
		Treated	Untreated	Treated	Untreated	Treated	Untreated
1.	Sri T. Koteswara Rao	4625	4150	4550	3750	4940	3740
2.	Sri T. Yerra Kotaiah	5360	4530	4970	4620	5780	4150
3.	Sri J. Yakobu	4270	3850	3850	3540	5130	3550
4.	Sri K. Babu Rao	4750	4230	4300	3960	5320	3900
5.	Sri T. Yesu	4590	4150	3980	3570	4800	3720

- **OFT on Evaluation of Green gram varieties for their tolerance to sodicity (Tiruchirappalli)**

Based on the results of two years experiment on greengram varieties tolerant to sodicity level, the Tamil Nadu Agricultural University has recommended for conducting on-farm trials in the farmer's field at different locations of Tamil Nadu during 2024-2025. Greengram varieties (VBN 5, VBN 6, VBN 2, CO 8 and CO 9) were grown during Kharif 2024 at different locations. The OFT was conducted ADAC&RI, Trichy, AC&RI, Kudumiyanmalai, CRS, Veppanthattai, RRS, Paiyur. The initial soil properties are presented in Table 6.11.

Table 6.11 Initial soil properties

Particulars	ADAC & RI Trichy	AC & RI Kudumiyanmalai	CRS Veppanthatai	RRS-Paiyur
Farmer's Name &	**Mr. Kannaiyan**	**Mr. R.Peter**	**Mrs. Subitha**	**Mr. Murugesan**
pH	8.65	9.7	8.60	8.56
EC (dS/m)	0.43	0.19	0.21	0.21
ESP (%)	21.5	24.5	16.9	17.2

The data on growth, yield parameters and seed yield were recorded at the time of harvest as:

ADAC & RI, Trichy: The highest plant height (50.5 cm), number of pods plant^{-1} (18), number of seeds pod^{-1} (10.5) and grain yield (778 kg ha^{-1}) were recorded with VBN 5 variety. This was followed by VBN 6, VBN 2, and Co 8 which recorded higher growth and yield parameters and yield than Co 9.

AC&RI, Kudumiyanmalai: The results revealed that among the different varieties, higher plant height (50.8 cm), number of pods plant^{-1} (17), number of seeds pod^{-1} (10.3) and grain yield (716 kg ha^{-1}) were recorded higher in VBN 5 variety when compared to VBN 6, VBN 2, Co8 and Co 9.

CRS, Veppanthatai: Among the varieties, VBN 5 green gram variety recorded higher plant height (52.3 cm), No. of pods plant^{-1} (19), No. of seeds pod^{-1} (10.2) and grain yield (796 kg ha^{-1}) followed by VBN 6 variety.

RRS, Paiyur: The results on growth and yield and yield parameters revealed that the VBN 5 green gram variety performrd better with higher plant height (53.5 cm), No. of pods plant^{-1} (21), No. of seeds pod^{-1} (10.6) and grain yield (803 kg ha^{-1}) as compared to other varieties tested.

From the mean values of four centres, it could be concluded that the VBN 5 green gram variety registered higher mean plant height (51.8 cm), number of pods plant^{-1} (19), number of seeds pod^{-1} (10.4) and grain yield (773 kg ha^{-1}) than VBN 6, VBN 2, Co 8 and Co 9 under sodicity. Green gram varieties *viz.,* VBN 5 and VBN 6 are tolerance to sodicity. Therefore, VBN 5 and VBN 6 green gram varieties can be recommended for getting higher productivity in sodic soil condition upto the ESP of 24.

- **SC SP activities (Agra)**

During Rabi season of 2024–25, mustard seed was distributed to nine farmers from the village of Bhahai Barari, Farah block, Mathura district, under the SCSP. In the same season, ten farmers were selected for the distribution of wheat seed (40 kg each). Of these, nine farmers were from Bhahai Barari and one farmer from Laramda. Wheat seed (variety KRL-210) from CSSRI, Karnal, along with fertilizer, was distributed to all the selected farmers.

During 2024–25, maize seed (to 2 farmers), jowar seed (to 8 farmers), and mung bean seed (to 5 farmers) were also distributed to farmers under the SCSP. In addition, 14 spray machines and 10 storage bins were distributed to farmers under the SCSP programme.

Seed distribution under SC SP

- **SCSP activities (Bikaner)**

During 2023 -24 and 2024-25 the activities undertaken under SCSP including distribution of agri inputs viz battery-operated sprayer pump, Zinc Sulphate, ferrous sulphate. These inputs distributed to 5 farmers during 2023-24 and 54 farmers during 2024-25 and explain the management of saline water in agriculture and significance of inputs in crop production.

- **SCSP Activities (Gangavathi)**

Under the SCSP program during 2022–23, agricultural inputs such as ferrous sulphate ($FeSO_4$), soil conditioner containing calcium, magnesium, and sulphur, and organic manure were distributed to farmers. The significance of these inputs in enhancing crop production, particularly in degraded soils, was explained to the beneficiaries. A total ten farmers were benefitted from the program.

Similarly, during 2023–24, the same agricultural inputs i.e. ferrous sulphate ($FeSO_4$), soil conditioner (Ca, Mg, and S), and organic manure were distributed. The importance of their application in improving soil health and productivity was once again highlighted, and ten farmers were benefitted during this period as well.

- **SCSP activities (Tiruchirappalli)**

The main objective of SCSP was facilitating improved farm productivity and economic development of scheduled caste farmers in Agriculture and allied sector through dissemination of improved farm technologies, on-farm and off-farm trainings, frontline demonstrations, on-farm trails, skill development, exposure visit and input distribution etc.,

- **SCSP activities (Vyttila)**

As part of the promotion of saline-tolerant rice cultivation during Kharif 2024, seeds of improved varieties Vyttila 8 and Vyttila 10 were distributed to Scheduled Caste (SC) farmers of Kuzhuppilly and Ezhikkara panchayats. A total of 280 kg seeds were provided to six beneficiary farmers through their respective Krishi Bhavans. Among these, farmers from Kuzhuppilly Panchayat received both Vyttila 8 and Vyttila 10 varieties, while one farmer from Ezhikkara Panchayat received Vyttila 10. The distributed seed quantity varied from 20 kg to 80 kg per farmer depending on their landholding and requirement. This initiative aims to enhance livelihood security and promote the adoption of climate-resilient rice varieties in saline-prone coastal areas.

Activities under SC&SP Programme during 2023-2024 at Aravakudi village, Manikandam Block, (Tiruchirappalli)

Sl. No	Name of the Training Cum Demonstration Programme	Date	No. of Beneficiaries	Input Distributed
1.	Training on Fruit crops cultivation techniques	28.02.2023	130 Farmers 130 Farmers	• 130 Guava seedlings (Lucknow-49 variety) • 190 Banana plants (Tissue culture)
2.	Training on Tree & Medicinal crops cultivation techniques	02.03.2023	160Farmers	• 630 Tree seedling (Gulmohar, Neem, Pungan etc.
3.	Training on Livestock Management in Summer	29.03.2023	36 Farmers 10 Farmers	• 300 Aseel chicks • 10 kg Goat mineral mixture
4.	Training on Vermicomposting techniques	29.03.2023	55Farmers	
5.	Training on Vegetable crop production techniques for salt affected soil	13.04.2023	100 Farmers	• 700 pkts Vegetable
6.	Management of salt affected soil, Vermicompost (VC) production demonstration	13.04.2023	130 Farmers 100 Farmers	- • 5442 kg VC
7.	Awareness programme on Agricultural Education	13.04.2023	55 students	• 55 Educational kits
8.	Awareness on Cleanliness Clean & Green village	13.04.2023	55 students	• 8 Dust bin
9.	Maintenance and management of poultry	23.01.2024	40	• 300 Aseel chicks
10.	Training on Organic farming	09.08.2024	80	• 5442 kg VC
11.	Training on Organic Vegetable crop production techniques	10.12.2024	50	• 50 Coconut seedlings • 50 Litres of Neem oil • 50 Pneumatic sprayers • 700 pkts Vegetable

QRT Team visit - 2024

QRT Team visited at ICAR-AICRP (MSW&ASA) –SCSP adopted village –for Impact of Extension activities

- **SCSP Activities at Panvel**

Under the head Scheduled Caste Sub-Plan (SCSP-General), 15 farmers were selected from Raigad district, Maharashtra state. The SCSP one day training programme conducted by Khar land research station, Panvel on dated 28.02.2023 at village Pitsayi, Taluka tala during the year 2022-2023. A lecture on "Nutrient management for different crops in konkan region" was delivered and also distributed agricultural inputs *viz.,* spray pump and seeds of *amaranthus* vegetable crop (*cv. Durangi*).

Distribution of Urea-DAP Briquettes during year 2023-2024 under the head "SCSP-General"

7. GENERAL

7.1 Organization

7.2 Mandate of Cooperating Centres

7.3 Staff Position

7.4 Weather Data

7.5 List of Publications

7.6 Finance

7.1 ORGANIZATION

The All India Coordinated Project on Management of Saline Water & Associated Salinization in Agriculture was first sanctioned during the IVth Five Year Plan under the aegis of Indian Council of Agricultural Research, New Delhi at four research centres namely Agra, Bapatla, Dharwad and Nagpur to undertake researches on saline water use for semi–arid areas with light textured soils, arid areas of black soils region, coastal areas and on the utilization of sewage water respectively. During the Fifth Five Year plan, the work of the project continued at the above four centres. In the Sixth Five Year Plan, four centres namely Kanpur, Indore, Jobner and Pali earlier associated with AICRP on Water Management and Soil Salinity were transferred to this Project whereas the Nagpur Centre was dissociated. As the mandate of the Kanpur and Indore centres included reclamation and management of heavy textured alkali soils of alluvial and black soil regions, the Project was redesignated as All India Coordinated Research Project on Management of Salt Affected Soils and Use of Saline Water in Agriculture. Two of its Centres located at Dharwad and Jobner were shifted to Gangavati (w.e.f. 01.04.1989) and Bikaner (w.e.f. 01.04.1990) respectively to work at the locations having large chunks of land afflicted with salinity problems. During Eighth Five Year Plan, two new centres at Hisar and Tiruchirappalli were added. These Centres started functioning from 1 January 1995 and 1997 respectively. Further, during Twelfth Five Year Plan, four new Volunteer centres namely Bathinda, Port Blair, Panvel and Vyttila were added to this AICRP. These four centres started functioning from 2014. As per recommendations of QRT (2011-2017) of ICAR-CSSRI, Karnal, Indore centre was converted from main cooperating centre to volunteer centre and Kanpur and Port Blair centre were closed on 31 March 2020. Based on f QRT (2011-17) recommendation, the AICRP has renamed as “Management of Saline Water and Associated Salinization in Agriculture” with the revised mandate. During 2021–2026, Project continued with an outlay of Rs. 3489.94 Lakhs at 6 main and 5 volunteer centres with the Coordinating Unit at ICAR-Central Soil Salinity Research Institute, Karnal. The ICAR share was of Rs. 2651.40 Lakhs while state share was of Rs. 838.54 Lakhs. The year wise actual allocation in terms of ICAR share for financial year 2021-22, 2022-23 and 2023-24 were Rs. 509.29 Lakhs, Rs. 435.40 Lakhs and Rs. 475.60, respectively.

7.2 MANDATES FOR COOPERATING CENTRES

Centre Wise Mandate

In view of scientific staff position reduction from 37 to 16 during SFC 2017-20, research prioritization exercise was done during Annual Review Meeting of the scheme held at ICAR- CSSRI, Karnal during 04-05 June 2018. Research priorities were reviewed by QRT of ICAR-CSSRI, time to time. After discussion with all concerned including ICAR nominated experts, priority areas for each centre were finalized. Priority research areas of the centres, which will continue during 2021-2026, are provided below (Table 7.2. 1).

Table 7. 2.1 Research Priorities for different centres

Name of Centre	Priority Areas of Research
Main Cooperating Centres	
Agra	• Survey and mapping of groundwater quality • Use of poor-quality water use including waste water • Screening for salt tolerance • Survey and mapping of Salt Affected Soils (with ICAR-CSSRI)
Bapatla	• Survey and mapping of groundwater quality of AP • Conjunctive use of fresh and saline water with emphasis on *doruvu* technology upscaling • Reclamation and management of irrigation induced salinization (including sodification). • Alternate land use
Bikaner	• Survey and mapping for ground water quality of Rajasthan • Use of saline water through micro irrigation for vegetables/field/horticultural crops etc.
Gangavati	• Reclamation and management of irrigation induced salinization (including sodification). • Micro irrigation in drainage areas/ shallow water areas/ poor quality area • Map of SAS of TBT command area
Hisar	• Ground water quality mapping of Haryana • Micro irrigation for saline water use along fertility treatments • Screening for salt tolerance
Tiruchirappalli	• Survey and mapping for groundwater quality in coastal Tamil Nadu • Reclamation and management of alkali water and irrigation induced sodification • Rain water harvesting based conjunctive use • Screening of crops and varieties for sodicity tolerance
Volunteer centres	
Bathinda	• Ground water quality mapping of South West Punjab • Poor quality water for crop production
Indore	• Control of Resodification in Sodic Vertisols • Revised/Updated map of ground water quality and SAS in MP • Irrigation water management for sodic Vertisols • Alternate land use • Updated map of SAS in Madhya Pradesh (with ICAR-CSSRI)
Panvel	• Survey and mapping of ground water quality of Konkan region • Rainwater harvesting based IFS models • Increasing cropping intensity during rabi season (Establishment of vegetable crops during the Rabi season through management practices)

Vyttila	• Mapping of groundwater quality/ SAS in the coastal Kerala • Integrated farming system including management of acid sulphate soils
Akola	• Survey and mapping of ground water quality • Management of saline/alkali groundwater for irrigation in heavy textured soils of dry- eco region • Management of soil salinity/sodicity of dryland • Screening of crops and varieties for sodicity tolerance

Mandate for the AICRP

AICRP on Management of Saline Water & Associated Salinization in Agriculture

ICAR-Central Soil Salinity Research Institute, Karnal, Haryana- 132001

Objectives of the scheme:

- Survey, characterization and mapping of groundwater quality for irrigation purpose
- Evaluation of effects of poor-quality groundwater irrigation on soils and crops under different agro-climate conditions
- Development of management practices for irrigation induced salinization and guidelines for saline water irrigation (including micro irrigation) under different agro-climatic regions
- Screen crop cultivars and tree species appropriate to soil salinity and alkalinity conditions

7.3 STAFF POSITION

Sanctioned staff positions at centres as per SFC 2017-20 are provided in Table 7.3.1 and as per 2021-26 are provided in Table 7.3.2 and Table 7.3.2.

Table 7.3.1 Sanctioned staff position at the cooperating centres as per approved SFC 2017-20

(31-12-2024)

Category	Agra	Bapatla	Bikaner	Gangavati	Hisar	Tiruchirappalli	Total
Scientific	2	2	2	2	2	2	12
Technical	2	2	2	2	2	2	12
Administrative	1	1	1	1	0	0	04
Supporting	1	0	1	1	1	1	05
Total	**6**	**5**	**6**	**6**	**5**	**5**	**33**

Table 7.3.2 Sanctioned/filled staff positions at the cooperating centres as per SFC 2021-26 proposal

(Status as on 31-12-2024)

Category	Agra	Bapatla	Bikaner	Gangavati	Hisar	Tiruchirappalli	Total
	San. Filled	San. Filled	San. Filled	San. Filled	San. Filled	San. Filled	San. Filled
Scientific	0	2	2	2	2	2	10
Technical	2	2	2	0	1	2	12
Administrative	1	1	0	0	0	0	06
Supporting	1	0	2	2	1	1	11
Total	**4**	**4**	**6**	**4**	**4**	**4**	**26**

Table 7.3.3 Details of centre wise staff positions (31-12-2024)

S.N.	Designation	Post sanctioned	Posts Vacant	Name of the employee posted	Date of joining	Date of leaving
	Agra					
1.	Jr. Soil Physicist	1	0	Dr. R.B. Singh	30.11.1987	Superannuated on 30.06.2024
2.	Jr. agronomist	1	0	Dr. R.S. Chauhan	01.08.1991	-do-
3.	STA (Soils)	2	0	Dr. P.K. Shishodia	11.07.1994	Contd.
				Dr. P.K. Shishodia	11.07.1994	Contd.
4.	U.D.C.	1	0	Mr. Rajeev Chauhan	04.09.1991	Contd.
5.	Lab Assistant	1	0	Mr. Sarnam Singh	18.12.1989	Retired on 30.10.2024

Bapatla						
1.	Principal Scientist	1	0	Dr. P. Madhu Van		
2.	Scientist (Agro)	1	0	Dr. K. Anny Mrudhula Sr. Scientist (Agro.)		
3.	Field Tech./Assistant	1	0	Sh. Shaik Baba Vali		
4.	Lab. Technician	1	0	Sh. M. Venkata Rao		
	Bikaner					
1	Chief Scientist & OIC	1	0	Dr. Ranjeet Singh Associate Professor Dr. Bhupender Singh, Professor	04.01.2019 26.12.2023	10.01.2024 Contd.
2.	Scientist (Agronomy/Soil water conservation Engg.)	1	0	Dr. Ranveer K. Yadav Asstt. Professor	03.04.2021	05.08.2024
3.	Field Tech./Assistant	1	0	Sh Pukhjraj Jagarwal	5.12.2024	Contd.
4.	Lab. Tech./Asstt.	1	1	Sh. S.K. Bazad	14.02.1994	31.10.2024
	Gangawathi					
1.	Principal Scientist & OIC (Soil Science)	1	0	Dr. Vishwanath J.	04.01.2012	Superannuated
2.	Scientist (Drainage Engg.)	1	0	Dr. A.V. Karegoudar	12.12.2009	Contd.
3.	Lab Assistant	1	0	Mr. Prakash Banakar	21.04.2011	Contd
4.	Field Assistant	1	0	Mr. Ramappa Talwar	09.07.2012	Contd
	Hisar					
1.	Associate Professor & OIC	1	0	Dr. Ram Prakash	31.01.2021	Contd
2.	Assistant Scientist	1	0	Dr. Sarita Asstt. Scientist (Agro.)	27.04.2022	Contd.
3.	Field Tech./Field Asstt.	1	0	Vacant	-	-
4.	Lab. Tech.	1	1	Sh. Sharwan Kumar Sh. Surender Kumar	01.03.2022 25.10.2024	30.09.2024 Contd.

Tiruchirapalli

1.	Chief Scientist (Soil Science)	1	0	Dr. M. Baskar	17.05.2022	Contd.
2.	Scientist (Agronomy)	1	0	Dr. S. Rathika	19.04.2022	Contd.
3.	Field Technician	1	0	Smt. A. Arivuselvi	22.06.2020	Contd.
4.	Lab. Technician	1	0	Mr. U. Jossephraj	05.12.2021	Contd.

Nodal officers and SRFs at Volunteer Centres

S.N.	Designation	Post sanctioned	Post Vacant	Name of the employee posted	Date of joining	Date of leaving
	Bathinda					
1.	Nodal Officer	1	0	Dr. B.K. Yadav	16.05.2014	Contd.
2.	SRF					
	Indore					
1.	Nodal Officer	1	0	Dr. Bharat Singh		
	Panvel					
1.	Nodal Officer	1	0	Dr. K.P. Vaidya	01.07.2020	01.07.2024
				Dr. P.B. Vanave	10.07.2024	Contd.
2.	SRF	1	0	Smt. S.S. Khobragade	08.12.2024	Contd.
	Vytilla					
1.	Nodal Officer	1	0	Dr. A.K. Sreelatha	03.07.2014	Contd.
2.	SRF	1	0	Dr. Roshni John	02.09.2024	Contd.
	Akila					
1.	Nodal Officer	1	1	Dr Bhagwan A Sonune	01.07.2025	Contd.
	SRF	1	1			

7.4 WEATHER DATA (2023-24)

Main Centre

AGRA (UTTAR PRADESH)

Latitude - $27^0 20'$ N   Longitude - $77^0 90'$ E

Months	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Evaporation (mm/day)	Water table (m)
	Maximum	Minimum				
			2023			
January	6.5	19.8	93.5	34.1	0.7	21.2
February	11.3	28.3	83.4	0.0	2.1	21.2
March	16.1	30.8	75.8	23.9	3.1	21.0
April	19.8	35.3	60.1	0.0	5.7	21.1
May	22.9	28.2	65.0	34.6	9.2	21.1
June	25.0	38.6	72.1	162.1	7.2	21.8
July	26.8	34.9	85.3	76.3	4.2	21.9
August	27.8	35.3	84.9	155.1	4.4	21.8
September	25.1	35.7	85.3	88.7	4.1	21.9
October	18.3	33.4	74.0	1.8	4.4	21.9
November	13.2	27.6	82.2	9.65	1.9	21.9
December	8.8	23.7	85.8	0.5	1.2	21.9
			2024			
January	6.4	18.1	85.3	0.0	0.6	21.9
February	9.3	24.4	81.6	11.0	2.3	22.0
March	14.5	30.5	72.0	8.4	3.8	22.0
April	20.3	37.0	64.5	0.0	6.6	22.0
May	26.4	41.9	61.4	5.0	8.0	22.1
June	29.6	43.2	58.2	104.35	6.8	22.1

BAPATLA

Latitude - 15° 54′ N Longitude - 80° 28′ E

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	*Evaporation (mm/day)
	Maximum	Minimum	Maximum	Minimum		
			2023			
January	30.3	16.7	86.0	67.0	0.0	-
February	32.3	18.6	86.0	66.0	0.0	-
March	33.1	21.7	85.0	69.0	12.0	-
April	35.7	25.0	82.0	66.0	0	-
May	37.6	26.7	79	68	129.4	-
June	40.7	27.7	67	50	50.3	-
July	33.6	25.2	82	71	192.9	-
August	36.3	25.6	80	71	211.1	-
September	34.7	25.2	85	80	273.8	-
October	34.2	23.8	84	69	29.3	-
November	30.7	22.4	86	78	100.1	-
December	29.8	19.8	86	72	286.8	-
			2024			
January	29.8	19.3	87	71	3.1	-
February	31.7	20.3	85	69	0	-
March	33.3	23.0	83	71	0	-
April	35.5	26.0	79	69	0	-
May	35.5	26.4	76	66	268.5	-
June	37.2	26.6	73	66	125.6	-
July	32.6	24.8	80	70	184.8	-
August	35.0	25.8	78	67	135.5	-
September	33.7	24.9	84.5	76.0	254.7	-
October	33.1	24.3	87	79	178.9	-
November	31.7	21.9	85	70	14.9	-
December	29.7	21.0	90	77	18.3	-

- Data not available

BIKANER

Latitude – 28° 01′ N	Longitude – 73° 35′ E

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm/day)	Wind velocity (km/hr)
	Maximum	Minimum	Maximum	Minimum			
				2023			
January	21.1	2.7	81.2	36.6	0.0	4.0	4.0
February	30.1	9.5	63.6	22.5	0.0	7.7	4.1
March	32.1	14.8	70.1	30.2	25.6	7.7	5.0
April	36.8	19.1	53.2	21.2	21.6	9.8	5.9
May	39.7	22.6	57.4	27.6	37.0	10.1	8.1
June	39.0	25.6	67.6	40.3	34.6	9.6	8.9
July	37.3	25.5	81.3	55.2	256.2	8.1	6.6
August	36.1	25.4	76.7	47.3	0.0	11.1	10.2
September	37.6	24.9	74.3	46.4	61.8	8.8	5.9
October	35.3	18.8	68.5	35.4	3.0	8.9	5.1
November	28.8	12.4	81.4	40.8	4.6	6.3	2.9
December	25.3	5.9	84.7	35.1	0.0	7.5	3.0
				2024			
January	19.5	4.3	80.4	53.5	0.0	4.8	2.9
February	25.8	12.9	77.2	30.2	2.2	7.6	5.0
March	32.0	13.8	60.2	23.0	0.0	7.8	5.9
April	37.2	20.1	49.8	23.5	17.8	8.4	6.0
May	44.2	24.9	40.3	17.9	22.0	10.7	6.4
June	42.6	28.8	53.1	28.1	5.0	9.5	9.6
July	39.8	27.0	90.1	84.1	134.4	8.6	7.5
August	34.3	25.2	95.7	91.3	181.8	7.4	5.5
September	36.1	23.6	97.0	95.8	49.8	6.2	3.6
October	37.4	19.5	92.7	97.0	1.8	6.3	3.6
November	32.4	13.1	92.2	94.9	0.0	4.0	2.4
December	22.5	4.9	82.7	75.3	1.2	2.9	2.7

GANGAVATHI

Latitude – 15° 00’N Longitude – 76° 00’ E

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation* (mm/day)
	Maximum	Minimum	8.00 AM	2.00 PM		
2023						
January	30.1	16.7	81.9	43.0	0	-
February	32.3	17.7	65.2	37.1	0	-
March	33.4	19.1	59.4	36.0	0	-
April	37.5	22.3	81.8	21.8	36	-
May	38.0	25.5	60.1	29.0	52.5	-
June	36.6	25.5	64.8	41.1	35.0	-
July	30.9	24.0	79.5	70.1	104.5	-
August	32.9	23.9	72.7	55.6	13.0	-
September	31.4	23.8	78.7	64.6	52.5	-
October	32.1	22.0	71.3	59.6	0	-
November	30.2	21.6	88.7	69.4	38.5	-
December	29.8	18.2	85.0	49.4	0	-
2024						
January	31.2	18.5	84.9	30.3	0	-
February	34.1	18.6	66.3	20.3	0	-
March	37.8	23.9	55.9	18.3	0	-
April	40.1	25.9	58.2	24.5	1.5	-
May	35.1	25.5	69.4	41.0	135.0	-
June	32.8	24.6	79.3	58.0	202.0	-
July	31.5	24.8	77.1	67.3	34.0	-
August	28.8	24.1	82.0	71.3	242.2	-
September	31.1	23.6	78.8	68.2	55.5	-
October	30.1	23.4	92.8	76.5	125.5	-
November	29.9	19.0	87.5	61.8	14.5	-
December	29.1	20.6	91.0	58.9	6.0	-

- Data not available

HISAR

Latitude - 29° 10’ N Longitude - 75° 46’ E

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm/day)
	Maximum	Minimum	M	E		
			2023			
January	17.0	5.7	97	74	4.7	1.2
February	25.9	8.9	95	57	0	2.1
March	28.9	13.9	89	57	12.8	3.2
July	34.7	17.5	65	28	5.2	5.7
August	36.9	21.4	65	33	59.7	7.0
September	36.9	25.8	72	47	18.8	6.1
October	35.0	27.1	87	68	107.3	4.2
November	35.9	26.7	82	55	16.6	5.6
December	35.8	25.0	87	54	14.2	5.4
			2024			
January	14.2	6.0	99	78	0	0.9
February	22.3	7.5	93	49	13.1	2.0
March	28.1	12.1	87	38	43.2	3.5

KARNAL

Latitude – 29° 43’ N Longitude – 76° 58’ E

Months	Temperature (°C)		Relative humidity (%)		Rainfall	Evaporation	Wind Velocity
	Maximum	Minimum	Maximum	Minimum	(mm)	(mm/day)	(km/hr)
2023							
January	16.5	6.8	96	73	22.6	1.1	0.8
February	24.9	9.3	95	51	0	2.3	1.3
March	28.2	13.9	91	53	96.2	3.3	1.2
April	34	17.5	63	28	38.2	6.0	1.4
May	34.8	20.8	69	39	85.5	6.8	2.4
June	35.5	24.9	74.1	51.5	214	6.9	2.3
July	32.5	26.5	89.9	76.7	390	3.7	2.2
August	33.3	26.5	89.5	73.9	53.6	4.3	1.1
September	34.1	24.6	92.0	63.1	63.7	4.3	0.7
October	32.2	17.6	88.4	44.6	17	3.3	0.6
November	28	13.2	94.3	44.5	0	1.6	0.2
December	21.6	8	97.5	59.2	0	1.1	0.2
2024							
January	13.4	06.1	99	82	00.0	0.5	00.3
February	21.7	07.9	91	54	25.8	2.0	01.1
March	27.5	12.1	85	44	43.4	3.6	01.1
April	35.8	17.8	56	23	08.4	7.0	01.1
May	39.8	24.2	56	29	10.4	8.9	02.7
June	40.1	27.0	64.6	45	43.0	10.0	02.7
July	34.6	27.5	88.1	69	58.9	5.0	02.9
August	33.0	26.2	91.2	72	180.8	3.4	03.6
September	32.3	24.1	92.9	73	177.5	3.1	01.8
October	33.4	19.9	90.8	47	17.8	3.1	01.1
November	27.6	13.6	93.9	49	00.0	2.1	01.0
December	21.0	07.4	85.1	52	46.0	1.9	01.6

TIRUCHIRAPPALLI

Latitude – 10° 45′ N Longitude – 78° 36′ E

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm/day)	Wind velocity (km/hr)
	Maximum	Minimum	Maximum	Minimum			
2023							
January	31.6	21.3	89.2	62.1	6.2	6.9	-
February	33.3	19.9	87.4	54.7	17.2	6.1	-
March	36.1	23.8	84.6	42.1	18.6	6.1	-
April	38.3	25.5	80.5	43.7	40.6	6.9	-
May	37.5	25.3	85.3	47.3	148.6	5.4	-
June	37.6	25.4	82.2	42.3	55.8	6.7	-
July	37.5	25.6	85.9	41.5	34.2	7.6	-
August	37.1	25.7	76.6	42.3	173.6	8.3	-
September	35.5	25.2	80.7	49.3	125.6	5.3	-
October	35.0	24.8	84.1	51.6	100.4	3.6	-
November	31.8	24.0	86.8	62.9	88.2	3.4	-
December	31.5	23.8	85.4	60.5	63.4	2.6	-
2024							
January	31.2	22.3	87.3	58.5	8.8	3.1	-
February	34.5	23.0	89.1	49.5	0.0	4.9	-
March	35.6	23.3	83.6	41.7	0.0	6.1	-
April	58.6	25.6	79.2	41.1	0.0	6.2	-
May	36.6	26.5	75.0	51.5	102.8	4.8	-
June	35.6	25.3	98.7	40.7	186.8	3.7	-
July	36.1	26.0	78.3	45.1	2.2	5.1	-
August	36.1	25.8	81.4	44.3	77.0	6.3	-
September	37.3	26.2	81.8	59.4	7.2	6.5	-
October	33.9	24.9	86.8	64.9	175.6	3.1	-
November	30.3	24.5	84.0	78.0	160.5	1.5	-
December	31.1	25.1	90.0	80.0	284.9	2.1	-

- Data not available

<u>**Volunteer Centre**</u>

BATHINDA

Latitude – 30° 23’ N Longitude – 74° 95’ E

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm/day)	Wind velocity (km/hr)
	Maximum	Minimum	Morning	Evening			
				2023			
January	3.2	16.3	88.3	56.4	11.0	31.2	3.1
February	10.7	26.4	83.4	39.9	10.0	91.2	3.8
March	14.8	28.0	80.2	51.6	54.4	146.4	4.3
April	18.2	35.1	66.7	31.3	19.6	254.8	4.6
May	21.6	36.9	56.8	29.1	52.6	290.8	5.7
June	26.1	37.6	58.2	35.2	40.6	279.8	5.0
July	26.8	34.5	70.7	52.5	109.3	205.9	4.9
August	27.1	36.4	68.8	47.4	0.0	266.6	3.8
September	25.0	35.0	71.1	50.3	7.2	183.8	4.1
October	17.9	32.2	81.9	52.4	27.6	131.4	2.5
November	12.8	26.3	82.7	51.9	3.0	43.2	1.6
December	6.9	21.4	87.2	54.9	0.0	34.6	1.8
				2024			
January	5.2	13.1	91.5	65.6	2.8	15.3	2.4
February	7.3	21.7	84.9	50.0	1.0	61.7	2.9
March	11.5	27.3	72.0	37.6	7.0	122.4	4.4
April	17.9	34.9	59.2	27.5	16.2	163.7	4.8
May	23.4	42.1	46.0	16.5	1.0	346.2	4.8
June	26.6	41.0	52.9	25.8	18.8	310.6	5.6
July	27.4	37.2	69.4	45.7	76.0	236.4	5.7
August	26.1	34.3	79.0	60.4	152.8	169.8	4.9
September	25.0	34.5	80.4	62.4	20.2	140.8	3.1
October	19.7	34.8	85.4	53.7	0.0	139.2	2.7
November	13.4	29.3	86.0	45.0	0.0	47.6	0.7
December	5.7	21.2	86.0	52.0	27.2	61.0	2.6

INDORE

Latitude – 22° 14' N Longitude - 76° 01' E

Months	Temperature* (°C)		Humidity* (%)	Rainfall (mm)	Evaporation (mm/day)
	Maximum	Minimum			
2023					
June	34.7	24.7	78.7	247.9	-
July	27.9	24.2	89.2	372.8	-
August	26.7	22.9	87.0	215.4	-
September	28.7	24.7	85.1	495.4	-
October	30.5	19.4	80.8	5.0	-
November	28.1	13.2	82.5	30.1	-
December	23.7	11.6	86.0	3.2	-
2024					
June	34.3	24.2	78.7	237.4	-
July	29.3	23.8	89.2	222.8	-
August	27.9	22.9	87.0	303.4	-
September	28.7	22.7	84.8	275.4	-
October	30.5	16.8	81.9	66.8	-
November	28.0	12.9	82.5	13.1	-
December	23.4	10.6	86.6	4.2	-

- Data not available

PANVEL

Latitude – 18° 59' N Longitude – 73° 06' E

Months	Temperature (°C)		Relative humidity (%)	Rainfall (mm)	Evaporation (mm/day)	Wind velocity (km/hr
	Maximum	Minimum				
			2023			
January	-	-	-	0	-	-
February	-	-	-	0	-	-
March	-	-	-	0	-	-
April	-	-	-	0	-	-
May	-	-	-	0	-	-
June	-	-	-	626.2	-	-
July	-	-	-	1909.4	-	-
August	-	-	-	378.8	-	-
September	-	-	-	559.4	-	-
October	-	-	-	25.4	-	-
November	-	-	-	11.0	-	-
December	-	-	-	0	-	-
			2024			
January	-	-	-	0	-	-
February	-	-	-	0	-	-
March	-	-	-	0	-	-
April	-	-	-	0	-	-
May	-	-	-	9	-	-
June	-	-	-	551	-	-
July	-	-	-	1885.4	-	-
August	-	-	-	609.6	-	-
September	-	-	-	604.6	-	-
October	-	-	-	165	-	-
November	-	-	-	0	-	-
December	-	-	-	0	-	-

- Data not available

VYTTILA

Latitude – 09° 97' N Longitude – 76° 32' E

Months	Temperature (°C)		Relative humidity (%)		Rainfall (mm)	Evaporation (mm/day)
	Maximum	Minimum	Maximum	Minimum		
			2023			
January	31.6	19.9	-	-	0.0	2.6
February	31.9	21.0	-	-	0.0	2.9
March	33.1	22.8	-	-	6.0	3.1
April	32.7	23.9	-	-	84.0	3.3
May	32.6	24.0	-	-	44.5	3.2
June	30.4	22.3	-	-	341.0	2.8
July	29.1	21.3	-	-	663.5	2.4
August	31.3	22.2	-	-	102.0	2.9
September	29.6	20.9	-	-	772.5	2.5
October	30.7	21.4	-	-	207.0	2.9
November	31.6	21.0	-	-	219.0	2.9
December	32.4	21.2	-	-	21.0	3.0
			2024			
January	33.0	20.3	-	-	45.0	2.9
February	33.9	21.1	-	-	0.0	3.2
March	33.7	22.9	-	-	0.0	3.3
April	33.8	22.0	-	-	46.0	3.6
May	32.6	21.9	-	-	658.2	2.3
June	30.2	21.3	-	-	441.0	3.2
July	29.7	21.4	-	-	618.5	2.5
August	30.4	23.0	-	-	170.0	2.8
September	31.4	23.2	-	-	153.5	2.8
October	31.3	22.8	-	-	261.0	2.7
November	31.8	22.3	-	-	178.0	2.7
December	31.0	22.3	-	-	88.5	2.8

- *Data not available*

7.5 LIST OF PUBLICATIONS (2023-24)

AGRA

Research Papers

Chauhan SK, Kaledhonkar MJ, Singh RB, Chauhan RS and Shishodia PK (2023). Feasibility of conjunctive use of canal and alkali groundwater for toria-chicory crop rotation in Uttar Pradesh, India, Irrigation and drainage, **72(2)**: 530-542.

Kaledhonkar MJ, Singh RB, Chauhan SK, Shishodia PK, Chauhan RS, Harode Pavan Kumar, Meena BL, Kumar Satendra, Sindhu VK and Brar AS (2024). Management of high SAR saline ground water for tomato cultivation with provision of recharge structure and drip system in semi- arid Agra region. *Journal of soil and water conservation*.

Technical Bulletin

Chauhan SK, Meena RL, Shishodia PK, Chauhan RS, Singh RB and Kaledhonkar MJ (2024). Conjunctive Use of Alkali/Canal waters for Enhanced Production of Toria-Chicory Crop Rotation in Western Uttar Pradesh.

BAPATLA

Research Papers

Divya Sree G, Mrudhula KA, Sunil Kumar M, Ramesh G, Kishore Babu G and Siddatha Naik BSS (2023). Effect of salinity and drip fertigation on maize (Zea mays) and water use efficiency. *Indian Journal of Agricultural Sciences* **94 (1)**:94-50.

Divya sree G, Mrudhula K A, Sunil Kumar M, Ramesh G, Kishore Babu G and Siddatha Naik BSS (2024). Evaluation of saline water effects on use efficiency and soil nutrients vilability of maize under drip fertigation. Plant Science Today. **ISSN 2348-1900. Vol x(x):xx-xx**.

Venkata Subbaiah, P, Anny Mrudhula K and Kaledhonkar MJ (2024). Assessment of spacial variability in ground water quality of Kurnool region for irrigation purpose and management options. *International Journal of Plant & Soil Science* **36(3)**:306-414.6.

Venkata Subbaiah, P, Anny Mrudhula K and Kaledhonkar MJ (2024). Soil properties and land use in salt affected soils of Prakasam district, Andhra Pradesh. *International Journal of Plant & Soil Science* **36(3)**:665-672.

Book chapters :

Mohan Rao P, Venkata Subbaiah P, Sudha Rani Y, Prasuna Rani P, Sambaiah A, and Kannan R (2023). Evaluation of Groundwater Quality for Irrigation-A Case Study of West Godavari District of Andhra Pradesh. Advances in Water Resource Planning and Sustainability, Advances in Geographical and Environmental Sciences. pp 239-252. **Springer**.

GANGAVATI

Research Papers

Hanamantappa M, Vishwanath J, Balanagoudar SR, Veeresh H and Karegoudar AV (2023). Feasibility of Drain Discharge Under 50 M Lateral Spacing Controlled Subsurface Drainage in Saline

Vertisols of TBP Command Area. *International Journal of Environment and Climate Change* **13(9):**1719-1726 (NAAS-5.16).

Rajkumar RH, Vishwanath J, Karegoudar AV, Kaledhonkar MJ, Anand SR, Kumar Anil, Dandekar T and Thakur RK, 2024. Drip irrigation for sustaining high sugarcane (Saccharum officinarum) yield in marginally to moderately waterlogged saline vertisols of Karnataka, India Irrig. and Drain. **2024;1–17.** (DOI: 10.1002/ird.2990) (NAAS-7.89).

HISAR

Research Papers

Dahiya S, Rita, Panghal RP, Singh VP and Gora MK (2023). Effects of saline water and N levels on the eggplant (Solanum melongena L.) fruit yield, water productivity, and nitrogen use efficiency by drip and surface flood irrigation. Horticultural Science (Prague). **50:2023 (1):** 32–44.

Prakash R, Devi S, Kumar N and Dhillion A (2023). Screening of mustard (Brassica juncea) varieties under different quality of saline water irrigation in semi-arid conditions of Haryana. *Journal of Environmental Biology* **44:** 259-266.

Prakash R, Kumar G, Rajpaul S and Ankush (2023). Characterization and spatial mapping of irrigation water quality and their effects on soil properties in Hathin Block of Palwal district, Haryana. *Journal of Environmental Biology* **44:** 310-316.

Prakash R, K Dinesh, Sanjay, Ankush, and Singh C (2023). Characterization and Mapping of Groundwater Quality of Sonipat District in Haryana, *India Journal of Soil Salinity and Water Quality* **15(1):**38-45.

Prakash R, K Dinesh, Sanjay and Kamaldeep (2023). GIS Mapping of Groundwater Quality for Irrigation in Hisar District of Haryana, India. *Journal of Soil Salinity and Water Quality*. **15(1):**46-51.

Prakash R, Kumar P, Kumar, Sanjay, Ankus., Rani, Sarita and Abhinav. (2023). Characterization and mapping of ground water quality in the barwala block of the Indian state of Haryana. *Journal of Plant Development Sciences* **15(6):** 299-304.

Book/Technical Bulletin/Book Chapter/Hindi Magazine:

Ankush, Prakash R, Singh A, Garhwal RS and Diwedi A (2023). Role of nano-fertilizers in sustainable agriculture. In: Rajput VD, Singh A and Minkina TM (Eds) Sustainable agriculture and food security. Deepika Book Agency, New Delhi, pp. 1-16.

Singh VK, Prakash R and Kushwaha DP (2023). Impact of Surface Temperature on soil chemical properties using coupled approach of satellite imagery, gamma test and regression based models in semi–arid area. (Eds) Surface and groundwater resources development in semi-arid region. Springer Hydrogeology, pp. 337-363.

Ankush, Lamba S, Ritambhara, Diwedi A, Kumar S and Singh V (2023). Source and Distribution of Lead in Soil and Plant-A Review. Lead Toxicity: Challenges and Solution, Edited by Kumar, N. and Jha, A.K., Springer, pp.3-16.

Ankush, Ritambhara, Lamba S, Deepika and Prakash R (2024). Cadmium in Environment-An Overview. Cadmium Toxicity in Water: Challenges and Solutions, Edited by Jha, A.K. and Kumar, N., Springer, pp.3-20.

Rani S, Kamboj N and Kamboj E (2024). Influence of environmental factors (Soil and climate) on performance (uptake, translocation, and metabolism) of soil applied herbicides. Farming the Future Advanced Techniques in Modern Agriculture Volume II. pp. 29-33.

Rani S, Kamboj N and Prakash R (2023). Contingent Planning. Exploration and development of agriculture in India. pp: 1-5.

Kamboj N, Kamboj E and Rani S (2023). Advance agronomic interventions for doubling farmer's income. Exploration and development of agriculture in India. pp. 62-65.

Prakash R, Kumar S, Rani, Sarita, Dinesh, Kautilya, Sharma MK, and Meena RL and Kaledhonkar (2024). Mapping of groundwater quality for irrigation in Hisar district of Haryana. pp:1-35.

Rani S, Kamboj N and Kamboj E (2023). Faslon ki paidavaar tatha mitti ki urvarta ko badhane mein hari khad ka mehtav. Haryana Kheti. June 2023, Page-8.

TIRUCHIRAPPALLI

Research Papers

Ravichandran R, Ayyavoo R, Rajangam L, Madasamy N, Baskar M and Shanmugam S (2023). Comparative Analysis of Groundwater Quality Index for Bhavani River Basin Using Remote Sensing and Statistical Analysis. Jordan Journal of Civil Engineering 17 (1)

Gauns AS, Nagarajan M, Lalitha R and Baskar M (2023) Geospatial Approach for Assessment of Groundwater Quality. Natural Hazards, 117 (3):2771-2806

Suguna TS, Balasubramaniam P, Baskar M (2023). Kaledhonkar MJ and Ravikumar V Assessment of sea water intrusion in Coastal District of Southern India. Current Science 3(4): pp.357-363

Sherene JRT, Vidhya, D, & amp; Baskar M (2023). Ixora a flower crop- Boon for Sodic soil farmers – To be addressed for Micronutrient deficiencies. YMER 22(10).

Dhanushkodi V, Balamurugan R, Baskar M, Rathika S, Shenbagavalli S, Hemavathy AT, Anitha R and Sangeetha S (2023). Paper Mill Effluent is an Alternate for Irrigation and Nutrient Sources in Improving Soil Health and Agricultural Productivity. International Journal of Plant & Soil Science 35(19):pp.444-453

Devi KC, Baskar M, Jagadeeswaran R, Meena S, Dhanushkodi V and Rathika S (2023). Delineation and Mapping of Ground Water Quality in Kanchipuram District of Tamil Nadu Using GIS Techniques. International Journal of Environment and Climate Change 13(10): pp.2321-31

Surya M, Baskar M, Meena S, Janaki D, Geethanjali S and Sundar M (2023). Evaluation of Physiological and Biochemical Traits in Relation to Sodicity Tolerance in Selected Rice Genotypes under Different Sodicity Levels. Agricultural Science Digest. 43(6):pp.796-801

Suresh T, Selvamurugan M, Baskar M, Santhy P and Balasubramaniam P (2023). Affected of ameliorated alkaline water and soil amendments on exchangeable cation, macro and micronutrients in sodic soil under drip irrigation. Int. J. Plant Soil Sci. 35(20): pp.203-208

Selvamurugan M, Balasubramaniam P, Baskar M, Alagesan A and Kaledhonkar MJ (2024). Irrigation methods suitable for vegetable crops cultivation in sodic soil with alkaline irrigation water. Paddy and Water Environment 22(4): pp675-683.

Sekar A, Valliammai A, Nagarajan M, Sivakumar SD, Baskar M and Sujitha E, (2024). Conjunctive use in water resource management: current trends and future directions. Water Supply 24(11): pp.3881-3904

Monisha N, Baskar M, Meena S, Rathika S, Dhanushkodi V, Nagarajan M and Meena RL (2024). Morphological and biochemical adaptations of finger millet (Eleusinecoracana) to salinity stress: A principal component analysis. Plant Science Today 11: p.5881

Rajavarshini T , Baskar M, Sherene JRT, Rathika S, Nagarajan M, and Meena RL (2024). Delineation and Mapping of Groundwater Quality Assessment in Salem District, Tamil Nadu, India Using GIS Techniques. International Journal of Environment and Climate Change 14 (11):487-502.

Surya M, Baskar M, Meena S, Janaki D, Geethanjali S and Sundar M (2024). Effect of different levels of sodicity on soil enzymes, soil microbial biomass carbon and activity of antioxidant enzymes in different rice varieties under semi-arid conditions. Agricultural Science Digest 44(3): pp.421-427

Suresh TM. Selvamurugan M, Baskar P, Santhy and Balasubramaniam P (2024). Impact of Soil Amendments and Improved Alkaline Water on the Physico -Chemical Characteristics of the Soil, the Distribution of Salt in the Soil, the Growth, and the Yield of Hybrid Cotton Grown in Sodic Soil with Drip Irrigation. Journal of Advances in Biology & Biotechnology 27(11): pp.657-663

Books (With ISBN)

Janaki D, ShereneJenitha T, Rajammal V, Dhanushkodi M, Baskar and Mohandas S 2023. Soil constraints and Management. Published by Shanlax Publications, Madurai. pp. 1-331 (ISBN: 978-81-19337-26-2).

BATHINDA

Research Papers

Yadav BK, Grover J and Singh S (2023). Irrigation water quality and constraints perceived by farmers in adoption of recommended technologies for irrigation in Bathinda district of Punjab. Journal of Community Mobilization and Sustainable Development 18(3): 901-907.

Yadav BK and Grover J (2023). Appraisal of groundwater nitrate accumulation in Faridkot and Firozpur district of South-Western Punjab. Journal of Soil Salinity and Water Quality 15(2): 158-163.

Yadav BK, Garg N, Pandove G and Kalia A (2024). Enhancing vegetable cowpea growth and yield in semi-arid Regions: effect of liquid microbial consortia and variable nitrogen doses under saline and canal water irrigation. Agricultural Research Journal 61 (1): 93-100.

Yadav BK, Meena HM and Meena RL (2024). Remediation of antagonistic saline effect on crops using organic amendments- A Review. Journal of Soil Salinity and Water Quality 16(2): 166-179.

PANVEL

Research Papers

Dodake SB, Khobragade SS, Borse DK, Wahane MR, Vaidya KP, Kaledhonkar MJ, and Meena BL (2023). Effect of Irrigation Level and Sowing Date on Yield of Field Bean in Saline Soils of Konkan Region of Maharashtra. Journal of Agricultural Engineering (India) 60(1): 100-107.

Patil KD, Khobragade SS, Palkar JJ, Dodake SB, Wahane MR, Borse DK, Vaidya KP, Kaledhonkar MJ, and Meena RL (2024). Profitability of rainwater pond-based integrated farming systems in coastal plains of western India: A case study. Journal of Agricultural Engineering (India) 61(2): 219-231.

VYTTILA

Research Paper

Sajan A, Sreelatha AK, Beena VI and Durga Devi KM. 2023. Soil carbon pools in different land uses of Pokkali agro-ecosystem. Journal of Tropical Agriculture 61(1):pp.50-55.

Book Chapter/Bulletin

Leno N, Joseph B, Gladis R, Sreelatha AK, Rajalekshmi K, and Ajin P, Asok (2025). Hydromorphic acid saline soils of Kerala: An ecohydrology based fertility assessment. In. Ecohydrology of river catchments and coastal backwaters in Kerala, India: An introduction and synthesis. In Ecohydrology of Kerala Vincent, SGT, Jennerjahn TC, Kunjupillai S, & Chattopadhyay S (Eds). (pp. 1-6). Elsevier.

Sreelatha, AK, Paul N, Sajan A and Meena RL (2024). Integrated Farming System for Livelihood Security in Pokkali Lands of Kerala. Technical Bulletin, Rice Research Station, Vyttila, Kochi. 32p.

Vighneswaran, V Sreelatha AK, Thomas D, and Amrithakumary S (2024). Genetic Improvement of Rice for Salt Tolerance at RRS, Vyttila. In Genetic Improvement of Rice for Salt Tolerance. Singh RK, Prakash M, Gautam RK, Krishnamurthy SL, & Thirumeni S (Eds.). Springer Nature Singapore.

7.6 FINANCE

The Three-Year Plan (2017–2020) was sanctioned by the Council vide letter No. NRM-24-4/2013-I-II dated 28-02-2014 with an outlay of Rs 4638.67 lakhs (ICAR Share Rs 3675.00 lakh). The budget head and Centre wise statement of expenditure for 2022-23 and 2023–24 is given below:

MAIN CENTRES

1. AGRA (100% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	0	0	0	0
2.	Grant in Aid-Salary	14000000	13070224	14162000	14161638
3.	TA (SWS)	60000	54510	45000	35081
4.	TA (ORP)	10000	2233	10000	2481
5.	Research Contingencies (SWS)	35000	35000	100000	93489
6.	Research Contingencies (ORP)	50000	48970	30000	29510
7.	Operational expenses (SWS)	360000	358383	425000	415838
8.	Operational expenses (ORP)	50000	49054	40000	37502
9.	SCSP (Capital)	0	0	0	0
10.	SCSP (General)	0	0	0	0
	Total:	**14565000**	**13618374**	**14812000**	**14775539**

2. BAPATLA (75% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grants in Aid-Capital	0	0	0	0
2.	Grants in Aid-Salary	5700000	5723346	5480000	6256683
3.	TA (SWS)	25000	22148	45000	38963
4.	TA (ORP)	10000	9072	10000	9959
5.	Research Contingencies (SWS)	125000	124261	100000	100000
6.	Research Contingencies (ORP)	50000	49216	40000	40000
7.	Operational expenses (SWS)	295000	295612	290000	289948
8.	Operational expenses (ORP)	50000	50515	50000	49910
9.	SCSP (Capital)	0	0	0	0
10.	SCSP (General)	20000	19997	20000	19999
	Total:	**6275000**	**6294167**	**6035000**	**6805462**

3. BIKANER (75% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grants in Aid-Capital	0	0	0	0
2.	Grants in Aid-Salary	5400000	4804876	5029000	5254935
3.	Travelling Allowance (TA)	70000	61714	20000	19850
4.	Research Contingency	125000	124972	125000	120034
5.	Operational expenses	250000	249792	300000	280866
6.	SCSP (Capital)	0	0	0	0
7.	SCSP (General)	20000	19984	29000	28893
	Total:	**5865000**	**5261338**	**5503000**	**5704578**

4. GANGAVATHI (75% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	0	0	0	0
2.	Grant in Aid-Salary	5000000	4522185	4600000	5659417
3.	Travelling Allowance (TA)	50000	40625	45000	35029
4.	Research Contingency	125000	123947	125000	110500
5.	Operational expenses	300000	294466	300000	288104
6.	SCSP (Capital)	0	0	0	0
7.	SCSP (General)	20000	19824	20000	19810
	Total:	**5495000**	**5001047**	**5090000**	**6112860**

5. HISAR (75% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	0	0	0	0
2.	Grant in Aid-Salary	3500000	3268871	3032000	3220907
3.	Travelling Allowance (TA)	40000	33317	10000	8676
4.	Research Contingency	125000	115000	115000	110000
5.	Operational expenses	270000	261371	300000	300162
6.	SCSP (Capital)	0	0	0	0
7.	SCSP (General)	0	0	0	0
	Total:	**3935000**	**3678559**	**3457000**	**3639745**

6. TIRUCHIRAPPALLI (75% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	0	0	0	0
2.	Grant in Aid-Salary	4900000	4632941	4800000	5350817
3.	Travelling Allowance (TA)	57000	56977	65000	65000
4.	Research Contingency	115000	115000	125000	125000
5.	Operational expenses	398000	398000	285000	285000
6.	SCSP (Capital)	0	0	0	0
7.	SCSP (General)	150000	150000	108000	108000
	Total:	**5620000**	**5352918**	**5383000**	**5933817**

VOLUNTEER CENTRES

1. BATHINDA (100% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	0	0	0	0
2.	Grant in Aid-Salary	0	0	0	0
3.	Travelling Allowance (TA)	17000	5722	15000	9957
4.	Research Contingency	100000	82988	100000	93943
5.	Operational expenses	193000	185620	155000	154535
6.	SCSP (Capital)	0	0	0	0.00
7.	SCSP (General)	0	0	10000	0.00
	Total:	**310000**	**274330**	**280000**	**258435**

2. INDORE (100% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	0	0	0	0
2(a)	Grant in Aid-Salary	0	0	0	0
(b)	Pay Arrear of 7th CPC	0	0	2729000	2726700
3.	Travelling Allowance (TA)	28000	27243	10000	7568
4.	Research Contingency	100000	100000	100000	100000
5.	Operational expenses	182000	182000	180000	180000
6.	SCSP (Capital)	0	0	0	0
7.	SCSP (General)	0	0	0	0
	Total:	**310000**	**309243**	**3019000**	**3014268**

3. PANVEL (100% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	00	0	0	0
2.	Grant in Aid-Salary	0	0	0	0
3.	Travelling Allowance (TA)	20000	20000	10000	10000
4.	Research Contingency	55000	54807	50000	49987
5.	Operational expenses	315000	314114	350000	347345
6.	SCSP (Capital)	0.00	0	0	0
7.	SCSP (General)	15000	15000	6000	6000
	Total:	**405000**	**403921**	**416000**	**413332**

4. VYTILLA (100% ICAR Share) **(Amount in Rupees)**

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	0	0	0	0
2.	Grant in Aid-Salary	0	0	0	0
3.	Travelling Allowance (TA)	15000	15000	25000	25000
4.	Research Contingency	100000	100000	100000	100000
5.	Operational expenses	195000	195000	245000	245000
6.	SCSP (Capital)	0	0	0	0
7.	SCSP (General)	20000	20000	20000	20000
	Total:	**330000**	**330000**	**390000**	**390000**

PROJECT COORDINATING UNIT, CSSRI, Karnal (100% ICAR Share)

(Amount in Rupees)

		2022-23		2023-24	
S.No.	**Budget details-Head-wise**	**Released**	**Expenditure**	**Released**	**Expenditure**
1.	Grant in Aid-Capital	0	0	0	0
2.	Grant in Aid-Salary	0	0	0	0
3.	Travelling Allowance (TA)	0	0	0	0
4.	Research Contingency	0	0	0	0
5.	Operational expenses	355867	355867	599370	599370
6.	SCSP (Capital)	0	0	0	0
7.	SCSP (General)	20000	20000	20000	20000
	Total:	**375867**	**375867**	**619370**	**619370**

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भाकृअनुप
ICAR

हर कदम, हर डगर
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