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Effect of mulching on maize growth and yield under saline irrigation conditions

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ABSTRACT

A field experiment was carried out on clay loam soils during *rabi*, 2024-2025 at Agricultural College Farm, Bapatla to assess the Effect of mulching on maize growth and yield under saline irrigation conditions. The experiment was laid out in a split plot design with four irrigation salinity levels (0.4, 2, 4, and 6 dS m^{-1}) as main plots and three mulching treatments (no mulch, straw mulch, and plastic mulch) as subplots. The results revealed that irrigation with best available water (0.4 dS m^{-1}) recorded significantly kernel yield (8200 kg ha^{-1}) and stover yield (14382 kg ha^{-1}), which was on par with 2 and 4 dS m^{-1} treatments. Among mulching treatments, plastic mulch recorded the maximum kernel yield (7780 kg ha^{-1}) and stover yield (13747 kg ha^{-1}), which was statistically at par with straw mulch and significantly superior to no mulch.

Keywords: *Kernel yield, Maize, Mulch, Plant height, Saline irrigation and Stover yield*

Maize (*Zea mays* L.) is a globally important cereal crop widely cultivated for food, fodder, and industrial purposes. In India, it is grown over 11.24 million hectares with a production of 37.67 million tonnes and a productivity of 3351 kg ha^{-1} (DES, 2023-24). In Andhra Pradesh, maize is cultivated on 0.292 million hectares with a productivity of 6225 kg ha^{-1} (des.ap.gov.in, 2023-24). The increasing scarcity of freshwater in coastal regions has led to the use of saline water for irrigation, which adversely affects plant growth, nutrient uptake, and yield. Salinity stress in maize results in osmotic imbalance and ion toxicity, significantly reducing growth and productivity (Braz *et al*., 2019). Drip irrigation is known to minimize the adverse effects of salinity by maintaining consistent soil moisture and reducing salt accumulation in the root zone (Goldberg *et al*., 1976; Kang, 1998) Divya Sree *et al*.,. Mulching is another agronomic practice that enhances water retention, regulates soil temperature, and mitigates the impact of salinity on crop performance. Among various mulches, black plastic and straw mulches are widely adopted due to their benefits in improving the microclimate and nutrient use efficiency (liu *et al*., 2015).

In this context, the present investigation was carried out to study the response of maize to saline water irrigation and mulching under drip irrigation during *rabi,* 2024–25 on growth and yield parameters of maize.

MATERIALS AND METHODS

A field experiment was conducted at Agricultura College Farm, Bapatla, Andhra Pradesh during *rabi*, 2024-25. The soil of the experimental field was clay loam in texture, neutral in reaction with pH 7.5, electrical conductivity 0.46 dS m^{-1}, low in organic carbon, low in available nitrogen, medium in available phosphorus and high in available potassium. Average mean maximum temperature was 33.3 ^{0}C and minimum temperature was 29.3 ^{0}C during the crop growth period. The experiment followed a split plot design with three replications. Main plot treatments included four saline water irrigation levels: M_1:0.4 dS m^{-1} (Best Available Water), M_2 :2 dS m^{-1}, M_3 :4 dS m^{-1}, M_4 :6 dS m^{-1}. Subplot treatments included three mulch types: S_1: No mulch, S_2: Straw mulch, S_3: Plastic mulch (30 μm). The variety used was PAC 751 and sown on 23rd November 2024 at a spacing of 20/30 × 50 cm. Saline water was prepared by diluting seawater (49 dS m^{-1}) with freshwater (0.4 dS m^{-1}) to achieve the desired EC levels. Drip irrigation was scheduled at 100% pan evaporation at 3-day intervals. Observations were recorded on plant height at harvest, days to 50 per cent tasseling and silking, kernel yield and stover yield. Statistical analysis was performed as per standard procedures given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant height (cm)

Plant height (Table 1) was significantly influenced by salinity levels and mulching treatments. Among salinity levels, significantly the tallest plants (236.5 cm) were recorded with best available water (BAW), which was statistically on par with 2 dS m^{-1} (231.6 cm) and 4 dS m^{-1} (217.1 cm), and significantly superior to 6 dS m^{-1} (183.7 cm). The decline in plant height with increasing salinity due to excess of salts in the root zone, causing a greater osmotic effect outside the roots and restricting the water flow from the soil to the plants (Lima *et al*., 2014). Among mulching treatments, plastic mulch recorded significantly higher plant height (224.6 cm), followed by straw mulch (219.4 cm). This reduction in the unmulched plot was due to greater moisture loss and water stress which limits the plant height was noted by Xu *et al*. (2015). The lowest height (207.7 cm) was noted in no mulch treatment. The interaction between subplots at main plots was found non-significant. However, the interaction of main plots at subplot level was significant under different salinity levels and mulching treatments. The interaction of salinity level and mulching treatment was found significant the tallest plants height (244.2 cm) was recorded under best available water with plastic mulch and the shortest plant height (174.3 cm) was recorded under 6 EC+ without mulch.

Drymatter accumulation (kg ha^{-1})

Drymatter accumulation at harvest was significantly influenced by salinity levels and mulching treatments. Among salinity levels, significantly higher drymatter accumulation (18760 kg ha^{-1}) was recorded under best available water, which was on par with 2 EC (18074 kg ha^{-1}) and 4 EC (16897 kg ha^{-1}), and these were significantly superior to 6 EC (14553 kg ha^{-1}) (Table 2). As, salinity increases, a marginal decrease in the rate of photosynthesis, this drop in photosynthetic efficiency directly limits carbohydrate production and biomass accumulation reported by Mittova *et al.* (2004). With respect to mulching, plastic mulch recorded the highest drymatter (17780 kg ha^{-1}), followed by straw mulch (17141 kg ha^{-1}), and the lowest was observed under no mulch (16292 kg ha^{-1}). Similar observations were made by liu *et al*. (2015). The interaction between subplots at main plots was found non-significant. However, the interaction of main plots at subplot level was significant among the different salinity levels and mulching treatments. Significantly maximum drymatter accumulation (19357 kg ha^{-1}) under best available water with plastic mulch and the lowest drymatter accumulation (1388 kg ha^{-1}) was recorded under 6 EC with no mulch.

Number of cobs $plant^{-1}$

Perusal of data presented in Table 3 reveals that different saline water levels and mulching failed to exert a significant influence on number of cobs $plant^{-1}$ in maize. The number of cobs $plant^{-1}$ had not

Table 1. Effect of saline water irrigation and mulching on plant height (cm) of maize

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	223.9	241.3	244.2	236.5
M_2: 2 EC	219.7	236	239.3	231.6
M_3: 4 EC	212.7	217.4	221.1	217.1
M_4: 6 EC	174.3	182.7	194	183.7
Mean	207.7	219.4	224.6	
	SEm (±)	**CD(0.05)**	**CV (%)**	
MAIN PLOT	5.96	20.6	8.2	
SUB PLOT	4.85	14.5	7.7	
Interaction				
S at same level of M (S X M)	9.69	29.1		
M at same or different level of S (M X S)	9.91	31.4		

Table 2. Effect of saline water irrigation and mulching on drymatter accumulation of maize (kg ha^{-1}) at harvest.

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	17740	19184	19357	18760
M_2: 2 EC	17274	18167	18781	18074
M_3: 4 EC	16334	16805	17551	16897
M_4: 6 EC	13818	14409	15431	14553
Mean	16292	17141	17780	
	SEm ($\pm$)	**CD (0.05)**	**CV (%)**	
MAIN PLOT	571.2	1977	10	
SUB PLOT	380.4	1140	9.7	
Interaction				
S at same level of M (S X M)	760.7	NS		
M at same or different level of S (M X S)	843.9	2709		

Table 3. Effect of saline water irrigation and mulching on number of cobs plant^{-1} of maize.

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	1	1.1	1.1	1.1
M_2: 2 EC	1	1.1	1.1	1.1
M_3: 4 EC	1	1	1	1
M_4: 6 EC	1	1	1	1
Mean	1	1.1	1.1	
	SEm ($\pm$)	**CD(0.05)**	**CV (%)**	
MAIN PLOT	0.02	NS	5.3	
SUB PLOT	0.02	NS	7.5	
Interaction				
S at same level of M (S X M)	0.05	NS		
M at same or different level of S (M X S)	0.04	NS		

differed significantly among the treatments imposed. Interaction between salinity level and mulching was also found to be non-significant.

Cob length (cm)

Cob length was significantly affected by salinity and mulching treatments. Significantly the longest cobs (16.8 cm) were observed under best available water, followed by 2 EC (16.2 cm) and 4 EC (15.4 cm), while the shortest cob length (11.7 cm) was observed under 6 EC. Similar findings were reported by Cucci *et al.* (2019). Among mulch treatments, plastic mulch recorded significantly longer cobs (15.5 cm), followed by straw mulch (15.0 cm) and no mulch (14.5 cm). These results are in agreement with the findings of Li *et al*. (2013). The interaction between subplots at main plots was found non-significant. However, the interaction of main plots at subplot level was significant under different salinity levels and mulching treatments (Table 4). In interaction significantly the maximum cob length (17.5 cm) under best available water with plastic mulch and the minimum (11.4 cm) under 6 EC with no mulch treatment.

Number of kernel rows cob^{-1}

Number of kernel rows per cob (Table 5) was significantly influenced by salinity levels and

Table 4. Effect of saline water irrigation and mulching on cob length of maize

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	16	16.8	17.5	16.8
M_2: 2 EC	15.5	16.5	16.7	16.2
M_3: 4 EC	15.1	15.4	15.8	15.4
M_4: 6 EC	11.4	11.5	12	11.7
Mean	14.5	15	15.5	
	SEm (+)	**CD (0.05)**	**CV (%)**	
MAIN PLOT	0.42	1.5	8.4	
SUB PLOT	0.31	0.9	7.2	
Interaction				
S at same level of M (S X M)	0.63	NS		
M at same or different level of S (M X S)	0.66	2.1		

Table 5. Effect of saline water irrigation and mulching on number of kernel rows cob^{-1} of maize

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	13.5	15	15.3	14.6
M_2: 2 EC	13.3	14.1	14.7	14
M_3: 4 EC	12.9	13.2	13.4	13.2
M_4: 6 EC	11.5	11.6	11.9	11.7
Mean	12.8	13.5	13.8	
	SEm (+)	**CD (0.05)**	**CV (%)**	
MAIN PLOT	0.55	1.9	12.4	
SUB PLOT	0.3	0.9	9.7	
Interaction				
S at same level of M (S X M)	0.6	NS		
M at same or different level of S (M X S)	0.74	2.4		

mulching treatments. Significantly the maximum number of kernel rows cob^{-1} (14.6) were recorded under best available water, followed by 2 EC (14.0) and 4 EC (13.2), while minimum number of kernel rows cob^{-1} (11.7) were observed under 6 EC. Among mulches, plastic mulch (13.8) recorded more number of kernel rows cob^{-1} than straw mulch (13.5) and no mulch (12.8). The results are in accordance with the findings Haque *et al*. (2018), where the use of plastic mulch under salinity conditions significantly increased the number of kernels per cob in maize than unmulched. The interaction between subplots at main plots was found non-significant. However, the interaction of main plots at subplot level was significant under different salinity levels and mulching treatments. significantely the highest number of rows (15.3) were reded under best available water + plastic mulch and the least (11.5) under 6 EC with no mulch.

Number of kernels cob^{-1}

Salinity and mulch significantly affected the number of kernels per cob (Table 6). Best available water recorded significantly the highest number of kernels (465.1), followed by 2 EC (444.0), 4 EC (419.6), while significantly the lowest number of kernels per cob (312.7) was under 6 EC. Among mulching treatments, plastic mulch recorded significantly more number of kernels per cob (431.4), followed by straw mulch (412.9), and the least was under no mulch (386.7). This might be attributed to effect of an increased number of grain rows cob{ ^{1}and a higher number of fertile grains row^{-1} under plastic mulch compared to the unmulched treatment, as reported by Haque *et al.* (2018). Significant interaction was observed, with the highest kernel count

Table 6. Effect of saline water irrigation and mulching on number of kernels cob^{-1} of maize

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	446.7	461.8	486.8	465.1
M_2: 2 EC	422.3	452.3	457.3	444
M_3: 4 EC	403.3	417.3	438.3	419.6
M_4: 6 EC	274.7	320	343.3	312.7
Mean	386.7	412.9	431.4	
	SEm (±)	**CD (0.05)**	**CV (%)**	
MAIN PLOT	13.4	46.4	10.8	
SUB PLOT	13.4	40.2	11.3	
Interaction				
S at same level of M (S X M)	26.8	NS		
M at same or different level of S (M X S)	25.66	80.2		

Table 7. Effect of saline water irrigation and mulching on test weight (g) of maize

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	24.7	26.3	27.3	26.1
M_2: 2 EC	24	25.7	26	25.2
M_3: 4 EC	23	23.4	24.6	23.7
M_4: 6 EC	19.9	21.3	22.3	21.2
Mean	22.9	24.2	25.1	
	SEm (±)	**CD(0.05)**	**CV (%)**	
MAIN PLOT	0.78	2.7	9.7	
SUB PLOT	0.54	1.6	8.7	
Interaction				
S at same level of M (S X M)	1.08	NS		
M at same or different level of S (M X S)	1.17	3.8		

(486.8) under best available water with plastic mulch and the lowest (274.7) under 6 EC with no mulch.

Test weight (g)

Test weight (100-kernel weight) was significantly influenced by salinity levels and mulch depicted in Table 7. Significantly the highest test weight (26.1 g) was recorded under best available water, followed by 2 EC (25.2 g) and 4 EC (23.7 g), while the lower test weight (21.2 g) was under 6 EC. The higher test weight at lower salinity levels may be attributed to better grain filling, whereas the reduction at higher salinity could be due to the adverse effects of toxic ions on plant metabolism, particularly the inhibition of potassium absorption, which is essential for grain quality (Munns and Gilliham, 2015; Taiz *et al*., 2017) Among mulch treatments, plastic mulch (25.1 g) recorded higher test weight than straw mulch (24.2 g) and no mulch (22.9 g). These findings are in corroboration with Fan *et al*., 2017. Significant interaction effect showed the highest test weight (27.3 g) under best available water with plastic mulch and lowest (19.9 g) under 6 EC with no mulch.

Cob weight (g)

Cob weight was significantly affected by salinity levels and mulchand treat,emts among salinity levels, the highest cob weight (152.2 g) was recorded under best available water, followed by 2 EC (146.7 g) and 4 EC (136.0 g), and lowest cob weight (118.2

g) under 6 EC. The results are in accordance with the findings of Li *et al.* (2018). Among the mulching treatments, significantly higher cob weight was recorded with plastic mulch (S_3) (145.8 g), which was statistically on par with straw mulch (S_2) (138.8 g). These were significantly superior to no mulch (S_1) (130.2 g), which recorded the minimum cob weight. This enhancement in cob weight under mulching treatments could be due to improved soil moisture retention, better root-zone aeration, and reduced plant stress during the reproductive stage, leading to enhanced assimilate partitioning towards the developing cobs. The results are in close conformity with Absy *et al.* (2020).The interaction between subplots at main plots was found non-significant. However, the interaction of main plots at subplot level was significant under different salinity levels and mulching treatments (Table 8). Interaction effect was significant with maximum cob weight (161.5 g) under best available water with plastic mulch and minimum (106.9 g) under 6 EC with no mulch.

Kernel yield (kg ha^{-1})

Kernel yield of maize was significantly influenced by salinity levels and mulching treatments is presented in Table 9. Significantly the highest kernel

Table 8. Effect of saline water irrigation and mulching on cob weight (g) of maize

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	**S_2: Straw Mulch**	**S_3: Plastic Mulch**	
M_1: BAW	144	151	161.5	152.2
M_2: 2 EC	138.2	147.6	154.4	146.7
M_3: 4 EC	131.6	135.9	140.5	136
M_4: 6 EC	106.9	120.9	126.8	118.2
Mean	130.2	138.8	145.8	
	SEm (+)	**CD (0.05)**	**CV (%)**	
MAIN PLOT	5.06	17.5	11	
SUB PLOT	4.05	12.1	10.1	
Interaction				
S at same level of M (S X M)	8.09	NS		
M at same or different level of S (M X S)	8.32	26.4		

Table 9. Effect of saline water irrigation and mulching on kernel yield (kg ha^{-1}) of maize

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	7556	8198	8846	8200
M_2: 2 EC	7308	7792	8011	7704
M_3: 4 EC	6734	7244	7669	7216
M_4: 6 EC	4930	5103	5681	5238
Mean	6632	7084	7552	
	SEm (+)	**CD(0.05)**	**CV (%)**	
MAIN PLOT	289.9	1003	12.3	
SUB PLOT	162.6	487	9.9	
Interaction				
S at same level of M (S X M)	325.1	975		
M at same or different level of S (M X S)	393.1	1277		

Table 10. Effect of saline water irrigation and mulching on stover yield (kg ha^{-1}) of maize

Salinity levels (dS m^{-1})	Mulch			Mean
	S_1: Without Mulch	S_2: Straw Mulch	S_3: Plastic Mulch	
M_1: BAW	8471	9437	9939	9282
M_2: 2 EC	8389	8857	9135	8794
M_3: 4 EC	8167	8296	8403	8289
M_4: 6 EC	6316	6556	7105	6659
Mean	7836	8286	8646	
	SEm (±)	**CD (0.05)**	**CV (%)**	
MAIN PLOT	292.4	1012	10.6	
SUB PLOT	235.9	707	9.9	
Interaction				
S at same level of M (S X M)	471.8	1415		
M at same or different level of S (M X S)	483.7	1532		

yield (8200 kg ha^{-1}) was recorded under beat available water, which was on par with 2 EC (7704 kg ha^{-1}) and 4 EC (7216 kg ha^{-1}), and significantly superior to 6 EC (5238 kg ha^{-1}). As soil salinity increases, plants expend more energy to maintain osmotic balance and ionic homeostasis, reducing the energy available for reproductive development and kernel filling (Morales-Garcia *et al*., 2009; Lima *et al*., 2020) Divya Sree et al., 2024. Plastic mulch registered significantly highest kernel yield (7552 kg ha^{-1}), followed by straw mulch (7084 kg ha^{-1}) and no mulch recorded significantly the lowest kernel yield (6632 kg ha^{-1}). Absy *et al*. (2020), reported that the use of black plastic mulch stimulated root growth through enhanced soil temperature and moisture conservation, ultimately leading to improved grain yield per plant. The interaction effect was significant with maximum kernel yield (8846 kg ha^{-1}) under best available water with plastic mulch and the minimum yield (4930 kg ha^{-1}) was recorded under 6 EC with without mulch treatment.

Stover yield (kg ha^{-1})

Stover yield followed a similar trend to kernel yield (Table 10). Among salinity treatments, significantly the highest stover yield (9282 kg ha^{-1}) was recorded with best available water, followed by 2 EC (8794 kg ha{ ^{1}) and 4 EC (8289 kg ha^{-1}). While 6 EC recorded significantly the lowest stover yield (6659 kg ha^{-1}). The results were in line with the findings of Heidarpour *et al*. (2009) and Amer (2010). Among mulching treatments, plastic mulch recorded significantly the highest stover yield (8646 kg ha^{-1}) which was on par with straw mulch (8286 kg ha^{-1}), these treatments performed significantly better than no mulch (7836 kg ha^{-1}). Plastic mulch, is more effective in enhancing biomass production and final stover yield, especially in spring-sown maize grown under semi-arid conditions reported by Bu *et al*. (2013). Similar findings was also reported by Liu *et al*. (2014). Interaction was found significant. Significantly the maximum stover yield (9282 kg ha^{-1}) was recorded under best available water with plastic mulch and minimum (7836 kg ha^{-1}) under 6 EC with without mulch treatment was recorded.

CONCLUSION

From the foregoing results and discussion, it is concluded that irrigation with best available water (0.4 dS m^{-1}) significantly enhanced growth and yield attributes, kernel yield, and stover yield of maize under drip irrigation. Irrigation with saline water up to 2 and 4 dS m^{-1} produced comparable results with best available water, whereas a marked reduction in growth and yield was observed at 6 dS m^{-1}. Among the mulching treatments, plastic mulch proved to be the most effective in improving plant growth, yield attributes, kernel yield, and stover yield, followed by straw mulch, while no mulch recorded the lowest values. The combination of best available water with plastic mulch resulted in the highest productivity of maize, indicating that plastic mulching effectively mitigates the adverse effects of saline irrigation and enhances maize performance under saline conditions.

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