Journal of Applied Science and Advanced Technology
Journal Homepage : https://jurnal.umj.ac.id/index.php/JASAT

Oil Palm Pressed Fiber Valorization: Improving Fiber Processing in Composting with Azotobacter for Use in Potting Media of *Brassica rapa*

Sylvia Madusari[1,2*], Zakat Firmanto[1], Rufinusta Sinuraya[1]
[1]Oil Palm Estate Management Study Programme,, Politeknik Kelapa Sawit Citra Widya Edukasi, Bekasi, Indonesia
[2]Production Technology of Crop Plantation, Politeknik Kelapa Sawit Citra Widya Edukasi, Bekasi, Indonesia

ARTICLE INFO

JASAT use only:
Received date : 9 January 2020
Revised date : 14 February 2020
Accepted date : 9 March 2020

Keywords:
Bioconversion
Compost
Nitrogen fixing bacteria
Oil palm fruit fiber
Pakcoy

ABSTRACT

Fiber (mesocarp fiber) is a solid waste generated in the oil palm factory which potentially used as fertilizer through composting. Addition of *Azotobacter sp*. in composting can increase nitrogen content, which improve the quality of compost. The purpose of this research was to determine the effect of the enrichment of *Azotobacter sp*. in composting of oil palm pressed fiber and analyzing the nutrient content and its potential as a planting medium of pakcoy (*Brassica rapa*). Descriptive method was used in the process of composting by assessing the physical and chemical properties of the compost produced. Fiber compost testing as a planting medium was carried out using a nonfactorial Randomized Complete Block Design in 3 variations of 30%, 50% and 70% treatment, and each mixed with subsoil. The results of compost physical parameters analysis showed the dark brown color, and the texture showed more crumb in the compost enriched with *Azotobacter sp*. The best pH was found in the compost treated with the addition of *Azotobacter sp*., which was 8.36. Analysis of compost application on pakcoy growth showed that the highest leaf area (69.73 cm2) and number of stomata (36.4 mm2)-1) were found in the F2P2 treatment (Azotobacter Fiber Compost 50% + Subsoil 50%); The highest root length (28.38 cm), shoot dry weight (2.58 g), and root dry weight (2.26 g) were found in the F2P3 treatment (Azotobaacter Fiber Compost. 70% + Subsoil 30%). From the results of these experiments, the compost enriched with azotobacter has beneficial effects on crop growth could be attributed to soil amendments.

INTRODUCTION

At the palm oil mill, where the Crude Palm Oil (CPO) is produced and it is likewise the solid waste and liquid waste is generated in large quantities. In 2013, the palm oil mill in Indonesia produced 28.7 million tons liquid waste and 15.2 million tons solid waste, annually (Ditjenbun, 2016). At the processing time in palm oil mill, every one ton of fresh fruit bunches (FFB) to CPO, it will produce 23% or 230 kg of oil palm empty fruit bunches (EFB), and 13% or 130 kg mesocarp fiber (fiber) (Susanto *et al*, 2017).

Based on the results of the laboratory analysis, the fiber has elemental content of nitrogen 0.32%, phosphorous 0.02%, potassium 0.78%, magnesium 0.16% and carbon to nitrogen ratio of 167.58% (Wahyono *et al*, 2008). Therefore, it is potentially to be decomposed, in order to increase the value of palm fruit fiber usage. In addition to increase the value, decomposing is one of the process that can reduce the C / N ratio of oil palm fiber. Compost is the result of the degradation of organic matters by microbes, furthermore, it can be used as planting media. Nowadays, many researches of using microorganism for enriching the compost value has been conducted. One of the potential bacteria to enrich the compost is Azotobacter. Azotobacter sp. is type of bacteria that behave

* Corresponding author.
E-mail address: smadusari@cwe.ac.id

DOI: https://dx.doi.org/10.24853/JASAT.2.3.65-72

as a decomposer and produce hormones while fixing the nitrogen which equivalent to 20-40 kg N ha (Siddiqi, 2006). According to the Hindersah and Simarmata (2004), this type of bacteria can produce cytokinins and gibberellins and can save 20 kg N ha-1 to increase plant yield by 1.24 tons ha-1 (Sattar *et al*, 2008).

Compost maturity have two characteristics. The secondary criteria of compost can be observed through its physical and chemical properties, while the primary criteria can be noticed by applying it as a planting media and observed on how the response of plant growth in the media (Wahyono et al, 2008). This is in line with the research of Yunindanova *et al*. (2013) which used fiber and empty fruit bunches as compost for tomato growth. The plant produces a high crop weight. Yunindanova *et al.* (2013) added that to test the level of compost maturity based on primary composting criteria, it should be done on sensitive plants. Based on the growing conditions of the plant, pakcoy (*Brassica rapa*) is sensitive in its growth process. Therefore, it is necessary to conduct a research on the application of fiber as a compost raw material which can be further utilized as organic growing media of Pakcoy (*Brassica rapa*). The efforts on conducting in-depth studies through research was done, so that waste from palm oil mills can be utilized as a more valuable substance.

EXPERIMENTAL METHOD

This research was conducted in Biology laboratory and experimental field of Politeknik Kelapa Sawit Citra Widya Edukasi located on Jalan Gapura, Bekasi, West Java, Indonesia. The oil palm fiber was obtained from palm oil mill at PT Kertajaya, PTPN VIII, Malingping, Banten and the *Azotobacter sp* isolate was cultivated and multiplied at the Biology laboratory at Politeknik Kelapa Sawit Citra Widya Edukasi.

The descriptive method was conducted to measure the level of compost maturity physically, while the chemical properties of the compost was analyzed in Analysis Laboratory, Departmenf of Agronomy and Agriculture of Institut Pertanian Bogor. The compost treatments consists of F1 (Fiber 50% + cow dung 50%) and F2 (Fiber 70% + cow dung 28% enriched by Azotobacter 2%). The composting process was replicated two times. Before the composting process, the fiber was boiled in a container filled with water which then heated on a gas stove. The boiling process was carried out for 60 minutes. After that, the boiled fiber was put in a sack to reduce excessive water content. Boiling process was done to weaken the chemical bond and to help separating the lignin in the plant fiber. The dried boiled-fiber were weighed then each container contained the same amount of the raw material. The boiled fiber was mixed with cow dung in ratio 3:1. After being weighed and mixed then put into a container according to treatment. About 2 wt (%) of the pure culture of Azotobacter sp. was aseptically injected in to the prepared composting material. Composting of the fibers was carried out for 12 weeks.

The temperature and the pH of the composting pile was monitored using the thermometer and pH meter. The probes were inserted into the composting pile and the reading were recorded after the reading was consistent. The temperature and pH were averaged from 5 samplings points of the composting pile.

The fibres from the composting pile were collected for the nutrient analysis at the beginning and the end of the research. The parameters of the nutrient analysis included total nitrogen (N), total carbon (C), carbon to nitrogen ratio (C/N), phosphorous (P_2O_5) and potassium (K_2O).

In the application of the compost as a planting media, the Randomized Complete Group Design (RCBD) method using one factor or non-factorial was carried out. The treatments consists of F0 (100% subsoil), F1P1 (30% fiber compost + 70% subsoil), F1P2 (50% fiber compost + 50% subsoil), F1P3 (70% fiber compost + 30% subsoil), F2P1 (30% fiber compost inoculated by Azotobacter + 70% subsoil), F2P2 (50% fiber compost inoculated by Azotobacter + 50% subsoil), F2P3 (70% fiber compost inoculated by Azotobacter + 30% subsoil). The parameters observed in the composting process were nutrient content, C / N ratio, temperature and acidity. The observation of parameters of

Journal of Applied Science and Advanced Technology 2 (3) pp 65-72 © 2020

growth of pakcoy were plant height, root length, wet weight and dry weight of the root, wet weight and dry weight of the shoot, leaf area and number of stomata.

Pakcoy that has been sown was moved to the container that has been prepared. Planting was done by taking the seeds from the seedling place carefully so that the roots of the plants not broken and damaged. Nurturing pakcoy was done by watering two times a day, in the morning and in the evening. Weed and pest control were done manually by picking weeds and pests that exist in plants. The harvesting of pakcoy was done at the aged of 25 days after planting. In the process of harvesting was done by pulling the plants up to the roots carefully, to avoid breaking the roots. The roots are used to determine the root biomass and root length.

The results of analysis of variance showed a significant effect on F value at α 0.05, then continued with the Honestly Significant Different (HSD) test. Calculations are carried out using STAR 2.0.1 (Statistical Tool For Agricutural Research).

RESULTS AND DISCUSSION

Physical and Chemical Properties

The physical characteristic of the composted fiber at the end of the composting period, the fibres were soft and short which can be tear manually and the colour was dark brown and blackish and earthy smell. In line with Kala *et al.* (2009) which mentioned that composting oil palm waste had darker colour and it's because the conjugation of C=O group on quinones and ketones of the humic substances can cause the dark colour of the compost.

The highest temperature increase occurred in F2, the treatment was (70% fiber + 28% cow dung + Azotobacter 2%), at the beginning of the study 28.76^{0}C and then slightly increased in the second month of composting to 30.4^{0}C. This increase was caused by the addition of Azotobacter as a decomposer that helps composting activities. Increasing the temperature in composting generated by the bacterial activity in degrading the organic matter (Widarti *et al*, 2015). In line with the Sahwan (2016) which mentioned that the rise in temperature is due to the accumulation of heat released by microbes that are degrading organic matter. The increase in compost temperature is caused by metabolic activities, this is caused by microbial respiration. In this research changes in temperature during the composting process was not high which was not optimally yet. According to Hoe *et al*. (2016), high degradation rate of organic matter reflected in the early composting stage which reached the mesophilic stade where the temperature is fluctuated between 45-55^{o}C. The effect of various composting treatments on temperature can be seen in Figure 1.

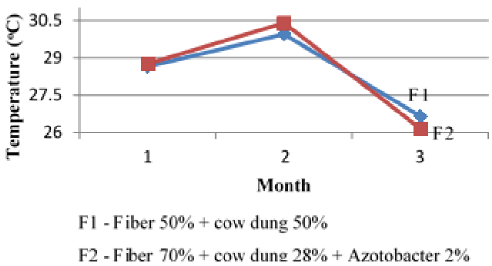

Fig. 1. Effect of various treatments on compost temperature.

The temperature of compost at the third month observation was lower than the second month. The lowest temperature reduction was found in the treatment of F2 (70% Fiber + 28% cow dung + Azotobacter 2%). This was related to the reduction of the activity of microorganisms due to the carbon element, which is a source of bacterial energy, has been decreased in the media. Microorganisms need carbon as an energy source in their metabolic processes (Widarti *et al*, 2015).

The values of pH play an important role in composting. The research results showed that changes in pH occurred every month of observation. In the first to two month showed an increase in pH for each treatment which was relatively the same but the highest was shown in F2 treatment (70% Fiber + 28% cow dung + Azotobacter 2%) with a value (8.36). In the third month the pH of compost was relatively constant for all treatments which indicated that the compost was stable. The effect of various composting treatments on pH can be seen in Figure 2.

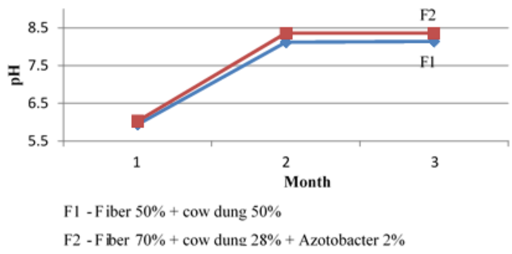

Fig. 2. Effect of various treatments on the pH of compost

Inoculating of Azotobacter sp. in F2 affects the pH of compost in the second and third month. The decrease in pH occurs because of the reduction reaction that binds oxygen. This process will increase the activity of microorganisms and produce organic acids which cause the pH to decrease (Wibawati, 2013). Mahdy (2011) mentioned also that compost generated from plant residues tend to redice pH values. The average pH range at the end of composting is 8.36. The pH value of the fiber compost was in the range based on the minimum technical requirements of solid organic fertilizer that is 4 - 9 (Permentan, 2011).

In related to the nutrient content in compost, the research result showed that the nitrogen nutrient content in compost with the addition of Azotobacter slightly higher than compost without the addition of Azotobacter. This showed that the nitrogen in the compost material were decomposed by Azotobacter. Azotobacter is a heterotrophic and aerobic bacteria that has been known as a biological agent for nitrogen fixation, which converts free nitrogen into ammonium nitrate (Hindersah and Simartapa, 2004). The nutrient content of compost at the end of the experiment can be seen in Table 1.

Table 1. Nutrient content of compost.

Treatment	(%)				
	N-Tot	C-Org	C/N Ratio	P (P_2O_5)	K (K_2O)
Fiber 50 % + Cow dung 50 % (F1)	1.27	45.96	36.09	1.87	3.06
Fiber 70 % + Cow dung 28 % + *Azotobacter sp*. 2 % (F2)	1.52	43.99	28.94	1.68	2.47

The highest content of phosphorus and potassium in the analysis results is in the treatment without the addition of Azotobacter. The high nutrient content was due to the proportion of cow dung which was 50%. Processing compost with cow dung that has high N, P and K content as compost can supply the nutrients needed by the soil and improve soil structure for the better (Widarti, 2015). In the combination of fiber, cow dung and Azotobacter sp. the phosphorous (P_2O_5) and potassium (K_2O) showed similar trend that was decrease in concentration from the initial stage compare to the end stage. According to the regulation of Permentan (2011), nitrogen, phosphorous, and potassium content are considered as well of amendment and must be less than 6%. At the end of the research, the C/N ratio of the fiber compost without Azotobacter and with Azotobacter were 36,09 and 28,94 respectively. The C/N ratio were still exceeds the recommended threshold. The recommended C/N ratio of compost that can be applied to the soil are between 15 – 25 (Permentan, 2011). According to the Kala *et al.* (2009), the nitrogen content during composting not only by the amount of total nitrogen and its mineralization rate, but also by the loss of this element through volatilization, denitrification and immoilization that may occur in the compost. Singh *et al*. (2019) mentioned that nitrogen fixing microorganisms can be utilized to fortify raw compost material for desired quality and potentially as bioorganic input enriched with N, P, and K and recycling microbial population.

Journal of Applied Science and Advanced Technology 2 (3) pp 65-72 © 2020

Table 2. Effect of treatment of fiber compost as growing media on plant height.

Treatment	Plant height (cm) Day after planting (DAP)				
	1	**7**	**13**	**19**	**25**
F0P1 (Subsoil 100%)	3.5	6.5 f	12.0 g	14.0 g	18.3 c
F1P1 (*Fiber* compost 30% + Subsoil 70%)	3.5	7.4 d	12.6 d	14.4 f	20.6 b
F1P2 (*Fiber* compost 50% + Subsoil 50%)	3.2	6.9 e	12.4 f	14.8 d	20.5 b
F1P3 (*Fiber* compost 70% + Subsoil 30%)	3.7	6.9 e	12.5 e	14.5 e	20.8 b
F2P1 (*Fiber* compost + Azot. 30% + Subsoil 70%)	3.6	8.4 b	13.1 b	15.5 a	23.2 a
F2P2 (*Fiber* compost + Azot. 50% + Subsoil 50%)	3.6	8.2 c	12.9 c	15.4 b	23.6 a
F2P3 (*Fiber* compost + Azot. 70% + Subsoil 30%)	3.1	8.9 a	13.3 a	15.3 c	23.3 a

Note: The numbers in the same column followed by different letters show significantly different according to the HSD Test at α 0.05

Plant height

The highest growth of pakcoy observed in the end of the resesarch was found in F2P2 (Azotobacter Fiber Compost. 50% + Subsoil 50%) with a value 23.6 cm but not significantly different from other treatments with the addition of Azotobacter sp (F2P1 and F2P3). Then the lowest plant height was found in F0P1 (Subsoil 100%) with a value 18.3 cm. All the treatment of compost growing media from oil palm fiber with composting technique was inoculated by Azotobacter (F2P1, F2P2, F2P3) have significant effect on the growth of pakcoy plants (*Brassica rapa*). The addition of amendments made from fiber (organic) may increase the plant height. In line with the Rahayu *et al.* (2019) research that the decomposition organic matters will produce proteins, ammonium and nitrate where the nitrogen composition can stimulate vegetative growth. The effect of various treatments of growing media on the growth of plant height can be seen in Table 2.

The results of the addition of cow dung in composting the fiber as a planting media showed significant higher plant height on pakcoy growth. The plant growing in the 100% subsoil media showed significantly the lowest height. According to Widarti (2015) other than as a source of nutrients, the provision of organic matter can improve the physical properties of the soil through reducing the weight of the soil volume, increasing moisture storage capacity and increasing the content of organic matter.

Root length, wet and dry weight of shoot, wet and dry weight of root, Leaf Area and Number of Stomata

The average root length results showed the use of F2P3 (Azotobacter fiber compost. 70% + Subsoil 30%) as growth media significantly affected pakcoy root length which reached the highest root length (28.38 cm). The lowest root length of pakcoy were the plant growth in F0P1 (100% Subsoil) media with a value (23.59 cm). The fiber compost has a significant effect on root length, because the media was friable then water and air easily enter and are stored in the growing media. It can stimulate root growth. In line with the statement of Azlansyah (2013) which states that if plant roots develop well, then the rest of the plants will grow and develop properly because plant roots are able to absorb nutrients and water well. The effect of various growth media treatments on root length, shoot wet weight, shoot dry weight, root wet weight, root dry weight, leaf area and number of stomata in pakcoy can be seen in Table 3.

Table 3. Effect of various treatments of compost fiber as growing media on root length, shoot wet weight, shoot dry weight, root wet weight, root dry weight, leaf area and number of stomata.

Treatment	Root length (cm)	Shoot wet weight (gr)	Shoot dry weight (gr)	Root wet weight (gr)	Root dry weight (gr)	Lef area (cm^2)	Number of Stomata $(mm^2)^{-1}$
F0P1 (Subsoil 100%)	23.59 d	30.43 d	1.61c	5.17 f	0.92 d	47.30 c	22.63 d
F1P1 (*Fiber* compost 30% + Subsoil 70%)	24.0 cd	38.57 c	2.31 b	5.23 e	1.61 c	60.33 b	24.23 cd
F1P2 (*Fiber* compost 50% + Subsoil 50%)	25.46 bc	39.87 bc	2.31 b	5.33 d	1.69 c	60.40 b	27.87 bcd
F1P3 (*Fiber* compost 70% + Subsoil 30%)	25.23 bc	43.1 abc	2.33 b	5.33 d	1.76 c	60.70 b	29.37 bc
F2P1 (*Fiber* compost + Azot. 30% + Subsoil 70%)	26.02 b	43.6 abc	2.40 b	5.53 b	1.92 bc	69.70 a	35.43 a
F2P2 (*Fiber* compost + Azot. 50% + Subsoil 50%)	26.55 b	45.23 ab	2.60 a	5.43 c	2.14 ab	69.73 a	36.40 a
F2P3 (*Fiber* compost + Azot. 70% + Subsoil 30%)	28.38 a	48.33 a	2.58 a	5.83 a	2.26 a	69.50 a	31.37 ab

Note: The numbers in the same column followed by different letters show significantly different according to the HSD Test at α 0.05

The highest shoot wet weight was shown by the F2P3 (Azotobacter Fiber Compost. 70% + Subsoil 30%) growing media with the value is 48.33 gr and the shoot dry weight value is 2.58 gr. The highest root wet weight were found in the treatment of F2P3 with a value is 5.83 gr and the root dry weight value is 2.26 gr. The root and shoot dry weight of pakcoy grew in the media enriched with Azotobacter is significantly higher compare to the root and dry weight of pakcoy grew in the media without Azotobacter enrichment. In line with Rodrigues *et al*. (2018) research and they mentioned that the organic amendments enriched with microorganisms yield more dry biomass and recovered more nitrogen than the non-enriched one, while on the contrary that the control treatment produced the lowest value. The organic amendments that non-enriched in Azotobacter produced the lower values of dry matter, nitrogen recovery and soil nitrate levels. According to Widarti (2015) the wet weight and dry weight of plants are the result of carbohydrate accumulation which is basically the result of photosynthesis activities so that the physiological processes that occur in plants run well and are supported by efficient compost absorption which is able to increase the wet weight and dry weight of plants. In line with Anisyah *et al*. (2014) research which explained that potassium can bind water in plant tissue hastening the process of photosynthesis. This process will affect the shoot and root formation and increase the dry weight of the shoot and root of pakcoy. Futhermore, Rahayu *et al.* (2019) mentioned that potassium is an enzyme activator that directly generate effect on metabolism.

The highest average leaf area and the number of stomata of pakcoy were in the use of F2P2 growth media (Azotobacter fiber compost 50% + Subsoil 50%). The media significantly influences the leaf area growth and stomata number with the values are 69.73 cm^2 and 36.40 $mm^{2}.^{-1}$, respectively. The lowest leaf area and number of stomata of pakcoy was shown in the F0P1 (100% Subsoil) growing media treatment with leaf area values is 47.30 cm^2 and the number of stomata value is 22.63 $mm^{2}.^{-1}$. From the results, it is known that the more surface area of the leaf the more the number of stomata in Brassica rapa plants. According to Banyo and Ai, (2011), the large number of stomata depends on the leaf surface area, because the leaves with a wide surface have a higher number of stomata than those with narrow surfaces.

CONCLUSION

Based on the results of the study, it can be concluded that to valorize fiber through composting process as growing media, the addition of 2% Azotobacter in combination material of 70% fiber and 28% cow dung, can increase the pakcoy growth. The highest nitrogen content of compost from oil palm fruit fiber was found in the treatment with the addition of Azotobacter Fiber compost with the addition of Azotobacter potentially used as a nutritious planting medium that can increase growth of Pakcoy (*Brassica rapa*).

REFERENCES

[1] Direktorat Jendral Perkebunan [DITJENBUN]. 2016. Statistik Perkebunan Indonesia Komoditas Kelapa Sawit 2014 - 2015. Jakarta..

[2] Susanto, J. P., Arif, D. S. dan Nawa, S. 2017. Perhitungan Potensi Limbah Padat Kelapa Sawit untuk Sumber Energi Terbaharukan dengan Metode LCA. *Jurnal Teknologi Lingkungan*, 18(2):165-172. Pusat Teknologi Lingkungan, BPPT. Tangerang Selatan.

[3] Wahyono, F.L. Sahwadan Dan F. Suryanto. 2008. Tinjauan Terhadap Perkembangan Penelitian Pengolahan Limbah Padat Pabrik Kelapa Sawit. *J. Tek. Ling Edisi Khusus* 8(4):64-74.

[4] Siddiqi, A.A. 2006. Agro Technology of Organic Farming. Department of Health Behavior and Health. Chapel Hill.

[5] Hindersah, R dan T Simarmata. 2004. Kontribusi rizobakteri Azotobacter dalam meningkatkan kesehatan tanah melalui fiksasi N2 dan produksi sitohormon di rizosfir. *Jurnal Natur Indonesia* 6(4): 127-133.

[6] Sattar, M.A., Rahman, M.F., Das, D.K and Choudhury. 2008. Propects of Using Azotobacter, Azospirillum and Cyanobacteria as Supplements of Urea Nitrogen for Rice Production in Bangladesh. Bangladesh..

[7] Yunindanova, M. B., Herdhata, A., Dan Dwi, A. 2013. Pengaruh Tingkat Kematangan Kompos Tandan Kosong Sawit Dan Mulsa Limbah Padat Kelapa Sawit Terhadap Produksi Tanaman Tomat (Lycopersicon Esculentum Mill.) Pada Tanah Ultisol. *Journal of soil science and agroclimatalogy*, 10(2):91-100.

[8] Kala, D.R., Rosenani, A.B., Fauziah, C.I., Thohirah, L.A. 2009. Composting Oil Palm Wastes and Sewage Sludge For Use in Potting Media of Ornamental Plants. *Malaysian Journal of Soil Science*. 13:77-91.

[9] Widarti, B.N., Wardah, K. W., dan Edhi, S. 2015. Pengaruh Rasio C/N Bahan Baku Pada Pembuatan Kompos Dari Kubis Dan Kulit Pisang. *Jurnal Integrasi Proses*, 5(2):75–80.

[10] Sahwan, F.L. 2016. Kaji Terap Teknologi Komposting Untuk Penanganan Limbah Ternak Sapi Potong. *Jurnal Teknologi Lingkungan*. 17(2):92-99

[11] Hoe, T.K., Sarmidi, M.R., Rabiah, S.S., Alwee, S., Zakaria, Z.A. 2016. Recycling of Oil Palm Empty Fruit Bunch as Potential Carrier for Biofertilizer

Formulation. *Jurnal Teknologi (Sciences & Engineering)*. 78(2):165-170.

[12] Wibawati, R. E. 2013. Rasio C/N, Kandungan Kalium (K), Keasaman (Ph), Dan Bau Kompos Hasil Pengomposan Sampah Organik Pasar Dengan Starter Kotoran Sapi Dalam Berbagai Dosis. [Skripsi]. Semarang: Ikip Pgri Semarang.

[13] Mahdy, A.M. 2011. Comparative Effects of Different Soil Amendments on Amelioration of Saline-sodic soils. *Soil and Water Research.* 6(4):205-216.

[14] Peraturan Menteri Pertanian [PERMENTAN]. 2011. Peraturan Menteri Pertanian Nomor 70/Permentan/SR.140/10/2011 Tentang Pupuk Organik, Pupuk Hayati dan Pembenah Tanah. Retrieved from http://perundangan.pertanian.go.id/admin.file/permentan-70-11/pdf.

[15] Singh, D.P., Prabha, R., Renu, S., Sahu, P.K., Singh, V. 2019. Agrowaste Bioconversion and Microbial Fortification Have Prospects for Soil Health, Crop Productivity, and Eco-enterprising. *International Journal of Recycling of Organic Waste in Agriculture*. https://doi.org/10.1007/s40093-019-0243-0

[16] Rahayu, Syamsiyah, J. Cahyani, V. R., and Fauziah, S. K. 2019. The Effects of Biochar and Compost on Different Cultivars of Shallots (Allium ascalonicum L.) Growth and Nutrient Uptake in Sandy Soil Under Saline water. *Sains Tanah Journal of Soil Science and Agroclimatology*, 16(2): 216-228

[17] Azlansyah, B. 2013.Pengaruh lama pengomposan tandan kosong kelapa sawit (TKKS) terhadap pertumbuhan dan perkembangan bibit kelapa sawit (Elaeis guineensis Jacq.) [Skripsi]. Pekanbaru (ID) Fakultas Pertanian UR.

[18] Rodrigues, M.A., Ladeira, L.C., Arrobas, M. 2018. Azotobacter-enriched Organic Manures to Increase Nitrogen Fixation and Crop Productivity. *European Journal of Agronomy*. 93:88-94

[19] Anisyah, F., Sipayung, R., Hanum, C. 2014. Pertumbuhan dan Produksi Bawang Merah dengan Pemberian Barbagai Pupuk Organik. *Jurnal Online Agroekoteknologi*. 2(2):482-496.

[20] Banyo, Y. dan Ai, N.S., 2011. Konsentrasi Klorofil Daun Sebagai Indikator Kekurangan Air Pada Tanaman. *Jurnal Ilmiah Sains*.11(2):30-38.