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Effects of AB mix hydroponic solution and ameliorant mixtures on cayenne pepper growth and yield in an Inceptisols

Abstract. Cayenne pepper (*Capsicum frustescens* L.) cultivation faces several problems, including acidic pH and inadequate nutrient management. These problems can be addressed by using a mixture of various ameliorants and AB mix nutrient solutions. This study aimed to determine the effect of ameliorant mixture dosage and AB mix solution concentration on soil chemical properties, growth, and yield of cayenne pepper. The experiment used a randomized block design, consisting of two factors: nutrient solution concentration and ameliorant dosage. The factor of nutrient solution concentration consisted of four levels, i.e., 700, 1000, 1300, and 1600 ppm, while the factor of ameliorant dosage also consisted of four levels, i.e., 0, 2, 4, and 6 t ha^{-1}. Observations were made on soil chemical properties, namely soil pH, organic carbon content, and cation exchange capacity (CEC). The agronomic characteristics observed were plant height, number of leaves, leaf area, chlorophyll content index, fruit length, number of fruits, and fruit weight per plant. The results showed no interaction between the concentration of AB mix solution and the ameliorant dosage on soil chemical properties, growth, and yield characteristics of cayenne pepper plants. The single effect of AB mix solution or ameliorant was observed on the number and weight of fruits per plant. The optimal dose for achieving the maximum harvested fruit weight was 6 t ha^{-1} of the ameliorant mixture (76.55 g pepper/plant), while the optimal AB mix concentration was 1600 ppm (65.02 g pepper/plant).

Keywords: Ameliorant · Horticulture crop · Soil chemical properties

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Introduction

Cayenne pepper (*Capsicum frustescens* L.) is a horticultural crop from the Solanaceae family that has high economic value and contains many nutritions, including protein, fat, calcium, and vitamins (Francis, 2025; Amaechi et al., 2021; Mardiyati & Natsir, 2024). Chili pepper production in farmers' fields faces several problems, including pH changes become too acidic and inappropriate nutrient management, resulting in decreased productivity (Ariani et al., 2021; Tajidan et al., 2022). The use of synthetic fertilizers (chemical fertilizers) causes acidic soils, mainly due to the release of hydrogen ions (H^+) into the soil during the decomposition process (Pahalvi et al., 2021). Rainwater or irrigation also triggers the loss of important alkaline nutrients such as Calcium (Ca^{2+}), Magnesium (Mg^{2+}), and Potassium (K^+), so that the soil becomes more acidic (Sharma et al., 2025). The decrease in soil pH is often not realized by farmers, resulting in insufficient fertilizer doses for plants (Gurmessa, 2021). In addition, the use of common synthetic fertilizers is usually not fully absorbed by plants, adding to the problems of chili pepper growth (Ahmed et al., 2017).

To solve nutrient absorption issues in cayenne pepper plants, easily absorbed fertilizer is needed. AB mix fertilizer, typically used in hydroponic solutions, boasts a complete nutrient mix (macro and micronutrients), almost 100% water solubility, and less sediment (Sanusi et al., 2024). This makes it significantly more effective and easily absorbed by plants (Marga et al., 2026). Research shows that applying AB mix to red chili plants can increase fruit weight (Sanusi et al., 2024).

A decrease in soil pH can be addressed by adding a mixture of ameliorants into the soil. Sugarcane filter mud is categorized as soil ameliorant because it is rich in organic matter, nitrogen, calcium, magnesium, and has been proven to increase pH (Moreira et al., 2021). Biochar is also a soil conditioner that can increase soil pH because it is rich in alkaline nutrients (such as calcium, magnesium, and potassium) derived from the combustion process of organic matter (Alkharabsheh et al., 2021). Dolomite increases soil pH because it contains calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) (Jyothsnaet al., 2024). When reacting with water in the soil, these compounds release carbonate ions that bind hydrogen ions (causing acid), thereby reducing acidity levels and returning the soil pH to neutral (Esilaba et al., 2023). The presence of alkaline cations such as calcium and magnesium in guano also helps neutralize soil acidity.

The use of an ameliorant mixture of sugarcane filter mud, biochar, dolomite, and guano not only increase pH, especially in an Inceptisols which has a slightly acidic pH (Rahmayuni et al., 2023), but also improve nutrient availability for plants. The AB mix concentration is expected to be efficient when used in conjunction with the ameliorant mixture. This study aims to determine the interaction effect between the AB mix concentration and the ameliorant mixture on the agronomic characteristics of cayenne pepper and also to determine the most optimal AB mix and ameliorant mixture concentration for cayenne pepper yield.

Materials and Methods

The experiment was conducted in the plastic house at Bale Tatanen, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency, West Java, at an altitude of approximately 745 m above sea level (m asl). The experiment was conducted from May to September 2025. The average air temperature in the plastic house was 33.4°C, and the average relative humidity was 46%. The temperature is higher, but the humidity is lower than recommendation. Fogging irrigation has been conducted to solve this problem.

The equipment used in the field experiment included analytical scale, SPAD-chlorophyllmeter, fertigation installation, pot tray, 100 cm ruler, dropper, measuring cylinder, Total Dissolved Solids (TDS) meter, sprayer, digital thermohygrometer, and digital pH meter. Equipment required for laboratory observations of soil organic carbon included burette, 25 ml measuring cylinder, 10 ml pipette, 250 ml Erlenmeyer flask, Erlenmeyer flasks, Kjeldahl flasks, distillation apparatus, burettes, and other equipment for soil fertility analysis.

The materials used in the field for this experiment were a growing medium from Inceptisols subgroup Fluventic Eutrudepts; 35 x 35 cm polyethylene plastic bags; cayenne pepper seeds cv. Sigantung; AB mix fertilizer; ameliorant made from 50% sugarcane filter cake compost,

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30% coconut shell biochar, 10% dolomite, and 10% guano (Table 1); seedling medium (rice husk charcoal, compost, and soil); rope; and pesticide. The results of the initial soil chemical analysis showed that the soil pH was neutral, the cation exchange capacity (CEC) and available P levels were high, and the organic C, total N, potential P, and total K contents were moderate (Table 2). The materials needed for laboratory analysis are 1 N $K_2Cr_2O_7$ solution, 98% H_2SO_4, 0.5 N FeSO4 solution, 0.025 N ferroin indicator, distilled water, ammonium acetate $NH_4CH_3CO_2$, 96% alcohol, 40% NaOH, boric acid, and Conway indicator.

The experiment used a randomized block design, consisting of two factors: nutrient solution concentration and ameliorant dosage, with two replications. The nutrient solution factor consisted of four levels, i.e., 700, 1000, 1300, and 1600 ppm, while the ameliorant dosage factor also consisted of four levels, i.e., 0, 2, 4, and 6 t ha^{-1}. Analysis of Variance (Anova) assumptions has been verified by Shapiro–Wilk and Levene's tests. Differences between treatments were analyzed using Duncan's test at a 5% significance level. Statistical tests were conducted using SPSS software.

Table 1. Analysis of ameliorant content

No.	Parameter	Unit	Value
1.	Organic C	%	19.56
2.	C/N	-	19.17
3.	Humidity	%	14.96
4.	Macro nutrients:		
	N	%	1.02
	P2O5	%	6.28
	K2O	%	0.52
5.	Ca	%	7.16
6.	Mg	%	2.19
7.	CEC	(cmol.kg^{-1})	35.02

Source: Soil Chemistry and Plant Nutrition Laboratory, Department of Soil Science and Land Resources, Faculty of Agriculture, Universitas Padjadjaran (2025).

Soil fertility was observed, including soil pH, organic carbon content, and CEC. Agronomic characteristics observed were plant height, number of leaves, leaf area, chlorophyll content index, fruit length, number of fruits, and fruit weight per plant. Soil pH was measured using a pH meter; soil organic carbon by the Walkley and Black method; and CEC using the extract method of 1 M NH_4OAc pH 7. Plant height and fruit length were measured using a tape measure. Leaf area was measured using the gravimetric method. The chlorophyll content index was measured using a SPAD-chlorophyll meter. Fruit weight per plant was measured using an analytical scale.

Table 2. Pre-treatment analysis of Inceptisols soil

No.	Parameter	Unit	Value	Criteria
1.	pH	-	6.04	Slightly acid
2.	Organic C	%	2.14	Moderate
3.	Total N	%	0.29	Moderate
4.	C/N	-	7.37	Low
5.	Total P	mg.100g^{-1}	35.28	Moderate
6.	Available P	ppm	17.33	High
7.	Total K	mg.100g^{-1}	36.18	Moderate
8.	CEC	cmol.kg^{-1}	36.14	High

Source: Soil Chemistry and Plant Nutrition Laboratory, Department of Soil Science and Land Resources, Faculty of Agriculture, Universitas Padjadjaran (2025).

The experiment began by adding soil and ameliorant (dose as treatments) to 35 cm x 35 cm polybags, then placed in beds with a spacing of 60 cm x 70 cm. Cayenne pepper seeds were sown in pot trays for 30 days. At 15 days after sowing, the seedlings were watered daily with 500 ppm AB mix solution. The seedlings were then transferred to polybags. Maintenance included applying nutrient solution (fertigation) according to the treatment, removing unproductive shoots, plant tying, and weed control. Harvesting began at 105 days after planting, with a 3-day rotation (five times harvest).

Results and Discussion

There was no interaction effect between the concentration of the AB Mix hydroponic solution and the ameliorant mixture on pH, organic carbon content, and CEC. The single effects of the AB Mix concentration or ameliorant mixture also did not significantly affect pH or CEC, while single effect of AB mix concentration affected organic carbon content (Table 3).

Pre-treatment soil analysis results indicated that the soil pH was slightly acidic. The addition of ameliorants did not significantly change the soil pH, indicating that the ameliorant mixture acted as a pH buffer (Tsapko et al., 2023). The concentration of the AB mix solution also did not change the pH because the groundwater used had a pH range of 6–6.5, which is considered slightly acidic. Several studies also indicate that soil tends to buffer and maintain the pH of the solution added to it (Ng et al., 2022).

Table 3. Effect of ameliorant dosage and AB mix concentration on pH, organic C, and soil CEC

Treatment	pH	Organic C (%)	CEC (cmol.kg^{-1})
Ameliorant Dosage			
a_0 = 0 t ha^{-1}	6.04 a	2.14 a	33.89 a
a_1 = 2 t ha^{-1}	5.96 a	6.70 b	33.20 a
a_2 = 4 t ha^{-1}	6.04 a	7.36 b	33.90 a
a_3 = 6 t ha^{-1}	5.98 a	7.65 b	33.86 a
AB Mix Concentration			
k_1 = 700 ppm	5.90 a	7.04 a	34.40 a
k_2 = 1000 ppm	6.10 a	7.50 a	32.70 a
k_3 = 1300 ppm	6.12 a	7.92 a	34.24 a
k_4 = 1600 ppm	5.90 a	6.72 a	33.50 a

Note: Mean value followed by the same letter within the same column are not different significantly based on Duncan Multiple Range test at 5% significance level

The addition of the ameliorant mixture significantly increased soil organic carbon content, shifting its classification from moderate to very high. The ameliorants used contained a significant amount of organic matter, namely sugarcane filter mud, biochar, and guano, thus increasing the soil organic carbon content (Krishnaveni et al., 2020; Gross et al., 2024; Zhao et al., 2026). The concentration of the AB mix solution did not change the soil organic carbon content because the AB mix solution does not contain carbon, unless it is grown with microalgae (Richa et al., 2020). The ameliorant mixture also had no significant effect on CEC. Pre-treatment soil analysis showed a high CEC, so ameliorant application did not alter CEC. On the other hand, the AB mix solution did not alter CEC because it did not reduce H^+ concentration (Kudirka et al., 2023).

Table 4 reveals no interaction effect between the AB mix solution concentration and the ameliorant mixture on the chlorophyll content index and growth characteristics of cayenne peppers 3 and 5 weeks after planting (WAP). Similarly, the independent effect of the AB mix concentration or the ameliorant mixture on the chlorophyll content index and growth characteristics of cayenne peppers was not significant.

The soil used was relatively fertile, with a slightly acidic pH, high CEC, high available P, and moderate total N and K contents. The fertile soil prevented the use of excessively high AB mix solution concentrations. Consequently, the adequate supply of nutrients from the soil resulted in low fertilizer dosages. Nitrogen from the soil is used for chlorophyll formation (Fathi, 2022). High CEC also makes magnesium, a chlorophyll-forming ingredient, available to plants (Antonangelo et al., 2024). Phosphorus available from the soil plays a role in providing energy for plants (Malhotra et al., 2018). Fertile soil also prevents ameliorants, ranging from 2 to 6 tons ha-1, from working effectively. High soil CEC prevents ameliorants from increasing CEC. Likewise, soil pH that is close to neutral.

Although soil fertility and growth were not affected by ameliorant dosage and AB mix concentration, several crop yield characteristics were affected by ameliorant dosage or AB mix concentration (Table 5). Fruit number was influenced by both ameliorant dosage and AB mix concentration. Increasing fruit number affected fruit weight, thereby increasing crop yield. The highest ameliorant dosage (6 t ha^{-1}) and the highest AB mix concentration (1600 ppm) produced the highest yields.

Fruit number is related to soil nutrient availability. Phosphorus is useful for flower formation and preventing flower drop (Noori et al., 2018; Astiari et al., 2019). Potassium plays a role in fruit filling, while calcium prevents flower and fruit nipple drop (Preciado-Rangel et al., 2018; Yfran et al., 2017). Ameliorants are applied to improve nutrient availability and provide nutrients for flower and fruit formation (Ismail et al., 2025; Table 1).

Table 4. The effect of ameliorant dosage and AB mix concentration on pepper growth

Treatment	Chlorophyll Content Index		Plant Height (cm)		Number of Leaves		Leaf Area (cm²)	
	3 WAP	5 WAP	3 WAP	5 WAP	3 WAP	5 WAP	3 WAP	5 WAP
Ameliorant Dosage								
a_0 = 0 t ha^{-1}	29.63 a	24.67 a	25.12 a	60.77 a	14.17 a	25.50 a	550.01 a	887.83 a
a_1 = 2 t ha^{-1}	26.37 a	30.44 a	24.89 a	57.33 a	14.88 a	26.46 a	372.53 a	823.42 a
a_2 = 4 t ha^{-1}	25.03 a	29.00 a	22.15 a	54.23 a	13.29 a	24.83 a	349.06 a	813.43 a
a_3 = 6 t ha^{-1}	26.24 a	24.76 a	24.38 a	55.77 a	13.75 a	24.17 a	301.26 a	833.83 a
AB Mix Concentration								
k_1 = 700 ppm	24.37 a	27.45 a	21.31 a	54.65 a	12.96 a	24.13 a	411.20 a	784.30 a
k_2 = 1000 ppm	28.08 a	25.48 a	24.49 a	55.71 a	14.21 a	25.58 a	406.73 a	853.58 a
k_3 = 1300 ppm	28.60 a	31.41 a	25.05 a	58.73 a	14.75 a	26.38 a	418.85 a	965.72 a
k_4 = 1600 ppm	26.21 a	24.53 a	25.69 a	59.03 a	14.17 a	24.88 a	336.08 a	754.91 a

Note: Mean value followed by the same letter within the same column are not different significantly based on Duncan Multiple Range test at 5% significance level

Table 5. The effect of ameliorant dosage and AB mix concentration on pepper yield

Treatment	Fruit Length (cm)	Number of Fruits	Weight of Fruit per plant (g)
Ameliorant Dosage			
a_0 = 0 t ha^{-1}	5.89 a	20.69 a	64.55 a
a_1 = 2 t ha^{-1}	5.91 a	30.30 ab	66.58 a
a_2 = 4 t ha^{-1}	5.14 a	36.25 ab	67.71 a
a_3 = 6 t ha^{-1}	4.91 a	40.55 b	76.55 b
AB Mix Concentration			
k_1 = 700 ppm	4.49 a	26.05 a	54.16 a
k_2 = 1000 ppm	5.77 a	28.80 ab	54.50 a
k_3 = 1300 ppm	5.59 a	31.56 ab	54.89 a
k_4 = 1600 ppm	6.01 a	37.38 b	65.02 b

Notes: Mean value followed by the same letter within the same column are not different significantly based on Duncan Multiple Range test at 5% significance level

Conclusion

There was no interaction effect ($p<0.05$) between the concentration of AB mix solution and the ameliorant dosage on soil chemical properties, growth, and yield of cayenne pepper plants. The single effect of AB mix solution concentration or ameliorant dosage was significantly affected the number of fruits and fruit weight per plant. The optimal dosage of the ameliorant mixture for maximizing harvested fruit weight was 6 t ha^{-1}, while the optimal AB mix concentration was 1,600 ppm.

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