International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 11, Issue: 04 "July-August 2025"

EFFECT OF STRAW MULCHING ON MAIZE (*ZEA MAYS* L.) PRODUCTIVITY IN SALT-AFFECTED SOIL IN THE MEKONG RIVER DELTA, VIETNAM

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DOI: https://doi.org/10.51193/IJAER.2025.11420

Received: 28 Jul. 2025 / Revised: 09 Aug. 2025/ Accepted: 11 Aug. 2025 / Published: 13 Aug. 2025

ABSTRACT

Straw mulching has become a common agricultural practice in the Mekong River Delta (MRD) of Vietnam. This study evaluated the effects of straw mulching on soil moisture content, soil electrical conductivity (ECe), maize productivity, and economic benefits in saline soils. The experiment was conducted using a randomized complete block design with four straw mulching rates (0, 3.5, 7.0, and 10.5 t ha^{-1}) and three replicates. The results showed that rice straw mulching significantly improved soil moisture content at 45 days after sowing (DAS) but did not significantly affect soil moisture retention at other crop stages. In addition, soil ECe showed no significant differences among mulch rates of 0, 3.5, 7.0, and 10.5 t ha^{-1} at both the initial and harvest stages in the 2021 and 2022 seasons. However, the application of straw mulching (3.5–10.5 t ha^{-1}) significantly improved plant height, leaf length, leaf width, leaf area, and fresh biomass compared to the no-mulch treatment. Maize yield in the treatments receiving 3.5–10.5 t ha^{-1} of straw mulching was significantly higher than in the treatments without straw mulching in both 2021 and 2022, by 0.58–1.82 t ha^{-1}. Furthermore, straw mulching at rates of 7.0–10.5 t ha^{-1} also significantly increased net benefits by 182–184% in 2021 and 133–147% in 2022 compared with the no-mulch treatment. Based on these findings, the application of straw mulching at rates of 7.0–10.5 t ha^{-1} is recommended for maize cultivation in salt-affected soils in the Vietnamese Mekong Delta.

Keywords: Economic benefit, Maize, Straw mulching, Saline soil

1. INTRODUCTION

Salinity intrusion and freshwater shortages are increasing in the MRD, the largest area agricultural cultivation in Vietnam (Loc et al., 2021; Morton et al., 2023). Salinity and drought stress have directly impacted in the crops cultivation, leading to significant crop productivity reduction (Machado & Serralheiro, 2017; Majeed & Muhammad, 2019; Zörb et al., 2019). Therefore, the selection of suitable crops for rotation in the saline-affected paddy soils during the dry season is regarded as an agricultural strategy, contributing to climate change adaptation and enhancing soil management efficiency.

Maize (*Zea mays* L.) is an upland crop, which is widely cultivated in the MD region, is used for rotating in on the paddy fields (Phuoc et al., 2024; Vi et al., 2017). According to Farooq et al. (2015), maize has moderate tolerance to salinity stress, particularly at the early vegetative stage. Previous studies reported that the application of maize cultivation in the paddy soils is one of the ways for increasing crop productivity, water use efficiency and farmer income (Han et al., 2020; Jat et al., 2019).

Recently, numerous studies have explored strategies to mitigate the impacts of salinity intrusion on soil characteristics, crop yield, and economic efficiency through soil and crop management (Demo & Asefa Bogale, 2024; Dong et al., 2018; Farzi et al., 2017; Memon et al., 2017; Wang et al., 2018; Wang et al., 2025; Zhang et al., 2020). Returning rice straw to the paddy field is recognized as an effective method to improve a range of soil properties and crop productivity (Chen et al., 2014; Han et al., 2020; Jat et al., 2019; Wang et al., 2017). Organic mulching are beneficial in conserving soil moisture by reducing evaporation and promoting seeds germination and root development (Kader et al., 2017). Several studied reported that applying organic mulching resulted in significantly increase plant growth, leaf area index, biomass and crop productivity (Acharyya et al., 2020; Gadelha et al., 2021; Li et al., 2018). In addition, the application of organic mulches is also considered an effective practice for improving soil properties by increasing soil moisture content, soil organic matter, pH, and microbial activity (Acharyya et al., 2020; Kader et al., 2017; Nhien et al., 2025; Song et al., 2025; Teame et al., 2017; Yang et al., 2018; Zhou et al., 2019). Although the effectiveness of organic mulching has been studied worldwide, study conducted in MRD - particularly in the coastal zones frequently affected by salinity intrusion - remains limited. Therefore, the objectives of this study were to evaluate the effects of rice straw mulching on the growth, maize productivity, soil characteristics, and economic profitability on salt-affected paddy soil in the MRD region, Vietnam.

2. MATERIALS AND METHODS

2.1 Experimental site and soil properties

ISSN: 2455-6939

Volume: 11, Issue: 04 "July-August 2025"

The field experiment was conducted in the double rice cropping system in Lieu Tu commune, Tran De district, Soc Trang province (9°28'82.21"N, 106°06'08.9"E), an area affected by salinity intrusion during the dry season. In this site, rice was cultivated in the rainy season, including the Summer–Autumn crop (from June to September) and Winter-Spring (from October to January) seasons. Farmers leave fields fallow due to salinity intrusion in the dry season (from January to June).

At the beginning of experiment, soil was classed as clay loam with the content of sand, silt, and clay are 28.5%, 42.5%, and 29.0%, respectively. Soil bulk density was approximately 1.31 g cm^{-3}, reflecting a moderately compacted soil. The topsoil is slightly acidic (pH = 5.70), and electrical conductivity was 3.36 mS cm^{-1}, indicating that the soil had entered the strongly saline level. Other soil characteristics are shown in Table 1.

Table 1: Soil characteristics in the beginning of experiment

Soil characteristics	Unit	Value
Sand	%	28.5
Silt	%	42.5
Clay	%	29.0
Bulk density	g cm^{-3}	1.31
pH_{H2O} (1:5)		5.70
ECe	mS cm^{-1}	3.36
Cation exchange capacity	cmol kg^{-1}	14.0
Soil organic matter		3.08
Available N	mg kg^{-1}	6.85
Available P	mg kg^{-1}	4.32

2.2 Experimental design and management

The field experiment was arranged in a randomized complete block design with three replicates. Four rice straw mulching rates were 0 (control), 3.5, 7.0, and 10.5 t ha^{-1}. The experiment used Purple Sweet 099 maize variety , which has moderate tolerance to salinity. The straw used as mulching material in this study was collected from rice residues remaining in the harvest in Winter-Spring cropping season at the experimental site.

The fertilizer application formula for maize was as 180N - $70P_2O_5$ - $70K_2O$ (kg ha^{-1}), applied in three split doses at 25 (50N - $20P_2O_5$ - $20K_2O$ kg ha^{-1}), 35 (60N - $20P_2O_5$ - $20K_2O$ kg ha^{-1}), and 45 (70N - $30P_2O_5$ - $30K_2O$ kg ha^{-1}) days after sowing (DAS).

2.3 Sampling and analyses

ISSN: 2455-6939

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Soil samples were collected at the beginning and end of the season, as well as at 15, 30, and 45 DAS in each season. Soil samples were taken from the top layer (0–20 cm) at five points within each experimental plot and mixed to obtain one composite sample. Soil moisture content was determined using the standard oven drying method as described by Rayment and Higginson (1992). Soil salinity was assessed by measuring the EC of a 1:5 ratio (soil : water) and conductivity probe (Rayment & Lyons, 2011) and converting $EC_{1:5}$ to ECe according to Slavich and Petterson (1993).

The growth parameters, including plant height, leaf length, and leaf area were measured by hand using a measuring tape at 50 DAS. Plant height (cm) was measured from the soil surface to the tip of the highest leaf. Leaf length (cm) was measured from the leaf base to the apex on the fully expanded uppermost leaf. Leaf width (cm) was measured at the widest point of the same leaf. Leaf area (cm^2) was calculated using formula:

$$\text{Leaf area } (cm^2) = \text{leaf length (cm)} \times \text{leaf width (cm)} \times 0.75$$

where 0.75 is the correlation factor (Milford et al., 1985).

Dry biomass ($t\ ha^{-1}$) and maize yield ($t\ ha^{-1}$) were determined at the harvest stage.

2.4 Statistical analysis

The effects of straw mulch rates on soil moisture content, ECe, plant growth, grain yield, and economic efficiency were analyzed using Minitab software (ver. 20.0). When significant treatment effects were detected, Tukey's test was performed at a significance level of 5%.

3. RESULTS AND DISCUSSION

3.1 Soil moisture content

The effects of straw mulching on soil moisture content in the growth stages of maize in 2021 and 2022 seasons are shown in Table 2. In general, no significant differences were found among the mulching rate treatments at 15, 30 DAS and harvest stage in both seasons ($p>0.05$). However, the study showed that the application of straw mulch resulted in a significantly affected soil moisture content at 45 DAS in both cropping seasons ($p<0.05$). In 2021, soil moisture content in the treatment applied rice straw mulching at a rate of 10.5 $t\ ha^{-1}$ was significantly higher than the treatments with 0, 3.5, and 7 $t\ ha^{-1}$. Similarly, the application of straw residues at a rate of 7.0 – 10.5 $t\ ha^{-1}$ on the soil surface was significantly increased soil moisture content compared to the treatment applied 0 – 3.5 $t\ ha^{-1}$.

Soil moisture content reflects the soil-water conditions and is closely associated with evapotranspiration processes (Verstraeten et al., 2008). According to Li et al. (2018), mulching organic residues on the soil surface acts as a physical barrier that reduces soil surface temperature and wind exposure, thereby lowering evaporative water loss, especially in tropical and subtropical agroecosystems. In this study, applying rice straw mulching higher 7.0 t ha^{-1} resulted in a significantly increase soil moisture content compared with treatments applied 0–3.5 t ha^{-1}. Similar findings have been reported in previous studies, indicating that mulching enhances soil moisture content during crop growth stages (Chen et al., 2014; Nhien et al., 2025; Yang et al., 2018).

Table 2: Soil moisture content under rice straw mulching rates at different growth stages of maize in 2021 and 2022

Mulching (t ha^{-1})	2021				2022			
	15 DAS	30 DAS	45 DAS	Harvest	15 DAS	30 DAS	45 DAS	Harvest
0	30.6	39.2	24.2^{b}	32.3	29.8	30.6	21.7^{b}	25.6
3.5	32.4	36.8	26.1^{b}	32.7	29.9	30.8	21.6^{b}	30.4
7.0	32.7	36.3	27.6^{b}	33.8	29.9	33.7	27.0^{a}	31.7
10.5	31.4	36.5	31.4^{a}	33.4	29.9	30.8	30.2^{a}	30.2
F-test	ns	ns	**	ns	ns	ns	**	ns

ns: p>0.05; ** p<0.01; In the same column, means followed by the different letters (a, b) are significantly different at 5% by Tukey's test.

3.2 Soil electrical conductivity

Table 3 shows the changes in soil ECe under different rice straw mulching rates at the beginning and end of the 2021 and 2022 cropping seasons. Generally, the results indicated that the application of 0, 3.5, 7.0, and 10.5 t ha^{-1} did not significantly affect soil ECe at two stages (beginning and end of the experiment) in both 2021 and 2022 seasons (p>0.05). In this study, applying rice straw mulch (3.5 – 10.5 t ha^{-1}) tended to reduce soil ECe compared with bare soil in both seasons. Numerous studies have also reported that the application of mulches significantly decreased soil ECe compared to no mulched soil (Chen et al., 2021; Haque et al., 2018; Nhien et al., 2025). This suggests that long-term experiments are necessary to evaluate the potential of mulching applications in mitigating soil salinity in the MRD region.

Table 3: Soil ECe under rice straw mulching rates at the beginning and end of the 2021 and 2022 seasons

Mulching ($t\ ha^{-1}$)	Soil ECe ($mS\ cm^{-1}$)			
	2021		2022	
	Initial	Harvest	Initial	Harvest
0	3.21	6.95	2.55	4.66
3.5	3.22	7.40	2.22	5.24
7.0	3.26	6.98	2.75	3.98
10.5	3.13	6.77	2.38	3.90
F-test	ns	ns	ns	ns

ns: $p>0.05$

3.3 Crops productivity

In general, the growth, biomass, and maize yield in both 2021 and 2022 were significantly influenced by mulch treatments (Table 4). The results showed that bare soil (treatments without mulch control) had the lowest performance in all cases. The application of rice straw mulch at s rates of 7.0–10.5 $t\ ha^{-1}$ resulted in a significantly higher plant height, leaf length, leaf width, leaf area, fresh biomass, and maize yield than the control treatment (no mulch application). In this study, applying 10 $t\ ha^{-1}$ of straw mulch increased by 51.0–72.8% maize yield compared with the no mulched soil treatment. Recent studies found that using mulches can improve maize yield by 15–26% (Dong et al., 2019; Xu et al., 2015), 26.7% (Zhang et al., 2020), 70% (Liu et al., 2015), and 71.8% (Xiukang et al., 2015). These findings strongly demonstrate that rice straw mulching is a supreme agronomic practice for enhancing maize productivity, particularly under conditions of water shortage or salinity intrusion.

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Table 4: The growth and maize yield under rice straw mulching rates in 2021 and 2022 seasons

Year	Mulching ($t\ ha^{-1}$)	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Dry biomass ($t\ ha^{-1}$)	Yield ($t\ ha^{-1}$)
2021	**0**	$86,2^{d}$	$47,2^{c}$	$7,43^{b}$	262^{b}	$2,53^{b}$	2.87^{b}
	3.5	106^{c}	$53,7^{b}$	$7,59^{b}$	306^{b}	$3,11^{b}$	3.58^{b}
	7.0	123^{b}	62.0^{a}	$8,26^{a}$	384^{a}	$3,82^{ab}$	4.43^{a}
	10.5	130^{a}	64.4^{a}	$8,48^{a}$	410^{a}	$5,30^{a}$	4.69^{a}
	F-test	**	**	**	**	**	**
2022	**0**	$78,1^{b}$	$52,6^{b}$	$6,49^{b}$	256^{b}	$3,03^{b}$	$3,45^{c}$
	3.5	$75,3^{b}$	$56,6^{b}$	$6,81^{b}$	289^{b}	$3,66^{b}$	$4,03^{bc}$
	7.0	114^{a}	$73,0^{a}$	$7,55^{a}$	413^{a}	$4,11^{b}$	$4,84^{ab}$
	10.5	113^{a}	$73,9^{a}$	$7,50^{a}$	415^{a}	$5,49^{a}$	$5,21^{a}$
	F-test	**	**	**	**	**	**

ns: $p>0.05$; ** $p<0.01$; In the same column, means followed by the different letters (a, b) are significantly different at 5% by Tukey's test.

3.4 Economic efficiency

Generally, the economic performance indicators of maize cultivation were significantly affected by the straw mulching treatments in both 2021 and 2022 (Table 5). The results showed that applying straw mulch at rates of 7.0–10.5 $t\ ha^{-1}$ resulted in significantly higher cost, total income, profit, and benefit-cost ratio compared to the unmulched and mulched 3.5 $t\ ha^{-1}$ straw mulching treatments ($p>0.05$). There was no significant difference in benefit between the treatment applied 3.5 $t\ ha^{-1}$ straw mulching and unmulched soil treatment (0 $t\ ha^{-1}$). However, benefits in the treatments applied 7.0–10.5 $t\ ha^{-1}$ were significantly higher than those without straw mulching in both 2021 and 2022 seasons by 21.1–21.3 million Vietnamese Dong (VND) and 17.8–19.7 VND, respectively. Straw mulching is a common agricultural practice in the MRD region aimedat improving soil health, nutrients availability, crops productivity and economic benefits (Dinh et al., 2024; Nhien et al., 2025; Thinh et al., 2025). The application of straw residues to soil surface increased the production cost compared with unmulched soil treatment. However, it also enhanced the growth and maize yield (Table 4), therefore leading to higher the total income and profit (Table 5). In this study, applying straw mulching at rates from 7.0 to 10.5 $t\ ha^{-1}$ resulted in a significantly higher profit than the treatment without applied straw mulching in 2021 and 2022 seasons, by 182–184% and 133–147%, respectively.

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Table 5: Economic performance indicators of maize under different rates of straw mulching in 2021 and 2022 seasons

Year	Indicators	Straw mulching treatments 0 ($t\ ha^{-1}$)	3.5 ($t\ ha^{-1}$)	7.0 ($t\ ha^{-1}$)	10.5 ($t\ ha^{-1}$)	F-test
2021	Cost (million VND ha^{-1})	31.9^{d}	35.9^{b}	34.6^{c}	38.3^{a}	**
	Total income (million VND ha^{-1})	43.5^{c}	54.3^{b}	67.2^{a}	71.3^{a}	**
	Profit (million VND ha^{-1})	11.6^{b}	18.4^{b}	32.7^{a}	32.9^{a}	**
	Benefit-cost ratio	1.36^{b}	1.51^{b}	1.94^{a}	1.86^{a}	**
2022	Cost(million VND ha^{-1})	37.8^{d}	42.3^{b}	40.6^{c}	44.1^{a}	**
	Total income (million VND ha^{-1})	51.1^{c}	59.8^{bc}	71.8^{ab}	77.2^{a}	**
	Profit (million VND ha^{-1})	13.4^{b}	18.6^{b}	31.2^{a}	33.1^{a}	**
	Benefit-cost ratio	1.35^{c}	1.45^{bc}	1.77^{a}	1.75^{ab}	**

** $p<0.01$; In the same column, means followed by the different letters (a, b) are significantly different at 5% by Tukey's test.

4. CONCLUSION

This study investigated the influences of straw mulching application on the soil characteristics, crop growth, maize yield, and economic benefits in the saline soils of the MRD. Applying straw mulching at rates of 7.0–10.5 t ha^{-1} significantly enhanced plant growth, maize yield, total income, net benefits, and benefit-cost ratio compared to treatments without mulch. These results highlight the potential of straw mulching as an effective agronomic practice for improving maize production and profitability in salt-affected soils.

CONFLICT OF INTEREST

All authors declare that there are no conflicts of interest regarding the publication of this paper.

ACKNOWLEDGEMENTS

This research was funded by the Australian Centre for International Agricultural Research through project SLAM/2018/144. We would like to thank the Project Management Board for facilitating this work.

ISSN: 2455-6939

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DATA AVAILABILITY

The data presented in this article are available from the corresponding author upon request.

REFERENCES

[1] Acharyya, P., Banerjee, A., Mukherjee, D., Mandal, J., & Sahoo, B. (2020). Impact of different types of organic mulch on growth, yield, soil dynamics and weed infestation in beetroot (Beta vulgaris L. cv. Detroit Dark Red) plots. *Int. J. Curr. Microbiol. App. Sci, 9*(7), 1419-1427.

[2] Chen, L., Zhang, J., Zhao, B., Yan, P., Zhou, G., & Xin, X. (2014). Effects of straw amendment and moisture on microbial communities in Chinese fluvo-aquic soil. *Journal of Soils and Sediments, 14*(11), 1829-1840.

[3] Chen, N., Li, X., Šimůnek, J., Shi, H., Hu, Q., & Zhang, Y. (2021). Evaluating the effects of biodegradable and plastic film mulching on soil temperature in a drip-irrigated field. *Soil and Tillage Research, 213*, 105116.

[4] Demo, A. H., & Asefa Bogale, G. (2024). Enhancing crop yield and conserving soil moisture through mulching practices in dryland agriculture. *Frontiers in Agronomy, 6*, 1361697.

[5] Dinh, V.-P., Tran-Vu, H.-A., Tran, T., Duong, B.-N., Dang-Thi, N.-M., Phan-Van, H.-L., Tran, T.-K., Huynh, V.-H., Nguyen, T.-P.-T., & Nguyen, T. Q. (2024). Improving Soil Quality and Crop Yields Using Enhancing Sustainable Rice Straw Management Through Microbial Enzyme Treatments. *Environmental Health Insights, 18*, 11786302241283001.

[6] Dong, Q., Dang, T., Guo, S., & Hao, M. (2019). Effects of mulching measures on soil moisture and N leaching potential in a spring maize planting system in the southern Loess Plateau. *Agricultural Water Management, 213*, 803-808.

[7] Dong, Q. g., Yang, Y., Yu, K., & Feng, H. (2018). Effects of straw mulching and plastic film mulching on improving soil organic carbon and nitrogen fractions, crop yield and water use efficiency in the Loess Plateau, China. *Agricultural Water Management, 201*, 133-143.

[8] Farooq, M., Hussain, M., Wakeel, A., & Siddique, K. H. (2015). Salt stress in maize: effects, resistance mechanisms, and management. A review. *Agronomy for Sustainable Development, 35*(2), 461-481.

[9] Farzi, R., Gholami, M., Baninasab, B., & Gheysari, M. (2017). Evaluation of different mulch materials for reducing soil surface evaporation in semi-arid region. *Soil Use and Management, 33*(1), 120-128.

[10] Gadelha, B. B., Freire, M. H. d. C., Sousa, H. C., Costa, F. H., Lessa, C. I., & Sousa, G. G. d. (2021). Growth and yield of beet irrigated with saline water in different types of vegetable mulching. *Revista Brasileira de Engenharia Agrícola e Ambiental, 25*(12), 847-852.

[11] Han, Y., Ma, W., Zhou, B., Yang, X., Salah, A., Li, C., Cao, C., Zhan, M., & Zhao, M. (2020). Effects of straw-return method for the maize–rice rotation system on soil properties and crop yields. *Agronomy, 10*(4), 461.

[12] Haque, M. A., Jahiruddin, M., & Clarke, D. (2018). Effect of plastic mulch on crop yield and land degradation in south coastal saline soils of Bangladesh. *International soil and water conservation research, 6*(4), 317-324.

[13] Jat, R., Singh, R. G., Kumar, M., Jat, M. L., Parihar, C. M., Bijarniya, D., Sutaliya, J. M., Jat, M., Parihar, M. D., & Kakraliya, S. (2019). Ten years of conservation agriculture in a rice–maize rotation of Eastern Gangetic Plains of India: Yield trends, water productivity and economic profitability. *Field Crops Research, 232*, 1-10.

[14] Kader, M., Senge, M., Mojid, M., & Ito, K. (2017). Recent advances in mulching materials and methods for modifying soil environment. *Soil and Tillage Research, 168*, 155-166.

[15] Li, S., Li, Y., Lin, H., Feng, H., & Dyck, M. (2018). Effects of different mulching technologies on evapotranspiration and summer maize growth. *Agricultural Water Management, 201*, 309-318.

[16] Liu, X.-E., Li, X. G., Guo, R.-Y., Kuzyakov, Y., & Li, F.-M. (2015). The effect of plastic mulch on the fate of urea-N in rain-fed maize production in a semiarid environment as assessed by 15N-labeling. *European Journal of Agronomy, 70*, 71-77.

[17] Loc, H. H., Van Binh, D., Park, E., Shrestha, S., Dung, T. D., Son, V. H., Truc, N. H. T., Mai, N. P., & Seijger, C. (2021). Intensifying saline water intrusion and drought in the Mekong Delta: From physical evidence to policy outlooks. *Science of the Total Environment, 757*, 143919.

[18] Machado, R. M. A., & Serralheiro, R. P. (2017). Soil salinity: effect on vegetable crop growth. Management practices to prevent and mitigate soil salinization. *Horticulturae, 3*(2), 30.

[19] Majeed, A., & Muhammad, Z. (2019). Salinity: a major agricultural problem—causes, impacts on crop productivity and management strategies. In *Plant abiotic stress tolerance: Agronomic, molecular and biotechnological approaches* (pp. 83-99). Springer.

[20] Memon, M., Zhou, J., Guo, J., Ullah, F., Hassan, M., Ara, S., & Ji, C. (2017). Comprehensive review for the effects of ridge furrow plastic mulching on crop yield and water use efficiency under different crops. *International Agricultural Engineering Journal, 26*(2), 58-67.

[21] Milford, G., Pocock, T., RILEY, J., & Messem, A. (1985). An analysis of leaf growth in sugar beet. III. Leaf expansion in field crops. *Annals of applied biology, 106*(1), 187-203.

[22] Morton, L. W., Nguyen, N. K., & Demyan, M. S. (2023). Salinity and acid sulfate soils of the Vietnam Mekong Delta: Agricultural management and adaptation. *Journal of Soil and Water Conservation, 78*(4), 85A-92A.

[23] Nhien, C. T., Khanh, T. D., Giang, C. D. A., Minh, D. D., & Khoi, C. M. (2025). Effect of straw mulching on soil moisture, salt accumulation, and beetroot growth in saline soil under greenhouse condition. *International Journal of Environmental Sciences, 38*, 1938-1947.

[24] Phuoc, L., Xuan, N., Tanh, N., Suliansyah, I., Arlius, F., Chaniago, I., Kha, N., & Quang, P. (2024). Effects of temperature and CO_2 on growth and yield of corn (*Zea mays L.*) under climate change in An Giang province Vietnam. IOP Conference Series: Earth and Environmental Science,

[25] Rayment, G., & Higginson, F. R. (1992). *Australian laboratory handbook of soil and water chemical methods*.

[26] Rayment, G. E., & Lyons, D. J. (2011). *Soil chemical methods- Australasia*. CSIRO.

[27] Slavich, P., & Petterson, G. (1993). Estimating the electrical conductivity of saturated paste extracts from 1: 5 soil, water suspensions and texture. *Soil Research, 31*(1), 73-81.

[28] Song, Y., Gao, M., & Li, Z. (2025). Impacts of straw return methods on crop yield, soil organic matter, and salinity in saline-alkali land in North China. *Field Crops Research, 322*, 109752.

[29] Teame, G., Tsegay, A., & Abrha, B. (2017). Effect of organic mulching on soil moisture, yield, and yield contributing components of sesame (Sesamum indicum L.). *International journal of agronomy, 2017*(1), 4767509.

[30] Thinh, N. V. D., Thu, H. N. A., Thao, N. V., & Vy, N. T. H. (2025). Rice straw management in Mekong Delta: a case study in Long An Province. In *The Mekong Delta Environmental Research Guidebook* (pp. 283-301). Elsevier.

[31] Verstraeten, W. W., Veroustraete, F., & Feyen, J. (2008). Assessment of evapotranspiration and soil moisture content across different scales of observation. *Sensors, 8*(1), 70-117.

[32] Vi, T. X. T., Le, H. D., Nguyen, V. T. T., Le, V. S., & Chu, H. M. (2017). Expression of the ZmDEF1 gene and Î±-amylase inhibitory activityof recombinant defensin against maize weevils. *Turkish Journal of Biology, 41*(1), 98-104.

[33] Wang, D., Feng, H., Liu, X., Li, Y., Zhou, L., Zhang, A., & Dyck, M. (2018). Effects of gravel mulching on yield and multilevel water use efficiency of wheat-maize cropping system in semi-arid region of Northwest China. *Field Crops Research, 218*, 201-212.

[34] Wang, R., Cao, H., Kang, S., Du, T., Tong, L., Kang, J., Gao, J., & Ding, R. (2025). Agronomic measures improve crop yield and water and nitrogen use efficiency under brackish water irrigation: A global meta-analysis. *Agricultural Systems, 226*, 104304.

[35] Wang, W., Sardans, J., Wang, C., Pan, T., Zeng, C., Lai, D. Y., Bartrons, M., & Peñuelas, J. (2017). Straw application strategy to optimize nutrient release in a southeastern China rice cropland. *Agronomy, 7*(4), 84.

ISSN: 2455-6939

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[36] Xiukang, W., Zhanbin, L., & Yingying, X. (2015). Effects of mulching and nitrogen on soil temperature, water content, nitrate-N content and maize yield in the Loess Plateau of China. *Agricultural Water Management*, *161*, 53-64.

[37] Xu, J., Li, C., Liu, H., Zhou, P., Tao, Z., Wang, P., Meng, Q., & Zhao, M. (2015). The effects of plastic film mulching on maize growth and water use in dry and rainy years in Northeast China. *PloS one*, *10*(5), e0125781.

[38] Yang, Y., Ding, J., Zhang, Y., Wu, J., Zhang, J., Pan, X., Gao, C., Wang, Y., & He, F. (2018). Effects of tillage and mulching measures on soil moisture and temperature, photosynthetic characteristics and yield of winter wheat. *Agricultural Water Management*, *201*, 299-308.

[39] Zhang, P., Wei, T., Han, Q., Ren, X., & Jia, Z. (2020). Effects of different film mulching methods on soil water productivity and maize yield in a semiarid area of China. *Agricultural Water Management*, *241*, 106382.

[40] Zhou, Z., Zeng, X., Chen, K., Li, Z., Guo, S., Shangguan, Y., Yu, H., Tu, S., & Qin, Y. (2019). Long-term straw mulch effects on crop yields and soil organic carbon fractions at different depths under a no-till system on the Chengdu Plain, China. *Journal of Soils and Sediments*, *19*(5), 2143-2152.

[41] Zörb, C., Geilfus, C. M., & Dietz, K. J. (2019). Salinity and crop yield. *Plant biology*, *21*, 31-38.