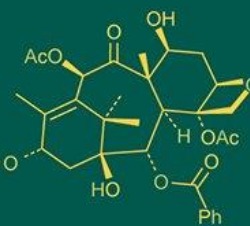
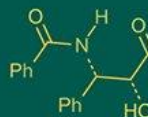


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B Navya Sree
Department of Soil Science and
Agricultural Chemistry,
Agricultural College, Bapatla,
Acharya N.G. Ranga
Agricultural University,
Andhra Pradesh, India

P Madhu Vani
Department of Soil Science and
Agricultural Chemistry,
Agricultural College, Bapatla,
Acharya N.G. Ranga
Agricultural University,
Andhra Pradesh, India

M Latha
Saline Water Scheme,
Department of Soil Science and
Agricultural Chemistry,
Agricultural College, Bapatla,
Acharya N.G. Ranga
Agricultural University,
Andhra Pradesh, India

K Anny Mrudhula
Saline Water Scheme,
Department of Soil Science and
Agricultural Chemistry,
Agricultural College, Bapatla,
Acharya N.G. Ranga
Agricultural University,
Andhra Pradesh, India

Corresponding Author:
K Anny Mrudhula
Saline Water Scheme,
Department of Soil Science and
Agricultural Chemistry,
Agricultural College, Bapatla,
Acharya N.G. Ranga
Agricultural University,
Andhra Pradesh, India

Effect of mulched drip irrigation with saline water on soil properties, yield, nutrient uptake and economics of maize

B Navya Sree, P Madhu Vani, M Latha and K Anny Mrudhula

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Abstract

A field experiment was carried out during *rabi*, 2025-26 to investigate the influence of saline water irrigation through drip system combined with mulching on soil properties, yield, nutrient uptake and economics. The experiment was laid out in a split-plot design with three mulch treatments viz., no mulch (M_1), paddy straw mulch (M_2), and black plastic film mulch (M_3) as main plots and five irrigation water salinity levels viz., good water (0.6 dS m^{-1}), 2, 4, 6, and 8 dS m^{-1} as sub-plots. The study revealed that Black plastic film mulch significantly enhanced kernel, stover yield, nutrient uptake and economic returns compared with paddy straw mulch and no mulch, whereas paddy straw mulch achieved the highest benefit-cost ratio due to its lower cultivation cost. These findings demonstrated that drip irrigation with black plastic film mulch is an effective strategy for improving maize productivity, nutrient uptake, and profitability under saline irrigation conditions.

Keywords: Drip irrigation, black plastic mulch, paddy straw mulch, nutrient uptake, kernel yield

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops worldwide, serving as a major source of food, feed, and industrial raw materials owing to its high productivity and wide adaptability. In India, maize occupies a prominent position after rice and wheat and contributes substantially to food security and the agricultural economy. However, sustaining maize productivity has become increasingly challenging because of declining freshwater availability and the growing dependence on marginal-quality irrigation water.

Salinity is a major abiotic stress limiting crop production in arid, semi-arid, and coastal regions. The use of saline water for irrigation has expanded due to increasing competition for freshwater resources. Continuous application of saline irrigation water leads to salt accumulation in the root zone, resulting in osmotic stress, ion toxicity, nutrient imbalance, and deterioration of soil physical and chemical properties, ultimately reducing crop growth and productivity.

Drip irrigation has emerged as an effective approach for improving irrigation water use efficiency while minimizing salt accumulation in the crop root zone. Frequent application of small quantities of water helps maintain favourable soil moisture conditions and reduces salinity-induced stress compared with conventional irrigation methods. Nevertheless, prolonged use of saline water, even under drip irrigation, may adversely affect soil health and nutrient availability if appropriate management practices are not adopted.

Mulching is widely recognized as a complementary practice for mitigating the adverse effects of saline irrigation. Organic mulches, such as paddy straw, improve soil organic matter, moisture retention, and soil structure, whereas black plastic film mulch effectively reduces soil evaporation, suppresses weed growth, and enhances soil moisture conservation. These benefits contribute to improved nutrient uptake, crop growth, and yield under saline conditions. Although several studies have independently demonstrated the advantages of drip irrigation and mulching, information on their combined influence under different irrigation water salinity levels, particularly on maize productivity, nutrient uptake, and economic returns, remains limited under the Inceptisols of the coastal agro-ecosystems of south India.

Materials and Methods

A field experiment was conducted during *rabi*, 2025-26 at the Agricultural College Farm, Bapatla, Andhra Pradesh, situated in the Krishna Agro-climatic Zone of Andhra Pradesh. The experiment was laid out in a split-plot design consisting of three main treatments viz., no mulch (M_1), paddy straw mulch (M_2) and black plastic film mulch (M_3), while the subplot treatments comprised five irrigation water salinity levels viz., good water (0.6 dS m^{-1}), 2 dS m^{-1} , 4 dS m^{-1} , 6 dS m^{-1} and 8 dS m^{-1} (S_1 to S_5) and all treatment combinations are replicated thrice. The experimental soil was sandy loam in texture, neutral in reaction (pH 7.5) and non-saline in nature ($\text{EC } 0.66 \text{ dS m}^{-1}$). The soil was low in available nitrogen (185 kg ha^{-1}), medium in available phosphorus (35.5 kg ha^{-1}) and high in available potassium (550 kg ha^{-1}). Irrigation was applied after 30 DAS through a drip irrigation system, it was stopped 10 days prior to harvest. Maize hybrid PAC-751 was sown at a spacing of $45 \times 20 \text{ cm}$. A recommended fertilizer dose of 240:80:80 NPK kg ha^{-1} was applied through urea, single super phosphate and muriate of potash. Nitrogen was applied in three equal splits (basal, knee high and tasselling). The entire phosphorous was applied as basal, while potassium applied in two equal splits. Crop was harvested plot wise at maturity and shelled separately for recorded observations on grain yield whereas, plants were cutoff from base of the plant and dried in field itself and recorded stover yield. Nutrient uptake was analysed in the laboratory by using powdered sample. The experimental data were analysed statistically following the standard procedures described by Gomez and Gomez (1984).

Results and Discussion

Bulk density

Bulk density was not significantly influenced by either mulch treatments or irrigation water salinity (Table 1). Nevertheless, black plastic film mulch (M_3) recorded the lowest bulk density (1.38 Mg m^{-3}), followed by paddy straw mulch (M_2) (1.40 Mg m^{-3}), whereas the highest bulk density (1.43 Mg m^{-3}) was observed under the unmulched treatment (M_1). The lower bulk density under mulched plots may be attributed to improved soil aggregation, enhanced biological activity and reduced soil compaction resulting from better soil moisture conservation. Similar observations were reported by Rakeshkumar (2015) [22] and Mehmood *et al.* (2015) [18].

A gradual increase in bulk density was observed with increasing irrigation water salinity, from 1.35 Mg m^{-3} under good irrigation water (S_1) to 1.46 Mg m^{-3} under 8.0 dS m^{-1} irrigation water (S_5). Although the increase was statistically non-significant, bulk density under S_5 was 8.15% higher than S_1 and 7.35% higher than the initial soil value. The increase could be attributed to salt accumulation and sodium-induced clay dispersion, which reduce soil pore space and increase soil compaction under saline conditions (Huang *et al.*, 2019; Calone *et al.*, 2021) [10, 5]. The interaction between mulch and irrigation water salinity was non-significant, indicating that the response of bulk density to mulching remained consistent across different salinity levels.

Aggregate stability

Aggregate stability was significantly influenced by both mulch treatments and irrigation water salinity (Table 1).

Black plastic film mulch (M_3) recorded the highest aggregate stability (48.74%), which was statistically comparable with paddy straw mulch (47.51%) and significantly superior to the unmulched treatment (44.12%). Improved aggregation under mulched treatments may be attributed to enhanced soil organic matter conservation, greater microbial activity and reduced surface disturbance, thereby promoting aggregate formation and stability. These findings are in agreement with Wang *et al.* (2017) [26].

Aggregate stability declined significantly with increasing irrigation water salinity. The highest value (51.54%) was recorded under good-quality irrigation water (S_1), which remained statistically comparable with S_2 (50.03%) and S_3 (48.03%). Further increases in salinity resulted in a marked decline, with the lowest aggregate stability (40.44%) recorded under S_5 , representing a 13.18% reduction compared with the initial soil condition. The decline in aggregate stability under saline irrigation may be attributed to increased exchangeable sodium and clay dispersion, which weaken inter-particle bonding and destabilize soil aggregates (Tang *et al.*, 2020) [25].

The interaction between mulch and irrigation water salinity was non-significant, it indicated that mulching improved soil structural stability under all irrigation treatments but could not completely offset the adverse effects of higher salinity.

Soil moisture content

Soil moisture content at harvest was significantly improved by mulch application, whereas irrigation water salinity had no significant effect (Table 1). Black plastic film mulch (M_3) maintained the highest soil moisture content (15.05%), followed by paddy straw mulch (14.39%), while the lowest value (12.52%) was recorded under the unmulched treatment. Compared with black plastic mulch, soil moisture under the no mulch treatment was reduced by 16.8%. The higher moisture content under mulched treatments can be attributed to reduced evaporation losses, improved infiltration and moderated soil temperature. Plastic mulch, in particular, acts as a physical barrier that effectively minimizes soil water loss through evaporation (Kader *et al.*, 2017) [13]. Similar findings have been reported by Muniswamy (2024) [19].

Although statistically non-significant, soil moisture content declined progressively with increasing irrigation water salinity, from 14.94% under S_1 to 12.97% under S_5 , representing a 7.75% reduction relative to the initial soil moisture status. The reduction may be attributed to the higher osmotic potential of saline soil solution, which limits the availability of water for plant uptake despite adequate soil moisture. The interaction effect between mulch and irrigation water salinity was non-significant, suggesting that the moisture-conserving effect of mulching remained effective across all salinity levels.

Soil pH

Soil pH was not significantly affected by mulching, irrigation water salinity, or their interaction at tasselling and harvest (Table 2). Although black plastic mulch recorded slightly higher pH values, the differences were statistically non-significant. The slight decline in pH from the initial value during crop growth may be attributed to root respiration and nutrient uptake, whereas the marginal increase at harvest could be due to reduced root activity and

the buffering effect of alkaline cations (Ca^{2+} , Mg^{2+} , Na^+ and K^+) present in irrigation water. The absence of significant changes indicates that the salinity levels applied were insufficient to alter soil reaction within a single cropping season. Similar findings were reported by Zhang *et al.* (2024)^[29] and Divyasree *et al.* (2024)^[6].

Electrical conductivity (EC)

Soil EC increased significantly with increasing irrigation water salinity, while mulching significantly reduced EC at both tasselling and harvest stage. (Table 2)

Black plastic mulch recorded the lowest EC because it reduced soil evaporation, thereby minimizing the upward movement and surface accumulation of soluble salts. In contrast, higher EC under saline irrigation resulted from the continuous addition and accumulation of dissolved salts in the soil profile. The non-significant interaction indicated that mulching consistently reduced salt accumulation across all salinity levels. These findings are consistent with those of Leogrande *et al.* (2016)^[15]

Soil organic carbon (SOC)

Soil organic carbon was not significantly influenced by mulching or irrigation water salinity (Table 2). However, paddy straw mulch maintained slightly higher SOC than black plastic mulch and the unmulched treatment. It might be due to contributed organic residues and improved soil moisture conditions that favour microbial activity. A slight decline in SOC with increasing salinity may be attributed to osmotic stress, which suppresses microbial activity and organic matter turnover, thereby limiting carbon accumulation. Similar observations were reported by Pawitar (2016)^[20] and Abhipsa *et al.* (2025)^[1].

Soil inorganic carbon (SIC)

Soil inorganic carbon was not significantly affected by mulching, irrigation water salinity or their interaction (Table 2). Nevertheless, a gradual increase in SIC with increasing salinity was observed, which may be associated with the accumulation of carbonate and bicarbonate ions and their precipitation with calcium and magnesium as stable carbonate minerals under saline conditions. Slightly higher SIC under black plastic mulch may also reflect greater soil moisture conservation, favouring carbonate formation. Similar results were reported by Jiang *et al.* (2025)^[12].

Kernel yield (kg ha^{-1})

Kernel yield was significantly influenced by irrigation water salinity and mulching, whereas their interaction was found to be nonsignificant (Table 3). Irrigation with good water (S_1) recorded the highest kernel yield (9067 kg ha^{-1}), which was comparable with S_2 (8869 kg ha^{-1}) and S_3 (8538 kg ha^{-1}), but significantly superior over S_4 (7252 kg ha^{-1}) and S_5 (6549 kg ha^{-1}). Overall, kernel yield declined by 27.7% with increasing irrigation water salinity, indicating that maize tolerated salinity up to 4.0 dS m^{-1} with only marginal yield reduction. The decline under higher salinity was associated with osmotic stress, ionic toxicity and nutrient imbalance, which reduced water uptake, photosynthetic efficiency and assimilate translocation to developing grains. Similar responses were reported by Yuan *et al.* (2018)^[28] and Shehzad *et al.* (2020)^[24].

Among the mulch treatments, black plastic film mulch (M_3) produced the highest kernel yield (8559 kg ha^{-1}) which was

statistically on par with paddy straw mulch (M_2 ; 8116 kg ha^{-1}) and significantly superior over nomulch treatment (M_1 ; 7491 kg ha^{-1}). Enhanced soil moisture conservation, favourable hydrothermal conditions and improved nutrient availability under plastic mulch promoted photosynthesis and grain filling, resulting in higher kernel yield. Similar findings were reported by Haque *et al.* (2018)^[8] and Zhao *et al.* (2023)^[30]. Whereas, the interaction was found to be non-significant.

Stover Yield

Stover yield was significantly affected by irrigation water salinity and mulching, while their interaction remained nonsignificant (Table 3). The highest stover yield was recorded under good irrigation water (S_1 ; 11195 kg ha^{-1}), which was statistically comparable with S_2 (10907 kg ha^{-1}) and S_3 (10543 kg ha^{-1}), but significantly higher than S_4 (9409 kg ha^{-1}) and S_5 (8311 kg ha^{-1}). Progressive reduction in stover yield with increasing salinity reflected the adverse effects of osmotic stress and sodium-induced ion toxicity, which impaired nutrient uptake, photosynthesis and biomass accumulation. Similar observations were reported by Heidarpouret *et al.* (2009)^[9] and Amer (2010)^[2].

Among the mulch treatments, black plastic film mulch (M_3) recorded the highest stover yield (10855 kg ha^{-1}), which was statistically on par with paddy straw mulch (M_2 ; 10061 kg ha^{-1}) and significantly superior to no mulch (M_1 ; 9273 kg ha^{-1}). Improved soil moisture retention and favourable soil temperature under plastic mulch enhanced vegetative growth and dry matter production, leading to greater stover yield. Comparable results were reported by Bu *et al.* (2013)^[4] and Liu *et al.* (2014)^[16]. The interaction between irrigation water salinity and mulching was found to be nonsignificant.

Harvest Index

Harvest index was not significantly influenced by irrigation water salinity, mulching or their interaction (Table 3). Although numerical differences were observed, black plastic film mulch (M_3) recorded a marginally higher harvest index (44.0%) than paddy straw mulch (43.9%) and no mulch (43.7%). Likewise, the highest harvest index was obtained under good irrigation water (44.5%), whereas the lowest value was recorded under 8.0 dS m^{-1} salinity (42.7%). The nonsignificant response indicates that increasing salinity reduced grain and stover yields proportionately without markedly affecting assimilate partitioning between economic and vegetative biomass. Similar findings were reported by Barbosa *et al.* (2012)^[3]. The nonsignificant interaction further suggested that the effect of mulching on biomass partitioning remained consistent across different irrigation water salinity levels.

Macronutrient uptake by maize

Nitrogen uptake

Nitrogen uptake by kernel and stover was significantly influenced by irrigation water salinity and mulching, whereas their interaction was nonsignificant (Table 4). Kernel nitrogen uptake was highest under good irrigation water (S_1 ; 78.88 kg ha^{-1}), which was statistically comparable with S_2 (75.39 kg ha^{-1}), but significantly exceeded S_3 (69.16 kg ha^{-1}), S_4 (55.12 kg ha^{-1}) and S_5 (45.19 kg ha^{-1}). Likewise, nitrogen uptake in stover declined from 54.86 kg ha^{-1} under S_1 to 26.60 kg ha^{-1} under S_5 , representing a reduction of

51.5%. Reduced nitrogen uptake under saline irrigation was associated with restricted root activity, osmotic stress and impaired nitrogen assimilation, leading to lower biomass production and grain yield. Similar findings were reported by Heidarpouret *et al.* (2009)^[9].

Among the mulch treatments, black plastic film mulch (M_3) recorded the highest nitrogen uptake in both kernel (71.90 kg ha⁻¹) and stover (48.98 kg ha⁻¹), followed by paddy straw mulch (64.12 and 41.25 kg ha⁻¹, respectively), while the lowest uptake was observed under no mulch (56.93 and 36.16 kg ha⁻¹, respectively). Enhanced soil moisture conservation and improved nutrient availability under plastic mulch promoted greater nutrient absorption and biomass production, resulting in higher nitrogen uptake. Similar responses were reported by Laxminarayana *et al.* (2009)^[14], Liu *et al.* (2023)^[17] and Zhang *et al.* (2024)^[29].

The interaction between irrigation water salinity and mulching was nonsignificant, indicating that the beneficial effect of mulching on nitrogen uptake remained consistent across all salinity levels.

Phosphorus uptake

Phosphorus uptake by kernel and stover was significantly affected by irrigation water salinity and mulching, whereas their interaction was nonsignificant (Table 4). Kernel phosphorus uptake was highest under good irrigation water (S_1 ; 22.67 kg ha⁻¹), remaining statistically comparable with S_2 (21.29 kg ha⁻¹), but significantly higher than S_3 (18.78 kg ha⁻¹), S_4 (14.50 kg ha⁻¹) and S_5 (12.44 kg ha⁻¹). Similarly, phosphorus uptake by stover decreased from 22.39 kg ha⁻¹ under S_1 to 9.14 kg ha⁻¹ under S_5 . The reduction under saline irrigation reflected restricted root growth, lower phosphorus availability and precipitation of phosphorus compounds under saline conditions, which limited nutrient absorption. Similar findings were reported by Santhosh *et al.* (2019)^[23] and Puli *et al.* (2019)^[21].

Black plastic film mulch (M_3) recorded the highest phosphorus uptake in kernel (20.54 kg ha⁻¹) and stover (19.59 kg ha⁻¹), followed by paddy straw mulch (17.86 and 16.10 kg ha⁻¹), while the lowest uptake was observed under no mulch (14.98 and 13.98 kg ha⁻¹). Improved soil moisture conditions, enhanced microbial activity and greater phosphorus availability under mulched conditions promoted higher phosphorus uptake. Similar observations were reported by Laxminarayana *et al.* (2009)^[14], Mehmood *et al.* (2015)^[18] and Rakeshkumar (2015)^[22].

The interaction between irrigation water salinity and mulching was nonsignificant, indicating that mulching improved phosphorus uptake uniformly across all salinity levels.

Potassium uptake

Potassium uptake by kernel and stover was significantly influenced by irrigation water salinity and mulching, whereas their interaction was nonsignificant (Table 4). The highest kernel potassium uptake was recorded under good irrigation water (S_1 ; 34.45 kg ha⁻¹), which was statistically on par with S_2 (32.82 kg ha⁻¹), but significantly exceeded S_3 (29.03 kg ha⁻¹), S_4 (21.06 kg ha⁻¹) and S_5 (17.68 kg ha⁻¹). Likewise, potassium uptake by stover declined from 109.71 kg ha⁻¹ under S_1 to 63.99 kg ha⁻¹ under S_5 . The reduction in potassium uptake under saline irrigation resulted from ionic

competition between Na^+ and K^+ , together with reduced root activity and biomass production under salt stress. Similar findings were reported by Wang *et al.* (2016)^[27] and Diya *et al.* (2025)^[7].

Among the mulch treatments, black plastic film mulch (M_3) recorded the highest potassium uptake in kernel (29.96 kg ha⁻¹) and stover (101.23 kg ha⁻¹), followed by paddy straw mulch (25.97 and 89.54 kg ha⁻¹), whereas no mulch recorded the lowest uptake (23.22 and 76.97 kg ha⁻¹). Improved soil moisture, favourable root-zone conditions and enhanced nutrient mobility under plastic mulch increased potassium absorption and accumulation in maize. Similar results were reported by Iqbal *et al.* (2009)^[11] and Mehmood *et al.* (2015)^[18].

The interaction between irrigation water salinity and mulching was nonsignificant, indicating that the positive effect of mulching on potassium uptake was maintained across all irrigation water salinity levels.

Economics

The economic analysis revealed that both mulching and irrigation water salinity levels markedly influenced the cost of cultivation, gross returns, net returns, and benefit-cost (B:C) ratio and the details are presented in the table 5.

The economic analysis revealed that the cost of cultivation (COC) varied among the mulching treatments due to differences in the cost of mulch materials. The lowest COC was recorded under the without mulch treatment (₹77,600 ha⁻¹), followed by paddy straw mulch (₹81,100 ha⁻¹), while the highest COC was observed with black plastic film mulch (₹87,400 ha⁻¹) because of the higher cost of plastic mulch and its installation.

Among the treatments, highest gross returns (₹246,864 ha⁻¹) and net returns (₹159,464 ha⁻¹) were recorded in M_3S_1 where black plastic film mulch and irrigation was given with good water. Whereas, the lowest gross returns (₹156,762 ha⁻¹) and net returns (₹79,162 ha⁻¹) in M_1S_5 (no mulch and irrigation water salinity at 8.0dS m⁻¹). A progressive decline in gross returns and net returns was observed with increasing irrigation water salinity across all mulching treatments. The reduction in economic returns under higher salinity levels can be attributed to the adverse effects of salt stress on crop growth and yield, leading to lower marketable produce and profitability.

The highest B:C ratio (1.83) was obtained in M_2S_1 where paddy straw was applied as mulch along with good quality water irrigation followed by black plastic mulch (1.82) and without mulch with good quality water irrigation (1.82). Although plastic mulch resulted in the highest gross and net returns, because of the higher cost of plastic mulch and its installation lowered the B:C ratio compared to paddy straw mulch.

Overall, the economics of the study indicated that application of mulch either black plastic film or paddy straw in conjunction with good quality water enhanced the economic returns by improving crop productivity, whereas negatively affected with increasing irrigation water salinity. Therefore, under conditions of limited salinity, paddy straw mulch offers the greatest economic efficiency, while black plastic film mulch provides the highest absolute monetary return.

Table 1: Influence of saline drip irrigation in conjunction with mulching on physical properties of soil in maize at harvest

Treatments	Bulk density (Mg m^{-3})	Aggregate stability (%)	Moisture content (%)
Main treatments			
M ₁ : Without mulch	1.43	44.12	12.52
M ₂ : Paddy straw mulch	1.40	47.51	14.39
M ₃ : Black Plastic film mulch	1.38	48.74	15.05
S. Em ($\pm$)	0.03	0.90	0.45
CD ($p \leq 0.05$)	NS	3.54	1.77
CV (%)	9.23	7.47	12.48
Sub treatments			
S ₁ : Good water ($<2 \text{ dS m}^{-1}$)	1.35	51.54	14.94
S ₂ : 2 (dS m^{-1})	1.37	50.03	14.52
S ₃ : 4 (dS m^{-1})	1.39	48.03	14.00
S ₄ : 6 (dS m^{-1})	1.44	43.90	13.50
S ₅ : 8 (dS m^{-1})	1.46	40.44	12.97
S. Em ($\pm$)	0.04	1.46	0.50
CD ($p \leq 0.05$)	NS	4.27	NS
CV (%)	8.16	9.38	10.62
Initial value	1.36	46.58	14.06
Interaction between mulch and water salinity levels ($M \times S$)			
Mulch at the same level of salinity			
S. Em ($\pm$)	0.07	2.02	1.01
CD ($p \leq 0.05$)	NS	NS	NS
Salinity at the same level of mulch			
S. Em ($\pm$)	0.07	2.53	0.86
CD ($p \leq 0.05$)	NS	NS	NS

Table 2: Influence of saline drip irrigation in conjunction with mulching on physicochemical properties of soil at tasselling and harvest stage of maize

Treatments	Soil reaction (pH)		Electrical conductivity (dS m ⁻¹)		Soil organic carbon (%)		Soil inorganic carbon (%)	
	At tasselling	At harvest	At tasselling	At harvest	At tasselling	At harvest	At tasselling	At harvest
Main treatments								
M ₁ : Without mulch	6.9	7.0	0.77	0.90	0.31	0.33	1.24	1.30
M ₂ : Paddy straw mulch	6.9	7.0	0.71	0.84	0.35	0.35	1.28	1.34
M ₃ : Black Plastic film mulch	7.0	7.1	0.68	0.79	0.34	0.34	1.35	1.38
S. Em (±)	0.16	0.17	0.02	0.02	0.01	0.01	0.03	0.04
CD (p ≤ 0.05)	NS	NS	0.06	0.07	NS	NS	NS	NS
CV (%)	8.82	9.14	8.17	8.22	12.88	10.83	9.71	10.47
Sub treatments								
S ₁ : Good water (<2 dS m ⁻¹)	7.0	7.1	0.64	0.73	0.35	0.36	1.24	1.28
S ₂ : 2 (dS m ⁻¹)	7.0	7.0	0.66	0.76	0.34	0.35	1.24	1.31
S ₃ : 4 (dS m ⁻¹)	6.9	7.0	0.70	0.79	0.33	0.34	1.28	1.34
S ₄ : 6 (dS m ⁻¹)	6.9	6.9	0.78	0.93	0.33	0.33	1.32	1.36
S ₅ : 8 (dS m ⁻¹)	6.9	6.9	0.83	1.01	0.32	0.32	1.36	1.40
S. Em (±)	0.24	0.24	0.02	0.02	0.01	0.01	0.04	0.03
CD (p ≤ 0.05)	NS	NS	0.07	0.07	NS	NS	NS	NS
CV (%)	10.24	10.25	10.03	8.29	9.47	9.31	8.86	7.79
Initial value	7.5		0.66		0.36		1.22	
Interaction between mulch and water salinity levels (M × S)								
Mulch at the same level of salinity								
S. Em (±)	0.35	0.37	0.03	0.04	0.02	0.02	0.07	0.08
CD (p ≤ 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Salinity at the same level of mulch								
S. Em (±)	0.41	0.41	0.04	0.04	0.01	0.02	0.07	0.06
CD (p < 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Influence of saline drip irrigation in conjunction with mulching on kernel yield, stover yield and harvest index of maize.

Treatments	Kernel yield	Stover yield	Harvest index (%)
	(kg ha ⁻¹)		
Main treatments			
M ₁ : Without mulch	7491	9273	43.7
M ₂ : Paddy straw mulch	8116	10061	43.8
M ₃ : Black Plastic film mulch	8559	10885	44.0
S. Em (±)	347	357	1.15
CD (p ≤ 0.05)	1040	1072	NS
CV (%)	12.74	10.50	10.2
Sub treatments			
S ₁ : Good water (<2 dS m ⁻¹)	9067	11195	44.5
S ₂ : 2 (dS m ⁻¹)	8869	10907	44.3
S ₃ : 4 (dS m ⁻¹)	8538	10543	43.8
S ₄ : 6 (dS m ⁻¹)	7252	9409	43.8
S ₅ : 8 (dS m ⁻¹)	6549	8311	42.7
S. Em (±)	341	334	1.31
CD (p ≤ 0.05)	1023	1004	NS
CV (%)	13.06	10.24	8.99
Interaction between mulch and water salinity levels (M × S)			
Mulch at the same level of salinity			
S. Em (±)	604.35	598.68	2.34
CD (p ≤ 0.05)	NS	NS	NS
Salinity at the same level of mulch			
S. Em (±)	607.27	595.65	2.27
CD (p ≤ 0.05)	NS	NS	NS

Table 4: Influence of saline drip irrigation in conjunction with mulching on macronutrient uptake by maize kernel and stover

Treatments	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
	(kg ha ⁻¹)			(kg ha ⁻¹)		
Main treatments						
M ₁ : Without mulch	56.93	14.98	23.22	36.16	13.98	76.97
M ₂ : Paddy straw mulch	64.12	17.86	25.97	41.25	16.10	89.54
M ₃ : Black Plastic film mulch	71.90	20.54	29.96	48.98	19.59	101.23
S. Em (±)	1.77	0.86	1.26	1.21	0.46	0.25
CD (p ≤ 0.05)	5.31	2.58	3.76	3.65	1.44	7.80
CV (%)	8.00	13.82	13.17	8.86	9.48	8.56
Sub treatments						
S ₁ : Good water (<2 dS m ⁻¹)	78.88	22.67	34.45	54.86	22.39	109.71
S ₂ : 2 (dS m ⁻¹)	75.39	21.29	32.82	50.17	19.63	101.44
S ₃ : 4 (dS m ⁻¹)	69.16	18.78	29.03	46.39	16.87	93.83
S ₄ : 6 (dS m ⁻¹)	55.12	14.50	21.06	33.87	13.17	79.04
S ₅ : 8 (dS m ⁻¹)	45.19	12.44	17.68	26.60	9.14	63.99
S. Em (±)	2.57	0.62	1.03	1.36	0.46	2.91
CD (p ≤ 0.05)	7.50	1.81	3.01	3.98	1.33	8.50
CV (%)	11.76	10.11	11.01	10.05	9.17	9.72
Interaction between mulch and water salinity levels (M × S)						
Mulch at the same level of salinity						
S. Em (±)	3.03	1.47	2.14	2.08	0.82	4.44
CD (p ≤ 0.05)	NS	NS	NS	NS	NS	NS
Salinity at the same level of mulch						
S. Em (±)	4.45	1.08	1.79	2.36	0.79	5.05
CD (p ≤ 0.05)	NS	NS	NS	NS	NS	NS

Table 5: Influence of saline drip irrigation in conjunction with mulching on economics of maize

Treatments	COC	Gross Returns	Net Returns	B:C Ratio
	(Rs. ha ⁻¹)			
Without mulch with good water (M ₁ S ₁)	77600	218801	141201	1.82
Without mulch with 2 EC(M ₁ S ₂)	77600	216017	138417	1.78
Without mulch with 4EC (M ₁ S ₃)	77600	207956	130356	1.68
Without mulch with 6EC M ₁ S ₄)	77600	168899	91299	1.18
Without mulch with 8EC (M ₁ S ₅)	77600	156762	79162	1.02
Paddy straw mulch with good water (M ₂ S ₁)	81100	237553	156453	1.93
Paddy straw mulch with 2 EC (M ₂ S ₂)	81100	229740	148640	1.83
Paddy straw mulch with 4EC (M ₂ S ₃)	81100	221193	140093	1.73
Paddy straw mulch with 6EC(M ₂ S ₄)	81100	186000	104900	1.29
Paddy straw mulch with 8EC (M ₂ S ₅)	81100	174909	93809	1.16
Black Plastic film mulch with good water (M ₃ S ₁)	87400	246864	159464	1.82
Black Plastic film mulch with 2EC(M ₃ S ₂)	87400	241904	154504	1.77
Black Plastic film mulch with 4EC (M ₃ S ₃)	87400	233039	145639	1.67
Black Plastic film mulch with 6EC (M ₃ S ₄)	87400	209616	122216	1.40
Black Plastic film mulch with 8EC (M ₃ S ₅)	87400	177289	89889	1.03

Conclusion

Saline irrigation significantly affected soil quality, crop productivity, nutrient uptake and economic returns in maize, with adverse effects becoming more pronounced beyond an irrigation water salinity of 4.0 dS m⁻¹. Although bulk density, soil pH, soil organic carbon and soil inorganic carbon remained statistically unaffected, increasing salinity increased soil electrical conductivity and reduced aggregate stability, soil moisture, kernel and stover yields, and N, P and K uptake. Among the mulching treatments, black plastic film mulch consistently improved soil physical conditions, minimized salt accumulation, enhanced yield and nutrient uptake, and produced the highest gross and net returns. Paddy straw mulch, however, recorded the highest benefit-cost ratio owing to its lower cultivation cost. Overall, the study demonstrated that drip irrigation with irrigation water salinity up to 4.0 dS m⁻¹, combined with black plastic film mulch, is an effective management strategy for sustaining maize productivity and profitability under saline irrigation conditions.

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