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Mitigation of Salinity and Drought with Soil Amendments for Sustainable of Rice Production

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ABSTRACT

Compost, biochar and a mixture of compost biochar and soil microbes can reduce impact of drought and salinity stress. 800 and 10000 ppm NaCl (11.2 and 14.0 dSm^{-1}) watering at Inpari 45 agritan and AU 11 Sigupai super green rice, for 3 days at reproductive phase. Irrigated with tab water, until field capacity (aerobic cultured) until harvest. Nutrient uptake, growth and yield of rice were varying. Reduce the salinity level in the reproductive phase from 10000 ppm (14 dSm^{-1}) to 387.22 µS cm^{-1}, while from 8000 ppm (11.2 $dSm^{-1)}$ to 519.22 in the Inpari 42 SGR variety while in the AU 11 Sigupai variety was decreased to (459.89, to 542.33 µS cm^{-1} at S_1, S_2. Biochar reduces soil salinity of S_1 and S_2 to 594.17, 476 µS cm^{-1} by using biochar (A_1) Meanwhile, compost can reduce salinity S_1 and S_2 to 433.50 µS cm^{-1}, to 527.00 µS cm^{-1}. While the mixed amendment (A_3) can reduce the salinity to 441.00 µS cm^{-1}, 392.33 µS cm^{-1} at harvest time. Change on nutrient uptake, chlorophyll content, leave drying score and shoot dry weight of rice. Soil amendments were effective in reducing drought and salinity. There is a close relationship between the parameters studied. Mixed soil amendment (biochar 25 g + compost 25 g + 40 g *mychorizha* + 25 g *tricoderma*) per 10 kg of soil were effective increasing rice yield. The highest yields were found in rice on soil mix amendment (A_3) followed by A_2 and A_1 with the yield potential 4.72, 4,69, 4.19 t ha^{-1}. While the rice at S_2 a yield potential of A_3, A_2, A_1 of 3.2, 2.8 and 2.9 in t ha^{-1} respectively. Other mechanisms need to be investigated that can increase yields and reduce salinity with the three types of organic amendments.

1. INTRODUCTION

Rice is the world's main food crop [1]. more than half of the world's population relies on calorie intake from rice [2]. However, in the last decade, various problems have caused a decrease in the productivity of rice, including salinity stress and drought [3, 4]. Salinity and drought can occur at any time [5]. Salinity is a global barrier to increasing rice production [6, 7]. Drought can exacerbate salinity. Salinity stress can occur in the dry season, at the beginning of rain o irrigation, after drought [8-10]. The salinity that occur depends on cultivation technique and water management [11]. The lack of irrigation water increase in salinity in agricultural lands both low and upland [9]. This needs to be overcome by using environmentally friendly strategies such as using organic matter [12]. Biochar, compost, or a mixture of compost biochar and soil microbes can reduce the level of salinization and improve soil quality. Biochar and compost can be produced by farmers from agricultural waste easily and cheaply. This can help overcome the problem of agricultural waste and at the same time can increase the fertility of agricultural land towards sustainable agriculture. The agricultural sector needs to be continuously improved to ensure sufficient food for the world's increasing population. Various studies have shown that biochar is able to overcome salinity stress through various mechanisms, including high sorption capacity. Biochar can reduce the salinity stress of the rice seedling phase, and can change leaf and mesophyll structure [13]. Biochar can control salinity [14]. Biochar with MgO can increase phosphorus retention and decrease salinity and optimize soil pH [15]. Biochar can desalinate soil [16]. Biochar is able to reduce Na^+ and Cl^- ions which can be replaced with other ions and cations that are beneficial to plants. Compost also has the ability to neutralize Na^+ and Cl^-. Compost has organic acids which are hydroxyl and carbonyl ions. Do chelation of cations that are beneficial for soil fertility and rice plant growth. The use of compost and biochar, reduces salinity, increase the growth of rice plants. Rice straws can reduce salinity in rice seedlings,and reduce soil bulk density and soil pH [17]. Soil amendments are needed to improve saline soils [12]. A mixture of phosphorus gypsum and manure can reduce soil salinity [18]. The use of mycorrhiza can increase the growth of rice plants under environmental stress conditions [19]. Rice plants also have the ability to reduce salinity levels. Rice is able to translocate sodium cations from roots to shoots to reduce sodium levels in the soil. Tolerant rice varieties are able to reduce salt accumulation in leaves [20]. There was a decrease in the number of leaves in rice that experienced salinity stress [1]. Salinity is inversely related to rice yield. The salinity level of

1.6 to 1.7 dSm^{-1} affects rice yields [21]. Salinity can reduce photosynthetic rate, respiration, enzyme systems, and antioxidant activity [22]. Salinity increases ABA, and stomatal closure reduces light harvest and carbon fission [23]. Increased salinity causes acidification failure of apoplast [5]. Salinity can reduce the number of panicles, affecting the ratio of Na and K [24]. Salinity causes osmotic stress, drought stress, and ion toxicity [25]. Salinity has a negative impact on rice productivity [26]. Rice is more sensitive to salinity the reproductive phase than in the grain-filling phase [12]. Rice changes in antioxidants, RWC, and chlorophyll due to salinity stress [3]. Rice is resistant to the salinity of 150 mM NaCl with a yield reduction of 5-20% [27]. Rice plants overcome salinity by increasing homeostasis in cells [5]. Mechanisms of tolerance to salinity depend on the activities of osmoregulatory, Osmoprotectors, antioxidants, hormonal and molecular, ion exchange, and apoplast acidity [22]. Planting rice decreases the salinity [28]. This is a beneficial property of rice plants to produce food even on saline soils. Salinity can occur in various phases of plant growth. Various studies have shown that rice plants are more sensitive to salinity and drought in the reproductive phase than the vegetative phase. Rice plants are more resistant to drought and can even increase the number of tillers in vegetative [29]. Several studies have also shown that rice plants that experience drought stress in the reproductive phase can reduce the number of panicles and grains [24]. Naturally, we cannot determine when salinity will occur, so it is necessary to anticipate it from the beginning, such as in land preparation by providing soil amendments. The soil that will be planted with rice plants by providing soil amendments in the form of compost and biochar as well as a mixture of soil amendments is expected to reduce the level of salinity and increase rice production in conditions of drought and salinity stress [30-33]. Several studies have shown resistance to salinity and drought stress of tolerant variety. The Sigupai variety has a high level of resistance to drought in the germination phase [34]. Inpari 42 agritan green superior rice is a superior variety for irrigated rice but is tolerant to drought and salinity [35].

A strategy is needed to maintain food availability to achieve the SDGs through handling salinity and drought [3, 29, 36, 37]. This is due to the rapidly increased salinity by 1.5 million tha^{-1}, with a total land area affected by the salinity of 331 million hectares in the world [38].

2. MATERIALS AND METHODS

2.1 Place and time

The study was carried out from April to July 2022 in the green house (5°34'00.8"N 95°22'20.3"E), soil microbiology laboratory and food analysis laboratory, Faculty of Agriculture, Syiah Kuala University (USK) Darussalam, Banda Aceh-Indonesia and BPPT Aceh province Lampineung Banda Aceh Indonesia.

2.2 Experimental design

The experimental pots cultured arranged in split plot design 3 × 2 × 2 with 3 replications. the main plot consists of soil amendments application, consisting of A_1 (rice husk biochar 50 g pot^{-1} equal to 10 t ha^{-1}), A_2 (leaves compost 50 g pot^{-1} equal to 10 t ha^{-1}) A_3 soil amendment mixture (25 g pot^{-1} leaves compost + rice husk biochar + 40 g Mycorrhiza + 25 g Trichoderma). Sub-plot consists of varieties: V_1 (Inpari 42 agritan GSR Green Super Rice), V_2 is variety AU 11 Sigupai which are local GSR, Aromatic with total 108 pots cultured (Figure 1).

BLOCK I	BLOCK II	BLOCK III
$A_1V_1S_2$	$A_2V_2S_1$	$A_3V_1S_2$
$A_1V_1S_1$	$A_2V_2S_2$	$A_3V_1S_1$
$A_1V_2S_1$	$A_2V_1S_2$	$A_3V_2S_2$
$A_1V_2S_2$	$A_2V_1S_1$	$A_3V_2S_1$
$A_3V_2S_1$	$A_1V_1S_1$	$A_2V_2S_1$
$A_3V_2S_2$	$A_1V_1S_2$	$A_2V_2S_2$
$A_3V_1S_2$	$A_1V_2S_2$	$A_2V_1S_2$
$A_3V_1S_1$	$A_1V_2S_1$	$A_2V_1S_1$
$A_2V_1S_2$	$A_3V_2S_2$	$A_1V_1S_2$
$A_2V_1S_1$	$A_3V_2S_1$	$A_1V_1S_1$
$A_2V_2S_1$	$A_3V_1S_1$	$A_1V_2S_1$
$A_2V_2S_2$	$A_3V_1S_2$	$A_1V_2S_2$

Figure 1. Pot culture is arranged in a split-split plot. A (Soil amendment), V (varieties), S (Salinity stress)

2.3 Preparation of pot culture

The soil used was Entisol soil from the experimental garden of the Faculty of Agriculture, Syiah Kuala University with characteristics 53.17% sand fraction, 30.54% dust, 16.29% clay, C/N ratio 7.25, C-Organic 0.86%, N Total 0.12%, P Available 18.75 ppm, K^+ Available 19.53 ppm. pH 5.78. The soil was sieved with an 8-mesh sieve. The dried sieved soil was filled with as much as 10 kg into the pot and mixed with soil an amendment of 50 g biochar pot^{-1} (A_1). (A_2) 50 g compost pot^{-1}, 25 g biochar + 25 g compost pot^{-1} + 40 g Mycorrhiza + 25 g *Trichoderma* (A_3). The soil is saturated with water and stirred until it forms a mud structure and then incubated for 2 weeks in a saturated state before applying soil amendment.

2.4 Sowing and planting rice

The rice used was Inpari 42 agritan GSR (Green Super Rice), drought and salinity tolerant, and AU 11 Sigupai GSR local varieties of Aceh, Indonesia. The uniform and healthy seeds were washed 5 times in tap water and then soaked for 2 days. After soaking the germinated rice seeds are sown in nursery trays containing 2 cm thick Entisol soil. Seedlings were transplanted at the age of 12 days after sowing. Rice seedlings aged 12 days after sowing, planted three seedlings pot^{-1}.

2.5 Watering

Irrigation from planting to the end of the vegetative phase soaking 2 cm. After the vegetative phase when entering the reproductive phase, irrigation by giving 8000 ppm NaCl (S_1) and 10,000 ppm (NaCl solution) (S_2) for 3 days. Then irrigation was carried out until field capacity or aerobic until harvesting.

2.6 Drought and salinity stress

NaCl was used as an agent of drought and salinity stress in irrigation water for rice. The salinity stress consists of S_1 (8000 ppm) (11.2 dSm^{-1}) S_2 (10.000 ppm) (14 dSm^{-1}) or NaCl content of 8 and 10 g of NaCl per liter of water or equivalent 11.2, 14 dSm^{-1}, equal to drought stress ψ w =-0.34 and 0.48 MPa. Drought and salinity stress are given by irrigation water at the reproductive phase, with the NaCl solution flooded until 2 cm stagnates for 3 days. After the salinity treatment, the rice plants were irrigated with tap water every afternoon until it reaches field capacity or aerobic condition cultivated.

2.7 Parameters and measurements

Plant height, biomass fresh and dried weight and leaves drying score were measured based on the rice method evaluation [29, 34, 39, 40]. Chlorophyll extraction using acetone 80% for (Arnon method), Described by study [41]. Nutrient absorption using the wet ashing method with extraction using H_2SO_4, and H_2O_2.

2.8 Data analysis

All Data were subjected to Analysis of variance (F test) and Duncan's new multiple range test at p< 5% probability level. The analyses using SPSS Version 26 (SPSS Inc, Chicago, IL, USA).

3. RESULTS AND DISCUSSION

3.1 Interaction between soil amendment and variety

Table 1 shows the change in the EC value at harvest due to the interaction between variety and salinity in the Inpari 42 variety. There was a decrease in the EC value at harvest to 387.22 at 10,000 ppm in treatment (S2), while in the Sigupai variety, the EC value at harvest was 542.33 (μS cm^{-1}) at the same salinity level treatment. This shows differences in the ability of varieties to adapt to salinity stress. Rice can reduce salinity in the soil by transporting salt levels from the soil to the shoot. The ability to transport salt levels for each variety is different [9, 34-37].

This difference causes differences in rice resistance to salinity and drought. Salinity also causes rice plants to experience drought stress, because the increase in osmotic pressure means that water cannot be absorbed by the plants.

Table 1. Interaction between salinity and varieties on soil electrical conductivity (EC) at harvest

Variety	Salinity	EC at Harvest (μS cm^{-1})	CVa (%)	CVb (%)	CVc (%)
V_1	S_1	519.22b	21.39	13.88	15.07
	S_2	387.22°			
V_2	S_1	459.89°			
	S_2	542.33b			

Numbers followed by the same letter, in the same column are not significantly different at significance, P < 0.05 DNMRT Test, A = Soil amendment, V = variety, CV = coefficient of Variant.

Table 2 shows, the increase in N uptake of 15.6% at A1 compared to A2 at the V1 variety, while in the V2 variety. There was an increase of 3.70% in N absorption and there was a 17.8% decrease in P absorption with different soil amendments (A3) compared to A2 at the V1 variety. It is in line with research results by [17, 31-33, 42, 43]. While at the V2 variety, there was a decrease in P uptake of 24.59% in the A3 soil amendment compared to rice plants at A2. it is in line with research results from the study [43].

Absorption of K at A1 was 9.2% lower than at A2. There was a decrease in P uptake by 15.16% compared to A2 in V1. In V2 there was an increase of 5.59% uptake of P at A2 compared to A1. It is in line with research results by studies [13-15, 43]. While in the A3 there was a 15.3% decrease in K uptake. This indicates that the differences in varieties and the soil amendments used caused the difference in nutrient uptake to be related to the properties of soil amendments used [42].

Which are generally based on organic matter. It can increase cations exchange through the hydroxyl and carbonyl group owned by soil amendments from organic matter [12, 17]. In addition, the V1 and V2 varieties have their nutrient uptake mechanism. This is in line with [24, 44].

Table 2. Changes in chlorophyll a, b and total, nutrient uptake of N, P and K in different varieties and soil amendments

Soil Amadement	Variety	Chl a (mg L^{-1})	Chl b (mg L^{-1})	Chl Total (mg L^{-1})	Nutrient Uptake of N (%)	Nutrient Uptake P_2O_5 (%)	Nutrient Uptake K_2O (%)	Shoot Dry Weight
A_1	V_1	5.45°	36.50b	40.72a	2.15c	0.051b	1.63c	83.23b
	V_2	9.16°	43.56d	53.31b	2.43d	0.057c	1.61c	99.85c
A_2	V_1	7.67b	42.85c	48.61b	2.50e	0.052bc	1.78e	79.43ab
	V_2	8.97b	53.30f	62.32b	2.52ef	0.061d	1.69d	85.75bc
A_3	V_1	9.09c	48.24e	57.56b	1.89°	0.046°	1.51b	73.08°
	V_2	5.96d	36.01a	41.50b	2.07b	0.046°	1.43a	71.65°
CVa (%)		11,07	3.14	1.11	0.29	2.47	0.79	5.12
CVb (%)		7.46	3.36	3.53	1.37	1.86	1.09	4.86
CVc (%)		7.57	5.78	4.06	0.59	1.66	0.80	4.99

Numbers followed by the same letter, in the same column are not significantly different at significance, P < 0.05 DNMRT Test, A = Soil amendment, V = variety, Chl = chlorophyll, CV = coefficient of Variant.

Compost has the ability to chelate cations, so K^+ can be released and taken up by rice plants. In addition, compost has a higher CEC. So that the cation exchange in the planting media given compost is higher which causes K uptake increase in both varieties. This is in line with the research results [5, 24, 42, 45, 46].

Soil amendments and varieties cause differences in K uptake in rice plants in line with research by studies [24, 26, 42, 47]. The highest K uptake at the V_1 variety at A_2. The K absorption was higher at A_1 and A_3. Likewise at the V_1 variety

[42]. This shows that soil amendments have an effect on K uptake. The value of K uptake is higher at A_2 compared to A_3 and A1. This is inland with the research result of [3, 12].

Compost has the ability to chelate cations that retain K^+. So that K can be released and taken up by rice plants. So that the cation exchange in the planting media given compost is higher, K uptake increases in both varieties. This is in line with the research results of [7, 28, 42, 48].

There was a decrease in shoot dry weight in different types of soil amendments. in the V_1 variety, shoot dry weight was greater at A1 than at A2 and A_3 Likewise in V2 in line with the research results by studies [14, 15]. This shows that soil amendment (A1) can increase the shoot dry weight more than A2 and A3 at the reproductive phase. This is in line with the results of research results by studies [16, 17, 44].

3.2 Interaction between variety and salinity

Table 3 shows, the interaction between varieties and salinity levels showed that V1, increased salinity and drought caused a decrease in N uptake of 6.2% but P uptake increased 9.61%. While at V2 increased salinity and drought caused an increase in N uptake by 25% as well as the P absorption increased by 27.8% in the V2 variety. It is in line with the research results of the study [42].

While the K absorption in the V_1 variety increased by 4.37% with increasing salinity and drought. While in the V_2 variety, there was an increase in K uptake by 10% with increasing salinity and drought. This is inland with study of [48]. The difference between varieties V_1 and V_2 causes differences in the transport of N, P, and K at different levels of salinity. This is in line with the results of studies [43, 49, 50].

The interaction between soil amendments and salinity levels shows that in the A_1 soil amendment, there was an increase in the chlorophyll a content, and chlorophyll b with increasing salinity but not at the A_2 soil amendment. There was a decrease in chlorophyll b with increasing salinity as well as in A_3. While the chlorophyll total at the A_1 there was an increase with increasing salinity. But at the A_2 and $A_{3,}$ there was a decrease in chlorophyll total content with increasing salinity. This is because the soil amendments A_1 A_2 and A_3 have different properties that cause differences in soil fertility properties that help absorb nutrients which ultimately becomes chlorophyll total and chlorophyll b in rice plants. This is in line with the research results of [12, 24, 37].

There was a decrease in N uptake with increasing salinity levels, but in the V_2 variety there was an increase in N uptake with increasing salinity levels. It is in line with research results by studies [12, 27, 51]. In the phosphorus uptake in the V_1 variety [28, 52]. The decrease in phosphorus uptake with increasing salinity at the V_2 variety. There was an increase in phosphorus uptake with increasing salinity levels from (S1) to (S2), while in K uptake as well in V_1 and V_2 with increasing salinity [12, 15, 43, 52].

V_1 variety increased K nutrient uptake with an increasing in salinity drought stress. Likewise at the V2. This shows that both varieties have a response to increase drought and salinity by increasing K uptake. It is in line with research results by [15, 17]. This is because K^+ plays a role in maintaining cell solution and catalyzing the formation of carbon hydrate.

Its derivatives become compatible compounds to maintain cell homeostasis. Sugar-derived compatible compounds which are carbon hydrates require K^+. Compatible compounds in the form of soluble sugars need to maintain fluid balance in cells. This is in line with the research results [5, 22, 53].

The rate of decrease in shoot dry weight was greater in V_1 with increasing salinity levels. This indicates that there is a mechanism in V_2 that can reduce the shoot dry weight loss under drought and salinity stress. Shoot dry weight is a reflection of carbon accumulation which is an indicator of growth rate. This is in line with research results [1, 21].

3.3 Interaction between soil amendment salinity

Table 4 shows the effect of variety and salinity on N uptake in the A1 variety, an increase in salinity from S1 to S2 caused a decrease in N uptake. While at the V2, an increase in salinity caused an increase in N uptake. Increased N uptake as material for the formation of bioactive components such as proline, glycine betaine as well as anti-oxidant compounds. This is in line with the research results [3, 5, 28, 46]. At A1, decreased shoot dry weight due to increased salinity and drought less than A2 and A3. This indicates that there was a different effect of the three soil amendments on the shoot dry weight. This is in line with the results of the study of [12].

Different types of soil amendments cause different levels of N nutrient uptake. At the A_1 soil amendment, N uptake was higher at S_2 compared to S_1. Likewise, at A_2 and A_3, an increase in salinity causes an increase in nutrient uptake of N. This is because higher salinity causes plants to experience a water deficit which stimulates plants to produce compatible compounds such as proline, and glycine betaine to maintain cell homeostasis. so that cell activities can take place. This is in line with research results [5, 24-26].

Different soil amendments cause different levels of K^+ nutrient uptake at different salinity levels. In planting media with A_1, an increase in salinity causes a decrease in K^+ nutrient uptake, but in A_2 an increase in salinity causes an increase in K^+ uptake, as well as at A_3. The highest nutrient uptake was found in planting media using A_2, followed by $A_1$and A_3. Meanwhile, at S_2, the highest K^+ nutrient uptake was at A_2, followed by A_3 and A_1. This shows that A_2 soil amendment can increase K^+ uptake compared to A_1 and A_3.

V_1 variety increased K^+ nutrient uptake with an increase in salinity drought stress. Likewise with the V_2. This shows that both varieties have a response to increased drought and salinity by increasing K^+ uptake. This is because K^+ plays a role in maintaining cell charge and plays a role in catalyzing the formation of carbon hydrate. its derivatives which can be compatible compounds to maintain cell homeostasis. Sugar-derived as compatible compounds which are carbon hydrates require K^+ part of the pathway to produce compatible compounds in the form of soluble sugars. It needs to maintain osmotic balances in cells. This is in line with research results [7, 48, 54].

Differences in nutrient uptake in A_1, A_2, and A_3 with increasing salinity and drought stress showed an increase in nutrient uptake with increased salinity in the three types of soil amendments used in planting media. Whereas in P absorption was a decreased at A_1 with increasing drought and salinity. but at A_2 and A_3 there was an increase in P uptake with increasing drought and salinity. As well as K^+ uptake in A_1, there was a decrease with increasing drought and salinity.

While at A_2 and A_3 increased K^+ uptake with increasing salinity and drought. This indicates that salinity and drought stress have different effects on rice plants. This difference indicates that soil amendments play a role in increasing nutrient uptake. This becomes an opportunity to increase nutrient availability in conditions of salinity and drought. Salinity and drought stress there were obstacles to water absorption. The difference in nutrient uptake in the three soil amendments is very different, related to the character of the soil amendments. This is in line with the results of research [13, 15].

Table 3. Changes in chlorophyll a, N, P and K nutrient uptake and rice leaf drying scores at different levels of salinity and varieties

Variety	Salinity	Chl a (mg L^{-1})	N total (%)	P_2O_5 (%)	K_2O (%)	Leaf Drying Scores	Shoot Dry Weight
V_1	S_1	71.22c	2.25c	0.052b	1.60b	1.29ab	92.41c
	S_2	143.29d	2.11b	0.047a	1.67d	1.38ab	64.76°
V_2	S_1	29.91a	2.00a	0.048ab	1.50a	1.28a	95.93c
	S_2	52.85b	2.67d	0.061c	1.65c	1.47b	75.57b
CVa (%)		11.07	0.29	2.47	0.79	2.46	5.12
CVb (%)		7.46	1.37	1.86	1.09	3.02	4.86
CVc (%)		7.57	0.59	1.66	0.80	5.08	4.99

Numbers followed by the same letter, in the same column are not significantly different at significance, $P < 0.05$ DNMRT Test, A = Soil amendment, V = variety, Chl = chlorophyll, CV = Coefficient of Variant, S= Salinity.

Table 4. Changes in chlorophyll b levels, total, N, P, and K uptake in rice leaves at different levels of soil amendment salinity

Soil Amadement	Salinity	Chl b (mg L^{-1})	Total Chl (mg L^{-1})	Nutrient Uptake of N Total (%)	Nutrient Uptake of P_2O_5 (%)	Nutrient Uptake of K_2O (%)	Shoot Dry Weight
A_1	S_1	38.27b	45.40b	2.17b	0.057c	1.63b	96.79d
	S_2	41.79b	48.63c	2.41d	0.051b	1.61b	86.29c
A_2	S_1	49.77d	58.02f	2.46d	0.052bc	1.72c	99.42d
	S_2	46.39b	52.90d	2.56e	0.061d	1.75c	65.77b
A_3	S_1	48.23c	56.37e	1.76°	0.041°	1.30°	86.30cd
	S_2	36.02a	42.69a	2.20c	0.051b	1.63b	58.43a
CVa (%)		3.14	1.11	0.29	2.47	0.79	5.12
CVb (%)		3.36	3.53	1.37	1.86	1.09	4.86
CVc (%)		5.78	4.06	0.59	1.66	0.80	4.99

Numbers followed by the same letter, in the same column are not significantly different at significance, $P < 0.05$ DNMRT Test, A = Soil amendment, V = variety, Chl = chlorophyll, CV = Coefficient of Variant, S = Salinity.

3.4 Interaction soil amendment, variety, and salinity

Table 5 shows the changes in the levels of chlorophyll a, b, total, and nutrient uptake of N, P, and K in rice leaves at different varieties, levels of salinity, and soil amendment.

Table 5. Interaction between salinity and soil amendments on grain per hill

Salinity	A_1	A_2	A_3	CVa	CVb	CVc
	g hil $^{-1}$	g hil $^{-1}$	g hil $^{-1}$	(%)	(%)	(%)
S_1	20,95c	23,45d	23,60d	6,12	5,55	4,61
S_1	14,60ab	14,58°	16,20b			

Numbers followed by the same letter, in the same column are not significantly different at significance $P < 0.05$ DNMRT Test, A = Soil amendment, V = variety, Chl = chlorophyll, CV = Coefficient of Variant, S = Salinity.

There was a change in nutrient uptake of N with the addition of A_1, A_2, and A_3 in different varieties. The use of A_1 increased N uptake. The use of A_1 caused higher N uptake in V_2 but was not significantly different from V_1. Similarly, the use of A_2 while at V_2 was higher than V_1 was also at A_3. When compared to the levels of N uptake, V_1 with different soil amendments, the use of A_2 led to an increase in nutrient uptake of N at V_1. Likewise, in V_2, there was an increase in nutrient uptake of N at A_2 which was higher than at A_1.

In the V_1 variety, the decreased in shoot dry weight with increasing salinity was lower in A_1 than in A_2 and A_3. While at V_2 the shoot dry weight lower loss rate with increasing salinity. However, the decrease was higher in V_1 at A_1 and A_3 and different things happened in V_2. In A_1 the shoot dry weight of the V_2 variety was not significantly different with increasing salinity from S_1 to S_2. This indicates the existence of a mechanism in V_2 in overcoming drought and salinity stress. This is in line with research result of studies [11, 13, 28, 50].

The highest N nutrient uptake was found at A_3 with V_2 and S_2. While the lowest was at A_3 with V_2 at S_1. This shows that in the same soil amendment and the same variety of salinity levels, V_2 rice plants increased N. nutrient uptake, at A_2. The highest nutrient uptake was found in the V_1 at S_2 which was higher than S_1. This shows that the salinity level and the soil amendments caused the V_2 to increase N uptake. While the A_1 soil amendment at V_2 with A_2, when increase in salinity caused a decrease in N uptake although not significantly different. Meanwhile, V_2, at A_2, an increase in salinity caused an increased in nutrient uptake. This shows the better characteristics of V_2 in response to salinity and drought stress. Increasing N uptake as materials for synthesizing compatible compounds in order to maintain homeostasis and cell activity. This is in accordance with research [20-22]. Showed that different varieties had different responses to increased salinity and drought. Soil with different soil amendments to their growing media. In the A_2, the highest N nutrient uptake was at S_2 which was higher and significantly different from K^+ nutrient uptake at S_1. This shows that the V_1 increases K^+ nutrient uptake with increasing salinity. This shows that salinity and drought stress induce the production of soluble sugars which causes an increase in K^+ uptake to synthesize soluble sugars, and bioactive components, reduce transpiration, and maintain a balance in the solution in the cell to maintain cell activity. This is in line with research results [15, 21, 48]. In A_2, the highest level of nutrient uptake was found in the V_1 with S_2. This indicates that the V_2 variety increased K^+ nutrient uptake when drought and salinity increased. This increase in nutrient K^+ is needed to synthesize compatible compounds in order to avoid cell damage. This is in line with the results of researches [24, 44, 46]. Whereas at the V_1, the highest K^+ nutrient uptake was found in A_2 with S_2 which was higher than the K^+ nutrient uptake of the V_2 at A_3 at S_1. This indicates that salinity stress causes an increase in K nutrient uptake, both in the V_2 and V_1 varieties, which are positive controls for salinity and drought resistance. This is in line with the results of study [19].

V_1 planted at A_1 increased salinity and drought caused a decrease in chlorophyll content, but an increase in chlorophyll b and chlorophyll total. Decreased uptake of N and P. While the uptake of K increased at V_1 at A_1. While at V_2 with A_1 increased in salinity and drought, caused a decreased in chlorophyll a and chl b but an increase in total chlorophyll content. While nutrient uptake increased N uptake as well as P and K at A_1. V_1 which was planted with soil amendment A_2, there was a decrease in chl a with increasing salinity and drought as well as chl b and chl total. But at V_1 there was an increase in N and K uptake with increasing salinity and drought. but a decrease in P uptake in V_1 at A_2. While in the V_2 at A2, an increase in salinity caused a decrease in chl a. but an increase in chl b and chl total. Increasing salinity, P decreased as well as K nutrient at V_2 with increasing salinity and drought. The rice grown on A_1, A_2, and A_3 at V_1 increased salinity and drought caused a decrease in chlorophyll a, b and total as well as absorption of P and K. But at V_2 with A_3 an increased in chlorophyll a content. While chlorophyll b and total there were a decrease as well as nutrient uptake, N, P. But there was an increase in the uptake of K with increasing salinity. A_3 (mix soil amendment) have soil microbes inoculated, influenced nutrient uptake. Also due to the ability of K as an element that has a valence of 1 which is easier to enter into plant tissues. The position of Na as an element which also has a valence of 1. At V_2 but not by the V_1. This is a distinct advantage of the V_2 variety which is able to increase K uptake under drought stress and salinity conditions at A_3.

3.5 Pearson correlation among parameter

Correlation between parameters chl a, b, total, nutrient uptake N, P, and K, plant height aged 7, 8, 9 WAP, and leaves drying score due to interactions between soil amendments, varieties with different drought salinity levels. A = Soil amendment, V = variety, Chl = chlorophyll, CV = coefficient of Variant, PH= Plant Height, WAP = Week After Planting, LDS = Leaf Drying Score, SDW = Shoot Dry Weight. Chl a was closely related to chl b (r=0.68) and also related to chl total (r=0.75) with chl b (r=0.98). The absorption of phosphorus (r=0.70) also correlated with potassium nutrient uptake (r=0.78) phosphorus nutrient uptake is closely related to nutrient uptake of potassium (r=0.70) N nitrogen (r=0,78). Plant height at 7 WAP closely related to plant height at 8 WAP, is closely related to plant height at 9 WAP, and closely related to leaf drying scores, r=0,91 (r=0.76) (r=0.75) respectively. Plant height at 8 WAP was closely related to plant height at 9 WAP (r=0.89) and was closely related to leaf drying score (r=0.66). Plant height at 9 weeks was closely related to leaves drying score (r=0.65). Pearson's correlation shows that the application of soil amendments on salinity stress by floading on two rice varieties can improve plant and soil health as seen from the relationship between chlorophyll content, nutrient absorption and soil EC values at harvest.

There is an interaction between soil amendments and salinity to EC A_1 soil that can reduce salinity from 11.2 dSm^{-1} to 5.94.17 $\mu S\ cm^{-1}$, from 14 dSm^{-1} to 476.00 $\mu S\ cm^{-1}$. While A_2 can reduce the salinity from 11.2 dSm^{-1} to 433.50 $\mu S\ cm^{-1}$, from 14 dSm^{-1} to 27.00 $\mu S\ cm^{-1}$. A_3 can reduce the salinity of 11.2 dSm^{-1} to 441.00 $\mu S\ cm^{-1}$. From 14.00 dSm^{-1} to 39.2.33 $\mu S\ cm^{-1}$. The one that reduced the level of salinity the most was A_3, which was a mixture of 25 g of compost + 25 g of biochar + 40 g of mycorrhizae + 20 g of trichoderma pot^{-1}. This is due to the addition of amendments mixed with microorganisms, besides being able to improve soil colloid, it can also reduce soil salinity because mycorrhiza and trichoderma also produce fatty acids which can neutralize salinity and increase nutrient solubility. This organic amendment has the potential to be used for sustainable farming systems to increase soil fertility and crop productivity.

Table 5 reflects the effect of salinity and soil amendments on rice yield. The highest yields were found in rice that received soil amendment treatment A_3 followed by A_2 and A_1 in the salinity treatment S_1 with the potential yield, 20,95, 23,45, 23,60 g $hill^{-1}$ or 4.72, 4,69, 4.19 t ha^{-1} (after multiply 200.000 population ha^{-1}), while rice that gets stress of 10000 ppm (S_2) in the productive phase has a potential yield of A_3 A_2 A_1 of (14,60, 14,58, 16,20 g $hill^{-1}$) or 3.2. 2.8 and 2.9 in t ha^{-1}, respectively (of each after multiplying by 200 thousand hills per hectare). A_3 is potentially to be used for decreasing the impact of salinity in the reproductive phase of rice.

4. CONCLUSIONS

Biochar, compost, and mixed soil amendments can mitigate the effects of drought and salinity stress. Rice plants that experienced drought stress and salinity in the reproductive phase caused changes in the levels of chl a b and total as well as nutrient uptake. Soil amendments were also effective in increasing nutrient uptake of N, P, and K under conditions of drought and salinity stress. There was a close relationship between the parameters studied. A_3 Mixed soil amendments potentially reduce the impact of salinity on rice, The soil amendment is important to increase food production and reduce the impact of climate change on agriculture. Further research is needed for the amendment of the mixture in flooded conditions. Which usually happens after a heavy rain. This is important to see whether mycorrhiza and trichoderma are able to survive in flooded conditions after experiencing drought.

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