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The Growth of Hiyung Cayenne in Peat Soil through Organic Materials Application

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Abstract:
Background*: Hiyung cayenne is the hottest chili in Indonesia and one of the local varieties of chili from Hiyung Village, South Kalimantan. Hiyung cayenne as an important commodity in the area of origin, was found to grow and produce well in swampy areas with low to high fertility rates. Peatland as type of land that mostly found in South Kalimantan, can be alternative to extensification Hiyung Cayenne's cultivation.*
Materials and Methods*: This research was carried out in June - November 2021 at private greenhouse Martapura Village, South Kalimantan, Indonesia. The experiment was designed using one-factor Completely Randomized Design (CRD) and was repeated twice. The factors used were the composition of cow manure (0.0, 2.5 and 5.0 t ha-1) and swallow manure (0.0, 2.5; 5.0 and 7.5 t ha-1).*
Results*: The results showed that the composition of cow manure and swallow manure had an effect on plant height at the age of 9 and 12 Week After Planting (WAP), stem diameter at 6, 9 and 12 WAP and the number of branches.*
Conclusion: *The composition of cow manure 2,5 t ha-1 + swallow manure 7.5 t ha-1 gave the highest plant height at the age of 9 and 12 WAP, 62.75 and 87.00 cm, respectively; the largest stem diameter at the age of 6, 9 and 12 WAP, respectively 3.95; 7.55 and 8.30 mm. Meanwhile, the highest number of branches was obtained from the treatment of swallow manure 7.5 t ha-1 (25.13 branches).*
Key Word*: Hiyung, Cayenne local variety, cow manure, swallow manure*

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I. Introduction

Cayenne (*Capsicum frutescens* L.) is a priority vegetable commodity because of its importance status in society, especially Indonesian. Not only to enriching the taste of food, cayenne also sources of vitamins A, B1, B2, C and alkaloid compounds such as capsaicin, oleoresin, flavonoids and essential oils [1] [2]. Another benefit of cayenne, which is believed to be a medicinal plant, includes improving the digestive system, treating heart and blood vessel disease, and as a catalyst and increasing the effectiveness of other herbal medicines when used together [3], as a lung cleanser, bronchitis treatment, colds, sinusitis, influenza, rheumatism and asthma [1].

South Kalimantan has a local variety of cayenne called 'Hiyung' according to its area of origin, namely Hiyung Village, Tapin Regency. The level of spiciness of Hiyung cayenne is 94,500 ppm, the highest among other cayenne varieties in Indonesia, making it the hottest cayenne pepper in Indonesia [4;5]. Not only being the hottest, this chili has a long shelflife of 10-16 days at room temperature longer than ordinary red chilies and cayennes [6].

Some of these advantages make Hiyung cayenne an important commodity for the people in Hiyung Village, most of them are Hiyung cayenne farmers [6]. The fertility rate of lebak swamp land in Hiyung Village which is planted with Hiyung cayenne is classified as low to high [7]. This research is expected to support the expansion of cayenne pepper cultivation in peat swamp land which is a type of land that is widely spread in South Kalimantan.

In the last five years, the production of cayenne in South Kalimantan has continued to increase. In 2016 the production of cayenne was recorded at 7,322 tons. Production continues to increase to 113.28% in 2020, reaching 15,616 tons [8]. This increase indicates the high demand for cayenne both for consumption and industry. Based on the potential for Hiyung cayenne, it is necessary to develop it outside the area of origin which may have different types of land. Peatland is a type of land that is widely spread in South Kalimantan and as an alternative land for cayenne cultivation.

Chili plants can be cultivated in peatland which has fertile soil conditions, unflooded, and with a peat thickness less than 100 cm [9]. The peatland areas in South Kalimantan is quite wide. Based on the Decree of the Minister of Environment and Forestry No. 129 and 130 in 2017, the area of the peat ecosystem in South

Kalimantan province is 102,902.95 ha. Therefore, peatland is a potentially for Hiyung cayenne extensification in wetland.

Generally, peatland has low fertility, characterized by acidic soil (low pH), low nutrients availability of macro (K, Ca, Mg, P) and micro (Cu, Zn, Mn, and Bo), low toxic organic acids, and has a high Cation Exchange Capacity (CEC) but low Base Saturation (BS) [10]. Therefore, proper land management is needed to fulfill the characteristics and properties that can support maximum plant growth and development. One of the efforts that can be done to improve soil characteristics is the application of organic matter.

Organic matter is an important element in the soil that has a role in determining soil fertility. Organic matter is obtained to improve the physical properties related to soil structure, chemical properties in adding nutrients to the soil [11;12], and biological properties as a source of energy and food for microorganisms. Organic matter varies depending on the basic ingredients of its formation, which come from plant residues, animal residues, or industrial residues [13]. Organic materials or organic fertilizers derived from animal residues include cow manure and swallow manure.

Besides as a source of nutrients, cow manure can also increase soil acidity. It contains 0.29% N, 0.17% P and 0.23% K [14]. Whereas, swallow manure contains 11.24% total N, 1.59% P, 2.17% K, 0.30% Ca, 0.01% Mg with pH 7.97 and C/N ratio 4.49 [15]. It can be seen that the N and P content in swallow manure is higher than in cow manure.

This study aims to determine the growth and production of Hiyung cayenne pepper on peatland with the application of organic matter, that are cow manure and swallow manure. The application of organic matter is expected to provide a positive trend for Hiyung cayenne cultivation. This is in accordance with the research that explains that one of the factors that influence the growth, yield and even the level of spiciness of Hiyung cayenne is the content of organic matter in the soil [7].

II. Materials and Methods

This research was conducted on Jl. Kampung Baru Sungai Paring Martapura Village, South Kalimantan from June to November 2021. The materials used in this study are Hiyung seeds, cow manure, swallow manure, peat soil, NPK Mutiara, and husk ash. The tools used include trays, polybags, pots, hoes, shovels, sacks, buckets, sieves, meters, calipers, scales, analytical balances, crop shears, ovens, cameras, and stationery.

This study is a field experiment designed using a completely randomized design (CRD) with one factor, namely the composition of the dose of organic matter in the form of cow manure (0.0, 2.5 and 5.0 t ha^{-1}) and swallow manure (0.0, 2.5, 5.0 and 7.5 t ha^{-1}). There are 12 compositions of organic matter with 2 replications.

Seed selection by soaking for two days is done before the sowing process. Normal seeds are sown on trays containing soil and cow manure (1:1), then covered with husk ash thinly and evenly. Seedlings are clenched at the age of two weeks and moved to small polybags until they are ready to be planted in pots (four weeks old).

Planting media in pots is a mixture of peat soil taken as deep as 0-20 cm from the soil surface and organic matter. Peat soil is put into a pot with organic matter added with the composition of cow manure and swallow manure according to the treatment. Then the planting medium was incubated for two weeks.

Seedlings in the nursery were moved into pots at the age of four weeks after sowing. Planting was made with a spacing of 0.75 m x 1 m. During planting, 25 g of NPK fertilizer was applied per plant. This fertilizer is applied in a single manner in the four cardinal directions at a distance of 5 cm from the plant.

The variables observed in this study were plant height and stem diameter at 3, 6, 9 and 12 Weeks After Planting (WAP), number of branches at harvest, wet weight of shoots and roots, dry weight of shoots and roots, and shoot-root ratio.

All data on each variable were first analyzed on the assumption of homogeneity of variance using the Bartlett test at a significance level of 0.05. If the variance of error in all variables is homogeneous, then it is appropriate to continue the analysis of variance using the F test at a level of 0.05. Furthermore, if the results of the F test show that the treatment has a significant effect, then a comparison test of the mean value is carried out using the Duncan Multiple Range Test (DMRT) at a significance level of 0.05.

III. Results

The results of the Bartlett test show that the variance of the data on all observed variables is homogeneous. The results of the analysis of variance showed that the composition of organic matter had no significant effect on plant height at 3 and 6 Week After Planting (WAP), but had a significant effect on 9 and 12 WAP. The average plant height at the age of 3, 6, 9 and 12 WAP is presented in Table 1.

Based on Table 1, the tallest plant at 9 WAP was obtained at the composition of cow manure 2.5 t ha^{-1} + swallow manure 7.5 t ha^{-1} which was significantly different from other treatments. The same results were also

obtained at 12 WAP but not significantly different from the composition of cow manure 2.5 t ha^{-1} + swallow manure 2.5 t ha^{-1}, cow manure 5.0 t ha^{-1} + swallow manure 2.5 t ha^{-1} and cow manure 5.0 t ha^{-1} + swallow manure 5.0 t ha^{-1}.

Table 1. The average plant height of Hiyung cayenne at 3, 6, 9 and 12 WAP on the composition of cow manure and swallow manure

Composition of Organic Matter	Plant height (cm)			
	3 WAP	6 WAP	9 WAP	12 WAP
Without Organic Matter	17.00	21.00	35.75 a	56.00 a
w 2.5 t ha^{-1}	17.00	21.50	42.50 a	64.00 abc
w 5.0 t ha^{-1}	17.25	20.75	38.50 a	69.00 abc
w 7.5 t ha^{-1}	18.00	21.75	41.00 a	58.00 ab
s 2.5 t ha^{-1}	16.00	18.00	35.75 a	57.50 ab
s 2.5 t h^{-1} + w 2.5 t ha^{-1}	14.50	20.50	44.75 a	76.00 cd
s 2.5 t h^{-1} + w 5.0 t ha^{-1}	17.25	21.25	43.25 a	64.00 abc
s 2.5 t h^{-1} + w 7.5 t ha^{-1}	19.00	15.90	62.75 b	87.00 d
s 5.0 t ha^{-1}	16.50	21.00	38.25 a	67.00 abc
s 5.0 t h^{-1} + w 2.5 t ha^{-1}	17.50	23.25	48.00 a	72.50 bcd
s 5.0 t h^{-1} + w 5.0 t ha^{-1}	12.75	21.00	43.00 a	75.50 cd
s 5.0 t h^{-1} + w 7.5 t ha^{-1}	16.00	21.75	37.00 a	66.50 abc

Note : Numbers followed by the same letter in the same column are not significantly different according to the DMRT test at a 5% significance level
s = cow manure; w = swallow manure

The results of the analysis of variance showed that the composition of organic matter did not significantly affect stem diameter at 3 WAP, but had a significant effect at 6, 9, and 12 WAP. The average stem diameter at 3, 6, 9 and 12 WAP can be seen in Table 2.

Table 2. The average stem diameter of Hiyung cayenne at 3, 6, 9 and 12 WAP on the composition of cow manure and swallow manure

Composition of Organic Matter	Stem Diameter (mm)			
	3 WAP	6 WAP	9 WAP	12 WAP
Without Organic Matter	2.13	2.58 ab	5.45 a	6.13 ab
w 2.5 t ha^{-1}	2.55	2.95 b	5.40 a	6.60 ab
w 5.0 t ha^{-1}	2.08	2.63 ab	4.95 a	6.10 ab
w 7.5 t ha^{-1}	2.20	2.90 b	4.73 a	6.00 ab
s 2.5 t ha^{-1}	2.00	2.33 a	4.85 a	6.38 ab
s 2.5 t h^{-1} + w 2.5 t ha^{-1}	2.00	2.55 ab	5.00 a	6.15 ab
s 2.5 t h^{-1} + w 5.0 t ha^{-1}	2.70	2.98 b	5.40 a	6.40 ab
s 2.5 t h^{-1} + w 7.5 t ha^{-1}	2.28	3.95 c	7.55 b	8.30 c
s 5.0 t ha^{-1}	2.20	2.68 ab	5.60 a	7.25 bc
s 5.0 t h^{-1} + w 2.5 t ha^{-1}	2.53	2.95 b	5.85 a	7.15 bc
s 5.0 t h^{-1} + w 5.0 t ha^{-1}	1.93	2.70 ab	5.70 a	7.25 bc
s 5.0 t h^{-1} + w 7.5 t ha^{-1}	2.08	2.55 ab	4.70 a	5.73 a

Note : Numbers followed by the same letter in the same column are not significantly different according to the DMRT test at a 5% significance level
s = cow manure; w = swallow manure

Showing similar trends with plant height, the largest stem diameter was also obtained from the composition of cow manure 2.5 t ha^{-1} + swallow manure 7.5 t ha^{-1} which was significantly different from other treatments at 6 and 9 WAP. While at 12 WAP, the stem diameter at the composition of cow manure 2.5 t ha^{-1} + swallow manure 7.5 t ha^{-1} was not significantly different from the treatments of cow manure 5.0 t ha-1; cow manure 5.0 t ha-1 + swallow manure 2.5 t ha^{-1} and cow manure 5.0 t ha^{-1} + swallow manure 5.0 t ha^{-1}.

The results of the analysis of variance showed that the composition of organic matter did not significantly affect the wet weight and dry weight of shoots and roots. The average wet weight and dry weight of shoots and wet weight and dry weight of roots are presented in Table 3.

Table 3. The average shoots wet and dry weight and roots wet and dry weight of Hiyung cayenne on the composition of cow manure and swallow manure

Composition of Organic Matter	Shoots Wet Weight (g)	Shoots Dry Weight (g)	Roots Wet Weight (g)	Roots Dry Weight (g)
Without Organic Matter	80.70	22.63	9.10	3.19
w 2.5 t ha^{-1}	67.80	14.92	9.91	3.26
w 5.0 t ha^{-1}	94.90	22.47	10.31	3.94
w 7.5 t ha^{-1}	102.60	22.90	8.34	3.07
s 2.5 t ha^{-1}	76.00	17.31	9.83	3.77
s 2.5 t h^{-1} + w 2.5 t ha^{-1}	99.40	23.50	11.63	3.58
s 2.5 t h^{-1} + w 5.0 t ha^{-1}	70.21	16.64	11.11	3.04
s 2.5 t h^{-1} + w 7.5 t ha^{-1}	112.80	28.34	13.40	4.89
s 5.0 t ha^{-1}	96.10	23.19	19.87	4.97
s 5.0 t h^{-1} + w 2.5 t ha^{-1}	81.30	18.58	6.27	2.47
s 5.0 t h^{-1} + w 5.0 t ha^{-1}	108.16	29.33	19.28	5.16
s 5.0 t h^{-1} + w 7.5 t ha^{-1}	102.21	26.51	13.99	3.75

Note: s = cow manure; w = swallow manure

Table 3 shows that the shoots wet weight ranged from 67.80-112.80 g and the shoots dry weight ranged from 14.92-29.33 g. Meanwhile, the wet weight of the roots ranged from 6.27-19.87 g and the dry weight of the roots ranged from 2.47-5.16 g. Shoot and root wet and dry weight showed not significantly different. The results of the analysis of variance showed that the composition of organic matter had no significant effect on the root-shoot ratio. However, on the variable number of branches, the composition of organic matter has a significant effect. The average root-shoot ratio and the number of branches are presented in Table 4.

Table 4. The average ratio of root shoots and the number of branches of Hiyung cayenne to the composition of cow manure and swallow manure

Composition of Organic Matter	Ratio of Root Shoots	Number of Branches
Without Organic Matter	5.50	21.13 bc
w 2.5 t ha^{-1}	5.31	18.75 a
w 5.0 t ha^{-1}	4.61	23.00 cd
w 7.5 t ha^{-1}	6.17	25.13 d
s 2.5 t ha^{-1}	5.74	23.25 cd
s 2.5 t h^{-1} + w 2.5 t ha^{-1}	7.35	22.50 c
s 2.5 t h^{-1} + w 5.0 t ha^{-1}	6.52	23.00 cd
s 2.5 t h^{-1} + w 7.5 t ha^{-1}	7.28	23.25 cd
s 5.0 t ha^{-1}	6.31	23.00 cd
s 5.0 t h^{-1} + w 2.5 t ha^{-1}	5.19	23.38 cd
s 5.0 t h^{-1} + w 5.0 t ha^{-1}	6.32	25.00 d
s 5.0 t h^{-1} + w 7.5 t ha^{-1}	6.68	19.88 ab

Note: Numbers followed by the same letter in the same column are not significantly different according to the DMRT test at a 5% significance level
s = cow manure; w = swallow manure

The root shoot ratio of Hiyung cayenne planted on peat soil ranged from 4.61-7.35 (Table 4). Meanwhile, the highest number of branches was obtained from the treatment of swallow manure 7.5 t ha^{-1} which was significantly different with no organic matter, swallow manure 2.5 t ha-1, cow manure 2.5 t ha-1 + swallow manure 2.5 t ha^{-1} and cow manure 5.0 t ha^{-1} + swallow manure 7.5 t ha^{-1}.

IV. Discussion

Effect Organic Materials to Plant Height

During the growth period until 6 WAP, the treatment had no significant effect on plant height because the organic matter had not been completely decomposed. so that the nutrients were not fully available. Organic fertilizers generally take a long time to decompose completely. At weeks 6-12, the composition of organic matter of cow manure 2.5 t h^{-1} and swallow manure 7.5 t ha^{-1} resulted in the tallest plant. This shows that the decomposition process of organic matter has been completely decompose, so that the nutrients can be available to plants and affect the vegetative growth of plants. The high N content in swallow manure was able to increase plant height where at a dose of 7.5 t ha^{-1} was able to provide the highest plant height compared to a lower dose. The application of N in plants can accelerate the growth of plants as a whole, especially stems, branches and leaves [16]. This element is important in the formation of chlorophyll which is very important in photosynthesis. The combination with cow manure 2.5 t ha^{-1} can increase N levels, although not too high. So, even though giving a higher dose (5 t ha^{-1}) of cow manure, it did not make a difference to plant growth.

Similar to element N, elements P and K contained in both swallow manure and cow manure also have a role in increasing plant growth, such as plant height. P nutrients work together with N in the photosynthesis process which affects the process of cell division and cell elongation [17]. As explained in the book that N is the main element for the formation of the vegetative part of plants and P functions as a constituent of proteins that play a role in the photosynthesis process so that the resulting photosynthate can be translocated to support plant growth and development. Meanwhile some researcher stated that the function of element K is to activate the work of several enzymes in the body's metabolism and to stimulate the translocation of carbohydrates from leaves to other plant organs [16]. The K element contained in organic fertilizers helps the formation of protein so as to strengthen plant tissues during growth and development [17].

In addition to improving soil chemical properties, organic fertilizers are also known to improve soil physical properties related to soil structure, increase water holding capacity and soil aggregate stability. The biological properties of the soil are also improved through the application of organic fertilizers. The application of organic fertilizers can increase the biological activity of the soil. Soil humus content will increase so as to create a desired condition for plants to grow and develop optimally [19;20]. Organic materials such as organic fertilizers can absorb water longer than usual in the soil. Organic matter is useful for improving aeration and oxygen circulation in the soil [21]. That statement means that organic matter can increase soil biological fertility in peatlands which showed in this research result.

Effect Organic Materials to Stem Diamater

Similar to plant height, the treatment of organic matter composition had no effect on stem diameter on the early growth period until 5 WAP. Reaching 6 to 9 WAP, the composition of cow manure 2.5 t ha^{-1} + swallow manure 7.5 t ha^{-1} gave the best effect on stem diameter. Likewise, until 12 WAP, this composition still showed better effect among all treatments. Thus, the composition of cow manure 5.0 t ha^{-1} + swallow manure 5.0 t ha^{-1} is able to provide nutrients for growth and development of stem diameter. Plant growth and development is strongly influenced by nutrient availability. If the availability of nutrients is in optimal, plant survival will be maintained and gain optimal growth [22].

The development of stem diameter is related to the nutrient content of swallow and cow manure, especially N, P and K nutrients [17]. Supported by previous research statement that P and K elements promote the development of plant stem diameter, especially in their role as a liaison between roots and leaves [23]. The availability of P and K nutrients stimulated the formation of carbohydrates and reinforced the translocation of starch to the stem circumference [17].

Effect Organic Materials to Shoot and Root

On the other hand, the root system at the age of 3 WAP has developed well so that it supports the process of nutrient absorption in the soil. This explained by previous research that the increase in plant height is influenced by the development of the plant root system so that it is able to absorb available nutrients [25].

Root-shoot ratio is an important factor in plant growth which indicates the ability to absorb nutrients in plants [17]. There was no significant difference in the various compositions of cow manure and swallow manure on the root-shoot ratio, presumably because the shoot and root growth in each treatment were balanced. The ratio of shoot and root is a comparison of the growth of one part of the plant followed by the growth of other parts of the plant [27]. The increased shoot weight was followed by an increase in root weight [28]. This is because the nutrients provided are able to be absorbed and utilized by plants for the formation of shoots and roots in relatively the same ratio even though the nutrient supply is different [17].

Observations on the number of branches are carried out after harvesting plants so that the number of productive branches can produce fruit. The results of this study, the dose of swallow manure 7.5 t ha^{-1} and cow manure 5 t ha^{-1} + swallow manure 5 t ha^{-1} gave higher number of branches among all treatments. This shows

that the application of swallow manure can better ensure the availability of nutrients for plants until the harvest period. Swallow manure is an organic fertilizer that is able to release nutrients slowly and continuously and is always available whenever needed (slow release) [29]. This is needed during plant growth which takes place gradually and continuously, so the nutrients needed by plants must always be available at every phase.

The results of the wet weight and dry weight of shoots and roots indicated the absorption of water and nutrients by the roots which were translocated to the plant shoots [17]. Nutrients available to plants from the application of cow manure and swallow manure in various compositions showed the same results on wet weight and dry weight. It is suspected that the nutrients absorbed by the plants were already at the optimal point of growth, both the shoots and roots of the plants, because the observations were carried out after the fifth harvest. It is suspected that the available nutrients have been absorbed a lot for the vegetative growth process to the generative period which begins with flowering followed by fruit formation until ripe so that it can be harvested.

Nutrients N, P and K from the applied organic matter were absorbed during the growth period and there was an accumulation of organic compounds and water which contributed to the wet weight of the plant. In line with statement tthat the elements contained in organic fertilizers such as N, P, and K can increase plant metabolism, resulting in the accumulation of organic matter in plants which can ultimately increase the wet weight followed by an increase in plant dry weight [17]. P plays an important role as a universal energy source for biochemical activities in living cells, including the activity of cell division [26]. In line with this, if the activity of cell division increases it will be followed by an increase in plant weight.

In addition, when it reaches the generative phase, photosynthetic is more focused on the process of fruit formation and ripening. This causes the growth process of cayenne plants is no longer significant. According to theory that the dry weight of the plant is strongly influenced by the optimal photosynthesis process where the resulting dry weight indicates the amount of photosynthate [24].

V. Conclusion

The composition of cow manure and swallow manure had an effect on plant height at 9 and 12 WAP, stem diameter at 6, 9 and 12 WAP and the number of branches. The composition of cow manure 2,5 t ha^{-1} + swallow manure 7.5 t ha^{-1} gave the highest plant height at 9 and 12 WAP, 62.75 and 87.00 cm, respectively; the largest stem diameter at 6, 9 and 12 WAP, respectively 3.95; 7.55 and 8.30 mm. Meanwhile, the highest number of branches was obtained from the treatment of swallow manure 7.5 t ha^{-1} (25.13 branches).

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