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Study on evaluating the effectiveness of compost fertilizer from jackfruit peel and fiber with various local agricultural materials on Green Mustard (*Brassica juncea*)

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Abstract. In recent years, jackfruit production in Vietnam has been growing very strongly in both quantity and quality. However, most of the jackfruit is harvested and processed for meat, the rest is the jackfruit peels, and fibers are discarded, which will affect environmental sanitation. The study aims to enhance the value of jackfruit by taking advantage of nutrient ingredients in the peel and fiber of jackfruit to blend into organic fertilizer. Initial results show that the compost substrate samples mixed with rice husk ash and coir and the organic substrate sample mixed with coconut fiber had the best quality. Tested nutritional ingredients include including humidity is 76.1%, total organic carbon content is 27.3%, fulvic acid is 0.9%, humid acid is 0.9%, total nitrogen is 0.85%, total phosphorus is 0.57% after 35 days of incubation. Their quality meets the national standards of QCVN 01-189: 2019/BNNPTNT on fertilizer quality. After testing all three samples of organic substrates on the green mustard with germination rate (%), a number of branches, and total fresh weight (g), the results showed that test plants are grown with the compost from the shell - jackfruit fiber mixed with coconut fiber developed better than the control sample.

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1 Introduction

Jackfruit (*Artocarpus heterophyllus*) is widely grown in the Mekong Delta, with an estimated production of about 33 thousand tons annually. In particular, in provinces such as Tien Giang, Dong Thap, Vinh Long - this plant is being expanded in the cultivation area. There are many types of jackfruit, such as honey jackfruit, wet jackfruit, chewy jackfruit, marang jackfruit, and Thai jackfruit. From there, products from jackfruit are very diverse such as fresh jackfruit, dried jackfruit, jackfruit yogurt, and jackfruit wine. However, the fruit pulp (edible) accounts for only 28.2%; by-products accounted for 71.8%, of which jackfruit fiber and peel accounted for 25.3% [1]. According to statistics, in 2020, Tien Giang will be the locality with the largest area of jackfruit in the Mekong Delta, with a total area of 6.031 ha. The harvested area is 3.797 ha, the yield is 20.5 tons/ha, output reaches 77.675 tons. The total area of jackfruit newly planted on paddy land from 2017 to now is 1150 ha. The rest is converted and intercropped in other orchards in Cai Be, Cai Lay, and Cai Be districts. In particular, the area is expanding rapidly on pineapple growing land in the Tan Phuoc district. However, most production is at a household scale and processed by traditional technology, so there is no appropriate method to deal with the by-products of jackfruit. Therefore, the utilization of by-products is essential, especially the by-products with high use-value, to create value-added products and reduce environmental pollution.

Several issues need attention regarding opportunities and challenges to increase the value of jackfruit. First of all, the large volume of jackfruit compared to other fruits and the amount of jackfruit fiber in one fruit is greater or equal to the pulp (edible portion). Using only a tiny part of the total volume causes economic and material waste. On the other hand, the known nutritional values of 100g of fruit pulp and fiber contain 287-323 mg of potassium, 30.0-73.2 mg of calcium, and 11-19 g of carbohydrates. Using the fruit pulp and taking advantage of the by-products of jackfruit such as peel and fiber [2]. Secondly, the phenomenon of black fiber appearing in Thai jackfruit (the most grown type) has increased, reducing the commercial value significantly. Black fibrous jackfruit can only be sold for 30-40% of the standard value, or even not sold if the level of black fiber is too heavy. Until now, the cause of the blackening phenomenon has not been determined [3]. Finally, Vietnam's agricultural industry currently mainly uses chemical fertilizers, so chemical residues in these fertilizers pollute the soil and water environment, affecting many organisms as well as humans [4]. Chemical fertilizers are being used very widely; even it is an essential factor directly determining crop yield. However, the widespread use of chemical fertilizers for a long time has caused agricultural land to lose most of the inherent organic matter of the soil. Therefore, productive land has been seriously degraded [5]. According to many studies, chemical fertilizers still play an essential role, but combining them with organic fertilizers is necessary to regulate and improve the soil. Using organic fertilizers has been proven to replace 50-100% of chemical nitrogen fertilizers. The organic fertilizers contain many humus substances, easily degradable organic matter, and the microbial community is close to the soil's microflora [6]. So, that supports the soil recovery, retains moisture well, and enhances the soil's ability to improve the soil for beneficial microorganisms to be active, making the soil more porous [7].

Besides, the research on the use of industrial waste products such as bark, fiber, and seeds of plants as organic fertilizer is a new idea in agriculture, and it is being developed globally. Some studies recently aim to recycle and create value-added products as well as contribute to reducing environmental pollution [8-10]. Various other research on the mixing of substrates will bring the best effect for the product after composting, such as Mercy.S et al. researched the fruit peels of bananas, pomegranates, sweet lemons, and orange are rich in potassium, ions, zinc. The results after 45 days show that the product is capable of vegetative growth on pecans through natural fertilization [11].

Hence, within the framework of aiming to improve the value of jackfruit, including making use of the whole jackfruit to create added value, researching to take advantage of by-products from jackfruit to produce organic media to solve the problem of residual resources of jackfruit is necessary and urgent. The resulting data can use as a reference guide to organic fertilizers production for planners to have more information and options.

2 Materials and research methods

2.1 Research Materials

2.1.1 Co-mixed substrate materials

Jackfruit fiber and peel were collected from jackfruit orchards and fish in Vinh Kim area, Chau Thanh district, Tien Giang province and My Long commune, Cai Lay district, Tien Giang province. Actinomycetes and fungi Trichoderma were isolated and propagated at the Faculty of High-Tech Agriculture - Nguyen Tat Thanh University. Substances such as rice husk ash and coconut coir were purchased at a retail store in My Tho city. Green mustard seed (Brassica juncea) was bought from Phu Nong seed brand (Can Tho City). The main ingredients for mixing and composting are shown in figure 1.

Fig. 1. Mixing materials for the production of compost (A) peel and fiber of jackfruit; (B) coconut coir; (C) husk ash.

2.1.2 The characteristics of the substrate materials

The characterization of input materials is critical for selecting a suitable and highly effective treatment method [12]. Therefore, fiber and husk of jackfruit, coir, and rice husk ash after collection are carried out for physicochemical analysis. The results in Table 1 show that the raw materials are very suitable for composting.

Table 1. The concentration of nutrient ingredients of input materials

Input materials	ToC (%)	Total nitrogen (%)	Humidity (%)
Fiber and jackfruit peel	18.8	3.9	85.6
Coconut coir	18.7	1	10
Husk ash	64.8	0.5	5

From the properties of the ingredients, based on the reference formula of Dougherty et al., calculate the required volume for the C/N ratio with a value of about 20 - 30 for the best composting process [13]. However, the input materials often do not have enough organic carbon content, so other substrates need to be mixed. The composting process of the treatments and the amount of materials used in the treatments (M1, M2, and M3) are shown in Figure 2.

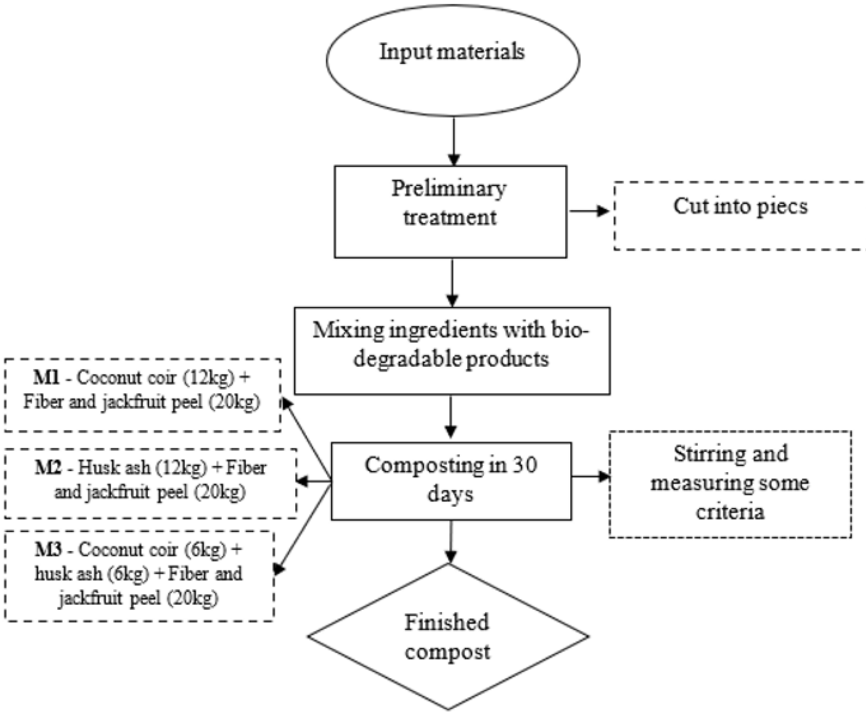

Fig. 2. Composting completion process and mass of ingredients materials.

2.2 Experiments and evaluation criteria

According to the above diagram, the experiment was arranged with 60kg of soil being homogenized, pounded to loosen, dried for three days, then performed as above treatments, and then put in a barrel with a hole in the bottom of the box. Carry out sowing according to the process of removing spots, each pot will have ten holes, and each hole will put two mustard seeds with a distance of 20cm between rows, 15cm between plants. The experiment was arranged in a completely randomized design so that the care was the same. These treatments are distributed as follows: S1 (control): control sample (chemical fertilizer); S2: M1 (coconut fiber); S3: M2 (rice husk ash); S4: M3 (coconut fiber + rice husk ash); S5: M1 and chemical fertilizers; S6: M2 and chemical fertilizers; S7: M3 and chemical fertilizers.

The total of the experimental boxes is 21 boxes (with seven treatments in triplicate) with an area of 0.15m2 (0.465 x 0.33) each. The time to apply fertilizer two times is priming before sowing and finishing after 12 sowing seeds. The monitoring and harvesting time for the experiment period was 35 days. The criteria evaluated after finishing and harvesting included the height of each plant (cm), the number of leaves (branches) of each plant, and the fresh weight of each plant (g).

The data collected from the experimental treatments were entered and preliminarily processed by Excel 2016. Then, run statistics (frequency and description mean, standard deviation, max, min, One–way ANOVA) using SPSS 20.

3 Results and discussion

3.1 The nutritional quality of the product after compost handling

After 30 days of incubation, the data in Figure 3 showed that the total nitrogen content of sample M1 (coconut coir) was the highest at 0.85%, compared with sample M2 (husk ash) 0.49% and M3 (coconut coir and husk ash) 0.60%. Samples M1 (coir) and M3 (coconut coir - husk ash) both have organic content reaching the permissible threshold of (QCVN 01-189:2019/BNNPTNT on fertilizer quality) of 27.3% and 25.1% of sample M2 (husk ash) with low organic content 11.6% failed to compare with (QCVN 01-189:2019/BNNPTNT on fertilizer quality) [14]. Although the input humidity is quite high at 85.6%, the moisture content is optimal at 20-30% after incubation with well-mixed and controlled substrates. This humidity will create favorable conditions for microorganisms to mineralize organic compounds and for storage [15].

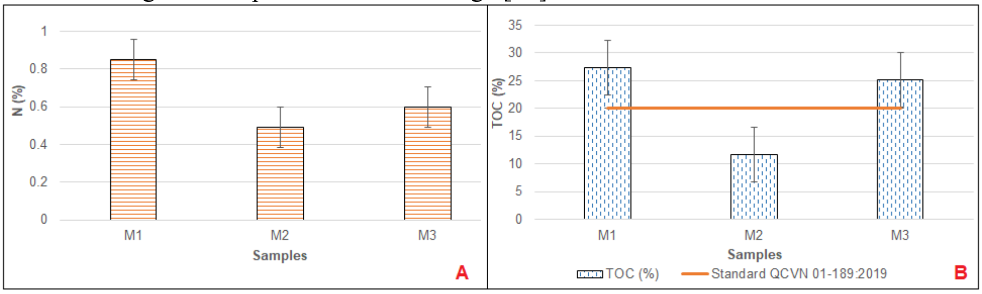

Fig. 3. Nitrogen (A) and total organic carbon (B) content of the treatments

With the humid acid of three treatments, the organic substrates are equal to 0.9%. Organic media containing humic acid content has been shown to have many outstanding effects on plants, from seed germination to growth. Humic acid, along with other humus acids such as fulvic acid applied to the soil, stimulates the development of the root system to absorb nutrients better and grow more robust plants. Humic acids can form complexes with ions commonly found in humic colloidal media, which function as necessary metal storage and ion exchange system. Fulvic acid is the most efficient carbon composed of the above nutrient-storing compounds. They are plant-friendly compounds and are therefore non-toxic when applied in relatively low proportions [16].

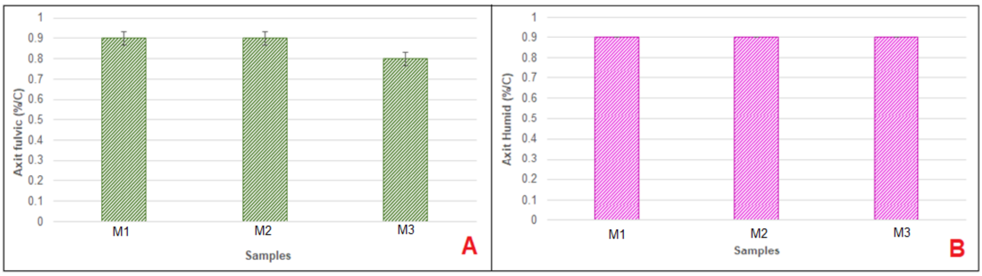

Fig. 4. Contents of (A) fulvic acid and (B) humid acid in the treatments Nitrogen (A) and organic (B) content of the treatments

3.2 Evaluating the effectiveness of the composting products on green mustard

Germination is the growth of a plant located inside a seed, resulting in the formation of a seedling. However, in some cases, after sowing, when they encounter adverse environmental conditions, they will not be able to germinate; they are called failed seeds [17]. The experiment was carried out under optimal conditions of the external environment with porous soil, disinfected with lime to kill pathogenic microorganisms, covered soil not exposed to direct sunlight, provided enough water twice a day. The results of Figure 5 show that on the 3rd day, the germination rate of 21 pots has not reached, in which the germination rate of pot 1, pot 8, pot 11, pot 14, pot 20, and 21 is the highest above 25 %. The germination rate of pot 2, pot 15, and 18 is the lowest, less than 10%. But on the 5th day, the pots were all germinated with a germination rate of over 90%.

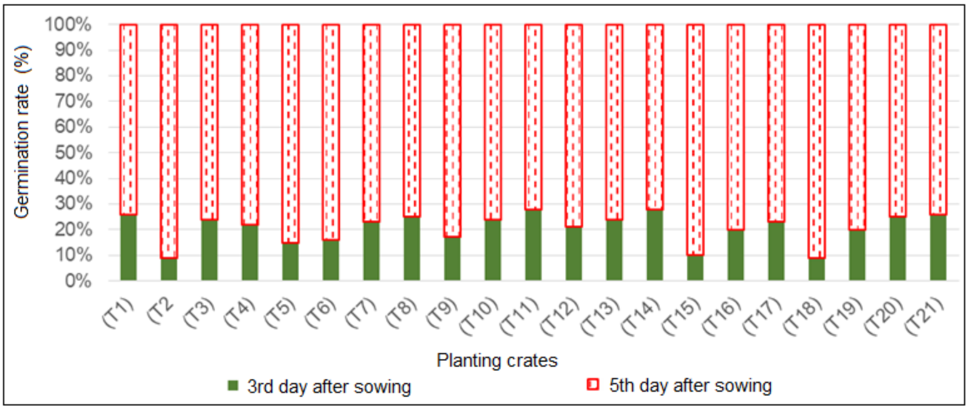

Fig. 5. Germination rate (%) of 21 boxes on the 3rd and 5th day after sowing.

The results in Figure 6 show that the number of plants of the treatments is higher than the Control treatment. Treatment S4 had 50% of plants with 10-13 leaf branches and 50% of plants with 7-10 leaf branches. Meanwhile, treatment S2 had the highest number of branches ranging from 4 to 13 leaves; 50% of the plants had 9-13 leaves, and 50% had 4-9 leaves. The Control sample is stable with 100% of the trees with the number of branches from 7-10 leaves. At the time of harvest, treatment S5 gave the best leaf tillering results on an average of 9.93 leaves/plant, and the lowest sample was the control treatment with 7.86 leaves/plant.

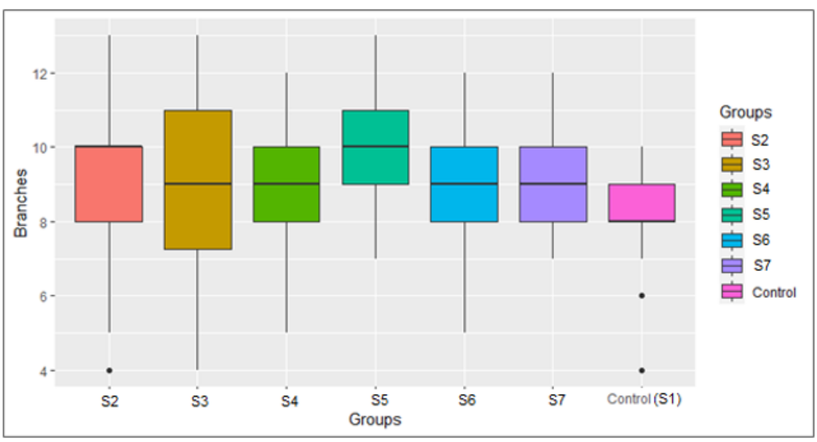

Fig. 6. Number of leaf branches of the experimental treatments

Compared with the study Phan Thi Thanh Thuy et al., it was found that the treatment with coffee pods supplemented with *Trichoderma* had the best compost quality, and the foliar yield was 9,603 leaves/plant, the control treatment had the lowest foliar production. is 5.64 leaves/plant [18]. According to the research results of Le Thi Minh Nguyet and colleagues using compost from green beans and weeds on green mustard, the number of common leaves is 7-8 leaves [19]. Thus, the result shows that the type of fertilizer affects the leaves of the green mustard. When the plants are fertilized with organic substrate and chemical fertilizers, the plants will grow better and produce more leaves.

Good root development will bring not only better vigor and growth but also increased disease resistance. [20]. Figure 7 (A) showed that the root length of the plants in all treatments was about 25% higher than the control treatment. The control sample had a root length of 4.3 - 6.1cm, while treatment S7 had the lowest range from 5.7 - 9.4 cm. Treatment number S2 was the highest with the highest variation from 3.1 to 12.5cm, 75% of plants with root length from 7.5 to 12.5cm more elevated than the other treatments, 50% of plants with root length from 3.1 up to 6.5cm. Thus, it can be seen that when using organic substrate support to the roots of green mustard will develop better.

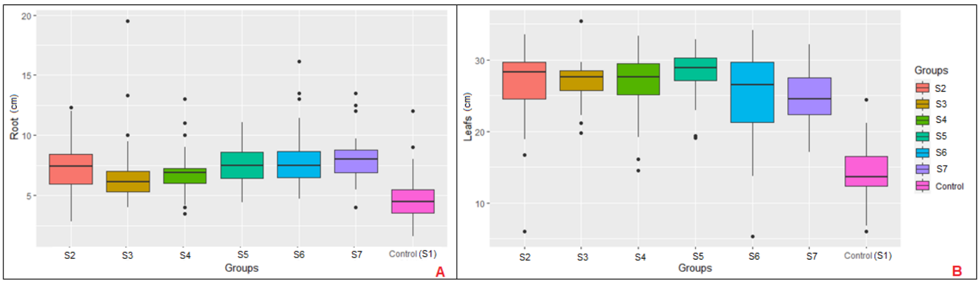

Fig. 7. Length of roots (A) and leaves (B) of experimental treatments

Figure 7 (B) shows that the leaf length of the treatments is higher than that of the control sample. Treatments S6 and S2 had the highest range from 14.05 to 34.11 cm and 18.9 to 33.50 cm. The control sample has 50% of the plants with leaf lengths from 18 to 21.5cm, but many plants have a low leaf length of about 5.3cm. Treatment S5 had the highest and best leaf length, with 75% of plants having leaf lengths between 26 and 36 cm. Compared with Thanh Thuy et al. with the application of compost from cashew shells, this experimental result was higher. The treatment with the addition of inoculant reached the highest level of about 17.62 cm, second place was the treatment mix with activated sludge 16.95 cm, and the control treatment was also the lowest with 11.66 cm [18].

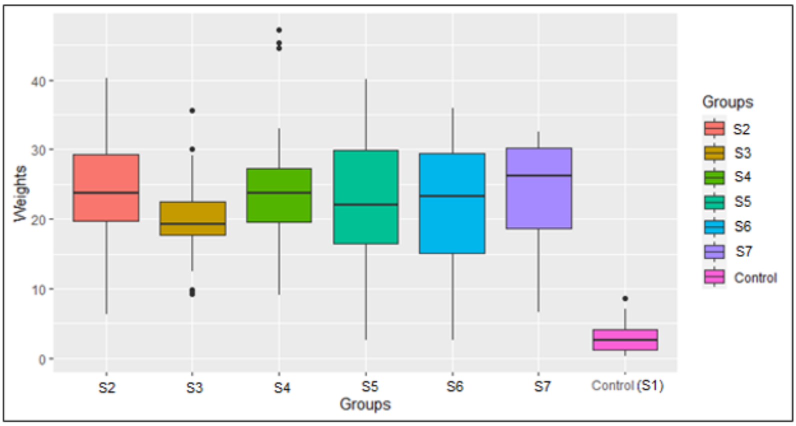

Fig. 8. Statistical weight and irrigated weight of the green mustard in the experimental treatments

From the results of Figure 8, it can be seen that all treatments have a higher fresh weight than the control sample. Treatment S5 had some of the largest and heaviest plants up to over 40g. Treatment S7 with the highest weight was with plants weighing from 8.6 to 35.91

grams/pot, while the lowest was the control with plants weighing from 1.25 to 7.07g. Compared with the research results of Nguyen Thi Minh et al., using compost from mushroom by-products to grow vegetables, the vegetable yield was 28.94 grams/pot, the control treatment had a vegetable yield of 6.06 grams/pot [21]. Thus, it can be seen that the control sample is equivalent to the results of Nguyen Thi Minh, but the remaining treatments are better.

The Anova assessment results with the observed significance level Sig = 0.000 < 0.05 show a statistically significant difference between the above plants of each treatment and the control sample. Evaluating the difference based on the index of leaf branches found that three treatments such as S2, S3, and S5, had significant differences with the control sample. The treatment S5 had the most and the highest difference. The results of the evaluation of differences based on the root length of the plants showed that the treatment S2 (sample added with coconut fiber) was the best and had a significant difference. The evaluation of differences based on the average weight of the plants showed that treatment S2 (samples with coconut fiber added) and S5 (samples supplemented with coir fiber and chemical fertilizers) had the best effect on supporting plant growth. In general, the experimental results show that the treatments of compost from the bark and jackfruit fiber mixed with coir (can be used in combination with chemical fertilizers) will give good yields.

Thus, the experimental results show that using organic substrates is better than using only chemical fertilizers. Especially when using a combination of organic and chemical fertilizers simultaneously, the cabbage plants grow and develop more than usual. This combination will lead to further studies on the appropriate ratios of organic and chemical fertilizers to bring the highest yield and savings on farming costs.

4 Conclusion

After composting, the treatments for jackfruit peel and fiber met the organic fertilizer standards based on the technical fertilizer regulations of QCVN 01-2019/BTNMT. Thus, coconut fiber and rice husk can be mixed with fiber and jackfruit skin to produce organic substrates to take advantage of nutrients and resources, bring economic efficiency, and protect the environment. Evaluating the results of applying organic substrate on green mustard showed that the quality of organic substrate affects the growth and development of green mustard and is better than the control sample (chemical fertilizer). The best growth and development was in the S5 treatment applied with chemical fertilizers. The growth parameters of the tree were recorded as follows: highest tree height 40.15 cm and average 21.90 cm/plant, highest 13 branches and average 9.60 leaves/plant, average root length 7.16 cm/plant, and the harvest yield reached 5.65 kg/0.15 m^2.

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