MAJALAH ILMIAH PETERNAKAN – VOLUME 25 (2) JUNI 2022
P-ISSN: 0853-8999 E-ISSN: 2656-8373
https://ojs.unud.ac.id/index.php/mip
DOI: https://doi.org/10/.24843/MIP.2022.v25.i02.p10

ANALYSIS OF CHICKEN MANURE FERTILIZER ON THE GROWTH EFFECTIVENESS OF WATER SPINACH (*Ipomoea reptans Poir.*)

RENGGA, W.D.P.[1], A. MALIKHANA[2], R. RAYDITYA[2], AND R. PRASETYO[3]

[1]Chemical Engineering Department, Universitas Negeri Semarang
[2]Biology Department, Universitas Negeri Semarang
[3]Chemistry Department, Universitas Negeri Semarang
e-mail: wdpitar@mail.unnes.ac.id

ABSTRACT

Livestock waste containing untreated protein feed can affect soil, air and air pollution and be a source of toxins. Chickens and those around them will know this by free ammonia. Broiler manure waste can be used as a high nitrogen nutrient that can be used as a fertilizer with additives needed by plants to increase soil fertility. The purpose of this study was to create and analyze nitrogen-rich fertilizers from broiler manure that affect plant growth or fertilizer efficiency on productivity, growth efficiency of water spinach (*Ipomoea reptans Poir*.). As a result, poultry compost contained water (63.38), nitrogen (N) (2.400%), P_2O_5 (3.914%), and K_2O (1.113%), so N levels, P, K (7.447%). It was performed for 14 days with 3 different nutritional sources. The most effective treatment for growing aquatic spinach was the use of a combination of soil and fertilizer applied in specific proportions to obtain stem height (23.55 cm), leaf number (6.2 leaves) and leaf width (3.1 cm). Results were better compared to other treatments.

Key words: broiler, livestock, organic fertilizer, nitrogen, ammonia

ANALISIS PUPUK KANDANG AYAM TERHADAP EFEKTIVITAS PERTUMBUHAN KANGKUNG DARAT (*Ipomoea reptans Poir.*)

ABSTRAK

Limbah peternakan dengan pakan berprotein yang tidak dikelola dengan baik dapat berdampak pada pencemaran tanah, udara dan air serta menjadi sumber racun. Ayam dan manusia di sekitarnya dapat berkenaan dengan ammonia bebas. Limbah kandang ayam pedaging berpotensi unsur hara N yang tinggi dapat dijadikan pupuk dengan tambahan sangat dibutuhkan tanaman dan meningkatkan kesuburan tanah. Tujuan penelitian ini membuat dan menganalisis pupuk kaya nitrogen dari kotoran ayam pedaging yang mempengaruhi pertumbuhan atau produktivitas tanaman, efisiensi pemupukan terhadap efektivitas pertumbuhan kangkung (*Ipomoea reptans Poir*.). Hasil penelitian menunjukkan bahwa kompos kotoran ayam mengandung kadar air (63,38), kadar Nitrogen (N) (2,400%), kadar P sebagai P_2O_5 (3,914%), dan kadar K sebagai K_2O (1,113%), sehingga untuk kadar N, P, K (7,447%). Pengamatan dilakukan selama 14 hari, dengan 3 perlakuan pemberian sumber hara yang berbeda. Perlakuan paling efektif terhadap pertumbuhan kangkung yaitu menggunakan kombinasi tanah dan pupuk kandang yang telah dibuat dengan perbandingan tertentu, mendapatkan tinggi batang (23,55 cm), banyak daun (6,2 leaves) hingga lebar daun (3,1 cm). Hasil lebih unggul didapatkan apabila dibandingkan dengan perlakuan lain.

Kata kunci: ayam pedaging, peternakan, pupuk organik, nitrogen, amonia

INTRODUCTION

Chicken farming provides benefits in meeting the community's needs in the consumption of healthy and nutritious food. However, livestock waste that is not utilized and managed correctly can impact the environment in soil, air and water pollution and become a source of disease. Livestock waste emits an unpleasant odour due to the production of poultry manure as a by-product of livestock. The increase in chicken manure methane gas also interferes with the aesthetics and comfort of humans in their activities (Nenobesi and Mella, 2017). One of the uses of chicken manure is to make fertilizer because it contains nutrients such as nitrogen (N), phosphorus (P), and potassium (K) needed by plants and soil fertility (Hapsari, 2013).

Rice husks are ending output of the harvesting and peeling after maturation for rice, and the naturalness gave it the primary source of many courses and practical uses (Chris, 2014). Rice husk composts are especially useful for increasing the content of humic acid in the soil's organic matter, thereby providing a source of nutrients in the soil. Organic fertilizers are fertilizers derived from plants, animal manure or other organic wastes that have gone through an engineering process in solid or liquid form. Fertilizers are enriched with minerals or beneficial microbes to increase nutrient content and improve soil physical, chemical and biological properties. Organic fertilizers can activate many soil microorganisms that release phytohormones to stimulate plant growth and increase nutrients (Adam *et al*., 2015). Organic fertilizer derived from manure is the best soil improvement material compared to other splitting materials.

Organic waste based on the type of raw material consisting of plant residues, animal waste and municipal waste has great potential to be composted into organic fertilizer. Composting is the biodegradation of organic materials by microbes that utilize organic matter as an energy source (Dewi, 2012). The principle of composting is to reduce the C/N ratio of organic matter so that it is equal to the C/N of the soil so that it is more easily absorbed by plants (Novitasari and Caroline, 2021). The effectiveness of composting, the speed of the process and the quality of the composting results are influenced by several factors, including the composition of the mixture of compost raw materials (Novitasari and Caroline, 2021). Testing the effectiveness of organic fertilizer is a field test or greenhouse activity to determine the effect of organic fertilizer on plant growth or productivity, fertilizing efficiency or increasing soil fertility.

Water Spinach is a vegetable plant from the Convolvulaceae family. Spinach contains many minerals and vitamins, essentially calcium and magnesium, which are good bone-supportive nutrients, phosphorus, iron, potassium, vitamin A, vitamin K, vitamin B, vitamin E and vitamin C, and a rich protein source (Quartacci *et al*., 2015). Pohan (2021) revealed that Water Spinach is resistant to drought, has strong adaptability to various environmental conditions, and has a short harvest period. The research results by Sudewa and Mudra (2018) reported that manure could increase the growth and yield of water spinach. Water spinach can be planted repeatedly, but subsequent plantings are not as good as the results of the first planting due to the decreased growth of water spinach. The addition of organic matter into the soil also affects organic matter content, decreases specific gravity, and decreases the value of soil mass density. The addition of rice husks at increasing doses on clay-textured soils reduces the density and increases the porosity of the soil (Demir and Gülser, 2015) Based on the background, this study aimed to analyze the content of chicken manure compost on the effectiveness of the growth of water spinach (*Ipomoea reptans Poir*.).

MATERIALS AND METHOD

Materials

The tools used in this study consisted of scoops, buckets, sacks, scales salter, polybags, NPK and pH test equipment. The materials used in this study were chicken manure, brown sugar, rice husks, fine bran, liquid organic fertilizer, water, and water spinach seeds.

Making Fertilizer

The main ingredients of fertilizer use 50% by weight of chicken manure and 50% of rice husks, then add 100 g of bran, 2 mL of liquid organic fertilizer, and 500 grams of brown sugar, the addition of bran, liquid organic fertilizer, and brown sugar is adjusted to total weight of chicken manure and rice husks. In this experiment, 1 type of fertilizer was made with adjusted composition and fermentation time, made fertilizer using 5 kg of chicken manure and 5 kg of rice husks, with a storage time of 14 days, spread fertilizer in a field and then closed tightly using a sack/MMT that could withstand from the water.

The Procedure of Analysis (Adam *et al.*, 2015)

1. Nitrogen determination:

- Sample preparation: All samples must be processed following soil specifications. The temperature was kept below 400°C to prevent the loss of nitrogen during digestion.
- Digestion: From 0.2 g (anticipated nitrogen concentration of 0.5%) to 1 g of a dry and milled fraction of the sample was employed for digestion (estimated nitrogen content of approximately 0.1%). Stir in 10 mL sulfuric acid until the acid is completely dissolved. Allow time for the mixture to cool. The catalyst mixture was then added in 2.5 g increments and cooked until the digested mixture was clear. The liquid was slowly heated for 5 h, allowing the sulfuric acid to condense to approximately 1/3 of the tube's end. The solution was kept at a temperature below 400°C.
- Titration: The tube is left to cool when digestion is completed. With steady shaking, 20 mL of water was added. The suspension was then distilled. Then, 5 mL boric acid was added to a 200 mL erlenmeyer flask, then placed under the distillation apparatus's condenser, with the condenser's end immersed in the solution. The alkali was then gently passed through the distillation chamber after 20 mL of sodium hydroxide was added to the appara-

tus' funnel. The condensate was distilled, the condenser end was cleaned, and a few drops of mixing indicator were added to the distilled water, which was then titrated with sulfuric acid to the purple endpoint. The process was carried out using steam distillation. When 100 mL of distillation had been collected, the process was terminated.

- Correction: Calibrators with known and unchanged nitrogen content were used for extinguishing controls and devices. Sulfanilic acid with a known nitrogen content was used. In addition to these substances, certified reference substances were used to control the entire procedure.
- Blank Determination: Two blanks were taken from each batch, and the average blank was used for subsequent calculations.
- Double Determination: Two subsamples were tested in the sample submitted for analysis. We set the control limits of the difference between the subsampling results of the harness and determined the accuracy.

2. Phosphorous determination:

The 1 g of air-dried soil was dissolved in 10 mL of 0.025 M HCl and 0.03 M NH_4F for 5 minutes to extract phosphorus. The molybdate blue method was used to quantify phosphorus in the filtrate, with ascorbic acid as a reactant. A Brinkmann PC 800 colourimeter was used to measure colour development at 880 nm.

3. Potassium determination:

Potassium was extracted from the soil by combining 1 gram with 1 g of standard neutral ammonium acetate in 10 mL of water and stirring for 5 minutes. The amount of exchangeable potassium was evaluated using an atomic absorption spectrophotometer set to emission mode at 776 mm and evaluating the filtered extract. Potassium (K) levels in the soil are measured in parts per million (ppm). In a 250 mL conical flask, a 20 g soil sample is mixed with 40 ml distilled water and shaken well for 1 hour. A conductivity meter was used to measure the conductivity of the supernatant (saturated soil extract).

4. pH determination:

A 1:1 (v/v) soil/water mixture (5 g soil spoon NCR for 13/5 ml deionized water) was used to evaluate the pH. Before and after a 15-min. equilibration period, samples were combined. A Beckman pH meter with glass and calomel reference electrodes calibrated for pH buffers 4 and 7 was used to measure the pH.

5. Growth of water spinach stem

The fertilizer effectiveness test was carried out by planting water spinach plants and seeing the increase in height. Three polybags would be filled with different media, the first polybag filled with ordinary soil, the polybag this would be used as a control, the second polybag filled with fertilizer from chicken manure that has been prepared. Fermented overnight for 14 days, the third polybag filled with a mixture of soil and chicken manure. The water spinach height was calculated every day to see the difference between the media used.

RESULTS AND DISCUSSION

N, P, K Content

The quality of manure from chicken is evaluated based on the nutrient content. The results of observations of macronutrients N, P, K, and water content. Table 1 shows that composted chicken manure is stored for two weeks, moisture content as much as 63.38, Kadar Nitrogen (N) as much as 2,400%. On the other hand, P as P_2O_5 is 3,914%, and K as K_2O as much as 1,113%, so the total is 7.447%. According to Musyoka *et al.* (2019), the nitrogen mineralisation rate is the single most crucial factor determining the quantity and period of nutrient availability of organic fertilizers for plant absorption. For optimal plant growth and yield, the pattern of N mineralization must match fluctuations in plant nutrient requirements to cause synchronization, namely the balance between N supply and N demand (Johnson *et al*., 2012).

Table 1. Test results of chicken manure compost

No	Parameter	Unit	Test Results
1	Water content	%	63.38
2	Nitrogen content	% (b/b) adbk	2.400
3	P as P_2O_5	% (b/b) adbk	3.914
4	K as K_2O_5	% (b/b) adbk	1.133
5	Amount of level N,P,K	% (b/b) adbk	7.447

This manure contains the results of the amount of N, P and K (Table 1), which supports the growth of spinach (*Ipomoea reptans Poir*.), because it has a high nutrient content so that boiler manure can improve fertility levels in problematic soils and can increase production yields (Pohan, 2021). The amount of phosphorus in fertilizers is influenced by the ingredients and the initial phosphorus content in the ingredients so that the phosphorus released can be controlled (Rengga *et al*., 2019). The increase in phosphorus levels impacts the microorganism *Lactobacillus sp*, which transforms glucose into lactic acid. The conditions in the material become more acidic, resulting in phosphate being dissolved in the organic acids produced by these microorganisms. The condition of the material becomes more acidic, resulting in dissolved phosphate in the organic acids produced by these microorganisms. Potassium is a compound produced by bacterial metabolism, where bacteria use free K^+ ion in the compost base for metabolic purposes. K^+ ions are essential in high concentrations in plant organs

such as leaves (Sardans and Peñuelas, 2021). According to Diether and Willing (2019), potassium is used by microorganisms in the substrate as a catalyst in the presence of bacteria, and its activity will significantly affect the increase in potassium.

According to Demir and Gülser (2015). Manure treatment increased the available K, and Mg content in the soil, different applications of agricultural waste increased the available K, Mg and P content in different textured soils. As a product of the decomposition of organic matter, organic acids provide nutrients available to plants, especially phosphorus and microelements resulting from organic processing into the soil. The level of soil productivity increases with the increase in the amount of available P.

Therefore, this is following the opinion of Hua *et al.* (2020) that manure can increase the availability of nutrients for plants that can be absorbed from the soil. Effect of manure and compost on improving soil fertility and increasing crop yields.

pH Test

The pH measurement was carried out to determine whether the chicken manure compost made met the standard requirements for solid organic fertilizer. In week 2, a pH test was carried out using pH paper. The pH value that appeared was 8. The nitrogen content influenced changes in pH in the fertilizer. According to Kaswinarni and Nugraha (2020), the pH value significantly affects microbial activity during composting because the pH value strongly influences microbial growth. As the fermentation process progresses, there will be a process of releasing acid to lower the pH. The quality of the total nitrogen content of manure compost enriched with rice husk is significantly improving (Murimi and Gbedemah, 2018).

Growth of Water Spinach Stem

This research was conducted in a greenhouse with a daily temperature between 32-38°C and relative humidity of 42-66%. Plant height was measured using a ruler starting from the base of the stem to the tip of the highest leaf of the plant. As the age of the land spinach stem plant is increases, the plant grows taller.

The growth of water spinach stem height was observed every four days until it reached 16 days. Figure 1 shows that growth on day 4 using ordinary soil without fertilizer is better than using fertilizer alone (3,331 cm). At the age of 16 days, the use of soil and fertilizer was better than using soil alone or fertilizer alone. It shows that applying organic fertilizer from chicken manure with a soil formulation at a specific dose can increase the height of spinach plants, besides that each dose given can absorb nutrients that are different in plants

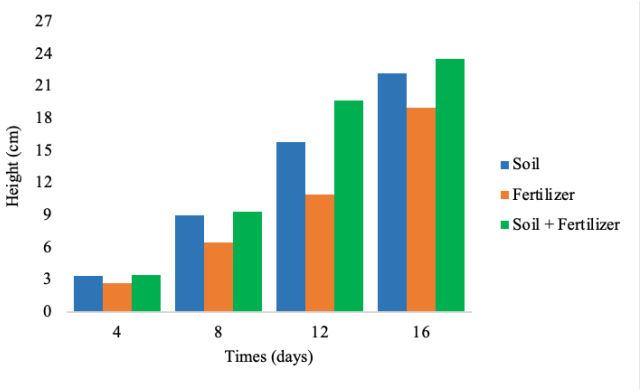

Figure 1. The growth rate of water spinach plant height

(Larramendy *et al.*, 2016). There is nitrogen in organic chicken manure, which can affect growth (Sari *et al.*, 2016). Nitrogen is an element of protein formation. If plant roots absorb nitrogen, the apical meristem will actively divide. So that the tip of the stem of the plant will be spurred on its growth (Thitithanakul, 2012)

In addition, it is suspected that the function of chicken manure is to increase the absorption and storage capacity of water, which as a whole can increase soil fertility (Mardiansyah *et al.*, 2020) so that the roots more easily absorb the nutrients contained in the soil and make soil and organic fertilizer formulations. It has higher and optimal growth. By the research of Larramendy *et al.* (2016), the combination of organic fertilizer application with soil can improve soil physical properties and meet the nutrients needed by plants.

Table 2. The shot number of water spinach

Treatment	Amount			
	4 days	8 days	12 days	16 days
Soil	2,0	4,2	5,2	6,0
Fertilizer	1,9	4	5,1	5,8
Soil+Fertilizer	2,3	4,4	5,3	6,2

The study results on the growth of the number of spinach leaves can be seen in Table 2. As the age of the spinach plant increases, the number of spinach leaves increases. Growth on day 4 using ordinary soil without fertilizer is better than using only fertilizer (2 leaves). However, other results showed that using soil and fertilizer was better than using soil alone or fertilizer alone, which produced 2.3 leaves on day 4 and 6.2 leaves on day 16.

It can be seen that the least number of leaves is on plants that only use manure, thus indicating that the application of manure is less practical. However, when combined with soil, at a specific dose can produce spinach plants with the most leaves. It is because the application of manure and soil can increase the availability of optimal nitrogen (N) and phosphorus (P) nutrients

(Larramendy *et al.*, 2016). Meanwhile, Damanik *et al.* (2011) stated that chicken manure contains three times more nitrogen. This content can increase the growth and development of the number of plants leaves more than other treatments.

From Table 3, it can be seen that as the age of the water spinach plant increases, the leaf length of the land spinach plant is getting longer. The most extended average leaf length of spinach on day 4 was spinach with soil with a combination of manure, while the shortest were plants with manure alone. These results reinforce the statement that manure application with a specific dose without being combined with other materials, such as soil, will show or produce different leaf lengths. However, if the plant does not get additional nitrogen, it will grow stunted, and the leaves will be smaller, thinner, the number of leaves will be small. Meanwhile, plants with sufficient additional nitrogen elements will form more and broader leaves (Aczel, 2019). In addition, observations showed that the leaf surface area of each plant was different in each treatment with chicken manure. So it is necessary to pay attention to the dosage and mix of each component so that the growth of plants becomes optimal. This study found that the combination of organic fertilizer application with soil showed the best results because it could meet the needs of plants to the fullest.

Table 3. The leaf length of water spinach

Treatment	Lengthy			
	4 days	8 days	12 days	16 days
Soil	0,65	1,55	2,31	2,90
Fertilizer	0,43	1,45	2,10	2,58
Soil+Fertilizer	0,88	1,78	2,65	3,10

Another thing that affects the leaf surface area is the effect of light and CO_2 capture. If the leaves get optimal light and CO_2, the rate of photosynthesis increases and is effective. So that the results of photosynthesis can be translocated to areas of vegetative use, namely roots, stems and leaves that affect growth and development. (Weraduwage *et al.,* 2015).

The process of making broiler chicken manure can be seen in Figure 2. With the addition of rice husks, brown sugar, and liquid organic fertilizer, this product has a high potential for the growth of spinach (*Ipomoea reptans Poir.*) as evidenced in (Tables 2, 3). This manure contains the yield of N, P and K (Table 1), which supports the growth of water spinach. Based on the study results, the best results were obtained with the formulation of organic fertilizers when combined with soil. Research Hayat *et al.* (2021) on the use of manure and inorganic fertilizers reported that the nutrient content of Nitrogen (N) could stimulate plant vegetative growth.

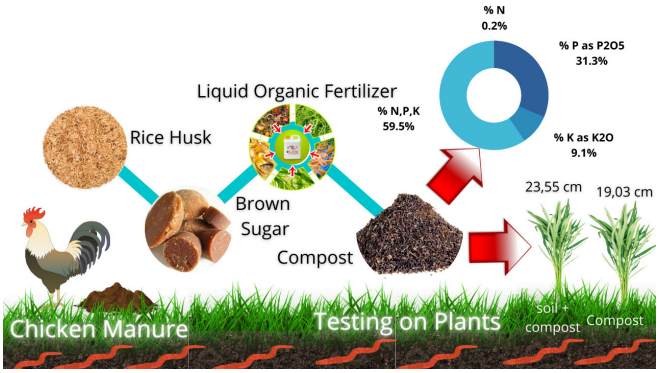

Figure 2. Schematic the process of making compost and its application

Application of organic fertilizers can increase the availability of nitrogen (N) and phosphorus (P) nutrients, organic fertilizers can add nutrients that are important for the growth of roots of land spinach plants, namely nitrogen (N). If the roots absorb nitrogen, the apical meristem at the tip of the root will actively divide so that the roots will grow faster. With this research, the use of fertilizer from chicken manure is highly recommended for spinach plants to produce better quality (Mardiansyah, 2020).

CONCLUSION

Based on observations, it can be concluded that chicken manure compost contains water content (63.38), Nitrogen content (N) (2.400%), P content as P_2O_5 (3.914%), and K content as K_2O (1.113%). So for the total levels of N, P, K (7.447%). The most effective treatment for growing aquatic spinach was the use of a combination of soil and fertilizer applied in specific proportions to obtain stem height (23.55 cm), leaf number (6.2 leaves) and leaf width (3.1 cm).

REFERENCES

Adam, A.H.M., I.M.F. Abdallah, M. AbdhKriem, and G.A. Ibrahim. 2015. Analyzing soil NPK, pH and electrical conductivity at Adhan area-Renk, Upper Nile state. Int J Sci Technol Res. 4(12):341-347.

Aczel, M. 2019. What Is the Nitrogen Cycle and Why Is It Key to Life?. Front. Young Minds. 7:41.

Chris, D. 2014. Introduction to Polymeric Composites with Rice Husks. SmithersRapra Technology. 5: 57-67.

Damanik, M.M.B., E.H. Bachtiar, and Fauzi. 2011. Kesuburan Tanah dan Pemupukan. USU Press. Medan.

Demir, Z. and C. Gülser. 2015. Effects of rice husk compost application on soil quality parameters in greenhouse conditions. Eurasian J. Soil Sci. 4(3): 185-190.

Dewi, Y.S. 2012. Pengolahan sampah skala rumah tangga

menggunakan metode composting. Jurnal Ilmiah, 8(2): 35–48.

Diether, N.E. and B.P. Willing. 2019. Microbial fermentation of dietary protein: an important factor in diet-microbe-host interaction. Microorganisms. 7(19): 1-14.

Hapsari, A.Y. 2013. Kualitas dan kuantitas kandungan pupuk organik limbah serasah dengan inokulum kotoran sapi secara semianaerob. Skripsi. Program Sarjana, Universitas Muhammadiyah Surakarta, Surakarta.

Hayat, E.S., S. Andayani, and R. Hayati, R. 2021. Substitution of inorganic fertilizer with organic fertilizer based on poultry waste combined with rice husk biochar. IOP Conf. Ser. Earth Environ. Sci. 824(1): 1-6.

Hua, W., P. Luo, N. An, F. Cai, S. Zhang, K. Chen, J. Yang, and X. Han. 2020. Manure application increased crop yields by promoting nitrogen use efficiency in the soils of 40-year soybean-maize. Sci.Rep. 10(1):1-10.

Johnson, H.J., J.B. Colquhoun, A.J. Bussan, and C.A.M. Laboski. 2012. Estimating nitrogen mineralization of composted poultry manure, organic fertilizers, and green manure crops for organic sweet corn production on a sandy soil under laboratory conditions. Horttechnology. 22: 37–43.

Kaswinarni, F. and A.A.S. Nugraha. 2020. Kadar fosfor, kalium dan sifat fisik pupuk kompos sampah organik pasar dengan penambahan starter EM4, kotoran sapi dan kotoran Ayam. Titian Ilmu: J. Ilm. Multi Sci. 12(1): 1-6.

Larramendy, M.L. and S. Soloneski. 2016. Organic fertilizers - from basic concepts to applied outcomes, use of organic fertilizers to enhance soil fertility, plant growth, and yield in a tropical environment. INTECH 4:85-108

Mardiansyah, K., A. Usup, and E.R. Asie. 2020. The effects of biochar and chicken manure application on red ginger (*Zingiber officinale Rosc.*) growth and yield of semi paludiculture in tropical peatlands. J. Tropical Peat. 10(2): 9-16.

Murimi, S.M. and S.F. Gbedemah. 2018. Suitability of rice husk and chicken droppings as organic fertilizer for sustainable agriculture in Ghana. JEIADC. 10(2): 2141-2731.

Musyoka, M.W., N. Adamtey, E.K. Bünemann, A.W. Muriuki, E.N. Karanja, M. Mucheru-Muna, K.K.M. Fiaboe, and G. Cadisch. 2019. Nitrogen release and synchrony in organic and conventional farming systems of the Central Highlands of Kenya. Nutr. Cycl. Agroecosyst. 113: 283–305.

Nenobesi, D., W. Mella, and P. Soetejo. 2017. Pemanfaatan limbah padat kompos kotoran ternak dalam meningkatkan daya dukung lingkungan dan biomassa tanaman kacang hijau (*Vigna radiata* L.). Pangan. 26(1): 43–56.

Novitasari, D. and J. Caroline. 2021. Kajian efektivitas pupuk dari berbagai kotoran sapi, kambing dan ayam. Seminar Teknologi Perencanaan, Perancangan, Lingkungan, dan Infrastruktur II. 1: 442–447.

Pohan, S.D. 2021. The effect of organic fertilizers on growth and yield of water spinach (*Ipomoea reptans Poir*). JIJCS. 3(2): 37-44.

Quartacci, M.F., C. Sgherri, R. Cardelli, and A. Fantozzi. 2015. Biochar amendment reduces oxidative stress in lettuce grown under copper excess. Agrochimica. 59(2): 188–202.

Rengga, W.D.P., M.A. Mubarok, and N.S. Cahyarini. 2019. Phosphate Release from Slow Release fertilizer using a mixture of Chitosan and Potato Flour as a coating. J. Bahan Alam Terbarukan. 8(1): 34-40.

Sardans, J. and J. Peñuelas. 2021. Potassium control of plant functions: ecological and agricultural implications. Plants. 10(419): 1-31.

Sari, K.M., A. Pasigai, and I. Wahyudi. 2016. Pengaruh pupuk kandang ayam terhadap pertumbuhan dan hasil tanaman kubis bunga (*Brassica oleracea var. Bathytis* L.) pada oxic dystrudepts lembantongoa. Agoritekbis. 4(2): 151-159.

Sudewa, K.A. and L.K.S. Mudra. 2018. Analisis pupuk kandang ayam dan biourine terhadap pertumbuhan dan hasil dari benih dan punggul tanaman kangkung darat (*Ipomea reptans*). GemaAgro. 23(1): 44-52.

Thitithanakul, S. 2012. Effect of nitrogen supply before bud break on early development of the young hybrid poplar. Agricultural sciences. Université Blaise Pascal - Clermont-Ferrand II, 2012. English.

Weraduwage, S.M., J. Chen, F.C. Anozie, A. Morales, S.E. Weise, and T.D. Sharkey. 2015. The relationship between leaf area growth and biomass accumulation in Arabidopsis thaliana. Front. Plant Sci. 6(1):1-21.