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The Utilization of Palm Oil Mill Effluent Decanter Cake as an Organic Fertilizer on Edamame Type Soybean (*Glycine max*)

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Abstract. Decanter cake is a solid waste from a palm oil mill with quite a lot of availability and has not been utilized optimally. This research aimed to utilize decanter cake (DC) palm oil mill solid waste as solid Fertilizer and liquid Fertilizer to increase the growth and yield of Edamame. The research design used was a Randomized Block Design (RBD) with a treatment of solid DC with liquid DC, namely solid DC 0 tons ha^{-1}, 10 tons ha^{-1}, and 15 tons ha^{-1}, with liquid DC concentrations of 0 % and 100 %. The variables observed were the number of leaves, number of pods, weight of pods, and yield of Edamame per hectare. The results showed that the highest number of leaves was achieved at 15 tons ha^{-1} solid DC dose with 100 percent liquid DC concentration. Likewise, the highest number of pods and weight of pods was at a quantity of 15 tons ha^{-1} and had the same effect as a dose of 20 tons ha^{-1} with a 100 percent liquid DC concentration. The best edamame yields per hectare were achieved in 15-ton ha^{-1} solid DC and 100 percent liquid DC concentrations.
Keywords: decanter cake; edamame; solid waste; soybean

INTRODUCTION

Green soybeans, or Edamame-type soybean, are harvested when the pods are whole but green. This plant, from its appearance, is taller than ordinary soybeans, with larger seed sizes, a refreshing taste, and is tender and easy to digest. Edamame is one type of nut widely used as a snack to lose weight. Besides having a good taste, Edamame is also rich in nutrients. Green soybeans are rich in protein and calcium but low in calories and cholesterol. This makes Edamame suitable for consumption when dieting. Fresh green pods have lower oil content and relatively higher protein and must be harvested at the right time to get maximum texture and taste. (Wszelaki et al., 2005), Late harvesting will reduce the quality. The potential of Edamame in Indonesia can reach 10-12 tons per hectare, but its productivity is only 7.5 tons per hectare (Alfurkon 2014). As a result, the market demand for 75 thousand tons can only be met by 5 thousand tons (Adi, 2019). Edamame productivity is still low, and there is a big difference between edamame production at the farm level and research results. It is necessary to expand the planted area. The obstacle is that fertile land is limited, and idle land is still widely available and dominated by dry land, especially the Ultisol soil type. This soil is formed through a further weathering process followed by intensive leaching, especially in the topsoil. The increase and production of plants in this type of soil face soil fertility constraints, including low pH, low organic matter, low macronutrient content, etc. Also, the range of organic matter is low (Agusni & Satriawan, 2012).

Based on the above, increasing soil fertility can be done by adding organic matter. Organic matter as fertilizer or soil enhancer can improve the soil's physical, chemical, and biological properties. The organic matter functions as a binder of nutrients and improve the aggregate and soil's physical quality. This situation affects nutrient uptake, porosity, water storage capacity, and aeration (Widianto et al., 2000). Organic materials commonly used are livestock waste and agricultural-based factory waste. The research on soybean (Duaja, 2019) and research on celery (Duaja, 2019), and Kailan (Duaja et al., 2019). According to (Duaja, 2020), palm oil mill waste decanter cake (DC) could be used as a source of organic matter to substitute for inorganic fertilizers.

Furthermore (Pahan, 2007) explained the content DC are N 1.56%, P 0.22%, K 0.23%, Mg 0, 24%, and Organic 16.82%. This means

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that 100 kg DC with a water content of 35 percent is equal to 10.56 kg of urea. The variation in nutrient content in DC depends on the length of time the DC waste is in a landfill.

Although complete, the nutrient content in DC does not meet the nutrient requirements needed for optimal plant growth and production. (Duaja, 2019) on celery, plants showed DC 15 tons ha^{-1} combined with 50 percent chemical fertilizer gave the highest celery yield. Likewise, the best soybean yield for soybean plants on peat soil was in the DC treatment of 15 tons ha^{-1} combined with chemical fertilizers at 50 percent of the recommended dose (Duaja, 2021).

Likewise, for Chinese kale, increasing plant growth and yield in ex-coal mining soil can be done by fertilizing NPK 50 percent from recommended doses + decanter cake 15 tons per hectare. Based on this, to replace the need for chemical fertilizers for Edamame, DC is combined with other organic materials, especially those that are more quickly available and have high nutrient content, namely liquid organic Fertilizers. According to (Rachmadhani et al., 2014), liquid Fertilizers can be made by utilizing waste by converting solid waste into liquid, making it easier and more practical. The use of solid waste in liquid form (liquid organic fertilizer) is called bio culture (Nurtika et al., 2008). Furthermore, the essential ingredients of liquid organic Fertilizers determine their effect on the best crop yields, which can be seen in sweet corn. Liquid fertilizer from mustard plant waste gives the highest result at 3 ml/plant (Atikah, Izzati & Parman, 2014).

Furthermore, (Subin, 2016) explains that liquid Fertilizers with the essential ingredients of Lamtoro can increase the growth and yield of Caisin at a low concentration of 10 percent due to the nutrient content of the essential elements. Likewise, according to (Khotimah et al., 2020), the highest wet weight of Caisin was at a dose of liquid fertilizer from papaya fruit waste of 250 ml per plant. Also, the research results by (Yunita et al., 2016) on red chili plants showed a liquid waste concentration of 8.0 percent had the best effect on the growth and yield of red chili. Likewise, plants that were applied with POC with the essential ingredients of a mixture of Gamal (*Gliricidia sepium*) leaves, chicken manure, and coconut water with a concentration of 100 percent gave the best growth and highest mustard yield. Likewise, the study by (Febrianna et al., 2018) found that the application of POC with a dose of 100% every four days was able to increase the nitrogen nutrient uptake of mustard plants by 23.80%, increase plant height growth by 19.06%, number of leaves 18,75%, plant wet weight 55.84%, and plant dry weight production 53.09%

Furthermore, according to (Novianto et al., 2020), liquid organic Fertilizers with the essential ingredients of coconut coir fermented for 35 days increased the growth and the highest wet weight of mustard plants. Furthermore, in (Arinong & Lasiwua 2011) research, liquid fertilizer with the essential ingredients of cow dung at a dose of 180 l/ha gave the highest mustard yield.

Based on the description above, this research aims to utilize palm oil mill waste decanter cake combined as a primary ingredient of solid fertilizers and liquid fertilizers, to increase the growth and yield of Edamame.

METHODS

This research is a field experiment on Ultisol soil on farmer's land in Mendalo Indah Village, Jambi Outer City District, Muaro Jambi Regency, 35 meters above sea level. Geographically, at -1.605040 South Latitude, 103.518239 East Longitude, from June to September 2021.

The Edamame seed used was the Ryoko 75 variety. The fertilizer used was decanter cake (DC) solid palm oil mill waste, fermented for eight weeks. Decanter cake in the fresh form taken from PT. Palm Oil Batanghari Sawit Sejahtera, Lubuk Raman Village, Muaro Sebo District (-1.347007, 103.541665) .The liquid fertilizer used was

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made from DC, i.e., 100 kg of DC was put into a sack and tied up in a container with a capacity of 150 liters. The drum was filled with fifty liters of water and fermented for four weeks with decomposer EM4. The experimental design used was a Randomized Block Design (RBD) with seven combination treatments of solid DC dose + liquid DC concentration, namely solid DC 0 tons/ha + 0% liquid DC, solid DC 10 tons/ha + 0% liquid DC, 15 tons solid DC /ha + 0% liquid DC, 20 ton/ha solid DC + 0% liquid DC, 0 ton/ha solid DC + 100% liquid DC, 10 ton/ha solid DC + 100% liquid DC, 15 ton/ha solid DC + 100% liquid DC, 20 ton/ha solid DC + 100% liquid DC.

The application of solid DC was carried out seven days before planting by spreading it throughout the experimental plots with the appropriate treatment dose and then hoeing evenly. Liquid DC fertilizer is given by spraying evenly on plant leaves two weeks after planting and then once a week until pods are formed (3 times). The concentration of fertilizer with fermented solid decanter base (liquid DC fertilizer) was given according to the treatment concentration. The concentration of 100 percent means that liquid DC fertilizer is given only liquid DC that has fermented without being diluted with water. Plants are harvested in the R6 phase, aged 60-65 days after planting).

Parameters observed were the number of trifoliate leaves per plant, pods per plant (performed every week on sample plants), and pod weight at harvest and converted to yield per hectare (conversion from experimental plots to hectares). The data obtained were analyzed by Anova and Follow-up Test with DMRT at 5 percent. The results of the solid decanter (DC) analysis and the liquid decanter (DC liquid) are shown in Table 1.

RESULTS AND DISCUSSION

The soil analysis results before planting show the content of solid decanter cake and the content of liquid Fertilizers with the basic ingredients from solid decanter cake.

Table 1. Compost Quality Standards based on SNI and results of nutrient analysis on solid and liquid DC

Parameter	Standard-based on SNI		DC content (%)		Liquid Fertilizers content (%)	
	Minimum	Maximum				
Water content (%)		50	6,39	Confirm		
				confirm	7,50	confirm
pH	6,8	7,49	8,25			confirm
C-Organik (%)	9,8	32	37,00	confirm		confirm
C/N	10	20	16,88	confirm		confirm
N-Total (%)	0,4		3,220	confirm	0,11	confirm
P-Total (%)	0,1		0,220	confirm	0,20	confirm
K-Total (%)	0,2		0,300	confirm	0,21	confirm
Hormone IAA					22,00	

Source**:** Compost Quality Based on SNI (2004), except for IAA hormone.

The soil analysis results before the research showed a pH of 4.64 (acidic) with a high Al content of 5.84 me/100g. Low CEC (13%), organic C 2.0%. The soil texture contains 32.08% sand, 40.32% dust, and 16.09% clay. Soil fertility before treatment can be said to be less fertile.

Number of Leaves

Analysis of variance showed differences between treatments on the number of

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edamame leaves per plant. The highest number of leaves was achieved at a dose of solid DC 20 tons ha-1 + 100% concentration of liquid DC.

Table 2. Number of edamame leaves per plant in each of each DC dose and liquid DC concentration

DC dose (DC) + concentration of liquid DC (LDC)	Number of leaves
DC 0 ton ha^{-1} + LDC 0 %	12,83 a
DC 10 ton ha^{-1} + LDC 0%	12,53 a
DC 20 ton ha^{-1} + LDC 0%	13,88 a
DC 0 ton ha^{-1} + LDC 100%	12,83 a
DC 10 ton ha^{-1} + LDC 100%	12,72 a
DC15 ton ha^{-1} + LDC 100%	13,91 a
DC 20 ton ha^{-1} + LDC 100%	17,16 b

Note: The numbers followed by the same letter show that they are not significantly different according to the DMRT test at a level of 5%

Based on Table 2, the number of Edamame leaves increased with increasing solid DC and liquid DC concentration doses. This follows (Anastasia et al., 2014) that the combination of solid and liquid fertilizers can increase the number of spinach plant leaves because liquid fertilizers increase the nutrient content of solid fertilizers, and liquid fertilizers are more easily absorbed. Furthermore, Solid organic fertilizers will improve the soil's physical properties, and roots will absorb nutrients in solid and liquid organic fertilizers to increase vegetative growth, significantly increasing the number of leaves. The primordial growth of leaves will stimulate the development of young leaves to increase the optimal number of leaves. The number of leaves on plants is related to the nitrogen nutrient content plants can absorb. Likewise in, (Abror & Alhaq 2017) research shows there are interaction effects on a number of fruits and the dry weight of red chili.

Table 1 shows that the nutrient content of N in solid DC is 3.22%, and liquid DC is 0.1%. Sufficient nitrogen content will stimulate leaf development. According to (Sutedjo, 2008), nitrogen (N) affects vegetative plant growth because it can stimulate growth, primarily in stems, branches, and leaves. It was also explained that the presence of nitrogen (N) nutrients in the media could support plant growth which is needed for the formation or development of vegetative parts such as leaves, stems, and roots. According to (Duaja, 2019), solid organic fertilizers with high N content can increase the growth and production of celery plants. The increased growth and development of the vegetative part of the celery plant directly affects increasing the fresh and dry weight of the plant. Likewise, according to Duaja (2021) on soybeans, the highest soybean yield was achieved at a dose of 15 tons ha^{-1} of organic matter (combination of decanter cake 5.0 tons ha-1 + chicken manure 10.0 tons ha^{-1}).

Number of Pods per Plant

The analysis of variance showed differences between treatments on the number of edamame pods. Increasing the DC and liquid DC concentration dose up to 10 tons per hectare with liquid DC concentration up to 100 percent had the same effect on the number of pods per plant. Different results started at a DC dose of 15 tonnes per hectare with a 100 percent liquid DC concentration. The average number of pods in the combination of solid DC dose 15 tons ha^{-1} and 20 tons ha^{-1} + liquid DC concentration was 100% higher than other treatments and significantly different. The lowest number of pods was at a combination of 0 and 10 tons ha^{-1} solid DC doses with 0 and 100 percent liquid DC concentrations.

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Table 3. Number of pods per plant in each DC dose with liquid DC concentration

DC dose (DC)+ concentration of liquid DC (LDC)	Number of pods per Plant
DC 0 ton ha^{-1} + LDC 0 %	24,77 a
DC 10 ton ha^{-1} + LDC 0%	27,37 a
DC 15 ton ha^{-1} + LDC 0%	31,74 b
DC 20 ton ha^{-1} + LDC 0%	28,65 ab
DC 0 ton ha^{-1} + LDC 100%	24,83 a
DC 10 ton ha^{-1} + LDC 100%	24,41 a
DC 15 ton ha^{-1} + LDC 100%	35,87 c
DC 20 ton ha^{-1} + LDC100%	37,67 c

Note: The numbers followed by the same letter show that they are not significantly different according to the DMRT test at a level of 5%

The number of pods formed in plants is determined by the amount of assimilation obtained during the optimal growth of vegetative organs. According to (Bennett et al., 2011), the growth and development of pods require incorporating sufficient quantities of leaves. According to (Surtinah 2018), the number of leaves is the vegetative organ that plays a role in determining soybean production. From Table 2, solid DC dosage treatment of 15 tons ha^{-1} with a 100 percent liquid fertilizer concentration showed the same effect as DC 20 tons ha-1 +100 percent concentration of DC liquid (Table 3).

Pod Weight Per Plant

The analysis of variance showed differences between treatments on pod weight per plant. The highest average pod weight was achieved at DC 20 tons ha-1 with 100% liquid DC but showed the same effect on pod weight per Plant with DC 15 tons ha-1+100% liquid DC. The lower dose of DC 10 tons ha^{-1} without liquid DC or with liquid DC did not increase pod weight per plant. Furthermore, the results of Purba et al. (2018) show the highest total number of edamame pods was achieved in the cow manure treatment of 30 tons/ha and was significantly higher than 10 tons/ha. This means that the treatment with the highest organic matter achieved the highest pod results.

Furthermore, according to Purba et al. (2018), combining organic fertilizers and chemical fertilizers can increase the fruit yield of watermelon plants even though there is no interaction. The application of Petrogenic organic fertilizer significantly increased the yield of watermelons. According to (Upadhyay & Rajeev, 2015), plant hormones are effective in several crops, and they have been found to balance the source and sink relationship, leading to an increase in the yield of crops. Plant growth hormones enhance the growth and physiological activity of the plant.

Pod weight per plant varied depending on the DC dose with liquid DC concentration, and the higher the dose and concentration achieved, the higher the pod weight per plant. This is because the development of pods and the pod number that is formed depends on the fertilizer given (Bennett et al., 2011), also on the dose (Sandeep &Singh, 2009), hormone content, and biological microbes from the essential ingredients of the fertilizer given (Safitry & Kartika, 2013). From Table 1, fertilizer from liquid decanter contains 22 percent IAA hormone. Auxin is a highly versatile hormone affecting virtually all aspects of plant development, including the formation of fruits (Grieneisen et al., 2013) and (Dong et al., 2019). It is, therefore, possible that auxin is also involved in mediating pod/seed intercommunication.

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Table 4. Pod weight per plant for each DC dose with liquid DC concentration

DC dose (DC) + concentration of liquid DC (LDC)	Pod weight per plant (g)
DC 0 ton ha^{-1} + LDC 0 %	67,07 a
DC 10 ton ha^{-1} + LDC 0%	73,68 a
DC 15 ton ha^{-1} + LDC 0%	79,57 a
DC 20 ton ha^{-1} + LDC 0%	79,76 a
DC 0 ton ha^{-1} + LDC 100%	63,75 a
DC 10 ton ha^{-1} + LDC 100%	65,76 a
DC 15 ton ha^{-1} + LDC 100%	82,12 b
DC 20 ton ha^{-1} + LDC100%	84,53 b

Note: The numbers followed by the same letter show that they are not significantly different according to the DMRT test at a level of 5%

Several research results show that the use of growth regulators improved the yield. (Grieneisen et al., 2013) Support the hypothesis that a delicate balance between the two phytohormones coordinates cell elongation and cell division activity. In the present experiment, the effect of growth regulators NAA, GA, and Kinetin was investigated on morphological parameters, biochemical constituents, product, and quality of soybean plants (De Jong et al., 2009).

Edamame Green Pods Yield per Unit Area

The analysis of variance showed the differences between treatments of edamame pods yield per unit area.

Table 5. The yield of edamame pods per plot for each combination of solid DC and liquid DC concentration

DC dose (DC) + concentration of liquid DC (LDC)	Average Yields per unit area ($g/2.25m^2$)
DC 0 ton ha-1 + LDC 0%	1613,75 a
DC 10 ton ha^{-1} + LDC 0%	1710,00 ab
DC 15 ton ha^{-1} + LDC 0%	1983,75 cb
DC 20 ton ha^{-1} + LDC0%	2100,00 cb
DC 0 ton ha^{-1} + LDC 100%	1442,50 a
DC 10 ton ha^{-1} + LDC 100%	1492,50 a
DC 15 ton ha^{-1} + LDC 100%	2012,50 cb
DC 20 ton ha^{-1} + LDC 100%	2292,50 c

Note: The numbers followed by the same letter show that they are not significantly different based on the DMRT test at a level of 5%

Table 5 shows that the dose of DC 0 tons ha-1 + 0% liquid DC concentration gave the same effect as solid DC 10 tons per hectare + 0 and 100% liquid DC concentration on pod yields per plot. This means that the combination has not been able to increase Edamame's yield. However, different effects started at 15 and 20 tonnes per hectare of DC dosages + 0 and 100 percent liquid DC concentrations. The highest pod yield per plot was at DC 20 tons per hectare + 100% liquid DC.

Duaja et al. (2021) showed that the dose of 20 tons ha^{-1} + 0% liquid DC concentration significantly affected the growth variables, the number of branches and leaves. This is because the nutrients from the dense decanter at a dose of 20 tons per hectare, especially

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nitrogen, are sufficient for vegetative growth. However, this research shows that when combined with liquid Fertilizers, the highest yield of Edamame was achieved at a lower DC dose.

A previous study (Gustianty & Hasibuan, 2017) showed that the best DC dose that gave the highest yield to Pakchoy (*Brassica rapa* L) was 15 tons per hectare of DC combined with 50 percent chemical fertilizer. Likewise, the highest celery yield was achieved at a DC dose of 15 tons per hectare combined with a 50 percent dose of NPK fertilizer from the recommended dose (Duaja, 2019). Furthermore, according to Duaja et al. (2020), on Kailan (*Brassica oleracea Alboglabra)* plants in suboptimal soil using DC as organic matter to increase pH. This study supported the pH improvement by adding organic matter from liquid DC. The results of soil analysis before the study showed that the pH was 4.64 and after the research increased to 5.45

CONCLUSION

Palm oil mill waste decanter cake, a primary ingredient of solid and liquid fertilizers, can increase edamame growth. For the number of leaves, increasing the combination dose of decanter cake solid to 0 tons per hectare with the concentration of liquid Decanter Cake fertilizer to 100 percent gave the same effect, up to 15 tons per hectare. A different result was only seen at the dose of solid DC 20 tons per hectare + liquid DC 100 percent. For the number of pods per plant, increasing the quantity of DC to 10 tons per hectare + concentration of liquid decanter cake up to 100% had the same effect on the number of pods. The result differed on solid decanter dosage at 15 tonnes per hectare + 100% liquid DC and higher subsequent doses. For pod weight per plant, an increase in the combined quantity of solid decanter to 10 tons per hectare with liquid

Palm oil mill waste Decanter cake concentrations up to 100 percent gave the same effect, with different results starting at a dose of 15 tons per hectare + 100 percent liquid decanter concentration. A yield of Edamame green pods per unit area (2.25 m^2) showed increasing the dose of solid DC, and liquid DC concentration up to 10 tons per hectare had the same effect on pod weight per plot. Different results started at a solid DC dose of 15 tonnes per hectare with a combined 100 percent liquid DC concentration, and increasing the DC dose to 20 tonnes per hectare had the same effect. Based on the description above, palm oil mill waste decanter cake can be used as a primary material for solid Fertilizers and liquid Fertilizers to increase the growth and yield of Edamame.

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