International Journal of Agricultural Technology 2026 Vol. 22(6):2855-2864
DOI: https://doi.org/10.63369/ijat.2026.22.6.2855-2864
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Agronomic performances of Genjer (*Limnocharis flava*) fertilized with poultry manure in combination with coal fly-ash and bottom-ash

Putra, R.[1], Fahrurrozi, F.[1*], Handajaningsih, M.[1], Supanjani, S.[1], Utami, K.[2] and Putri, A. H.[1]

[1]Department of Crop Production, University of Bengkulu, Bengkulu,38121, Indonesia; [2]Department of Soil Science, University of Bengkulu, Bengkulu,38121, Indonesia.

Putra, R., Fahrurrozi, F., Handajaningsih, M., Supanjani, S., Utami, K. and Putri, A. H. (2026). Agronomic performances of Genjer (*Limnocharis flava*) fertilized with Poultry Manure in combination with coal fly-ash and bottom-ash. International Journal of Agricultural Technology 22(6):2855-2864.

Abstract Organic vegetable of yellow velvetleaf (*Limnocharis flava* L.) production is widely grown without using fertilizers and eventually resulted low crop productivity. Results indicated that treatments significantly affected plant height, number of leaves, number of clumps, leaf greenness, length of middle shoot leaf, and weight of middle shoot leaf. Yellow velvetleaf plants grown without fertilizer consistently had lower responses compared to those grown with organic fertilizer amendment. The application of 10 Mg ha^{-1} PM+5 Mg ha^{-1} FABA provided the best growth of yellow velvetleaf which produced the highest length of middle shoot leaf, and weight of middle shoot leaf of yellow velvetleaf which were the main economic parts of this plant. The use of organic fertilizer of poultry manure and coal fly-ash and bottom-ash, either alone or its combinations increased economic part of yellow velvetleaf. Further research should be addressed on understanding the synergistic effects of poultry manure and FABA in creating favorable mud-growing conditions for yellow velvetleaf growth development.

Keywords: Coal fly-ash and bottom-ash, Organic vegetable, Poultry manure, Sustainable Agriculture, Yellow velvetleaf

Introduction

Yellow velvetleaf (*Limnocharis flava* L.), also known as "genjer" in Indonesia, is widely used as a traditional vegetable in many parts of Southeast Asia. This perennial herb crop is regarded as a neglected and underutilized crop species (NUCS), with its leaves, stems and flower buds commonly harvested for culinary use (Toensmeier *et al*., 2020). According to Yesuph *et al.* (2025) NUCS are those that have been mainly disregarded in conventional agriculture, even though they hold promise for enhancing food security, nutritional diversity, and climate change resilience. From the nutrient point of view, Saupi *et al*. (2010)

[*]**Corresponding Author:** Fahrurrozi, F.; **Email:** fahrurrozi@unib.ac.id

concluded that on a dry weight basis, the edible portions of *L. flava* had a total carbohydrate content of 14.56±0.14%, a gross calorific value of 343.26 kJ/100 g, moisture content of 79.34%, ash content of 0.79%, and crude protein content of 0.28%. K (4202.50 mg/100 g), Ca (770.87 mg/100 g), Cu (8.31 mg/100 g), Na (107.72 mg/100 g), Mg (228.10 mg/100 g), Zn (0.66 mg/100 g), crude fat (1.22%), and crude fiber content (3.81%). These nutritive properties of yellow velvetleaf might be among the major reasons for many people in Southeast Asia region to consume it in their cuisines as vegetable.

In Indonesia, yellow velvetleaf is mostly grown by traditional Indonesian farmers as an aquatic crop in moist areas like marshes, rice fields, and swamps. In some areas it was farmed all year round, frequently in tandem or in rotation with rice farming, and mostly it was organically grown. Farmers rarely fertilized this plant and its nutrient sources are generally relied on the residual nutrients from the previous growing seasons or naturally provided by growing site for yellow velvetleaf. For commercial yellow velvetleaf production, such traditional practice must be corrected by amended the growing site with organic matter and or soil ameliorant. According to Fernandez *et al*. (2022) in organic vegetable production, nutrient sources might be derived from decomposed organic matter such as compost, animal manures, and plant residues. Manure fertilizer is highly recommended for use on vegetable plants because it is more environmentally friendly and contains more complete nutrients. Common types of animal manure fertilizer include chicken, cow, horse, sheep, and rabbit manure, all of which come from herbivores and are good for organic vegetable production.

The combining application of poultry manure with Coal Fly Ash and Bottom Ash (FABA) is justified by their complementary nutrient characteristics. Poultry manure is rich in essential macronutrients, *i.e.,* nitrogen, phosphorus, potassium, calcium, magnesium as well as organic carbon (Agbede, 2025) is able to support vegetative growth and chlorophyll formation in leafy plants such as *Limnocharis flava*. According to Kacprzak *et al*. (2023), the phosphorus content in poultry manure ranges from 13.6 to 25.4 g of P_2O_5 per kg dry matter, generally 2 to 4 times greater than in other types of manure and is mainly inorganic (32-84%). Essential macronutrient of P is able to stimulate seed germination, root growth and development, branching, flowering and seed formation of many plants, including leafy green vegetables like yellow velvetleaf plants (Fathi and Afra, 2023). In contrast, FABA generally contains lower organic nutrients but is a source of mineral elements such as calcium, magnesium, potassium, silicon, and several micronutrients. Previous studies have demonstrated that FABA has potential as a growing media amendment due to its ability to improve nutrient availability and support plant growth. The application of FABA as a component of growing media has been reported to improve plant growth, yield, and quality,

particularly when applied at an appropriate proportion. These improvements are associated with the contribution of macro- and micronutrients contained in FABA, such as K, Na, Ca, Mg, Fe, Cu, Zn, and Mn, which support plant physiological processes (Putri *et al*., 2025). Previously, Ramzi *et al.* (2016) concluded that coal bottom ash has unique physical and chemical characteristics when compared to natural river sand. Bottom ash, due to its porous/rough structures, and angular-irregular particles, has reduced density (approximately 641 kg m^{-3}) and lower specific gravity (around 2.21), even though its particle size distribution resembles that of natural sand. Meanwhile the chemical properties of the ash are primarily composed of silica, alumina, and iron oxide, with their total content ranging from approximately 53.6% to 58.5%.

It appeared when poultry manure and FABA are combined, these materials would provide a more balanced and sustained nutrient supply than when applied individually. Poultry manure improves soil organic matter, aggregation, water-holding capacity, and microbial activity, while FABA can enhance soil texture, porosity, aeration, and pH buffering. This synergy would create a moist yet well-aerated growing medium, which is suitable for yellow velvetleaf growth and development. Jayengswasono and Wicaksono (2022) concluded that available P increases with each additional dose of coal fly ash, and the application of 10 tons ha^{-1} of FABA increased plant height growth, biomass production, and P absorption in kangkung plants. In addition, Wilujeng *et al*. (2020) found that the amount of total P in the soil increased with the increasing dose of FABA applied. Besides its potential benefits for plant growth, the safety aspect of FABA utilization in agricultural systems has also received attention. Previous research showed that the application of FABA-based growing media did not increase heavy metal accumulation in several vegetable crops and remained within acceptable consumption limits, indicating that FABA can be safely utilized as an agricultural amendment when applied at an appropriate proportion (Putri *et al*., 2023). Nonetheless, there have been less reports on the effects of using poultry manure in combination with FABA in producing organically grown yellow velvetleaf.

The research aimed to determine the best poultry manure and FABA combinations in promoting growth and fresh-leaf properties of yellow velvetleaf cultivated organically.

Materials and methods

This experiment was conducted in Kota Bengkulu (3º045’23.61 SL and 102 º 016’39.45 EL) from August to November 2024. Plant materials were collected from farmer who continuously grows organic yellow velvetleaf.

Treatments of this single factor experiment were consisted of six treatment combination dosages of poultry manure and FABA. The treatments included (1) Control (no poultry manure, no FABA), (2) 20 Mg ha^{-1} poultry manure and 0 FABA, (3) 15 Mg ha^{-1} poultry manure and 2,5 Mg ha^{-1} FABA, (4) 10 Mg ha^{-1} poultry manure and 5 Mg ha^{-1} FABA, (5) 5 Mg ha^{-1} poultry manure + 7.5 Mg ha^{-1} FABA, and (6) 0 Mg ha^{-1} poultry manure and 10 Mg ha^{-1} FABA. Please note that 20 Mg ha^{-1} poultry manure is the 100 % recommended dosages (Lalenoh *et al.,* 2022), and 10 Mg ha^{-1} FABA equals to the 100 % recommended dosages (Jayengswasono and Wicaksono, 2022). All treatments were evaluated by using randomized complete block design with three replicates. Blocking was arranged based on the leaf number uniformity; 2, 4, and 6 leaves for block 1, 2, and 3 respectively. Each experimental unit consisted of two plants that individually planted in a 22 L black plastic bucket.

The mud-growing medium used for planting was taken from farmer's land who continuously grows organic yellow velvetleaf. The planting medium of 10.5 kg was put into each bucket saturated with water for two weeks to get a mud-like texture. The distance between the buckets is 30 cm and then arranged neatly on the opened land.

Local variety seedlings of yellow velvetleaf were planted into the growing medium after one week of planting medium preparation. Plant watering was conducted by maintaining the water level up to 10 cm from the top of growing bucket. Weeds were manually controlled every other week until the crops were harvested. Grasshoppers (*Atractomorpha crenulata*) were periodically controlled by spraying insecticide contained profenofos 1 mL/L.

Crops were harvested after four weeks of transplanting, characterized with green color and partially unfurled leaf, by cutting the stems and middle leaf of the plant. Harvestings were conducted three times a week and stopped at eight weeks after transplanting. Crop responses to treatments were observed in terms of plant height, number of leaves per clump, number of shoots, leaf area, shoot fresh weight, root fresh weight, plant fresh weight per clump, leaf greenness, length of middle shoot leaf, and weight of middle shoot leaf.

Data were subjected to homogenous test before analysis of variance at $P \leq 0.05$. Means of treatment effects were compared using Duncan's Multiple Range Test at $P \leq 0.05$. Supporting data were also collected on contents of pH, N, P, K, and organic C in mud-growing medium, poultry chicken manure and FABA. In addition, data on monthly rain fall, relative humidity and air temperatures during the experiment were collected from Meteorology, Climatology, and Geophysical Agency Bengkulu (ID WMO: 96255).

Results

Environmental condition

Weather reports from the meteorology station during the experiment indicated that average daily temperatures on August, September, October and November 2024 were 27.7ºC, 27.7ºC, 28.0ºC and 27.2ºC, respectively. Meanwhile the average of daily relative humidity during the same periods were 83.9%, 83.1%, 83.1% and 87.4%, respectively. Additionally, the monthly averages of rain fall were 0.4, 3.3, 3.4 and 10.6 mm. These growing conditions were likely suitable for yellow velvetleaf since this plant grows well in humid and waterlogged environments.

Laboratory analysis indicated that the nutrient content of the planting medium had a pH of 4.89 (acidic), 0.16% N (low), 5.53 ppm P (low), 0.34 me/100 g K (high) and 2.71% organic C (medium), meanwhile poultry chicken manure was reported to have pH of 6.78, 2.11 % N, 1.23% P, 1.11 % K, and 25.79 % organic C. The nutrients magnitude of FABA had pH of 9.15, 1.06 % N, 0.96 % P, 3.53 % K, and 31.97 % organic C.

Crop responses

Treatments (six combination dosages of poultry manure and FABA) significantly affected plant height ($P \leq 0.0011$), number of leaves ($P \leq 0.0281$), number of clumps ($P \leq 0.0077$), leaf greenness ($P \leq 0.0115$), length of middle shoot leaf ($P \leq 0.0001$), and weight of middle shoot leaf ($P \leq 0.0001$). The effects of six combination dosages of poultry manure and FABA on plant height, number of leaves, number of clumps, leaf greenness of yellow velvetleaf are presented in Table 1.

It appeared that yellow velvetleaf fertilized with P2 (20 Mg ha^{-1} poultry manure and 0 FABA), P3 (15 Mg ha^{-1} poultry manure and 2,5 Mg ha^{-1} FABA), P4 (10 Mg ha^{-1} poultry manure and 5 Mg ha^{-1} FABA), and P5 (5 Mg ha^{-1} poultry manure + 7.5 Mg ha^{-1} FABA) generally had superior plant height and the number of leaves than those of fertilized with other treatments (P1 and P6). However, yellow velvetleaf fertilized with P2 (20 Mg ha^{-1} poultry manure and 0 FABA) had the highest number of clumps. However, control plant grown without poultry manure and FABA (P0) were among the lowest leaf greenness. In addition, treatments also significantly affected plant length of middle shoot leaf, and weight of middle shoot leaf of yellow velvetleaf. The responses of these variables are presented in Figure 1.

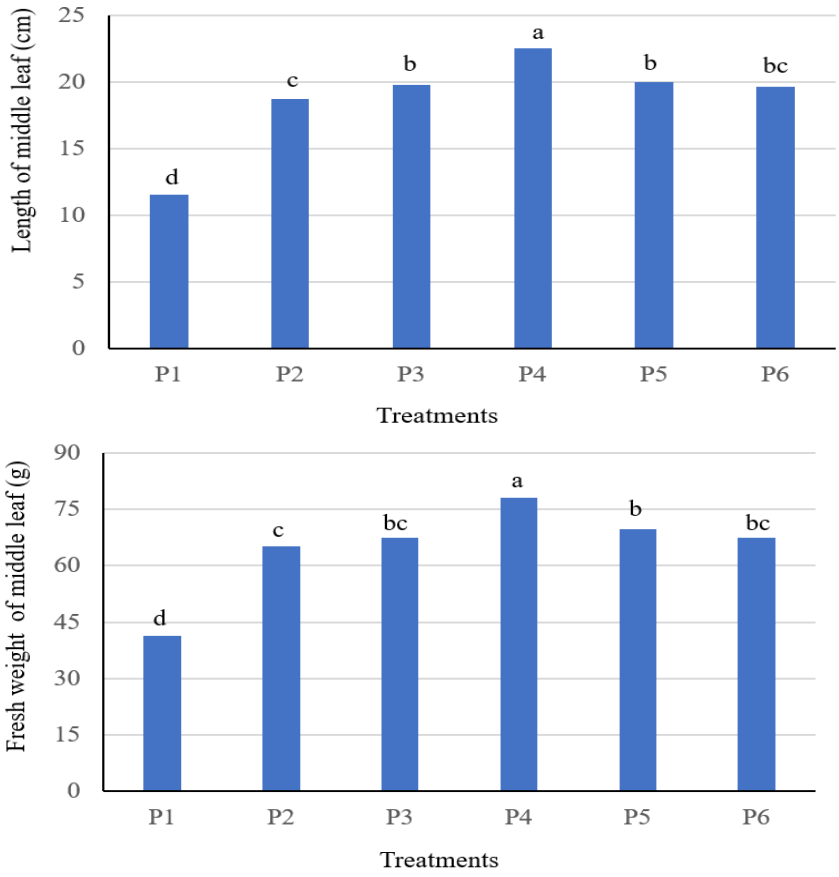


Figure 1. Effects of six combination dosages of poultry manure and FABA on length of middle shoot leaf (above), and weight of middle shoot leaf (below) of yellow velvetleaf [Notes: Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test. (P1) Control (no poultry manure, no FABA), (P2) 20 Mg ha^{-1} poultry manure and 0 FABA, (P3) 15 Mg ha^{-1} poultry manure and 2,5 Mg ha^{-1} FABA, (P4) 10 Mg ha^{-1} poultry manure and 5 Mg ha^{-1} FABA, (P5) 5 Mg ha^{-1} poultry manure + 7.5 Mg ha^{-1} FABA, and (P6) 0 Mg ha^{-1} poultry manure and 10 Mg ha^{-1} FABA.]

Table 1. Effects of six combination dosages of poultry manure and FABA on plant height, number of leaves, number of clumps, leaf greenness of yellow velvetleaf

Treatments	Plant height (cm)	Number of leaves	Number of clumps	Leaf greenness
P1: control (no poultry manure, no FABA)	37.57 c	13.33 b	3.00 b	28.33 b
P2: 20 Mg ha^{-1} poultry manure and 0 FABA	43.93 b	17.33 a	5.00 a	39.77 a
P3: 15 Mg ha^{-1} poultry manure and 2,5 Mg ha^{-1} FABA	47.80 ab	17.67 a	4.00 b	37.37 a
P4: 10 Mg ha^{-1} poultry manure and 5 Mg ha^{-1} FABA	48.83 ab	18.00 a	4.00 b	41.00 a
P5: 5 Mg ha^{-1} poultry manure + 7.5 Mg ha^{-1} FABA	51.67 a	15.00 ab	3.33 b	34.43 ab
P6: 0 Mg ha^{-1} poultry manure and 10 Mg ha^{-1} FABA	49.10 ab	13.67 b	3.33 b	34.40 ab

Notes: Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test.

Discussion

Yellow velvetleaf plants grown without fertilizer (control) consistently had lower plant height, number of leaves, number of clumps, leaf greenness, length of middle shoot leaf, and weight of middle shoot leaf plant height, number of leaves, number of clumps, leaf greenness, length of middle shoot leaf, and weight of middle shoot leaf compared to those grown organic fertilizer amendment. According to Sukewijaya *et al*. (2025) suitable combination of growing medium is one important aspect in promoting growth and nutritional contents of particular vegetables. This experiment suggested that the application of (P4) 10 Mg ha^{-1} poultry manure and 5 Mg ha^{-1} FABA in general provided the best growth of yellow velvetleaf, except in number of clumps. The synergistic effects of poultry manure and FABA may have created more favorable mud-growing conditions for yellow velvetleaf by simultaneously improving nutrient availability as well as growing medium properties. This result is consistent with previous studies showing that FABA application can improve the chemical properties of growing media. The addition of FABA has been reported to increase soil pH and contribute essential mineral elements that support plant growth (Putri *et al*., 2023). Furthermore, suitable FABA proportions were found to enhance crop productivity and quality, suggesting that FABA can complement organic fertilizers in improving plant growing conditions (Putri *et al*., 2025). Poultry manure supplied readily mineralizable nutrients and organic matter, while FABA contributed alkaline minerals such as Ca and Mg and increased soil pH (Jala and

Goyal, 2006; Faoziah *et al*., 2022). Similar positive responses have been reported when FABA was combined with organic amendments, signifying that their complementary functions can enhance growth and biomass of yellowvelvet.

In the market, the quality and weight of the middle leaves are the primary determinants of market price, though all parts of the young shoots (leaves, stems, and flowers) are edible for consumers (Perkasa and Petropoulos, 2020; Assauwab *et al*., 2023). With respect to economic parts of this plant, this treatment resulted the highest length of middle shoot leaf, and weight of middle shoot leaf of yellow velvetleaf. Clearly, the combination of 10 Mg ha^{-1} of chicken manure and 5 Mg ha^{-1} of FABA increased the weight of the middle leaves of yellow velvetleaf due to the complementary supply of nutrients. Chicken manure provided macronutrients (N, P, K) for cell division, while FABA improved the structure of the growing medium and supplied essential micronutrients that support photosynthesis and leaf tissue formation.

Results also suggested that increased fresh weight of middle shoot leaf of yellow velvetleaf (main economic part of this plant) due to the combination of P4=10 Mg ha^{-1} of chicken manure and 5 Mg ha^{-1} of FABA (P4) was 89% significantly higher than those grown in control pots (P1=no poultry manure, no FABA) and 20 % significantly higher than P2=20 Mg ha^{-1} poultry manure, and 0 FABA. In addition, it was 14% significantly higher than yellow velvetleaf grown with P6=0 Mg ha^{-1} poultry manure and 10 Mg ha^{-1} FABA. It is clear that synergistic effects of poultry manure and FABA may have created more favorable mud-growing conditions for yellow velvetleaf compared to growing medium with poultry manure, or FABA only. It appeared signifcant increased in fresh weight of middle shoot leaf of yellow velvetleaf was resulted from the significant increase of plant height, number of leaves, number of clumps, leaf greenness and length of middle shoot leaf. These indicated there was an increase and expansion of photosynthetic organs and plant photosynthetic activity, resulting in greater biomass accumulation in the leaves. According to Juhaeti (2013), NPK fertilization increased fresh weight and plant leaves of yellow velvetleaf were in line with the increased of plant height, leaf number, leaf length, leaf width and plant leaves of yellow velvetleaf. Furthermore, increased leaf greenness indicates improved photosynthetic conditions, allowing for greater production and subsequent accumulation of photosynthates within leaf tissues. Such combined increases in leaf size, number of leaves, and leaf greenness stimulated plants to have higher fresh weight of middle-shoot leaves (Sesanti *et al*., 2025).

In conclusion, results demonstrated that the combination of chicken manure and FABA increased growth and economic yield of yellow velvetleaf compared with the unfertilized control. The application of 10 Mg ha^{-1} chicken

manure combined with 5 Mg ha^{-1} FABA produced the greatest middle shoot leaf length and weight. This combination can be considered an effective organic fertilizer treatment for enhancing the growth and productivity of yellow velvetleaf. Future research should focus on elucidating how the combined application of poultry manure and FABA in creating favorable growth conditions for yellow velvetleaf.

Acknowledgements

Authors sincerely thanked the Agronomy Laboratory, University of Bengkulu for allowing to use of equipment for chemical analysis as well as CAPS Research Group for sharing research facilities.

Conflicts of interest

The authors declare no conflict of interest.

References

Agbede, T. M. (2025). Poultry manure improves soil properties and grain mineral composition. maize productivity and economic profitability. Scientific Reports, 15:16501. https://doi.org/10.1038/s41598-025-00394-8

Assauwab, M. H., Yusuf, H., Abdi, Z. and Munthe, M. N. (2023). Potensi Budidaya *Limnocharis Flava* L dalam Peningkatan Pendapatan Ekonomi Masyarakat di Aceh Tenggara. Jurnal Agroplasma, 10:252-256.

Faoziah, N., Iskandar and Djajakirana, G. (2022). The effect of cow manure compost and fly ash-bottom ash (FABA) addition on the chemical properties of sandy soil and tomato growth. Jurnal Ilmu Tanah dan Lingkungan, 24:1-5. https://doi.org/10.29244/jitl.24.1.1-5

Fathi, A. and Afra, J. M. (2023). Plant growth and development in relation to phosphorus: A review. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca Agriculture, 80:1-7. https://doi.org/10.15835/buasvmcn-agr:2022.0012

Fernández, J. A., Ayastuy, M. E., Belladonna, D. P., Comezaña, M. M., Contreras, J., de Maria Mourão, I., Orden, L. and Rodríguez, R. A. (2022). Current trends in organic vegetable crop production: Practices and techniques. Horticulturae. 8:893. https://doi.org/10.3390/horticulturae8100893

Jala, S. and Goyal, D. (2006). Fly ash as a soil ameliorant for improving crop production—A review. *Bioresource Technology*, 97:1136-1147. https://doi.org/10.1016/j.biortech.2004.09.004

Jayengswasono, P. and Wicaksono, K. S. (2022). Pemanfaatan abu terbang batubara untuk meningkatkan ketersediaan P. serta pengaruhnya terhadap pertumbuhan tanaman kangkung darat (*Ipomoea reptans poir*). Jurnal Tanah dan Sumberdaya Lahan, 9:457-464. https://doi.org/10.21776/ub.jtsl.2022.009.2.27.

Juhaeti, T. (2013). Respon genjer (*Limnocharis flava* L. Buchenau.) terhadap pemupukan dan potensi gizinya untuk diversifikasi konsumsi sayuran. Berita Biologi, 12. https://media.neliti.com/media/publications/68535-IDnone.pdf?exp=1786612036&kid

=1&sig=6O95z3jcH0KdMmjPN2B_-bLZVFZkdkcVWbQ9o0WfRvc

Kacprzak, M., Malinska, K., Grosser, A., Sobik-Szołtysek, J., Wystalska, K., Drozdz, D., Jasinska, A. and Meers, E. (2023). Cycles of carbon. nitrogen and phosphorus in poultry manure management technologies – environmental aspects. Critical Reviews in Environmental Science and Technology, 53:914-938. https://doi.org/10.1080/10643389.2022.2096983

Lalenoh, K. C. A. P., Sinolungan, M. T., Tamod, Z. E., Warouw, V. R. C. and Wiesje, K. (2022). Pengaruh pemberian pupuk kandang ayam pada campuran fly ash bottom ash sebagai media tumbuh pada tanaman pakis. Jurnal COCOS, 4:1-7. https://doi.org/10.35791/cocos.v15i4.52005.

Perkasa, A. Y. and Petropoulos, S. (2020). "Genjer" Yellow Velvetleaf used as indigenous vegetable in Indonesia. Anatolian Journal of Botany, 4:76-79. https://dergipark.org.tr/en/pub/ajb/article/710777

Putri, A. H., Agusta, H., Djoefrie, M. H. B., Santosa, E. (2023). Effect of fly ash and bottom ash application as mix growing media on heavy metals status in vegetables. Indonesian Journal of Agronomy, 51:346-355. https://dx.doi.org/10.24831/jai.v51i3.46783

Putri, A. H. (2025). Pemanfaatan fly ash-bottom ash (FABA) sebagai campuran media tanam terhadap pertumbuhan, hasil, dan kualitas tomat. Seminar Nasional Pertanian Pesisir V, 4:151-160.

Ramzi, N. I. R., Shahidan, S., Maarof, M. Z. and Ali, N. (2016). Physical and chemical properties of coal bottom ash (CBA) from Tanjung Bin power plant. IOP Conference Series: Materials Science and Engineering, Volume, 160:012056. https://dx.doi.org/10.1088/1757-899X/160/1/012056

Saupi, N., Zakaria. M. H. and Bujang, J. S. (2009). Analytic chemical composition and mineral content of yellow velvetleaf (*Limnocharis flava* L. Buchenau)'s edible parts. Journal of Applied Sciences, 9:2969-2974. https://dx.doi.org/10.3923/jas.2009.2969.2974

Sesanti, R. N., Purwanto, E., Samanhudi. and Sudadi (2025). Effects of nutrient solution and substrate on *Limnocharis flava* performance in hydroponic systems. Asian Journal of Agriculture, 9:590-597. https://smujo.id/aja/article/view/23171/8956

Sukewijaya, I. M., Dwiyani, R. and Bimantara, P. O. (2025). Optimization of Growing Media to Support Microgreens Growth and Nutritional Profile. Agro Bali: Agricultural Journal. 8:102-113. https://doi.org/10.37637/ab.v8i1.2249

Toensmeier, E., Ferguson, R. and Mehra, M. (2020). Perennial vegetables: A neglected resource for biodiversity. carbon sequestration. and nutrition. PLoS ONE, 15:e0234611. https://doi.org/10.1371/journal.pone.0234611

Wilujeng, R., Ichriani, G. I., Fahrunsyah, F., Nuraini, Y. and Handayanto, E. (2020). The possible use of coal fly ash and phosphate-solubilizing fungi for improving the availability of P and plant growth in acid soil. Journal of Degraded and Mining Lands Management. 8:2471-2480.

Yesuph, D. S., Dalka, D. D. and Baye, M. T. (2025). Underutilized and neglected crop species and their role in enhancing household food security amid climate change. Wolaita Zone. Ethiopia. Heliyon, 11:e42345. https://doi.org/https://doi.org/10.1016/j.heliyon.2025.e42345

(Received: 27 August 2026, Revised: 16 November 2026, Accepted: 18 November 2026)