p-ISSN 1410-5659 e-ISSN 2621-5144
Published by Fakultas Peternakan UNPAD
Unpad Press

Jurnal Ilmu Ternak Universitas Padjadjaran, Desember 2022, 22(2):111-117
DOI: 10.24198/jit.v22i2.41456
Available online at http://jurnal.unpad.ac.id/jurnalilmuternak

Optimization of Using Cow's Manure Fertilizer at Different Rates on Growth and Production of *Salvinia* sp as Forage Feed

Uti Nopriani[1,a], Yusuf Randi Maugo[1], Juni Sumarmono[2]
[1]*Program Studi Peternakan, Fakultas Pertanian, Universitas Sintuwu Maroso, Poso*
[2]*Fakultas Peternakan, Universitas Jenderal Soedirman, Purwokerto*
[a]*email*: utinopriani86@unsimar.ac.id

Abstract
Salvinia sp is a high-quality aquatic plant with a high potential forage source for animals. The purpose of this study was to determine the effect of the use of cow manure on the growth and production of *Salvinia* sp *crops*. The variables in this study are leaf cover area (LCA), replication time, leaf diameter, and biomass production of *Salvinia* sp plants. The design used in this study was a completely randomized design (CRD) with four treatments of cow manure as fertilizer, consecutively: without manure; 5 g/L; 10 g/L; and 15 g/L. Each treatment has five replicates. The results showed that cow manure fertilizer significantly increased leaf cover area, replication time, leaf diameter, and biomass production of *Salvinia* sp. Cow manure fertilizer at a rate of 15 g/L is the best treatment. Increase in leaf cover area = 557.48 cm; replication time = 2.99 days; fresh weight = 8.80 g; dry matter = 0.72 g. Results of linear regression analysis showed that the replication time of leaf cover area had a significant relationship with crop biomass production of *Salvinia* sp.
Keywords: Growth, Production, Cow Manure Fertilizer, *Salvinia* sp

Optimalisasi Penggunaan Pupuk Kandang Sapi dengan Dosis yang Berbeda Terhadap Pertumbuhan dan Produksi Tanaman Salvinia sp sebagai Hijauan Pakan

Abstrak
Salvinia sp ialah tanaman air yang berkualitas tinggi sehingga berpotensi dimanfaatkan sebagai sumber hijauan pakan ternak. Tujuan penelitian ini yaitu untuk mengetahui efek penggunaan pupuk kandang sapi terhadap pertumbuhan dan produksi tanaman Salvinia sp. Variabel yang diamati dalam penelitian ini ialah pertambahan luas cover area (LCA), waktu replikasi, diameter daun, dan produksi biomassa tanaman Salvinia sp. Rancangan yang digunakan dalam penelitian ini ialah rancangan acak lengkap (RAL) dengan 4 perlakuan pupuk kandang sapi, secara berturut-turut: tanpa pupuk kandang; 5 g/L; 10 g/L; 15 g/L. Tiap perlakuan diulang sebanyak 5 kali. Hasil penelitian menunjukan bahwa perlakuan pupuk kandang sapi berpengaruh nyata (P<0,05) terhadap pertambahan luas cover area (LCA), waktu replikasi, diameter daun, dan produksi biomassa tanaman Salvinia sp. Perlakuan pupuk kandang sapi dengan dosis sebanyak 15 g/L merupakan perlakuan yang terbaik. Pertambahan luas cover area (LCA) = 557,48 cm; waktu replikasi = 2,99 hari; berat segar = 8,80 g; bahan kering = 0,72 g. Hasil analisis regresi linier menunjukan bahwa waktu replikasi luas cover area (LCA) mempunyai hubungan yang signifikan terhadap produksi biomassa tanaman Salvinia sp.
Kata kunci: Pertumbuhan, Produksi, Pupuk Kandang Sapi, Salvinia sp

Introduction

The availability and quality of fodder are particularly crucial for ruminants (Salami *et al*., 2019). The provision of forage feed for ruminants has always been a significant problem, especially in the dry season. The demand for sustainable feedstock that could be productive under existing conditions is increasing. Aquatic plants, such as the free-floating species duckweed, have begun to garner interest due to their unique characteristics, which provide advantages over terrestrial plants (Tran *et al*., 2020). *Salvinia* sp is a potential aquatic plant that can be used as a source of forage feed with reasonably high quality. In addition to availability problems, the quality of feed forage in Indonesia is generally low, namely low in protein and high in fiber in the form of lignocellulose and mineral deficiencies. An alternative that can be done is using forage other than grass and legume groups.

Salvinia sp is rich in nutrient content. The protein content of the *Salvinia molesta* plant is

13.26%, dry matter 61.05%, hemicellulose 11.01%, and cellulose 6.06% (Martínez-Yáñez *et al*., 2018). *Salvinia* sp is rich in phenolic compunds such as ascorbic acid, quercetin, gallic acid, resorcinol, catechol, vanillin, and benzoic acid (Gini & Jeya Jothi, 2018).

Salvinia sp is one of aquatic plants which has a practical phytoremediation ability to improve the water quality polluted by heavy metals (Wickramasinghe & Jayawardana, 2018; Singh & Kumar, 2022). For example, *Salvinia* sp can absorb the heavy metal chromium in the tannery waste as much as 80.4% (Safarrida *et al*., 2015). The high potential of the *Salvinia* sp plant can be developed as an alternative source of forage feed for supporting livestock productivity. *Salvinia* sp plants can be propagated by controlled cultivation with good fertilization using organic fertilizers. One of the types of organic fertilizers is cow manure.

A cow can produce fresh manure of approximately 8-10 kg/day. Cow manure has the potential to be used as a source of material to make organic fertilizer (Ayamba *et al*., 2021). The manure contains nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, sodium, iron, and copper (Font-Palma, 2019). Cow manure is a solid fertilizer that contains a lot of water and mucus. The nutrient composition in solid cow manure is self-contained 0.50% N, 0.25% P_2O_5, 0.50% K_2O, and moisture content 0.5%. Prasetyo (2014) stated that the water content of cow manure is high, which is 85%; thus, the humidity will also increase. High humidity will also be followed by the rate of the decomposition process and the availability of nutrients in cow manure so that these nutrients can be easily absorbed, and plant growth will increase.

Cow manure contains nutrients and organic matter that can improve the soil's physical, chemical, and biological properties. Using organic fertilizer is a viable option to reduce soil deterioration caused by the excessive use of chemical fertilizers, which can alter soil bacterial diversity and community structure (Zhang *et al*., 2020).The use of cow manure significantly affects plant height, number of leaves, leaf area, fresh weight, and dry weight of mustard plants (Gole *et al*., 2019). The application of cow manure of as much as 30 tons/ha resulted in the fresh weight of *Brachiaria humidicola* grass as much as 3.8 kg/plot (Satata & Kusuma, 2014).

Studies on the application of cow manure as fertilizer for *Salvinia* sp plants are limited. For this reason, it is imperative to study the use of cow manure at different rates and determine the optimal rate of cow manure as fertilizer for *Salvinia* sp. The purpose of this study was to study and establish the use of cow manure at an optimal rate to increase the growth and production of *Salvinia* sp.

Materials and Methods

Material

The material used in this research was *Salvinia* sp 40 g; well-water 140 liters, rice field sludge 7 liters, and cow manure 210 g. Manure in the form of dry cow feces obtained from a local beef cattle farmer. Cow manure contains nutrient, including 3% N, 2% P_2O_5, and 1% K_2O (Gilroyed *et al*., 2015; Sanni, 2016). The equipment used in this study was a plastic tub measuring 30×20 cm, digital scales, measuring cups, rulers, plastic bags, buckets, and ovens.

Method

This study was designed using a completely randomized design (CRD) with four treatments of cow manure: without cow manure, cow manure 5 g/L, cow manure 10 g/L, and cow manure 15 g/L. Each treatment was repeated five times.

Research Procedure

Preparation and Seeding of *Salvinia* sp

Salvinia sp seeding was carried out in a tub containing a mix of well-water and rice field sludge for one month to propagate the plants so that the same size was obtained. The research started by preparing 20 plastic tubes measuring 30×20 cm. Each treatment bath contains 7 liters of well-water mixed with rice field sludge, as much as 5% of the total volume of water in the tub. Cow manure fertilizer was dissolved in the media according to the treatment, namely 5 g/L, 10 g/L, and 15 g/L. Then, the mix was allowed to stand for a week to decompose.

Planting and Harvesting of *Salvinia* sp

Salvinia sp planting was carried out after the planting media had been dissolved for a

week according to the respective treatment. A total of 2 g of seedlings was planted in each treatment tub. Plants were harvested after being allowed to grow for three weeks, and the plants covered all the surface area. Then, the plant was weighed to obtain fresh weight.

Variable Observed

The variables observed in this study were the increase in leaf cover area (LCA), replication time of LCA, leaf diameter, fresh weight, and dry weight production.

1. LCA of the *Salvinia* sp was obtained by measuring its length and width using two rulers each week. The measurement was done by collecting the plant until the water's surface was not visible (Boti *et al*., 2018; Nopriani *et al*., 2014).
2. The time replication of the LCA of *Salvinia* sp plant was the time required by the plant to double itself in just two days to cover all areas. The replication time was calculated based on the formula ISO 20079 (Nopriani *et al*., 2014):

$$GR_i = \frac{\ln Nt_i - \ln Nt_0}{t_1 - t_0} \qquad T_i = \frac{\ln 2}{GR_i}$$

Description:

GR_i	:	*Growth Rate* or plant growth rate ($^{day-1}$)
Ln	:	Natural logaritm
Nt_0	:	Leaf covers area of the plant at t_0
Nt_i	:	Leaf covers area of plants at the time t_i
t i-t_0	:	Interval or difference in the time of the initial and final measurements
T_i	:	Time replication ($^{day-1}$)

3. The leaf diameter of the *Salvinia* sp plant was obtained by measuring the part of the leaf in each unit of the experiment using a caliper. This step was carried out at the beginning and end of the study.
4. The fresh weight production of the *Salvinia* sp plant was obtained by weighing the final fresh weight minus the initial fresh weight.
5. The production of dry-weight *Salvinia* sp was obtained through 2 stages. Initially, fresh *Salvinia* sp was dried under the sun for 24 hours. Furthermore, the plant was dehydrated at a temperature of 60°C for 24 hours. The percentage of dry matter was obtained by dividing the weight of the *dried Salvinia* sp plant by the fresh weight of *Salvinia* sp.

Data Analysis

Data analysis was carried out using the Analysis of Variance (ANOVA) followed by a posthoc test *Duncan's Multiple Range Test* (DMRT). Data were analyzed by using SPSS version 18.

Results and Discussion

Increase in Leaf Cover Area (LCA) of *Salvinia* sp

Table 1 presents the increase of LCA of *Salvinia* sp as affected by different rates of cow manure fertilizer. LCA of *Salvinia* sp treated with cow manure fertilizer was significantly higher than the control.

Table 1 shows that using cow manure fertilizer at different rates increased the growth of *Salvinia* sp plants every week. The ANOVA showed the significant effects ($P<0.05$) of cow manure fertilizer on the increase in LCA of the *Salvinia* sp. The addition of cow manure fertilizer at a rate of 15 g/L resulted in the highest LCA (557.48 cm^2). In contrast, the lowest LCA was obtained from the control treatment (without cow manure fertilizer). This shows that the treatment of cow manure at a rate of 15 g/L is enough to release organic matter and macronutrients such as nitrogen, phosphorus, and potassium to increase the LCA of the *Salvinia* sp. Organic matters contained in cow manure fertilizer improved and increased the nutrient content of the growing media. The more nutrients in the growing media, the better the plant growth rate. The research results by Surdina *et al*. (2016) showed that planting media added with manure rich in nitrogen and phosphate increase plant growth and production of *Azolla microphylla*. Compared to chemical fertilizers, the use of cow manure fertilizer promote higher available nitrogen, phosphorus, and organic matter in the soil (Hasnain *et al*., 2020).

Replication Time of Leaf Cover Area (LCA), Leaf Diameter, and Biomass Production of *Salvinia* sp

Table 2 presents the average replication time of LCA, leaf diameter, and biomass production of *Salvinia* sp.

Replication Time Leaf Cover Area (LCA) of *Salvinia* sp

Salvinia sp is a vegetatively multiplying plant, where propagation is carried out by dividing themselves by forming new saplings only in about 2-4 days.

Table 1. The average increase in leaf cover area (LCA) of *Salvinia* sp

Treatment	LCA of *Salvinia* sp (cm^2) at week:				Total increase in LCA (cm^2)
	0	1	2	3	
Without cow manure	22.51	79.00	153.60	261.80	239.29[d]
Cow manure 5 g/L	22.52	154.80	273.20	364.00	341.48[c]
Cow manure 10 g/L	22.50	245.80	359.80	420.00	397.50[b]
Cow manure 15 g/L	22.52	395.60	512.00	580.00	557.48[a]

Means followed by different superscripts in the same column differ significantly (P<0.05)

Table 2. Replication time of leaf cover area, leaf diameter, and biomass production of *Salvinia* sp

Treatment	Variables			
	LCA Replication Time (days)	Leaf Diameter (mm/leaf)	Biomass Production	
			Fresh Weight (g)	Dry Weight (g)
Without cow manure	3.96[d]	3.85[b]	4.20[d]	0.30[d]
Cow manure 5 g/L	3.49[c]	4.05[b]	5.60[c]	0.40[c]
Cow manure 10 g/L	3.32[b]	4.12[a]	6.60[b]	0.52[b]
Cow manure 15 g/L	2.99[a]	4.10[a]	8.80[a]	0.72[a]

Means followed by different superscripts in the same column differ significantly (P<0.05)

Results showed that the use of cow manure fertilizer significantly (P<0.05) affected the replication time of LCA of *Salvinia* sp. (Table 2). The addition of cow manure fertilizer at a rate of 15 g/L sped up the growth of *Salvinia sp*. The *doubling time* was much shorter compared to other treatments. The increased speed of replication time is likely caused by the increase of nitrogen (N) nutrient content in the planting media. Adding cow manure fertilizer of 15 g/L provides sufficient nitrogen for *Salvinia* sp to grow and develop. Nitrogen is needed to trigger growth, especially as part of enzymes. This is in line with Patti *et al*. (2013) that nitrogen increases plants' vegetative growth. Furthermore, Tando (2018) elaborated that nitrogen is essential as a constituent of enzymes in plant metabolic processes. *Salvinia* sp optimally utilizes the presence of nitrogen in the planting media so that replication time can take place quickly.

Leaf Diameter of *Salvinia* sp

Table 2 shows the significant effects (P<0.05) of cow manure fertilizer at different rates on the leaf diameter of the *Salvinia* sp. At a rate of 15 g/L, the plant produced the highest leaf diameter, 4.10 mm/leaf, although the differences were not significant compared to that of 10 g/L cow manure fertilizer. In contrast, the lowest value was obtained on the treatment without cow manure. The increase in the leaf diameter of the *Salvinia* sp plant was in line with the increase in the rate of cow manure. Cow manure contains nitrogen which is absorbed to promote leaf growth. The availability of nitrogen nutrients in the planting media significantly affects vegetative growth, especially on the leaves. This is in line with Triadiati *et al*. (2012) that vegetative plants actively need and absorb nitrogen (N) nutrients. The process of plant growth is also often characterized by the diameter of the leaves to carry out the process of photosynthesis. Harsono *et al*. (2021) stated that leaf area determines the rate of plants' photosynthesis.

Salvinia sp Plant Biomass Production

Results showed that the use of cow manure fertilizer had a significant influence (P<0.05) on the biomass production of *Salvinia* sp (Table 2). The lowest average biomass production of *the Salvinia* sp plant was obtained in the treatment without cow manure, fresh weight of 4.20 g and a dry weight of 0.30 g. The highest fresh and dry weight production was obtained from plants fertilized with cow manure at 15 g/L, with a fresh weight of 8.80 g and a dry weight of 0.72 g. The high biomass production is influenced by the relatively short replication time of LCA. This is likely due to the availability of nutrients in the planting media, where the *Salvinia* sp absorbs nutrients optimally in the planting media enriched with nitrogen. Nitrogen is a macronutrient that has a crucial role in plant growth. This is in line with the results of research by Arif *et al*. (2021) showing that the application of manure can increase the vegetative growth of plants.

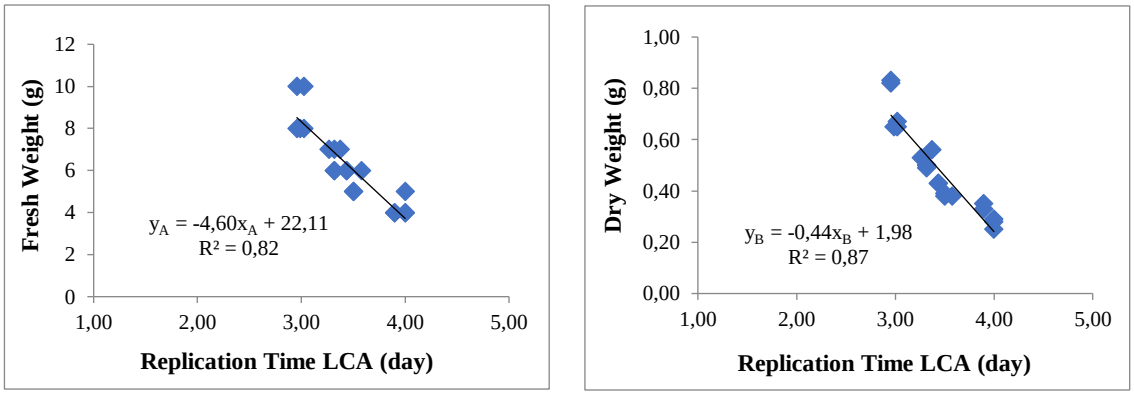

Figure 1. Correlation between leaf cover area replication time (LCA) and biomass production of *Salvinia* sp

The balanced availability of nutrients according to the plant's needs will result in optimal growth and production. Furthermore, growing media is one of the factors that determine plant growth, nitrate, carotenoids, vitamin C, and chlorophyll in lettuce leaves (Sarkar *et al*., 2021).

Correlation of Leaf Cover Area (LCA) Replication Time with *Salvinia* sp Biomass Production

The increased rates of cow manure fertilizer for *Salvinia* sp significantly reduce the time required to replicate LCA and biomass production. Figure 1 presents the correlation between leaf cover area (LCA) replication time and biomass production of *Salvinia* sp.

The variables x_A and x_B are the replication time of LCA, y_A is the fresh weight and y_B is the dry weight (Figure 1). The linear equation representing the correlation between the replication time of LCA and the fresh weight of *Salvinia* sp in all treatments was $y_A = -4.60x_A + 22.11$ (R^2=0.82). The linear correlation equation between the replication time of LCA and the dry weight of *Salvinia* sp in all treatments was $y_B = -0.44x_B + 0.98$ (R^2=0.87). The value of R^2 indicates that 82% of fresh weight and 87% of dry weight are affected by the replication time of the plant. The correlation value shows a negative correlation, where the more prolonged the replication time, the lower the biomass production. The linear regression analysis showed that replication time significantly correlates with plant biomass production of *Salvinia* sp. Replication time has a significant relationship with the biomass production of aquatic plants (Boti *et al*., 2018; Gustafsson & Norkko, 2019; Nopriani *et al*., 2014).

Using cow manure fertilizer in the growing media speeds up the replication time of plants. The faster the replication time, the faster the *Salvinia* sp plant absorbs nitrogen nutrients dissolved in the planting media. This shows that the nitrogen content in cow manure fertilizer contributes to the faster growth of *Salvinia* sp. The availability of nitrogen in plants in sufficient quantities can facilitate the process of cell division because nitrogen has a vital role in stimulating growth (Sheoran *et al*., 2021). Cow manure is rich in nutrients to promote the growth of *Salvinia* sp.Investigation on the aquatic plant *Azolla* sp by Azab & Soror (2020) showed that the addition of the fertilizers significantly increase the contents of N and P in the tissue compared to the untreated plant.

Conclusion

The use of cow manure has a noticeable influence on the growth and production of *Salvinia* sp crops. Using cow manure fertilizer with a rate of 15 g/L optimally increases the growth and production of *Salvinia* sp. crops. Extensive cover area replication time has a significant relationship to the biomass production of the *Salvinia* sp.

References

Arif, F. A., Susanto, H., & Pujisiswanto, H. (2021). Pengaruh pupuk kandang kambing dan sapi terhadap pertumbuhan Azolla microphylla. *Jurnal Agrotropika*, *20*(1), 35–41. https://doi.org/10.23960/ja.v20i1.4740

Ayamba, B. E., Abaidoo, R. C., Opoku, A., & Ewusi-Mensah, N. (2021). Enhancing the fertilizer value of cattle manure using

organic resources for soil fertility improvement: A Review. *Journal of Bioresource Management*, *8*(3), 89–107. https://doi.org/10.35691/JBM.1202.0198

Azab, E., & Soror, A. S. (2020). Physiological behavior of the aquatic plant Azolla sp. in response to organic and inorganic fertilizers. *Plants*, *9*(7), 1–13. https://doi.org/10.3390/plants9070924

Boti, E. S., Nopriani, U., & Loliwu, Y. A. (2018). Efektivitas pemberian pupuk kandang sapi terhadap produktivitas Lemna minor sebagai hijauan pakan ternak. *Jurnal Agropet*, *15*(1), 1–8.

Font-Palma, C. (2019). Methods for the treatment of cattle manure-A Review. *C Journal of Carbon Research*, *5*(2), 27. https://doi.org/10.3390/c5020027

Gilroyed, B. H., Li, C., Reuter, T., Beauchemin, K. A., Hao, X., & McAllister, T. A. (2015). Influence of distiller's grains and condensed tannins in the diet of feedlot cattle on biohydrogen production from cattle manure. *International Journal of Hydrogen Energy*, *40*(18), 6050–6058. https://doi.org/10.1016/j.ijhydene.2013.07.014

Gini, T. G., & Jeya Jothi, G. (2018). Column chromatography and HPLC analysis of phenolic compounds in the fractions of Salvinia molesta mitchell. *Egyptian Journal of Basic and Applied Sciences*, *5*(3), 197–203. https://doi.org/10.1016/j.ejbas.2018.05.010

Gole, I. D., Sukerta, I. M., & Udiyana, B. P. (2019). Pengaruh dosis pupuk kandang sapi terhadap pertumbuhan tanaman sawi (Brassica juncea L.). *Agrimeta: Jurnal Pertanian Berbasis Keseimbangan Ekosistem*, *9*(18), 46–51.

Gustafsson, C., & Norkko, A. (2019). Quantifying the importance of functional traits for primary production in aquatic plant communities. *Journal of Ecology*, *107*(1), 154–166. https://doi.org/10.1111/1365-2745.13011

Harsono, P., Handayanta, E., Hartanto, R., Yunus, A., Rahayu, M., & Anggara, W. S. (2021). Pertumbuhan dan hasil tanaman sorgum manis (Sorghum bicolor L.) dengan aplikasi pupuk kandang di lahan kering. *Jurnal Agrotek Indonesia (Indonesian Journal of Agrotech)*, *6*(1), 33–43. https://doi.org/10.33661/jai.v6i1.4411

Hasnain, M., Chen, J., Ahmed, N., Memon, S., Wang, L., Wang, Y., & Wang, P. (2020). The effects of fertilizer type and application time on soil properties, plant traits, yield and quality of tomato. *Sustainability*, *12*(21), 1–14. https://doi.org/10.3390/su12219065

Martínez-Yáñez, R., Albertos-Alpuche, P. J., Guzmán-Mendoza, R., Robaina-Robaina, L. E., Álvarez-González, A., & Díaz-Plascencia, D. (2018). Production and chemical composition of hydrophytes cultivated in aquaponics. *Ecosistemas y Recursos Agropecuarios*, *5*(14), 247–257. https://doi.org/10.19136/era.a5n14.1447

Nopriani, U., Karti, P. D. M. H., & Prihantoro, I. (2014). Produktivitas Duckweed (*Lemna minor*) sebagai hijauan pakan alternatif ternak pada intensitas cahaya yang berbeda. *Jurnal Ilmu Ternak dan Veteriner*, *19*(4), 272–286. https://doi.org/10.14334/jitv.v19i4.1095

Patti, P. S., Kaya, E., & Silahooy, C. (2013). Analisis status nitrogen tanah dalam kaitannya dengan serapan N oleh tanaman padi sawah di Desa Waimital, Kecamatan Kairatu, Kabupaten Seram Bagian Barat. *Agrologia: Jurnal Ilmu Budidaya Tanaman*, *2*(1), 51–58. https://doi.org/10.30598/a.v2i1.278

Prasetyo, R. (2014). Pemanfaatan berbagai sumber pupuk kandang sebagai sumber N dalam budidaya cabai merah (Capsicum annum L.) di tanah berpasir. *Planta Tropika: Journal of Agro Science*, *2*(2), 125–132. https://doi.org/10.18196/pt.2014.032.125-132

Safarrida, A., Ngadiman., & Widada, J. (2015). Fitoremediasi kandungan kromium pada limbah cair menggunakan tanaman air. *Jurnal Bioteknologi & Biosains Indonesia (JBBI)*, *2*(2), 55–59. https://doi.org/10.29122/jbbi.v2i2.509

Salami, S. A., Luciano, G., O'Grady, M. N., Biondi, L., Newbold, C. J., Kerry, J. P., & Priolo, A. (2019). Sustainability of feeding plant by-products: A review of the implications for ruminant meat production. *Animal Feed Science and Technology*, *251*, 37–55. https://doi.org/10.1016/j.anifeedsci.2019.

02.006

Sanni, K. O. (2016). Effect of compost, cow dung and NPK 15-15-15 fertilizer on growth and yield performance of Amaranth (Amaranthus hybridus). *International Journal of Advances in Scientific Research*, *2*(03), 076–082. https://doi.org/10.7439/ijasr

Sarkar, M. D., Rahman, M. J., Uddain, J., Quamruzzaman, M., Azad, M. O. K., Rahman, M. H., Islam, M. J., Rahman, M. S., Choi, K., & Naznin, M. T. (2021). Estimation of yield, photosynthetic rate, biochemical, and nutritional content of red leaf lettuce (Lactuca sativa L) Grown in Organic Substrates. *Plants*, *10*(6), 1–13. https://doi.org/10.3390/plants10061220

Satata, B., & Kusuma, M. E. (2014). Pengaruh tiga jenis pupuk kotoran ternak (sapi, ayam dan kambing) terhadap pertumbuhan dan produksi rumput Brachiaria humidicola. *Jurnal Ilmu Hewani Tropika*, *3*(2), 5–9.

Sheoran, S., Kumar, S., Kumar, P., Meena, R. S., & Rakshit, S. (2021). Nitrogen fixation in maize: breeding opportunities. *Theoretical and Applied Genetics*, *134*, 1263–1280. https://doi.org/10.1007/s00122-021-03791-5

Singh, A., & Kumar, S. (2022). Application of aquatic plants dead biomass in remediation of heavy metals pollution by adsorption: a review. *Indian Journal of Science and Technology*, *15*(16), 729–735. https://doi.org/10.17485/IJST/v15i16.82

Surdina, E., El-rahimi, S. A., & Hasri, I. (2016). Pertumbuhan Azolla microphylla dengan kombinasi pupuk kotoran ternak. *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah*, *1*(3), 298–306.

Tando, E. (2018). Review: Upaya efisiensi dan peningkatan ketersediaan nitrogen dalam tanah serta serapan nitrogen pada tanaman padi sawah (Oryza sativa L.). *Buana Sains*, *18*(2), 171–180. https://doi.org/10.33366/bs.v18i2.1190

Tran, T. L. N., Miranda, A. F., Abeynayake, S. W., & Mouradov, A. (2020). Differential production of phenolics, lipids, carbohydrates and proteins in stressed and unstressed aquatic plants, Azolla filiculoides and Azolla pinnata. *Biology*, *9*(10), 1–15. https://doi.org/10.3390/biology9100342

Triadiati, T., Pratama, A. A., & Abdulrachman, S. (2012). Pertumbuhan dan efisiensi penggunaan nitrogen pada padi (Oryza sativa L.) dengan pemberian pupuk urea yang berbeda. *Buletin Anatomi dan Fisiologi*, *20*(2), 1–14. https://doi.org/10.14710/baf.v20i2.4767

Wickramasinghe, S., & Jayawardana, C. K. (2018). Potential of aquatic macrophytes Eichhornia crassipes, Pistia stratiotes and Salvinia molesta in phytoremediation of textile wastewater. *Journal of Water Security*, *4*, 1–8. https://doi.org/10.15544/jws.2018.001

Zhang, S., Sun, L., Wang, Y., Fan, K., Xu, Q., Li, Y., Ma, Q., Wang, J., Ren, W., & Ding, Z. (2020). Cow manure application effectively regulates the soil bacterial community in tea plantation. *BMC Microbiology*, *20*(1), 1–11. https://doi.org/10.1186/s12866-020-01871-y