Influence of Bokashi Fertilizers on Soil Chemical Properties, Soybean (*Glycine max* (L.) Merrill) Yield Components and Production

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Abstract: The application of bokashi may improve soil chemical properties and beneficial to crop production. This research aimed to examine the effect of various bokashi (compost) fertilizers composted from agricultural wastes on soil chemical properties and the yield of soybean. The experiment consisted of 5 organic fertilizer (bokashi) treatments, namely: without Bokashi fertilizer (M0), Bokashi “komba-komba” (*Chromolaena odorata)*(M1), Bokashi “water hyacinth” (*Eichornia crassipes)*(M2), Bokashi sago dregs (M3), and Bokashi burned-rice husk (M4), arranged in a randomized complete block design (RCBD), with three replicates. Research data were analyzed using analysis of variance and treatment means were compared using Honestly Significant Difference (HSD). Research results showed that bokashi fertilizers improve soil chemical properties. Different bokashi fertilizers gave different effects on yield components and production of soybean, as well as on several soil chemical properties. Bokashi burned-rice husk (M4) and bokashi sago dregs (M3) give the best influence on the yield components and production of soybean, which reached about 3.1 tonnes per hectare, an increase of approximately 30% compared to the treatment of without Bokashi which only reached 2.4 tons per hectare. The use of bokashi could help overcoming environment pollutions caused by agriculture wastes. Soil amendment with bokashi may be a practicable and an environmentally friendly alternative for traditional farmers who own marginal farmlands.

Key-Words: Agriculture waste, bokashi fertilizer, compost, production, soybean

1 Introduction

Soybean (*Glycine max* L. Merrill) is an important source of vegetable oil and protein [1]. In most parts of the world, especially in Asian countries, soybean is used for the production of various daily popular consumed products, such as for tauco, soy sauce, “tempe” (soy cake), tofu, soy milk, and for animal feed industries.

The development of food production areas in often faced with the problem of suboptimal dryland, the land that has one or more soil fertility constraints [2, 3]. Dryland has various soil fertility constraints such as limited water availability, low soil pH, low CEC, and low levels of organic matter that is classified as suboptimal land. One effort that can be done to improve the productivity of suboptimal land is through the improvement of land quality through fertilization. However, fertilization will be futile if the physical condition of the soil is not improved. It was suggested by [4] that there are at least four main technologies for the management of acid soils, namely: (1) calcification, (2) fertilization, (3) organic matter, and (4) the use of plants tolerant to aluminum.

The use of organic fertilizers can help to modify the plant microclimate, which in turn can optimally improve soybean production. Organic matter can improve fertility, structure and will indirectly retain aggregation and porosity of the soil, which means it will maintain the soil's capacity to hold water [5]. Increase in organic matter content of the soil will increase ability of the soil to absorb and exchange soil nutrients. Therefore, the application of inorganic fertilizer would be more efficient due to the released nutrients will be absorbed by the organic matters and become available for the plants, so that the plants will grow and develop optimally, as well as produce high yields. More than 2% organic matter of the soil will generate further agricultural system [6].

The organic matters can be managed from various sources, such as green manures and bokashi. Bokashi is a stable manure that is processed through fermentation using EM-4 technology, which contains bacterial culture that could disperse the organic matters faster, so that the contained nutrients in bokashi would be able to be used by the plants immediately. Adding bokashi will increase C-organic of the soil and nutrients in the plants [6].

Utilization of organic fertilizers is also very important to reduce the use of synthetic fertilizers. [6] reported that organic fertilizer of 20 ton bokashi/ha could reduce the need of inorganic fertilizer for about 50%. They have proven that the organic fertilizer of bokashi would be able to increase efficiency of inorganic fertilizer in providing nutrients, so that the plants could optimally absorb the nutrients. The application of organic inputs can stimulate the microorganism activities in the soil, which play their roles in decomposition process and mineralization of organic matters of the soil, so that they can increase essential nutrients availability in the soil. It was argued by [3] that the use of organic fertilizer on Ultisols can increase levels of Ca - organic, N and P soil contents. Organic fertilizers can improve the physical, chemical and biological soil properties, such as improving soil aeration, soil cation exchange capacity (CEC), water binding capacity, nutrient supply as a result of mineralization of organic materials, and the energy source for soil microbes. **[7] also reported that** EM bokashi can reduce the necessary amount of chemical fertilizer application, thereby improving the agricultural environment. EM bokashi treatments increased soi fertility by increasing CEC and available nutrients, by improving soil porosity and permability due to a significant soil bulk density decrease, and by increasing the microbial biomass of soil.

Agriculture in general often produces wastes, which could potentially pollute the environment [8]. For examples rice husk waste and sago dregs waste Rice husk and sago dregs wastes are generally abandoned or dumped into rivers, causing bad odors and pollute the river water [9]. The use of fertilizer made from organic materials is an appropriate alternative choice to reduce the negative impacts of agricultural wastes. Organic farming systems emphasize utilization of on-farm resources by recycling waste into useful organic matter. Water hyacinth and “Komba-komba” which are locally available and in large quantities can be composted to prepare organic fertilizers and effectively used as an organic soil amendment to restore soil and increase maize production. Application of water hyacinth compost significantly influenced the growth attributes of maize [10].

Availability of fertilizers often becomes a bottleneck and in general, the ability of farmers to buy inorganic fertilizers is also very low, especially the need and availability of organic fertilizer for the cultivation of food crops and horticulture are very important. If farmers only rely on livestock manure, then it certainly is not adequate, especially for a relatively extensive farming. Agricultural solid wastes that have become compost can actually be used as fertilizer or plant growing media. Solid wastes of sago and rice industries that have accumulated over the years can be decomposed into compost and can be used as a medium or organic fertilizer.

Simple and inexpensive technology has been available to take advantage of agricultural wastes such as rice husks, sago dregs and other plant materials that are abundant [11], like “komba-komba” [12] and hyacinth, to be processed into organic fertilizers, such as compost and bokashi. Bokashi is compost produced through the fermentation process using Effective Microorganism 4 (EM-4), which is one of the activators to accelerate the composting process [13]. Many research results have indicated that the bokashi is relatively better than the simple composting. In the process of making bokashi, organic matter is decomposed by involving microorganisms in controlled circumstances [14]. The conventional method of building up soil organic matter is through the application of manures and various compost preparations. Effective microorganisms (EM) is a mixed microorganism culture which consists of lactic acid bacteria, yeast, fermenting fungi, actinomycetes and photosynthetic bacteria. EM is widely used as a beneficial microbial inoculums for making bokashi (biological fertilizer) and the use of EM helps to increase crop yields by enhancing soil fertility, conserve the soil productivity, improve biological properties and also physical amelioration of soil structures [15].

The decomposition process of organic matter into organic matter (in ionic form available to plants) generally takes a relatively long time of about 2 to 3 months. Application of organic material that has not been perfectly decomposed may have negative consequences for plants, because there will be competition between microorganisms and plants to get nutrients in the soil. Effective microorganisms-4 (EM-4) can help the process of decomposition of organic material faster which is about 1 to 2 weeks. In addition, this process leaves no residual negative effects, such as bad odor and heat [13]. Base materials for the production of Bokashi can be obtained easily around the farms, like straw, grasses, legumes, rice husk, manure and sawdust.

This research was conducted to utilize agricultural wastes into useful organic fertilizers, while indirectly helping reduce environmental pollution. This research was undertaken to examine the effect of bokashi fertilizers composted from various agriculture wastes on improving soil chemical properties and increasing the yield of soybean.

2 Materials and Methods

The research methods followed the same procedure as reported by [16], as follows:

2.1 Making "Bokashi"

Bokashi production process begins with making a solution which is a mixture of EM-4, molasses/sugar and water, with a ratio of 1 : 1 : 1 (v : v : v). Bokashi basic materials (especially plant materials), are cut into small pieces, and then the material is evenly mixed with rice bran on dry floor. Furthermore, the bokashi base material is slowly and gradually watered with a solution of EM-4 to form dough.

The good dough is if clenched by hand, then there is no water coming out, also when the fist is released then the dough re-inflates (water content of about 30%). Next, the dough is laid on the floor as high as 15-20 cm. Mound is then covered with a sack or a plastic tarp over 1-2 weeks. During the process, the material temperature is maintained between 40-50^{o}C. If the material temperature exceeds 50^{o}C, then the cover sack is opened and dough material is inverted, then mound is closed again.

2.2 Land preparation and soil cultivation

Soil was cultivated twice. The first, soil cultivation is done by using a hoe to a depth of 15 cm - 20 cm, for cutting and turning the soil. The second is soil tillage, and then beds were set up with a size of 3 m x 1.5 m by 25 plots. The plot distance in the group was 0.3 m and the distance between groups was 0.5 m.

2.3 Fertilization

Fertilizer treatments used in this study were bokashi hyacinth (*Eichhornia crassipes*), bokashi komba - komba (*Cromolaena odorata*), bokashi sago dregs and bokashi rice husk, with the dose of 10 tons per hectare, equivalent to 4.5 kg per plot. Each bokashi fertilizer was applied one week before planting, together with the preparation of experimental plots, by broadcasting to the surface of the plots and then mixed evenly with soil.

2.4 Soybean planting

Soybean seeds were planted as many as 2 seeds each planting hole with the depth of ± 3 cm. The planting spacing was 40 cm x 20 cm, so that in each plot contained 112 plants.

2.5 Plant maintenance and harvesting

Stitching was done to replace plants that did not grow or died, at the age of 7 days after planting (DAP). Plant spacing was conducted at 10 DAP by cutting the plants so that only 1 plant remains per planting hole. Each plot had 56 plants with a sample of 5 plants per plot.
Watering was done regularly in the afternoon, which was carried out according to the conditions of crops and rainfall. Weeding and pest and disease control was done as needed, when the plants experienced an attack.

Harvesting was done when approximately 95 % pods in each plot have physiologically matured, characterized by a color change of pods from greenish to yellowish brown, and the number of leaves left on the plants around 5-10%.

2.6 Observed variables

The number of plant samples for each plot was 5 plants, taken randomly. The variables measured were soil chemical properties, number of total pods per plant, number of productive branches per plant, weight of 1000 seed grains (g) with the moisture content of ± 13 %, and yield per hectare (ton per hectare).

2.7 Research design and data analysis

This research was arranged in a randomized complete block design (RCBD). The treatments were without bokashi fertilizer (M0), bokashi "Komba - komba" (M1), bokashi hyacinth (M2), bokashi sago dregs (M3), bokashi rice husk (M4), with the dose of 10 tons/ha, equivalent to 4.5 kg per plot. Each treatment was repeated five (5) times, so that altogether there were 25 experimental units.

Bokashi was applied 1 week before planting, at the time of soil cultivation. Inorganic fertilization was then performed at 14 DAP by providing NPK fertilizer (16:16:16), at a dose of 0.845 ton/ha, or equivalent to 448 g per plot, as additional fertilizers.

Research data were analyzed by analysis of variance, treatment means were compared using Honestly Significant Difference (HSD) test at the level of 95%.

3 Results and Discussion

In general, bokashi fertilizers gave significant effect on all observed variables. Previous report [16] showed that the highest average of soybean plant height, leaf number and stem diameter at the age of 34 DAP is obtained in treatments M3 and M4, which is significantly different from that of treatments M0, M1 and M2. Bokashi sago dreg and burned rice husk significantly effected soybean plant height at 34 DAP.

Similar results have previously been reported on upland rice by [17], in which rice husk bokashi (10 ton/ha) significantly increased plant height, leaf number, total leaf width, and tiller number. It seemed that both bokashi fertilizers (sago dreg and burned rice husk) stimulated plant growth and provided a rapid effect on the crop. This is in accordance with the research report by [18], that bokashi had a rapid effect on plants because it directly supplied nutrients for the plants. Previously, [19] reported that sago pith waste bokashi increased soil pH, P availability in soil, P-uptake of plant, and dry grains yield of maize, as shown on data in the following Table 1.

Table 1. Effect of sago bokashi treatments on soil pH, P nutrient availability and uptake

Sago bokashi treatment (ton/ha)	Soil pH	Soil P-available (ppm)	P-Uptake of Plant (%)
0	5.58a	4.30a	0.14a
40	6.01b	7.73b	0.15b
80	6.04b	9.67c	0.18c

Source: [19].

Application of sago bokashi improved soil chemical properties, especially for soil P-availability and soil pH. Increased soil P-availability increased P-uptake by plant roots and dry grains yield. The dry grains yield was significantly increased with treatment combination of bokashi and P fertilizer by 240 kg/ha [19].

Earlier, [20] reported that the application of sago pith waste bokashi with dosage of 15 ton/ha significantly decreased soil bulk density, decreased rapid drainage pores, increased water available pores (field capacity) and dry weight yield. The chemical properties of sago pith waste bokashi are as follows:

Table 2. Chemical properties of sago pith waste bokashi

Chemical Properties	Content
C-organik (%)	30.16
N-total (%)	2.16
C/N ratio	13.96
Water content	15.83

Source: [20].

But this was not the case with bokashi “komba-komba” (*Cromolaena odorata*) and water hyacinth (*Eichornia crassipes*), probably both materials had not completely been decomposed especially for their stems and roots, so that the absorption of nutrients by plants was still not optimal. Previously, [10] reported that water hyacinth compost prepared with EM performed well in most vegetative parameters evaluated including plant height, shoot dry weight, root dry weight and root diameter. However, reproductive components such as 100 seed weight and grain yield were not significantly influenced by various hyacinth compost treatments.

Research results [16] showed that the use of various types of bokashi fertilizers on soybean also had significant effect on the increase of the number of leaves. Increased leaf number was demonstrated in both bokashi sago dregs and burned rice husk, most likely because both types of bokashi were able to provide macro and micro nutrients, and can maintain the availability of water in sufficient quantities in the soil [21; 22]. Report by [14] also showed that bokashi application effected soybean growth, including the number of leaves, leaf area, plant dry weight and the number of effective root nodules.

Soybean stem diameter significantly increased at the age of 34 DAP. The largest increase in stem diameter occurred as a result of burned rice husk treatment (M4), because it was easy to decomposed and have high nutrient content. In addition, the activity of soil microorganisms is capable of decomposing organic matter. The rate of decomposition of organic material in the treatment without fertilizer Bokashi (M0) seemed to be slower, because in M0 treatment lacked the availability of soil microorganisms that play a significant role in accelerating the decomposition process of organic matter.

EM-4 that were mixed during the process of bokashi making has a role that is quite effective in creating physical and chemical environment suitable for plant growth [23]. According to [24], microorganisms work synergistically to enrich the soil and promote plant growth so that by increasing the activity of soil microorganisms will speed up the rate of decomposition of organic matter in the soil.

The research results showed that bokashi treatment also significantly affected the number of pods. Data in Table 3 shows that the highest average number of pods per plant, number of productive branches per plant and weight of 1000 seeds is obtained in treatments M4 and M3, although for productive branch number and weight of 1000 seeds had no significant difference with that of treatment M1.

Table 3. The effect of various bokashi treatments on the number of pods, number of productive branches, and weight of 1000 seeds of soybean (g) [16]

Bokashi treatment	Number of pod	Number of productive branches	Weight of 1000 seeds (g)
Without bokashi (M0)	14.68 b	1,64 b	78,40 b
'Komba-komba" (M1)	26.24 b	3,16 a	87,46 a
Hyacinth (M2)	20.76 b	1,88 b	83,30 b
Sago dregs (M3)	122.00 a	4,12 a	92,46 a
Burned rice husk (M4)	129.36 a	4,52 a	92,98 a
BNJ test	11.61	1.45	6.30

This indicates that application of bokasi can improve soil conditions that favor plant growth, increase soil biological life and optimize the availability and the balance of nutrient cycling through nitrogen fixation, nutrient absorption, addition and cycling of external fertilizers. The lowest increased number of soybean pods occurred in treatment M0 (without bokashi). This was due to low soil pH and less organic matter [25]. A significant increase in pod number occurred in M3 and M4 treatments (Table 3). The availability of plant nutrients is one of the factors affecting crop productivity. These results indicate that treatment of various types of bokashi fertilizers influenced the increased number of pods per plant.

The highest number of productive branches occurred as a result of bokashi burned rice husk treatment (M4). This is presumably because the burned rice husk contains high C, N elements [11] and other nutrients (unpublished data, 2015). The lowest number of productive branches occurred in the treatment of without bokashi fertilizer (M0). It was reported by [26] that organic matter (animal manure) affected the increased activity of respiration and leaf width, affected the photosynthetic activity, and ultimately affected the yield and dry matter content of the crop. This is also supported by research results of [18], in which organic matter, with higher phosphorous levels, can increase the weight of red chili. [27] reported that the application of rice husk bokashi improved soil chemical properties, such as pH, C-organic, nitrogen (N), phosphor (P) and potassium (K), as shown in the following Table 4.

Table 4. Effect of rice husk bokashi on soil chemical properties

Soil Properties	Before bokashi application	After bokashi application
pH	4.69	4.89
C-Organic (%)	3.60	2.51
Nitrogen (%)	0.22	0.23
C/N ratio	16.5	10.90
P2O5 (ppm P)	2.39	1.88
K2O (ppm K)	57.98	83.44

Source: [27].

The highest weight of 1000 soybean seeds per plant was obtained at the treatment of bokashi burned rice husk (Table 3). Environmental factors are also believed to play a role in optimizing crop soybean pod filling [28]. The ability of soybean to produce pods is highly dependent on interactions between plants and environmental factors. Organic materials have an important role in soil fertility, among others as a source of plant nutrients, forming a stable structure which has an influence on the growth and development of plants [28]. The lowest weight of 1000 seeds was obtained at treatment without bokashi (M0). This is apparently due to the lack of nutrients available to plants during pod filling (Table 3). Bokashi decomposition produces organic acids, capable of dissolving the compound of Al-P or Fe-P, insoluble becomes soluble, so that it becomes available to plants [29].

It is also expected that the use of organic matters would be able to improve soil fertility, in which one of them is increasing cation exchange capacity (CEC) of the soil. CEC plays its role in catching ions of the nutrients in the soil, including nutrients that derived from inorganic fertilization, so that they would be available for the plants. Organic matters have much higher CEC than soil clay, so that the nutrients availability for the plants would not easily lose because of leaching process.

Research report (Table 5 below) by [6] indicates that application of bokashi (organic fertilizer) improves soil chemical characteristics, including CEC and essential nutrients (N, P, and K) contents.

Table 5. Effect of organic fertilizer (bokashi) application on soil chemical properties.

Organic fertilizer	pH	CEC (cmol/kg)	N (%)	P (mg/kg)	K (cmol/kg)
No organic fertilizer	5.44	19.98	0.06	2.65	0.19
Bokashi 20 ton/ha	5.48	21.90	0.07	4.20	0.27

Source: [6].

Data in Table 6 shows that the highest average soybean yield per hectare is obtained in treatment M4 and M3, which is significantly different from those of treatments M0, M1 and M2.

Table 6. The effect of various Bokashi fertilizer treatments on soybean yield (tonnes per hectare) [16]

Bokashi treatment	Soybean yield (ton ha^{-1})
Without bokashi (M0)	2,392 b
‘Komba-komba” (M1)	2,667 b
Hyacinth (M2)	2,652 b
Sago dregs (M3)	3,134 a
Burned rice husk (M4)	3,197 a
BNJ test	0.308

The research results showed that the grain yield per hectare resulted for each treatment was M0 = 2.392 ton ha^{-1}, M1 = 2.667 ton ha^{-1}, M2 = 2.652 ton ha^{-1}, M3 = 3.134 ton ha^{-1}, and M4 = 3.197 ton ha^{-1}. The results showed the highest soybean grain yield per hectare was obtained in treatment bokashi burned rice husk (M4). This is presumably because the decomposed organic material has a significant influence particularly on the generative phase. C : N ratio is usually used as an index of ease of decomposition of organic materials and also as soil biological activity indicators. It is also supported by higher number of leaves, so more photosyntate generated. The process of photosynthesis is directly related to leaf area and leaf area index. The high number of leaves can increase the number of chloroplast that is crucial in increasing the rate of photosynthesis. Photosyntate will be used for the process plant growth, and during the generative period it will be allocated to pod formation and increases the weight of the pods and seeds.

The research results in line with research reports by [30] and [31] who used organic matters in the form of organic mulch. They found that organic mulch increased number and weight of nodules of soybean, as well as soybean yield (Table 7.). Another work [32] also reported that EM bokashi fertilizer significantly increased both the nodule numbers per plant and fresh weight per nodule in peanut. The vegetative and reproductive growth in EM Bokashi treatment was promoted significantly. The total pod number and pod dry weight in EM bokashi fertilizer treatment were significantly higher than those in chemical fertilizer treatment. These results suggested that EM bokashi is an effective organic fertilizer in nature farming crop production.

Table 7. Effect of organic mulch on nodule number and weight, and soybean yield.

Mulch Treatment	Nodule number/ plant	Nodule weight (g)/plant	Soybean yield (g/plot)
Without Mulch (M0)	39.00	2.08	660.77b
Teak Leaf Mulch (M1)	71.38	3.99	862.66ab
Chromolaena odorata Mulch (M2)	69.50	3.35	983.08a
Imperata cyllindrica Mulch (M3)	68.25	3.51	757.49ab

Source: [30] and [31].

Overall, this research has proven that the cultivated soil fertility improvement could be derived from available biomass and build up biological activity of the soil by using EM in the form of compost (bokashi). In this regard, nature farming with EM technology is an attractive option that is simple and affordable to average farmers [15].

Chemical fertilizers offer soluble nutrients which are instantly availed to the plants hence perform significantly better compared to the control while compost provides the nutrients slowly but steadily and improve the soil's physical properties with time thus better uptake of nutrients by the crop but the effects are not very significant compared to the control especially at early stages of crop development [10]. Even crop yields obtained from bokashi applications was sometime less than those found from chemical fertilizer alone, but taking into account chemical fertilizer cost, which is around ten times higher than biological fertilizer, the soil amendment with bokashi may be a practicable alternative for the low-income farmers who own degraded farmlands. Moreover, heavy and continuous use of pesticides may accelerate serious negative effects on farmers' health, depletion of soil organic matter, nutrient deficiency in soil, crop yield reduction and increase cultivation cost.

4 Conclusion

The application of Bokashi gave a significant effect on improving soil chemical properties and in turn increase almost all observed variables of soybean yield. Bokashi burned-rice husk and sago dregs with the dose of 10 ton ha^{-1} give the best effect on the growth and yield of soybean, which reached about 3.1 tonnes per hectare, an increase of approximately 30% compared to the treatment of without bokashi which only reached 2.4 tons per hectare. The use of bokashi made from agriculture wastes help overcoming environment pollutions caused by agriculture wastes. Organic fertilizers, e.g. bokashi, with effective microorganism technology is simple, sustainable, economically viable, beneficial for farmers' livelihoods and environmentally friendly.

References:

[1] K. Verma, R. Saini and A. Rani, Recent advances in the regeneration and genetic transformation of soybean. *Journal of Innovative Biology* 1(1), 2014, pp.15-26.

[2] Lakitan and Gofar, Policy on technology innovation for management of sustainable suboptimal land, *Seminar Proceeding on Suboptimal Land*, Palembang, 2013.

[3] U. Kurnia, Sudirman and H. Kusnadi, *Technology, Rehabilitation and Degraded Land Reclamation*, Pusat Penelitian Tanah dan Agroklimat. Badan Litbang Pertanian, 2005, pp. 141-167.

[4] D. Nursyamsi, *Efforts to inprove dryland productivity*, Graduate School, Institut Pertanian Bogor, 2004.

[5] H.P. Forth, 1994. *Basic Soil Science*. Publisher Erangga, Jakarta, 6th Edition, 1994.

[6] A.I. Yuliana, T. Sumarni, T. Islami, Application of bokashi and sunn hemp (*Crotalaria juncea* L.) to improve inorganic fertilizer efficiency on maize (*Zea mays* L.). *Journal of Degraded and Mining Lands Management* Vol. 3, No. 1, 2015, pp. 433 – 438.

[7] S. Xiaohou, T. Min, J. Ping, and C. Weiling, Effect of EM Bokashi application on control of secondary soil salinization. *Water Science and Engineering* Vol. 1, No. 4, 2008, pp.99-106.

[8] A. Fadillah, A. Pusaka, S. Manullang, Y. A. Dewanto, and D. Faturachman, Strategy for Reducing Pollutant Emissions from Ship Activities at the Port of Tanjung Perak, Surabaya, *WSEAS Transactions on Environment and Development*, Vol. 11, 2015, pp. 155-162.

[9] M. Nsaif, and F. Saeed, The Feasibility of Rice Husk to Remove Minerals From Water by Adsorption and Avail From Wastes, *WSEAS Transactions on Environment and Development*, Vol. 9, Issue 1, 2013.

[10] N. Osoro, J. O. Muoma, A. Amoding, D. Mukaminega, M. Muthini, O. Ombori and J. M. Maingi, Effects of Water Hyacinth (*Eichhornia crassipes* [mart.] solms) Compost on Growth and Yield Parameters of Maize (*Zea mays*). *British Journal of Applied Science & Technology* Vol. 4, No. 4, 2014, pp.617-633.

[11] M. Nsaifabbas, and F. S. Abbas, Application of Rice Husk to Remove Humic Acid from Aqueous Solutions and Profiting from Waste Leftover, *WSEAS Transactions on Biology and Biomedicine*, Vol. 11, 2014, pp. 62-69

[12] L. Sabaruddin, L.M.H. Kilowasid, and H. Syaf, Effect of "Komba-Komba" pruning compost and planting time of mungbean in intercropping with maize on yield and soil fauna, *Agrivita* Vol. 35, No. 1, 2013, pp. 13-21.

[13] G.N. Wididana, *Application of EM-4 Technology in Agriculture in Indonesia.* IKNFS. Bogor, 1992.

[14] M. Nur, The effect of rice straw bokashi and EM-4 on growth and yield of soybean (*Glycine max* L) Var. Tampomas. *Skripsi. Badan Perencanaan Pembangunan Daerah Provinsi Nanggroe Aceh Darussalam. Aceh*, 2005, 55 pages.

[15] S. Vetayasuporn, Effects of biological and chemical fertilizer on growth and yield of glutinous corn production. *Journal of Agronomi* Vol. 5, No. 1, 2006, pp.1-4.

[16] T. Wijayanto, Zulfikar, M. Tufaila, A. M. Sarman, M. Zamrun F., Agricultural Wastes Based-Organic Fertilizers (Bokashi) Improve the Growth and Yield of Soybean (*Glycine max* (L.) Merrill). *International Journal of Agricultural Science* Vol. 1, 2016, pp. 27-32.

[17] R. S. Haslim, R.S., Growth of upland rice under different dosages of risk husk bokashi and *Trichoderm* sp., *Thesis, Faculty of Agriculture, University of Halu Oleo, Indonesia*, 2016.

[18] Nurlenawati, Production of red chilli (*Capsicum anum*) at various dossages of cow manure bokashi. *Skripsi*. *Fakultas Pertanian Universitas Haluoleo*, 2010.

[19] M.L. Habi, Phosphate availability, uptake, and corn yield, as a results of sago bokashi applications with P fertilizer on Inceptisols. *Buana Sains* Vol. 12, No. 1, 2012, pp. 63-70.

[20] J. A. Putinella, The Improvement of Physical Characteristics of Cambisol Soil and the Response of Corn due to the Application of Composted Sago Pith Waste and Flower-fruit ABG (Amazing Bio Growth) Fertilizer. *Jurnal Budidaya Pertanian* Vol. 10, No. 1, 2014, pp. 14-20.

[21] K.S. Bhosale and B.P. Shinde, Influence of Arbuscular Mycorrhizal Fungi on Proline and Chlorophyll Content in *Zingiber Officinale* Rosc Grown Under Water Stress. *Indian Journal of Fundamental and Applied Life Sciences* (Online: http://www.cibtech.org/jls). 1, 2011, pp. 172-176.

[22] L. Yi, S. Yufang, Y. Shenjiao, L. Shiqing and G.T. Chen, *African Journal of Agricultural Research* Vol. 6(10), 2011, pp.2175-2182, Available online at http://www.academicjournals.org/AJAR.

[23] M.L.C. Bartz, Earthworms as soil quality indicators, *Brazilian no-tillage systems*, 2013.

[24] G.N. Wididana and T. Higa, *Guide for Rice Planting using EM-4 Technology*. PT. Songgolangit Persada, Jakarta, 1993.

[25] Ernawati, Growth of *Allium fistulosum* at residual soil modified by soil worm and biochar, *Thesis, Faculty of Agriculture, University of Halu Oleo, Indonesia*, 2016.

[26] M. Husma, The effect of organic material and K fertilizer on growth and yield of Melon (*Curcumis melo* L.). *Tesis Program Studi Agronomi Universitas Haluoleo*, 2010.

[27] R. Kesumaningwati, The use of harvesting residues as rice husk bokashi on improving paddy soil chemical properties (pH, C-organic, N, P, and K). *Prosiding Seminar Nasional Kimia 2014*

[28] F.P. Gardner, R.B. Pearce, and R.L. Mitchell, *Physiology of Cultivated Crops*. Translated by H. Susilo. Universitas Indonesia Publisher, Jakarta, 1991.

[29] T. Higa, and G.N. Wididana, *Concept and Theories of Effective Microorganism Proceeding of the Future of Mankind*, Japan. 1991

[30] Rosmiati, Effect of the application of sustainable organic mulch on micro climates and growth of soybean, *Thesis, Faculty of Agriculture, University of Halu Oleo, Indonesia, 2015*.

[31] I M. Sulawijaya, Effect of the application of sustainable organic mulch on soybean production, *Thesis, Faculty of Agriculture, University of Halu Oleo, Indonesia, 2015*.