

Research article

Effectiveness of OP-EFBs and Rice Straw Compost to Improve the Growth and Yield of New Maize Hybrids in Coastal Land

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Abstract

Amelioration is a technique used to increase the suitability of coastal land for plant growth. Among various ameliorants, compost is widely used because of its ability to improve the physical, chemical, and biological properties of the soil. An experiment arranged in a split plot design with three replications was implemented to evaluate the effect of compost amelioration on the growth and yield of several maize hybrids cultivated in coastal land. The main plot was the compost treatments including a control, rice straw compost at 15, or 30 tons/ha, and oil palm empty fruit bunches (OP-EFBs) compost at 15 tons/ha, or 30 tons/ha. The subplot was hybrid genotypes consisting of CT19, CT29, CT34, CT35, CT48, BIS18. The results indicated that both rice straw compost and OP-EFBs compost at 15 tons/ha were sufficient to ameliorate the coastal land, which significantly enhanced plant growth and the number of grains per ear, although they did not increase the yield. The OP-EFBs compost improved maize vegetative growth better than the rice straw compost did. The maize hybrids exhibited varied responses to increasing compost rates. Specifically, hybrids CT19, CT34, and BIS18 demonstrated greater responsiveness to rice straw compost, while CT48 responded more favorably to OP-EFB compost. Hybrids CT34 and CT35 were potential for coastal area but still need improvement to increase yields. Further optimization of compost types and rates is necessary to maximize the potential of these new maize hybrids for coastal land cultivation.

Keywords: corn; empty palm oil bunch; hybrid; organic fertilizer; rice straw; sandy soil

1. Introduction

Coastal land is abundant in archipelagic countries like Indonesia. Coastal areas directly bordering the sea are largely affected by salinity (Yu et al., 2014) and less fertile due to low nutrient content (Edman et al., 2018). The primary challenges for plant cultivation in coastal areas include low levels of essential nutrients such as phosphorus (P), nitrogen (N), and potassium (K) (Naher et al., 2011) and limited water-holding capacity, which significantly impacts crop yields (Carpenter & Bennett, 2011). Environmental engineering specifically designed to utilize coastal land for agriculture is crucial (Rustikawati et al.,

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2022). This environmental engineering aims to improve the biological, chemical, and physical properties of the soil favorable to plant growth. Among various strategies to enhance soil fertility, amelioration with organic matter is the most effective.

Organic matter is known to improve soil fertility. Compost, the product of decomposed organic matter, contains carbon and nitrogen-rich components that stimulate microbial activity and nutrient cycling (Clarholm et al., 2015). Compost also enhances soil structure (Shepherd et al., 2002) and water retention (Lal, 2020), which are critical for plant growth in sandy soils (Rajkovich et al., 2012; Obia et al., 2016). Additionally, compost releases nutrients slowly, providing a sustainable supply of essential elements for plants and promoting their growth and development.

Agricultural by-products are abundantly available. Rice straw and oil palm empty fruit bunches (OP-EFBs) are available year-round and have the potential to be effective soil ameliorants. Among the various types of solid waste generated by the oil palm industry, empty fruit bunches constitute the largest proportion (Windiastruti et al., 2022). Rice straw compost increases soil pH, and the contents of N, P_2O_5 , K_2O , SOC, and CEC. The K_2O content in soil increases more than sevenfold after rice straw compost treatment (Chivenge et al., 2020). Huang et al. (2023) reported that rice straw compost could replace 10% of the recommended synthetic fertilizer for rice cultivation. Applying rice straw compost at a dose of 4 tons/ha enhanced rice growth and yield (Danapriatna et al., 2023), while a dose of 10 tons/ha did not improve maize yield (Setiawati et al., 2022).

Palm oil waste presents a unique challenge due to its increasing volume alongside rising palm oil production. This challenge can be transformed into an opportunity by utilizing it as a resource for ameliorating marginal land (Windiastruti et al., 2022). OP-EFBs, a by-product of palm oil processing, constitute about 30.9% of fresh fruit bunches (Dolah et al., 2021). The structural components of OP-EFBs include carbohydrates such as glucan, xylan, and arabinan, and lignin, accounting for 31.2%, 18.7%, 2.7%, and 27.7% respectively, with non-structural components mainly comprising ash and extractives at 0.10% and 11.87% (Rosli et al., 2017). The decomposition OP-EFBs through composting produces OP-EFBs compost, which is rich in macro- and micronutrients, including C (42.8%), N (0.8%), P_2O_5 (0.22%), K_2O (2.9%), MgO (0.30%), Cu (23 ppm), and Zn (51 ppm) (Zahrim et al., 2015). OP-EFBs compost increased soil K content to 6.7% after 8 weeks, compared to 5.8% in the control (soil without compost). OP-EFBs compost enhanced the growth and performance of various crops, including oil palm, cocoa, bananas cassava, sweet corn, sweet potatoes, cauliflower, maize, eggplants, and peppers (Anyaocha et al., 2018). Applying 20 tons/ha of OP-EFBs compost significantly improved maize yield (Fahrussyah et al., 2019).

In addition to environmental engineering, plant breeding for the development of coastal-adaptive cultivars represents a complementary and strategic approach. Maize hybrids were developed from crossbreeding between gamma-ray irradiation mutants (Rustikawati et al., 2012) and local lines specific to the Bengkulu Province, Indonesia. Evaluating their adaptability on coastal land is essential to determine high-yielding varieties compared to commercially available ones. While rice straw and OP-EFBs compost have potential benefits, their effectiveness in enhancing maize yield on coastal land remains underexplored. Therefore, studying the specific impacts of these organic materials on maize growth and yield in coastal areas is crucial for developing sustainable and efficient agricultural practices. Moreover, the information on the newly developed hybrids tested will serve as a foundation for breeding programs aimed at developing new coastal-adaptive varieties.

The objective of this study was to evaluate the effect of compost amelioration on the growth and yield of several maize hybrids grown in coastal land. The findings of this

study offer important insights into the viability of compost as a sustainable means of enhancing maize productivity on coastal land, supporting the advancement of eco-friendly and site-specific agricultural practices. The study of ameliorating sandy coastal lands using compost derived from organic materials with varying decomposition rates remains limited. Furthermore, the adaptability of newly developed hybrid maize has not yet been evaluated in these coastal sandy soils. The novelty of this research lies in providing information on the types of compost and newly developed hybrid maize that have the potential to enhance maize production in sandy coastal areas.

2. Materials and Methods

The research was conducted on the coastal land of Bengkulu City, Indonesia, at an elevation of 1 m above sea level. Prior to the study, the site was overgrown with *Imperata cylindrica* weeds. Soil samples were collected from five zigzag points across the experimental field for chemical and sand content analysis before compost application. The levels of nitrogen (N), phosphorus (P), potassium (K), and organic carbon (C) were evaluated.

The experiment was arranged in a factorial split plot design with three replications. The main plot was the compost treatments including a control (without compost), rice straw compost at 15, or 30 tons/ha, and oil palm empty fruit bunches (OP-EBs) compost at 15 tons/ha, or 30 tons/ha. The subplot was hybrid genotypes consisting of CT19, CT29, CT34, CT35, CT48, and BISI 18, respectively. The combination of these factors resulted in 30 treatments, each of which were replicated three times, totaling 90 experimental units. Each main plot measured 4.5 m x 3 m. The hybrid genotypes were planted in rows (one row per genotype) with a planting distance of 25 cm within subplots. Each genotype was represented by 12 plants. The distance between subplots was 75 cm, between main plots 1 m, and between replications 1.5 m.

Hybrid maize seeds were sown in planting holes previously treated with Furadan 3G insecticide to prevent insect infestations. At planting, half the recommended doses of urea, triple super phosphate (TSP), and KCl fertilizers were applied at 150 kg/ha, 100 kg/ha, and 50 kg/ha, respectively, following the method of previous research (Rustikawati et al., 2021). Plant maintenance, including irrigation, weed control, and pest and disease management, was carried out as needed. Harvesting was done at full maturity, which was indicated by the yellowing of the corn husks on more than 75% of the plant population.

Observations were made on all variables using five sample plants selected through simple random sampling. The observed variables included plant height, number of leaves, shoot fresh weight, root fresh weight, ear length, ear diameter, ear weight, number of grain rows, number of grains per plant, and yield per plant. Soil analysis was performed for total N content, available P, exchangeable K, and organic C for each treatment. Soil samples were collected from three replications 14 weeks after compost application. Data were analyzed by the F-test at a 5% significance level. Mean comparison was performed using the least significant difference (LSD) test at $\alpha=5\%$ significance level if significant treatment effects were detected.

3. Results and Discussion

This research builds on previous studies that explored the use of manure for coastal land amelioration (Rustikawati et al., 2021). The findings of this study provide valuable insights

into the impact of different compost types and dosages on the physical and chemical properties of soil, as well as on the growth and yield of hybrid maize.

According to the Meteorological, Climatological, and Geophysical Agency, the average temperature during the study ranged from 27.3°C to 27.6°C, which is suitable for the growth and yield of maize (Ali et al., 2020). The average monthly rainfall varied from 182 mm to 497 mm. The temperature required for maize growth is 15°C-32°C. The humidity during the study ranged from 83% to 87%. These weather conditions were generally favorable for maize growth, except for the very low rainfall at the end of the study, which actually supported the drying process of the maize.

The vegetation on the research site was dominated by *Imperata cylindrica*. Weed control was performed manually using hoes to remove the rhizomes of *Imperata cylindrica*. The land was cleared twice to ensure it was free of these weeds. The characteristics of the research land were evaluated to determine the initial nutrient content essential for plant growth. Soil samples were collected from the field and analyzed for their chemical and physical properties at the Soil Science Laboratory, Faculty of Agriculture, University of Bengkulu. The soil analysis revealed that the experimental site had a sandy loam texture with 80% sand content, and the initial nutrient levels were very low to low (Table 1). This is consistent with previous findings that coastal soils often exhibit poor fertility due to high sand content and low organic matter (Sarkar et al., 2019).

Compost amelioration was applied one week before seeding. The nutrient content of organic carbon (C), nitrogen (N), phosphorus (P), and potassium (K) in the two types of compost was analyzed at the Soil, Plant, Fertilizer, and Water Laboratory of the Agricultural Technology Assessment Center (ATAC) in Bengkulu. The initial analysis of the nutrient content of OP-EFBs compost and rice straw compost revealed notable differences. The nitrogen (N) content in OP-EFBs compost was higher than that in rice straw compost, while the contents of organic carbon (C), potassium (K), and phosphorus (P) were lower in OP-EFBs compost compared to that in rice straw compost (Table 1). This disparity in nutrient content is crucial as it influences the efficacy of these composts in improving soil fertility and supporting plant growth (Manirakiza & Şeker, 2020).

The composts applied in this study had reached a well-matured state, as indicated by the C/N ratios of 13.6 for rice straw compost and 9.71 for OP-EFBs compost (Table 1). Compost with a low to moderate C/N ratio (10-20) is generally considered to undergo balanced decomposition. Under such conditions, sufficient nitrogen is available to support microbial activity, and any excess nitrogen is mineralized and subsequently released into the soil, making it available for plant uptake.

At 14 weeks after planting, soil samples were taken to evaluate the impact of compost application on soil nutrient composition. The application of 30 tons/ha of rice straw compost led to a 0.06% increase in total nitrogen, equivalent to 18 kg N/ha or 39.13 kg urea per hectare. This result was in harmony with previous studies demonstrating the positive effects of organic amendments on soil nitrogen levels (Aytenew & Bore, 2020).

Furthermore, the increase in exchangeable potassium by 88% and organic carbon by 260% highlights the effectiveness of rice straw compost in enhancing soil fertility. Increased organic carbon content contributes to better soil structure, increases water-holding capacity, and promotes microbial activity, all of which are essential for supporting plant growth (Mangalassery et al., 2015). This suggests that compost derived from rice straw is especially effective in enhancing soil quality and agricultural productivity.

In contrast, OP-EFBs compost was less effective than rice straw compost in increasing soil nutrient status. Increasing the rate of OP-EFBs compost from 15 tons/ha

to 30 tons/ha did not significantly increase total N and exchangeable K levels (Table 2). The nitrogen content in OP-EFBs compost was higher than that in rice straw compost.

Table 1. Compost chemical characteristic of rice straw and OP-EFBs

Nutrient Analysis	Nutrient Content	
	Rice Straw	OP-EFBs
N (Kjeldahl) (%)	1.12	1.40
P (Bray) (ppm)	0.88	0.82
K (AAS) (mol ⁽⁺⁾ /kg)	0.65	0.60
C-organic (%)	15.07	13.6
C/N ratio	13,46	9,71

Table 2. Soil characteristics before and after compost application

Nutrient and Sand Content	Analysis Method	Before Compost Application*	14 Weeks after Compost Application			
			Rice Straw 15 ton/ha	Rice Straw 30 ton/ha	OP-EFBs 15 ton/ha	OP-EFBs 30 ton/ha
N-total (%)	Kjeldahl	0.24 (M)	0.28	0.30	0.27	0.28
P (ppm)	Bray	1.36 (VL)	1.16	1.17	1.00	2.12
K _{dd} (mol ⁽⁺⁾ /kg)	AAS	0.24 (L)	0.34	0.45	0.22	0.28
C organic (%)	Kurmish	1.32 (L)	3.33	3.43	3.08	3,88
CEC (me/100g)	Kjeldahl	14,28 (L)				
pH H ₂ O		6.8 (N)				
Sand (%)		80 (SL)				

* Classification according to Pusat Penelitian Tanah (1995) and Mechram et al. (2021) M=medium, VL=very low, L=low, N=neutral, SL=sandy loam texture.

Conversely, the contents of phosphorus, potassium, and organic carbon were lower. Although the nitrogen (N) content in OP-EFBs compost was higher than in rice straw compost, twelve weeks after compost application, the total soil nitrogen content in the rice straw treatment was higher compared to the OP-EFBs treatment. This indicates that nutrient release from OP-EFBs compost is slower than from rice straw compost. The lesser impact of OP-EFBs compost could be attributed to its slower decomposition rate and lower nutrient release (Zahrim et al., 2015).

The potassium (K) and organic carbon (C) content in the composts enhanced soil organic C, and K levels. Increasing compost application rates led to more substantial improvements in soil potassium and organic carbon levels. Rice straw compost provided more K and organic C nutrients compared to OP-EFBs. Additionally, increasing the dose of OP-EFBs compost from 15 tons/ha to 30 tons/ha did not significantly enhance total nitrogen and exchangeable potassium levels. This suggests that higher application rates

of OP-EFBs compost may not necessarily translate to better nutrient availability for plants, likely due to its slower decomposition and nutrient release rates. An increased compost application rate tends to raise the C/N ratio. At high C/N ratios, microbes utilize available nitrogen to break down the excess carbon, leading to nitrogen immobilization. Consequently, the amount of nitrogen available for plant uptake is reduced (Macias-Corral et al., 2019).

Phosphorus levels generally did not increase with compost addition compared to pre-treatment levels, except with the addition of OP-EFBs at 30 tons/ha (Table 2). This may be due to the utilization of released phosphorus to meet the plants' phosphorus requirements, given the very low soil phosphorus availability and suboptimal addition of phosphorus from inorganic fertilizers (Ahmad et al., 2022).

The findings of this study have important implications for agricultural practices, particularly in choosing and applying appropriate compost types. Rice straw compost, characterized by higher phosphorus, potassium, and organic carbon content, demonstrated to be more effective in upgrading soil fertility compared to OP-EFBs compost. Its capacity to enhance soil structure, water-holding capacity, and microbial activity makes it a valuable amendment for sustainable agriculture.

The application of compost as an ameliorant for coastal land significantly affected the growth and yield of maize hybrids. The interaction between compost and genotype was evident in the variables of ear length and ear weight. Other variables did not show a significant interaction, including the yield, which was influenced by ear weight. Compost had a notable effect on all growth and yield component variables, except ear diameter and grain weight per plant. In contrast, the hybrid genotypes showed significant effects on all measured variables (Table 3).

The interaction between compost type and hybrid genotype was significant for ear length and ear weight. The application of rice straw compost increased ear length in hybrids CT19, CT34, and BISI 18; however, higher compost rates did not result in further enhancement of ear length. This indicates a genotype-specific response to compost application, which is crucial for optimizing fertilizer management practices for different maize hybrids (Mwafurirwa et al., 2021). Interestingly, OP-EFBs compost was more effective in enhancing the growth of hybrid CT48, suggesting that different hybrids may respond differently to various types of organic amendments (Table 4).

Table 3. F-values from the analysis of variance (ANOVA) on growth and yield variables

Variables	F-value			CV (%)
	Compost	Genotype	Interaction	
Plant height	14.74 **	5.99 **	1.57 ns	8.67
Number of leaves	4.94 **	19.69 **	1.33 ns	6.81
Shoot fresh weight	6.97 **	2.59 *	1.66 ns	28.35
Root fresh weight	6.82 **	2.86 *	1.45 ns	26.49
Ear length	4.90 **	13.44 **	2.40 **	8.27
Ear diameter	1.77 ns	4.39 **	1.43 ns	9.34
Ear weight	4.18 **	19.70 **	2.45 **	16.36
Number of grain row	5.11 **	23.23 **	1.54 ns	6.33
Number of grains per plant	2.69 *	14.17 **	1.58 ns	15.74
Yield per plant	2.05 ns	11.20 **	1.36 ns	17.03

Note: ns, *, and **are not significantly different at $\alpha=5\%$, significantly different at $\alpha=5\%$, and 1%, respectively

Table 4. The interaction effect between compost application and maize hybrid on ear length

Compost Treatments	Ear Length (cm)											
	CT19		CT29		CT34		CT35		CT48		BISI 18	
Control	18.39	b	16.13	a	21.00	ab	19.23	a	14.89	c	19.87	b
	AB		B		A		A		B		A	
Rice straw 15 ton/ha	21.28	a	17.03	a	21.33	ab	19.10	a	15.50	bc	20.20	ab
	A		BC		A		AB		C		A	
Rice straw 30 ton/ha	19.11	ab	18.63	a	22.06	a	19.90	a	16.66	bc	22.47	a
	CD		CD		AB		BC		D		A	
OP-EFBs 15 ton/ha	17.12	b	16.33	a	18.33	c	19.65	a	17.75	ab	17.14	c
	AB		B		AB		A		AB		AB	
OP-EFBs 30 ton/ha	17.66	b	17.01	a	19.31	bc	17.78	a	19.32	a	19.47	bc
	A		A		A		A		A		A	

Note: Means within the same column followed by the same lowercase letter or the same row followed by the same uppercase letter are not significantly different according to LSD ($P \leq 0.05$). F-value=2.40**, CV=8.27%. ** was significantly different at $\alpha=1\%$ according to ANOVA.

The ear weight response varied among the maize hybrids with the application of compost. For hybrid CT19, ear weight increased with the addition of rice straw compost or OP-EFBs compost, but only up to 15 tons/ha. In contrast, hybrids CT29, CT34, and CT35 did not show an increase in ear weight with the application of either rice straw compost or OP-EFBs compost. Hybrid CT48 was more responsive to OP-EFBs compost, as evidenced by an increase in ear weight. The ear weight of CT48 was significantly greater with OP-EFBs compost compared to rice straw compost. For hybrid BISI 18, ear weight increased with the application of 30 tons/ha of compost (Table 5).

3.1 Effect of compost application on the growth and yield of maize hybrids

Compost application significantly enhanced vegetative growth parameters of maize hybrids, including plant height, leaf number, shoot fresh weight, and root fresh weight. These improvements were likely due to increased nutrient availability and improved soil physical properties resulting from the compost amendments (Adugna, 2016). However, the study found that increasing the rate from 15 tons/ha to 30 tons/ha did not further enhance vegetative growth, except root fresh weight in OP-EFBs (Table 6). This suggests that a threshold level of nutrient availability was reached, beyond which additional compost did not result in further growth benefits.

Vegetative growth in plants is fundamentally dependent on adequate nutrient availability, particularly nitrogen (N), which is crucial for processes such as photosynthesis and protein synthesis. Applying 50% of the recommended inorganic fertilizer rate on sandy coastal soils did not supply sufficient nitrogen to meet the nutritional needs of maize. This resulted in stunted growth similar to the control, which highlight the limitations of inorganic fertilizers in such challenging soil conditions. These

findings align with recent studies highlighting the importance of adequate and balanced nutrient inputs to promote optimal plant growth in nutrient-deficient soils (Leghari et al., 2016).

Table 5. The interaction effect between compost application and maize hybrid on ear weight

Compost Treatments (ton/ha)	Ear Weight (g)					
	CT19	CT29	CT34	CT35	CT48	BISI 18
Control	175.1 b	149.0 a	228.5 a	215.2 a	121.1 b	249.7 bc
	BC	C	AB	AB	C	A
Rice straw 15 ton/ha	243.6 a	168.5 a	221.2 a	212.0 a	108.4 b	255.8 bc
	A	B	AB	AB	C	A
Rice straw 30 ton/ha	217.2 ab	189.3 a	220.7 a	225.6 a	140.6 b	339.9 a
	B	BC	B	B	C	A
OP-EFBs 15 ton/ha	187.5 ab	180.7 a	214.0 a	236.0 a	215.0 a	221.6 c
	A	A	A	A	A	A
OP-EFBs 30 ton/ha	234.3 a	202.9 a	262.1 a	190.9 a	209.9 a	291.1 ab
	BC	C	AB	C	BC	A

Note: Means within the same column followed by the same lowercase letter or the same row followed by the same uppercase letter are not significantly different according to LSD ($P \leq 0.05$). F-value=2.45**, CV=16.36%. ** was significantly different at $\alpha=1\%$ according to ANOVA.

Table 6. The effect of compost on the growth of maize hybrids

Compost Treatments	Plant Height (cm)	Number of Leaves	Shoot Fresh Weight (g)	Root Fresh Weight (g)
Control	194.45 c	11.4 c	288.05 c	50.66 c
Rice straw 15 ton/ha	206.31 bc	11.9 bc	352.38 bc	70.98 ab
Rice straw 30 ton/ha	213.03 b	12.1 ab	368.55 b	79.28 a
OP-EFBs 15 ton/ha	233.14 a	12.0 ab	408.88 ab	64.54 b
OP-EFBs 30 ton/ha	233.02 a	12.5 a	466.96 a	74.98 ab
F-value	14.74 **	4.94 **	6.97 **	6.82 **
CV (%)	8.67	6.81	28.35	26.49

Note: Data followed by the same letter indicate no significant differences between treatments as detected by the LSD test ($p \leq 0.05$). ** was significantly different at $\alpha=1\%$ according to ANOVA.

Compost application, particularly OP-EFBs compost, significantly improved the growth parameters of maize. Compost applied as a treatment increases the amount of N in the soil, resulting in increased maize growth. Analysis of the compost showed that the N content in OP-EFBs compost was higher than that in rice straw compost, which correlated with the maize growth data. The higher nitrogen content in OP-EFBs compost, relative to rice straw compost, resulted in an increase in shoot fresh weight. This enhancement in shoot fresh weight is primarily attributed to the increased plant height and leaf number, as indicated by correlation coefficients of $r = 0.94$ and $r = 0.95$, respectively. The OP-EFBs treatment at 30 tons/ha yielded the highest values for all variables, indicating that OP-EFBs compost was more effective in enhancing vegetative growth of maize compared to rice straw compost. Recent studies have also found that composts rich in organic matter and essential nutrients can increase plant growth by improving soil structure and fertility (Singh et al., 2020).

The study also revealed that compost application affected the root-shoot ratio of maize, with OP-EFBs compost resulting in a lower ratio (0.16) compared to rice straw compost (0.21). This negative correlation between root-shoot ratio and soil nitrogen status suggests that higher N availability promoted shoot growth higher than root growth. This finding aligned with that of Asibi et al., (2019), who reported that increased nitrogen availability typically enhanced shoot biomass due to greater allocation of resources to above-ground growth.

Despite the significant improvements in vegetative growth, the increase in biomass did not correspond to a proportional increase in yield and yield component. This suggests that while compost enhances early growth and development, other factors might limit reproductive success and final yield. However, the OP-EFBs compost treatment at 30 tons/ha did result in higher yields compared to other treatments, though not significantly different statistically. Interestingly, the study found that even at a lower application rate of 15 tons/ha, OP-EFBs compost was as effective as 30 tons/ha in increasing the number of grains per plant (Table 7).

The discoveries of this study have important implications for the management of coastal agricultural lands. The significant improvement in soil fertility and maize growth with the application of OP-EFB compost highlights its potential as a sustainable soil ameliorant. However, rice straw compost can also be a valuable resource for improving the productivity of marginal coastal soils (Kim et al., 2017).

3.2. Maize growth and yield in coastal land

The vegetative growth of the new hybrid maize varieties demonstrated promising results, with most hybrids exhibiting greater plant height compared to the established BISI 18 variety, with the exception of CT34. This finding is consistent with previous studies indicating that genetic improvements in maize hybrids can lead to increased plant height, which is often associated with better light interception and potentially higher biomass production (Chen et al., 2019). However, it is noteworthy that the increased height did not correlate with an increased number of leaves, as BISI 18 maintained the highest leaf count among all hybrids tested. This might be due to the fact that plant height and leaf number are controlled by different genetic factors, and improvements in one trait do not necessarily enhance the other (Incognito et al., 2022).

In terms of biomass production, hybrids CT34 and CT35 showed superior performance in both shoot fresh weight and root fresh weight, which were comparable to BISI 18 (Table 8). This aligns with the findings of recent studies that emphasize the

importance of robust root systems for nutrient uptake and overall plant health, particularly in stressful environments (Francis et al., 2023). The higher biomass of these hybrids indicates their potential for better growth and adaptation, which is crucial for their development in diverse agricultural settings.

Table 7. The effect of compost on yield components and the yield of maize hybrids

Compost Treatments	Ear Length (cm)	Ear Weight (g)	No. of Grain Row	No. of Grain per Plant	Yield per Plant (g)
Control	18.25 bc	189.81 c	12.9 bc	378.2 b	116.34 a
Rice straw 15 ton/ha	19.07 ab	201.62 bc	12.9 bc	371.6 b	116.86 a
Rice straw 30 ton/ha	19.81 a	222.27 ab	13.9 a	398.7 ab	122.73 a
OP-EFBs 15 ton/ha	17.72 c	209.17 abc	12.8 c	411.0 ab	126.91 a
OP-EFBs 30 ton/ha	18.42 bc	231.91 a	13.4 ab	431.0 a	133.16 a
F-value	4.90 **	4.18 **	5.11 **	2.69 *	2.05 ns
CV (%)	8.27	16.36	6.33	15.74	17.03

Note: Data followed by the same letter indicate no significant differences between treatments as detected by the LSD test ($p \leq 0.05$). ns, * and ** were non significantly different, significantly different at $\alpha=5\%$ and significantly different at $\alpha=1\%$, respectively, according to ANOVA.

Table 8. Growth of maize hybrids in coastal land

Maize Hybrid	Plant Height (cm)	Number of Leaves	Shoot Fresh Weight (g)	Root Fresh Weight (g)
CT19	219.74 ab	11.2 cd	303.23 b	60.58 c
CT29	223.08 ab	12.4 b	358.86 ab	63.36 bc
CT34	203.54 c	11.8 c	378.07 ab	74.87 ab
CT35	233.43 a	12.8 ab	419.44 a	70.67 abc
CT48	213.19 bc	10.7 d	377.10 ab	60.18 c
BISI18	202.96 c	13.0 a	425.09 a	78.85 a
F-value	5.99 **	19.69 **	2.59 *	2.86 *
CV (%)	8.67	6.81	28.35	26.49

Note: Data followed by the same letter indicate no significant differences between treatments as detected by the LSD test ($p \leq 0.05$). * and ** were significantly different at $\alpha=5\%$ and $\alpha=1\%$ according to ANOVA.

Despite the encouraging vegetative growth, the new hybrids exhibited significantly lower reproductive performance in terms of ear weight, number of grain rows, and number of grains per plant compared to BISI 18. However, no significant differences were observed in ear length and ear diameter (Table 9). This result highlights a common

challenge in plant breeding, where improvements in vegetative traits do not always translate to enhancements in yield components (Rustikawati et al., 2021). Among the hybrids, CT34 showed some promise with its larger ear diameter and slightly higher yield per plant, indicating its potential for development in coastal areas. The findings suggest that while the new hybrids exhibit advantageous vegetative growth traits, further breeding and selection efforts are needed to enhance their reproductive performance. This dual focus on vegetative and reproductive traits will be essential for developing high-yielding hybrids that can thrive in various environmental conditions (Worku et al., 2020).

Additionally, the study underscores the importance of considering genotype-specific responses to soil amendments. This is particularly relevant for breeding programs and agricultural extension services, as selecting the appropriate hybrid for a given soil amendment can maximize crop yield and resource use efficiency (Aduugna, 2016).

Table 9. Yield and yield component of maize hybrids in coastal land

Maize Hybrid	Ear Length (cm)	Ear Diameter (mm)	Ear Weight (g)	No. of Grain Row	No. of Grain per Plant	Yield per Plant (g)
CT19	18.71 b	43 ab	211.59 b	13 bc	371.7 bc	126.61 b
CT29	17.03 c	40.57 bc	178.13 c	12.6 cd	376.8 bc	113.94 bc
CT34	20.4 a	44.24 a	229.36 b	12.6 cd	391.8 b	129.21 b
CT35	19.13 b	42.84 ab	215.98 b	12.3 d	390.4 b	117.92 b
CT48	16.82 c	39.78 c	159.04 c	13.5 b	341.3 c	98.64 c
BISI18	19.83 ab	45.47 a	271.63 a	15.1 a	516.7 a	152.87 a
F-value	13.44 **	4.39 **	19.70 **	23.23 **	14.17 **	11.20 **
CV (%)	8.27	9.34	16.36	6.33	15.74	17.03

Note: Data followed by the same letter indicate no significant differences between treatments as detected by the LSD test ($p \leq 0.05$). * and ** were significantly different at $\alpha = 5\%$ and $\alpha = 1\%$ according to ANOVA.

4. Conclusions

The rice straw compost and OP-EFBs compost were effective as coastal sandy land ameliorants. The OP-EFBs compost improved maize vegetative growth better than rice straw compost did. At a rate of 15 tons/ha both composts enhanced growth and grain number per ear of maize. Increasing the rate of compost to 30 tons/ha improved vegetative growth but not the yield of maize. Hybrids CT19, CT34, and BISI18 responded well to rice straw compost, while CT48 preferred OP-EFBs compost. Hybrids CT34 and CT35 showed potential for cultivation in coastal area but still need improvement to increase yields. Further optimization of compost types and rates is necessary to maximize the potential of these new maize hybrids for coastal land cultivation.

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6. Authors' Contributions

Rustikawati designed, performed research and wrote the paper; Catur Herison analyzed data and wrote the paper; Nanik Setyowati wrote the paper.

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7. Conflicts of Interest

The authors affirm that there are no conflicts of interest related to the research, authorship, or publication of this article.

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