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Enhanced Agronomic Efficiency in Pechay Using a Humate Soil Conditioner

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ABSTRACT

One of the most critical concerns in crop production is fertilizer-use efficiency. Hyperkompost, a potassium humate soil conditioner rich in humic acid, nitrogen, and potassium content, is a plant growth promotant for various crops that can be applied as a foliar and drenched amendment to enhance crop productivity. In this study, this humic acid-based product was evaluated for its potential in enhancing agronomic efficiency in pechay under farmer's field conditions. The experiment followed a randomized complete block design with three replications. Inorganic fertilizer was initially applied basally during seed sowing while the humates were drenched on standing crops at different time intervals. The study revealed that Hyperkompost Soil Conditioner was able to enhance pechay production in terms of total fresh yield, plant height, leaf length, leaf width, and the number of leaves. The plants treated with one dose of inorganic fertilizer recommended rate (rr) and one dose rr of Hyperkompost Soil Conditioner can significantly improve the yield and quality of pechay. In terms of its feasibility in pechay production, one dose of Hyperkompost Soil Conditioner at 20g per 16-liter water is highly recommended to obtain the highest possible income.

Keywords: pechay, Hyperkompost, soil conditioner, *Brassica rapa*, plant growth promotant

INTRODUCTION

Pechay (*Brassica rapa*) is an annual biennial herb and is one of the most common leaf vegetables in the Philippines. Its leaves are smooth and erect, 30 cm long, broad at the tip narrowing gradually at the base extending downward to the upper end of its elongated, thick, and whitish stalks, with flowers that are pale yellow (Cresastre, 2010). It is cultivated as an annual of about 15-30 cm tall in the vegetative stage. The petioles are enlarged and grow upright forming a subcylindrical bundle. Its seeds colored brown with black tinged are 1 mm in diameter. The leaves are green and mild flavored and less crisp than other cabbages. It is a short-duration crop, requiring an immediate source of nutrients. In the organic production of pechay, a plant food supplement that can assist in the immediate absorption of nutrients is needed. Furthermore, the continuous practice of tillage and planting on the same land every year has deleterious effects on soil texture and structure. Humic acid-based products have been used in recent years as fertilizer supplements to ensure the sustainability of agriculture production.

Many benefits could be derived from applying potassium humate in the soil. Humic acid (HA) plays an essential role in improving soil properties, plant growth, and agronomic parameters that can be sourced from coal, lignite, soils, and organic materials (Ampong et al., 2022). The application of humic acid (HA) has been reported to have beneficial effects on the texture and structure of degraded soils (Billingham, 2012; Yang et al., 2021). Increased

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adsorption of HA onto clay surfaces promotes soil structural stability (Chen et al., 2017). It increases the water-holding capacity or water retention ability of the soil with extended use. The addition of HA leads to the formation of chelates with cationic metals (Yamaguchi et al., 2004; Billingham, 2012). It increases the efficacy of fertilizer, by preventing excessive leaching away from the root zone and ultimately releasing it to the root zone as needed. It helps to reduce soil erosion by increasing the cohesive forces of very fine soil particles. It changes the physical and mechanical properties of the soil in structure, color, and consistency to a very great degree as the organic matter increases. It increases the permeability of plant membranes, enhancing the uptake of nutrients more efficiently. It improves the soil environment to its optimum, which is needed for the uninterrupted growth of various groups of beneficial microorganisms. It buffers pH problems, allowing plants to adapt better until the pH can be corrected. It decreases stress deterioration, until it can be corrected and increases the germination capacity of seed via the improved CEC levels of the soil.

The rising demand for the adoption of sustainable solutions is the major factor driving the growth of humic-based biostimulants in the global market, which is expected to reach an estimated value of USD 1,112.7 Billion and grow at a CAGR of 9.80% in the forecast period 2021 to 2028 (Data Bridge Market Research, n..d.). A product that shares this market is Hyperkompost, a natural soil conditioning substance and plant growth promotant for various crops. It is made up of 70% humic acid and 12% K_2O with a pH of 8-11, plus minor elements that include zinc, iron, and magnesium (Fertilizer and Pesticide Authority, 2022). Humic acid-based products are available mostly as concentrated aqueous solutions of potassium or sodium humates produced by alkali extraction of raw organic matter such as lignite, leonardite, or peat, and have substantial content of silicates due to the presence of clay minerals in the raw materials, (Karpukhina et al., 2019). Hyperkompost is marketed as a potassium humate soil conditioner that can be applied as a foliar and drenched amendment to enhance crop productivity. Hence, this study was designed to validate its agronomic efficiency-enhancing effect in pechay.

METHODOLOGY

The trial was conducted from October to December 2022 for one season Puypuy, Bay, Laguna Philippines. An open-pollinated pechay variety Pavito was used as the test crop/variety. Prior to preparing soil plots, surface (0-15 cm) soil samples were randomly collected from five different points on the trial site for soil analysis. The levels of soil organic matter, nitrogen, phosphorus, and potassium were determined, while moisture and pH were also measured. The trial field was plowed and harrowed twice in different directions, and 18 plots measuring 5x2 m^2 were prepared.

Seed Sowing. Five rows were line drilled covering the 5-meter drenches for each plot, with a distance between rows of 20 cm. Pechay seeds were sown along the trenches at a rate of 1 gram per 2 square meters.

Trial Design. The following treatments were used (Table 1), laid out in a randomized complete block design with three replications (Figure 1).

Table 1. Treatment combinations for the Hyperkompost agronomic efficiency trial in pechay

Treatment	BASAL APPLICATION	
	Inorganic Fertilizer	Hyperkompost @ Drench Spray
1	Control	
2	1 rr 425 kgs 14-14-14 & 200 kgs urea/ha	
3		1 RR 20 g Hyperkompost/ 16 L @ 15, 19, and 23 DAE
4	1 rr 425 kgs 14-14-14 & 200 kgs urea/ha	1 RR 20 g Hyperkompost / 16 L @ 15, 19, and 23 DAE
5	1 rr 425 kgs 14-14-14 & 200 kgs urea/ha	0.5 RR 10 g Hyperkompost / 16 L @ 15, 19, and 23 DAE
6	1 rr 425 kgs 14-14-14 & 200 kgs urea/ha	1.5 RR 30 g Hyperkompost / 16 L @ 15, 19, and 23 DAE

Note: *DAE – days after emergence

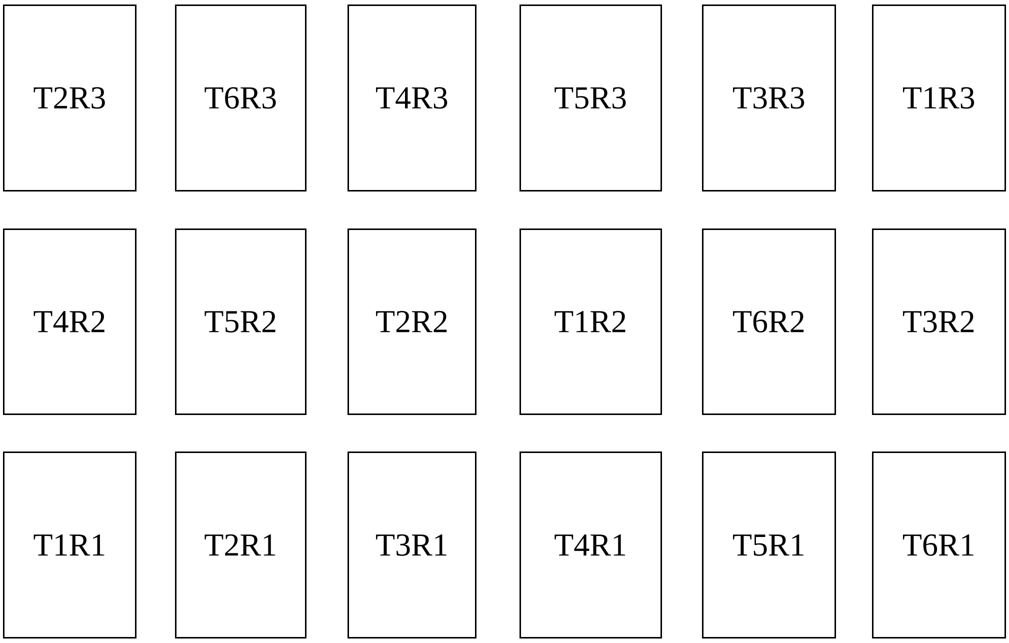

Figure 1. Treatment assignment of the field trial laid out in a randomized complete block design (RCBD) with three replications

The inorganic fertilizer was applied basally during the seed sowing while the humates were drenched on standing crops at different time intervals.

Cultural Management. The following cultural practices were implemented as needed:

- Irrigation. Watering was done every day depending on soil moisture content and weather condition.

- Weeding. Weeds were removed at weekly intervals to avoid competition with the crop.
- Cultivation. Tilling the soil was done to aerate the soil and to control some weed pests.
- Disease Control. Fungal diseases were controlled by applying fungicides.
- Insect Pest Control. Insect infestation was managed by applying insecticides to the target insect pest.

Harvesting. At 30 days after sowing, the pechay plants were harvested and sorted into either marketable or non-marketable based on appearance. Non-marketable yields were categorized based on plants whose leaves had damage, and holes ≥1 cm dia.

Data Gathering. The fresh weight yield of the above-ground biomass plants was measured and recorded as kg/ha. While the non-marketable yield was recorded as percent (%) of the total (marketable + non-marketable) yield. Growth parameters such as plant height, number of leaves, and leaf width were measured from a sample of 30 plants per treatment (10/rep).

Data gathering procedure:

- Fresh weight yield – Total yield was derived from matured plants harvested per treatment per replication. The plants for each plot were weighed using a standard weighing scale.
- Percent marketable and non-marketable yield – This was computed after separating the marketable from non-marketable plants. Non-marketable plants are plants that are deformed, small, and damaged by insects or other organisms (≥ 1 cm holes).
- Plant height – The distance between the base of the plant and the longest/highest leaf was measured using a ruler after harvesting. A sample of 10 plants per replication was measured.
- Number of leaves – The number of mature leaves not smaller than one-inch diameter was counted. A sample of 10 plants per replication was measured.
- Leaf width – This was done by getting 10 sample plants per replication and measuring the biggest leaf for each plant.

Data Analysis and Interpretation. The data were analyzed statistically using Genstat for Windows 22nd Edition (16). Analysis of variance and treatment mean comparison using Tukey's HSD Test were performed at 5% level of probability. Two-way tables were prepared to show the means and their corresponding alphabet notations. Interpretations were done by comparing all pairs using a studentized range distribution that evaluated every pair of all groups. Conclusions and recommendations were formulated based on the results generated.

RESULTS

Effect on Total Fresh Yield of Pechay

The total yield was derived from the 10 m^2 plot area and converted to fresh yield per hectare (Figure 2). The highest fresh yield was obtained from the plants treated with the 1rr Hyperkompost Soil Conditioner + inorganic fertilizer (Table 2), however, this was not significantly different from the plants treated with 1.5rr Hyperkompost Soil Conditioner + inorganic fertilizer. On the other hand, the lowest fresh yield was obtained from the control plants which were comparable to the plants treated with 1rr Hyperkompost Soil Conditioner alone. Moreover, the plants treated with inorganic fertilizer alone and ½rr Hyperkompost Soil Conditioner + inorganic fertilizer were comparable with each other having the median values among the treatments.

The results revealed that pechay plants were responsive to the recommended rate of Hyperkompost Soil Conditioner at 20g per 16 liters water, thrice application plus inorganic fertilizer, which gave a yield increase of 2.54 and 5.11 tons per hectare over the granular inorganic fertilization alone and the control, respectively. Hyperkompost Soil Conditioner was already effective at 20 g per 16-liter water in combination with inorganic fertilizer and higher rates would not provide any significant yield advantage.

Table 2. Total fresh yield of pechay treated with Hyperkompost Soil Conditioner

TREATMENT		MEAN YIELD (tons/ha)			MEAN*
		1	2	3	
1	Control	4.10	3.33	1.75	3.06 c
2	Inorganic Fertilizer alone	6.38	6.18	4.33	5.63 b
3	20 g Hyperkompost alone (1rr)	2.95	2.60	3.88	3.14 c
4	Inorganic Fertilizer + 20g Hyperkompost Soil Conditioner	8.15	11.05	5.30	8.17 a
5	Inorganic Fertilizer + 10g Hyperkompost Soil Conditioner	8.28	6.78	3.60	6.22 ab
6	Inorganic Fertilizer + 30g Hyperkompost Soil Conditioner	10.08	6.95	4.48	7.17 a

Note: cv= 47.25642, $p<0.001$; *Means with the same letter are not significantly different at $\alpha = 0.05$ by Tukey's HSD.

Figure 2. Plots for the different treatment: (Top row, L-R) Control plants (T1R1), Inorganic fertilizer alone (T2R2), 1rr Hyperkompost Soil Conditioner alone (T3R2); (Bottom row, L-R) 1rr Hyperkompost Soil Conditioner + inorganic fertilizer (T4R2), ½rr Hyperkompost Soil Conditioner + inorganic fertilizer (T5R2), 1.5rr Hyperkompost Soil Conditioner + inorganic fertilizer (T6R2).

Effect on Number and Percent Marketable Yield of Pechay

The marketable yield was found to be equivalent to the total yield since the pechay plants were all in good condition, with no significant damage observed, and the quality passed the requirements of the consumers (Figure 3). The leaves are free from any insect damage, deformities, and disease symptoms. The preventive measure applied was successful in preventing any economic damage to the pechay plants, thus all plants were considered acceptable to the consuming public.

Figure 3. Harvested pechay sample for data gathering, in good condition with no significant damage observed, and the quality has passed the requirements of the consumers

Effect on Plant Height of Pechay

The plant height data was gathered during harvesting by measuring the length between the base of the plant and the tallest leaf. The data showed that the tallest plants were obtained from the plants treated with 1rr Hyperkompost Soil Conditioner + inorganic fertilizer but were not significantly different from the 1.5rr Hyperkompost Soil Conditioner + inorganic fertilizer treated plants (Table 3). On the other hand, the shortest plants were obtained from the control plots which were significantly different from the rest of the treated plants except for the 1rr Hyperkompost Soil Conditioner alone treated plants. The inorganic fertilizer-treated plants were significantly different from the rest of the treatments except for the ½rr Hyperkompost Soil Conditioner + inorganic fertilizer-treated plants. The data have demonstrated that Hyperkompost Soil Conditioner has an enhancing effect on the growth of pechay, however, higher rates beyond 20 g per 16 liters of water did not make any significant difference at all.

Table 3. Plant height of pechay treated with Hyperkompost Soil Conditioner

TREATMENT		PLANT HEIGHT (cm)			MEAN*
		1	2	3	
1	Control	18.90	18.60	18.20	18.57 c
2	Inorganic Fertilizer alone	23.60	22.20	22.00	22.60 b
3	20 g Hyperkompost alone (1rr)	20.00	19.10	19.40	19.50 c
4	Inorganic Fertilizer + 20g Hyperkompost Soil Conditioner	25.10	24.00	23.30	24.13 a

5	Inorganic Fertilizer + 10g Hyperkompost Soil Conditioner	23.20	22.30	22.90	22.80 b
6	Inorganic Fertilizer + 30g Hyperkompost Soil Conditioner	24.70	25.50	21.80	24.00 a

Note: cv 10.77629, p<0.001; *Means with the same letter are not significantly different at α = 0.05.

Effect on Leaf Length of Pechay

The leaf length data were collected from the biggest leaf of each plant sample (Table 4). The data followed a similar trend to the plant height data. The longest leaves were obtained from the plants treated with 1.5rr Hyperkompost Soil Conditioner + inorganic fertilizer and were significantly different from the rest of the treatments, except with the 1rr Hyperkompost Soil Conditioner + inorganic fertilizer. Further, the shortest leaves were obtained from the control plants but were comparable with the 1rr Hyperkompost Soil Conditioner alone treated plants.

Table 4. Leaf length of pechay with Hyperkompost Soil Conditioner at harvest

TREATMENT		LEAF LENGTH (cm)			MEAN
		1	2	3	
1	Control	11.90	12.20	9.80	11.30 c
2	Inorganic Fertilizer alone	15.40	12.10	12.20	13.23 b
3	20 g Hyperkompost alone (1rr)	12.60	11.50	11.80	11.97 c
4	Inorganic Fertilizer + 20g Hyperkompost Soil Conditioner	13.90	14.60	13.90	14.13 a
5	Inorganic Fertilizer + 10g Hyperkompost Soil Conditioner	14.60	13.30	12.90	13.60 b
6	Inorganic Fertilizer + 30g Hyperkompost Soil Conditioner	14.80	15.00	12.70	14.17 a

Note: cv 13.95929, p<0.001; *Means with the same letter are not significantly different at α = 0.05.

Effect on Leaf Width of Pechay

The leaf width data were gathered from the biggest leaf of each plant at harvest (Table 5). Once more, the data trend was very similar to the plant height. The data showed that the widest leaves were from the plants treated with 1rr Hyperkompost Soil Conditioner + inorganic fertilizer and were significantly different from the rest of the treatments, except for the 1.5rr Hyperkompost Soil Conditioner + inorganic fertilizer treated plants. Furthermore, the narrowest leaves were obtained from the control plants and were significantly different from the rest of the treatments, except for the 1rr Hyperkompost Soil Conditioner alone treated plants.

Table 5. Leaf width of pechay with Hyperkompost Soil Conditioner at harvest

TREATMENT		LEAF WIDTH (cm)			MEAN
		1	2	3	
1	Control	8.60	8.90	6.80	8.10 c
2	Inorganic Fertilizer alone	11.90	11.10	9.30	10.77 b
3	20 g Hyperkompost alone (1rr)	8.80	8.30	8.40	8.50 c
4	Inorganic Fertilizer + 20g Hyperkompost Soil Conditioner	11.60	11.90	10.90	11.47 a
5	Inorganic Fertilizer + 10g Hyperkompost Soil Conditioner	11.80	11.40	9.30	10.83 b

6	Inorganic Fertilizer + 30g Hyperkompost Soil Conditioner	12.60	10.70	10.50	11.27 a

Note: cv 15.46810, p<0.001; *Means with the same letter are not significantly different at α = 0.05.

Effect on Number of Leaves of Pechay

The number of leaves data was obtained by counting all matured leaves bigger than one inch in size and summarized in Table 6. The highest number of leaves was obtained in the plants treated with 1.5rr Hyperkompost Soil Conditioner + inorganic fertilizer which was significantly different from plants treated Hyperkompost Soil Conditioner at any rate + inorganic fertilizer. Moreover, the least number of leaves was obtained from the 1rr Hyperkompost Soil Conditioner alone treated plants. All the plants treated with either inorganic fertilizer alone or in combination with Hyperkompost Soil Conditioner, at any rate, were comparable with each other, except for the 1rr Hyperkompost Soil Conditioner treated plants.

Table 6. Number of leaves of pechay with Hyperkompost Soil Conditioner at harvest

TREATMENT		NUMBER OF LEAVES			MEAN
		1	2	3	
1	Control	7.50	3.30	2.70	4.50 b
2	Inorganic Fertilizer alone	5.10	4.50	3.60	4.40 b
3	20 g Hyperkompost alone (1rr)	4.20	3.00	3.60	3.60 c
4	Inorganic Fertilizer + 20g Hyperkompost Soil Conditioner	5.20	4.60	4.50	4.77 ab
5	Inorganic Fertilizer + 10g Hyperkompost Soil Conditioner	5.10	4.80	3.70	4.53 ab
6	Inorganic Fertilizer + 30g Hyperkompost Soil Conditioner	5.60	4.70	4.50	4.93 a

Note: cv 24.07884, p<0.001; *Means with the same letter are not significantly different at α = 0.05.

DISCUSSION

The enhancing effect Hyperkompost, a natural soil conditioning substance and plant growth promotant for various crops, was studied for its ability to improve pechay production based on total fresh yield, plant height, leaf length, leaf width, and the number of leaves. The treatment with Hyperkompost was found to be an effective enhancer of pechay plants' agronomic efficiency. The humic acids (HA) contents of this soil conditioning substance play an essential role in improving soil properties, plant growth, and agronomic parameters (Ampong et al., 2022), resulting in better yield in the pechay plants used in the present study. Better growth and development of plants, and most especially in yield were observed after treatment with a humate fertilizer in many crops (Ilieva & Vasileva, 2013) (Kumar & Singh, 2017; Kumar et al., 2013).

Pettit (2004) explains that man became distracted from the importance of organic compound cycling when soluble acidic-based NPK fertilizers were found to promote plant growth, however, the continued use of these acidic fertilizers in the absence of adequate humic substances (in the soil) has caused ecological and sociological problems. Thus, man needs to reconsider preserving soil humus in the fertilization approach, and the importance of humic substances and their value as fertilizer ingredients should be emphasized.

According to Billingham (2015), there are numerous humic products available in the market with the promise of enhanced plant growth and improved soil physical, chemical, and biological properties with claims closely resemble the properties of humic substances that are naturally occurring in soils responsible for most of its functions. There are doubts about whether the claims can be made for humic products based on their similarity to humic substances in soils. However, in the present study, it was clearly demonstrated that adding Hyperkompost to the plants significantly improved its agronomic efficiency. A major consideration is the cost of the product and recommended application rates, so producers are encouraged to conduct their own trials before committing to a major purchase of humic products. The results of the present study have shown that there is an optimum level of the product to be applied, and anything beyond that will not be profitable anymore. In terms of its feasibility in pechay production, one dose of Hyperkompost Soil Conditioner at 20g per 16-liter water is highly recommended to obtain the highest possible income.

CONCLUSION

The new product, Hyperkompost Soil Conditioner performed well in the trial by giving yield advantages over the control and slightly to the conventional inorganic fertilization. The study revealed that the test product was able to enhance pechay production in terms of total fresh yield, plant height, leaf length, leaf width, and the number of leaves, with an estimated increase of more than 31.09%, 6.34%, 6.4%, 6.1%, and 7.76%, respectively relative to inorganic fertilizer application alone. The plants treated with 1rr Hyperkompost Soil Conditioner + inorganic fertilizer can significantly improve the yield and quality of pechay. In addition, the bioefficacy data on total fresh yield, plant height, leaf length, leaf width, and number of leaves, showed significant differences with the control. The control plants are relatively inferior in quality in terms of size and color. Thus, Hyperkompost Soil Conditioner can be applied as a foliar and drenched amendment to enhance pechay production.

In general, pechay is very responsive to granular fertilization and the application of Hyperkompost Soil Conditioner. At a very conservative amount of 920 grams/hectare + the recommended rate of inorganic fertilizer, it gave a yield advantage of 2,540 and 5,110 kgs/ha over the full dose of inorganic fertilizer and the control, respectively. This could be translated to additional income of PhP 76,200 (USD 1,370.50) to PhP 153,300 (USD 2,757.20) per hectare at Php 30/kg (USD 0.54) (as of December 2022 farm gate price) over the full dose of inorganic fertilizer alone and the control, respectively.

The data also revealed that the granular inorganic fertilization generally dictates the growth and performance of pechay but the addition of a Hyperkompost Soil Conditioner would further improve the quantity and quality of harvested pechay. In terms of its feasibility in pechay production, one dose of Hyperkompost Soil Conditioner at 20g per 16 liters of water is highly recommended to obtain the highest possible income.

It is hereby recommended that Hyperkompost Soil Conditioner be used on pechay and bioefficacy tests be conducted on other crop groups especially the fruit-bearing vegetable crops to determine its optimal effects on fruit set.

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