Application of Green Mussel Shell Waste (*Perna viridis*) to the Growth and Production of Celery (*Apium graveolens*)

Elfarisna[1♥], Erlina Rahmayuni[1], Nur Oktavia[1], Welly Herman[2]

[1]Department of Agrotechnology, Faculty of Agriculture, University of Muhammadiyah Jakarta, Jakarta, Indonesia
[2]Department of Soil Science, Faculty of Agriculture, University of Bengkulu, Bengkulu, Indonesia
♥Correspondence: elfa.risna@umj.ac.id

Abstract
Background: Green mussel shell waste (GMS) is a nutrient source that can be applied to celery plants. This study aimed to assess the potential of green mussel shell waste as a natural ameliorant that can improve soil fertility and support celery growth and production. **Methods:** The study was conducted from January to April 2022 at the experimental garden of the Faculty of Agriculture, Muhammadiyah University of Jakarta. The study used a Randomized Complete Block Design (RCBD) with five treatments: inorganic fertilizer (control), GMS waste 4 g/plant, GMS waste 8 g/plant, GMS waste 12 g/plant, and GMS waste 16 g/plant . **Results:** The results showed that the use of GMS waste increased soil pH from acidic (6,13) to neutral (6.63-7.33), particularly at doses of 12 g and 16 g per plant. Despite this, inorganic fertilizers provide the best results in terms of plant growth, particularly in terms of plant height, number of leaf stalks, and fruit weight. **Conclusion:** GMS waste shows potential as an alternative fertilizer, but its effectiveness in supporting celery plant growth is still limited, due to its incomplete nutrient content and slower nutrient release compared to inorganic fertilizers.

Keywords: celery; green mussel shells; inorganic fertilizer; nutrients

Introduction

Green mussels (*Perna viridis*) are a popular food, but their shell waste is often discarded without processing. The hard shells of green mussels take a long time to decompose naturally, so proper management is essential to prevent environmental pollution. Mussel shells accumulate in people's yards or become litter along beaches, not only polluting the environment and affecting public health but also disrupting fishermen's activities, as the piles of shells carried by waves can make it difficult for them to moor or dock their boats (Elfarisna, 2023).

Unoptimally utilized green mussel shell waste creates environmental problems such as pollution and the accumulation of organic waste. Mussel shell waste management has become a significant issue in several countries. Mussel shells are a major component of industrial waste in New Zealand, contributing 90% of the factory's effluent, approximately 100,800 m3 per year (Prihanto, et.al., 2020). Mussel production in Indonesia continues to grow significantly, accelerating the generation of mussel shell waste. According to Hidayah (2023), green mussel production has continued to increase since 2017, reaching 348,880 tons in 2021. Each kilogram of green mussels consists of approximately 457.5 grams of meat and 511.9 grams of shell. Therefore, in 2021, an estimated 178,640 tons of green mussel shell waste were generated.

Green mussel shells are primarily composed of 99.5% calcium (Ca), 0.245% scandium (Sc), and 0.477% strontium (Sr). The high calcium content in the shells, when properly processed, can be used as an adsorbent to reduce iron (Fe^{2+}) levels in water. Calcium carbonate ($CaCO_3$) in green mussel shells is also effective in reducing iron levels with an efficiency of up to 100% within 60 minutes (Aridhani et al., 2021). Ismanto (2016) stated that clam shells contain higher levels of calcium carbonate ($CaCO_3$) than limestone, eggshells, ceramics, or other materials. This can be seen from the hardness of the shells. The harder the shell, the higher the content of calcium carbonate. Shellfish is a mineral and biopolymer composite consisting of 95-99% $CaCO_3$ in the form of aragonite crystals and a small amount of oxide, while the remaining 1-5% is in the form of organic macromolecules. Alfred (2015) stated that green mussel shells contain 95.69% calcium carbonate, higher than blood cockles, which contain 66.7%. Setyowati and Chairudin (2016) also added that the calcium carbonate ($CaCO_3$) contained in mussel shells can function as an alternative fertilizer to neutralize soil acidity in peatlands. Green mussel shells are composed primarily of calcium (Ca), magnesium (Mg), phosphorus (P), potassium (K), sulfur (S), and active calcium.

Green mussel shells have a high calcium carbonate ($CaCO_3$) content so they have the potential to be used as a soil ameliorant to increase soil fertility. Calcium carbonate from green mussel shells can play a role in increasing the pH of acidic soils and is a source of calcium, which acts as a source of macronutrients that are important for plants. The use of this waste as an ameliorant can reduce the use of agricultural lime, thus offering a more economical and sustainable solution for soil management. In addition, the use of green mussel shell waste supports the concept of sustainable agriculture by reducing waste while improving soil quality so that it can support plant growth. One of the plants that has great potential for cultivation is celery. Elfarisna et.al, (2023a) state that various doses of GMS powder with urea had the same effect as inorganic fertilizers on the growth and production of Edamame plants on both Oxisol and Ultisol soils. Edamame plants grown on Oxisol soil had better yields than plants grown on Ultisol soil. Results also indicated that GMS can be used as an ameliorant due to its ability to increase soil pH. Elfarisna et.al, (2023b). The results showed that ameliorants gave similar results as controls and did not increase the growth and production of sweet corn plants. The treatments given were P0 (without ameliorant as control)), P1 calcite 5 g/plant(1 ton/ha), P2 dolomite 5 g/plant (1 ton/ha), P3 green mussel shell waste 5 g/plant (1 ton/ha), and P4 zeolite 5 g/plant (1 ton/ha). (Elfarisna et.al, (2024) based on the research results, the application of green mussel shell waste as an ameliorant did not significantly affect the growth and yield of sweet corn. However, the application of 20 g of green mussel shell per plant appeared to produce the best results on plant growth, particularly in terms of plant height and leaf number. The study was conducted using a Randomized Complete Block Design (RCBD) with five dosage levels of green mussel shells: 0 g/plant, 5 g/plant (1 ton/ha), 10 g/plant (2 ton/ha), 15 g/plant (3 ton/ha), and 20 g/plant (4 ton/ha).

Celery (*Apium graveolens*) is a horticultural crop with high economic value and is widely cultivated to meet domestic and export market needs. Celery offers numerous benefits, including increasing appetite, serving as a side dish, and garnishing. This plant also has significant potential for development as an anti-inflammatory drug due to its key compound, Apiin, an essential metabolite with anti-inflammatory properties (Anuar & Levita, 2018). Celery is also used as a flavoring agent, in beverages, and as a medicine for treating various ailments (Anisatu, 2021).

Celery growth requires fertile soil with an optimal pH to support growth and yield. However, the primary obstacle in celery cultivation is the availability of land with high fertility, necessitating efforts to improve soil conditions through the application of calcium-rich ameliorants, such as those derived from green mussel shells. This study aims to evaluate the potential of green mussel shell waste as a natural amendment to enhance soil fertility and promote celery growth and production. By utilizing green mussel shell waste, an alternative solution for managing fishery waste can be created that is both effective and supports the sustainability of the agricultural sector.

Methods

Place and Time

The research was conducted from January to April 2022 at the experimental garden of the Faculty of Agriculture, Muhammadiyah University of Jakarta. The research location is at an altitude of ± 25 meters above sea level with Latosol soil.

Research Design and Data Analysis

The research was arranged using a Randomized Complete Block Design (RCBD) with five doses of green mussel shells (GMS), which include: Inorganic Fertilizer (Urea, SP-36, KCl) (P0), GMS waste 4 g/plant (0.8 t/ha) (P1), GMS waste 8 g/plant (1,6 t/ha) (P2), GMS waste 12 g/plant (2,4 t/ha) (P3), and GMS waste 16 g/plant (3,2 t/ha) (P4). Each treatment was repeated 5 times, so there were 25 experimental units. Each experimental unit consisted of 3 plants, for a total of 75 plants. Polybags (40 × 40 cm, filled with 10 kg of soil) were arranged randomly within a 2 × 3 m plot area, spaced 30 cm apart to prevent shading and competition. The data were analyzed using the F Test (ANOVA), then continued with the Honestly Significant Difference Test (HSD) at the 5% level.

Green mussel shell Production

Green mussel shells were ground into flour that had been previously processed. The green mussel shells were cleaned of dirt, then dried in the sun and oven-dried for 30 minutes at 200ºC. Oven-drying reduces the water content, making them brittle and easy to grind. The shells were then ground to achieve a flour-like texture.

Celery Planting Procedure

GMS flour was applied two weeks before planting at the specified treatment rate. The planting medium used consisted of 10 kg of soil per polybag, supplemented with 100 g of cow manure per polybag. Inorganic fertilizers were used according to celery plant recommendations: approximately 497 kg/ha of urea (2.48 g/plant), 311 kg/ha of SP36 (1.55 g/plant), and 224 kg/ha (1.12 g/tan) of KCl for control, urea was added in stages at the beginning of planting, 2 and 4 weeks after planting (WAP). For the GMS waste treatment, urea was added in stages at the beginning of planting, 2 and 4 weeks after planting (WAP), and SP36 and KCl were not given. Celery seeds are sown first, and after 36 days, they are transferred to polybags. Celery seeds are planted 1 plant per polybag. Harvesting is carried out when the celery plants are 90 days after planting.

Observations were made on the soil pH and celery growth and production, including plant height, number of leaf stalks, root length, number of roots, fresh weight, and consumption weight. The results of the conversion per hectare using a planting distance of 40 cm x 40 cm with a population of 625,000/ha

Results and Discussion

The research location has an air temperature ranging from 27.6-27.7°C with a humidity of 83%. Sunlight exposure is approximately 12 hours per day, with rainfall of approximately 1,242 mm. The climate at the research location does not fully support celery growth. Temperatures exceeding celery's optimal range, although humidity (83%) supports growth, may be insufficient with only 4 hours of sunlight per day. Furthermore, very high rainfall (1,242 mm) far exceeds celery's requirements and can cause the soil to become waterlogged, increasing the risk of root damage.

These environmental conditions affect celery growth. Various pests and diseases were observed when plants were 1 and 2 weeks after planting (WAP), and when plants were 3 and 4 WAP, they toppled due to weather changes with continuous, heavy rainfall. A mealybug infestation was detected 6 weeks after planting, causing the leaves to curl slightly. This was quickly controlled with Decis® insecticide, which was applied weekly. Plant growth is shown in Figure 1.

These pest and disease attacks demonstrate that unfavorable environmental conditions, such as high rainfall and high humidity, play a significant role in increasing plant susceptibility to these attacks. Pest and disease attacks can inhibit plant growth, lead to decreased yields, and reduce crop quality. Therefore, effective pest and disease management, as well as environmental control, are crucial to ensure optimal celery plant growth.

Figure 1. Leaf caterpillar (*Diaphania indica* S.) attack (a), mealybug (*Paracoccus marginatus*) attack (b), conidial disease (*Septoria apii*) (c)

Soil pH Analysis

Changes in soil pH before and after treatment with various doses of green mussel shell waste and inorganic fertilizer. These data illustrate the effectiveness of the treatment in increasing soil pH from acidic to neutral (Table 1).

Table 1. Soil pH values resulting from the use of green mussel shell waste

Dose Green Mussel Shells	Soil pH			
	Initial	Criteria	Final	Criteria
Anorganic Fertilizer	6.13	Acid	6.33	Acid
4 g/plant	6.13	Acid	6.67	Neutral
8 g/plant	6.13	Acid	7.00	Neutral
12 g/plant	6.13	Acid	7.00	Neutral
16 g/plant	6.13	Acid	7.33	Neutral

Table 1 shows that the initial soil pH before treatment was 6.13 (acidic) for all treatments. Inorganic fertilizer increased the soil pH from 6.13 to 6.33. Despite this increase, this pH is still classified as acidic (pH <6.5). Meanwhile, GMS waste at doses of 4, 8, and 12 g/plant + urea increased the soil pH to neutral (6.67 to 7.00). The highest dose, 16 g/plant, produced the highest pH of 7.33. This indicates that green mussel shell waste is more effective in increasing soil pH than inorganic fertilizer.

This increase in pH is due to the high calcium carbonate ($CaCO_3$) content in mussel shells, which functions to neutralize soil acidity (Aryanti,et.al,, 2016); (Ganti, et.al.,2023). Therefore, GMS waste is more effective than inorganic fertilizer in increasing soil pH. This demonstrates the potential of using organic waste as an alternative to improve soil chemical properties, particularly in the context of sustainable and environmentally friendly agriculture. A more significant increase in pH can support plant growth by increasing nutrient availability in the soil (Lawing et al., 2015).

Plant Height

Plant height showed a significant difference after using green mussel shell waste (GMS), which was visible after 5 weeks of planting.

The best treatment for plant height was demonstrated by organic fertilizer from 5 to 8 weeks after planting, and the lowest was seen with the use of 8 g/plant plus GMS waste urea.

Inorganic fertilizers showed better plant height compared to GMS waste, due to their more complete nutrient content compared to GMS waste. Inorganic fertilizers can provide nutrients quickly, making them immediately available for plant absorption. This results in inorganic fertilizers, resulting in better celery growth.

Table 2. Celery plant height resulting from the use of green mussel shell waste

Dose Green Mussel Shells	Plant Height (cm)						
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
Anorganic Fertilizer	4.45	6.59	9.17	13.02b	17.31b	21.50b	25.05b
4 g/plant	4.04	5.74	8.10	10.09ab	14.13ab	18.17ab	22.22ab
8 g/plant	3.33	4.30	6.37	8.13a	12.33a	14.74a	18.49a
12 g/plant	4.37	6.58	8.36	10.73ab	14.90ab	18.11ab	23.52ab
16 g/plant	3.95	5.99	8.42	10.33ab	14.73ab	18.29ab	22.39ab

Note: Numbers followed by the same letter in the same column are not significantly different based on the 5% BNJ follow-up test.

Inorganic fertilizers accelerate plant growth, improve plant health, and help prevent disease. These fertilizers are more efficient because they decompose quickly, allowing nutrients to be readily absorbed by plants. The use of inorganic fertilizers should be adjusted to the correct dosage, as their nutrient content is already measured and concentrated (Arintoko, et.al., 2023). Inorganic fertilizers containing nitrogen, phosphorus, and potassium directly meet the nutrient requirements needed to support maximum plant growth and development (Panjaitan et al., 2023).

Number of Leaf Stalks

The number of celery leaf stalks showed significant differences at 2, 5, 6, and 7 weeks after planting.

Table 3. Number of celery leaf stalks resulting from the use of green mussel shell waste

Dose Green Mussel Shells	Leaf Stalks						
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
Anorganic Fertilizer	4.27b	5.27	6.73	16.73b	37.53b	58.13b	81.47b
4 g/plant	3.47a	4.60	5.87	10.73a	22.73a	38.00ab	46.93a
8 g/plant	3.40a	4.07	5.00	8.87a	19.47a	30.47a	44.80a
12 g/plant	4.07ab	5.13	6.33	14.53a	30.87ab	49.40ab	70.03ab
16 g/plant	3.87ab	4.87	6.27	13.07ab	32.67b	47.67ab	70.87ab

Note: Numbers followed by the same letter in the same column are not significantly different based on the 5% BNJ follow-up test.

Table 3 shows the number of celery leaf stalks affected by the application of green mussel shell waste at various observation times (WAP 2 to WAP 8). In general, the treatment with inorganic fertilizer resulted in a higher number of leaf stalks compared to the GMS waste dose. The 4 g/plant + urea dose produced fewer leaf stalks than the higher GMS dose but still showed an increase over time. The 12 and 16 g/plant + urea doses showed significant and different numbers, although not yet comparable to the inorganic fertilizer.

Nitrogen plays a crucial role in vegetative plant growth, as it is essential for forming proteins, nucleic acids, nucleotides, and chlorophyll in plants. Therefore, the presence of nitrogen can accelerate the growth of celery leaf stalks (Rina 2015). The high calcium content in GMS waste also affects the growth of celery leaves and stems. The results of the study showed that calcium can accelerate the growth of leaves and stems of plants. GMS waste not only contains calcium but also magnesium at 0.05%. That which plays a role in the process of forming new leaves and chlorophyll in plant leaves is Mg (Tangkeallo, 2019).

Root Length, Number of Roots, and Root Weight

Table 4 presents data on the root length, number of roots, and root weight of celery plants affected by the use of green mussel shell waste at various doses.

Table 4. Root Length, Number of Roots, and Root Weight Due to the Use of Green Mussel Shell Waste

Dose Green Mussel Shells	Root Length (cm)	Number of Roots (fruits)	Root Weight (g)
Anorganic Fertilizer	20,79b	15.47b	11.78b
4 g/plant	16,42a	11.27ab	6.11a
8 g/plant	14,87a	6.04a	3.80a
12 g/plant	18,94ab	10.83ab	7.57ab
16 g/plant	19,49ab	9.87a	7.37ab

Note: Numbers followed by the same letter in the same column are not significantly different based on the 5% BNJ follow-up test.

Inorganic fertilizers consistently produced the best results for root length, number, and weight. Doses of 12 and 16 g/plant plus GMS waste urea showed better results than lower doses, although still lower than those of inorganic fertilizers. This indicates that GMS waste has potential as a nutrient source, but its effectiveness is still limited compared to inorganic fertilizers. Inorganic fertilizers such as urea and NPK provide nutrients in a form that plants directly absorb, enabling faster plant growth and longer and more numerous roots compared to the use of organic fertilizers or GMS waste (Perwira, 2022); (Sulaminingsih, 2024).

Clamshell flour can be used as an alternative ameliorant to replace dolomite because it contains high levels of calcium (Ca). Calcium deficiency in plants can inhibit root system growth. In addition, magnesium (Mg) deficiency can disrupt the activity of enzymes in the citric acid cycle, which is important for the respiration process. In contrast, phosphorus (P) deficiency can inhibit root growth and the development of the generative phase of plants (Setyowati & Chairudin, 2016). Doses of 12 and 16 g/plant + urea showed better results in root growth, although still below the results of inorganic fertilizers. This shows that although GMS waste can increase growth, its effectiveness is not optimal when compared to inorganic fertilizers (Indriyati, 2018) .

Wet Weight and Consumption Weight

The results of the analysis of variance showed significant differences in the wet weight and consumption weight of celery plants. This is presented in Table 5.

Table 5. Wet weight, consumption weight, and conversion per hectare due to the use of green mussel shell waste

Dose Green Mussel Shells	Wet Weight (g)	Consumption Weight (g)	Conversion Per Hectare (kg)
Anorganic Fertilizer	53.80b	37.34b	3.36
4 g/plant	30.85ab	23.72ab	1.93
8 g/plant	18.67a	12.93a	1.17
12 g/plant	38.47ab	28.55ab	2.40
16 g/plant	38.33ab	26.73ab	2.40

Note: Numbers followed by the same letter in the same column are not significantly different based on the 5% BNJ follow-up test.

Inorganic fertilizers have high wet weight and consumption weight for celery plants, and the use of 4 g/plant plus urea from GMS waste showed the lowest weight. This indicates that GMS waste is not fully able to meet the nutrient needs of celery plants due to its incomplete nutrient content. Research shows that inorganic fertilizers provide better results for celery plant growth compared to GMS waste. Inorganic fertilizers contain more complete and readily available nutrients, and their use is one method that can be used to meet plant nutrient needs (Rahmayuni et al., 2023).

GMS waste has a slower nutrient availability process compared to inorganic fertilizers. This can result in celery plants not receiving sufficient nutrients for optimal growth, resulting in lower wet weight and consumption weight (Arlingga et al., 2014; Lesmanasari & Barunawati, 2022). The application of 4 g/plant plus urea from GMS waste showed the lowest yield in terms of wet weight compared to the inorganic fertilizer treatment. This indicates that although GMS waste can be used as a fertilizer, its effectiveness in supporting celery growth is still limited (Santi et al., 2023).

Conclusion

The use of green mussel shell waste has potential as an alternative organic fertilizer, although its effectiveness is still lower than that of inorganic fertilizers. GMS waste can increase soil pH, but higher doses are required to achieve optimal results. GMS use also affects celery plant growth, although not as well as inorganic fertilizers in terms of plant height, number of leaf stalks, and consumption weight. Therefore, although GMS waste can be a source of nutrients for plants, the use of inorganic fertilizers is more effective in increasing celery yield and quality. Further research is needed on the former research soil treated with green mussel shell waste to assess the residual effects and nutrient content of the treated soil.

References

Anuar, A. H. B. S., & Levita, J. (2018). Review: Seledri (*Apium graveolens* Linn.) Sebagai Tablet Anti-Inflamasi. Jurnal Farmaka, 16(1), 72–82. https://doi.org/10.24198/jf.v16i1.17343.g8610

Aridhani, A., Kurnyawaty, N., & Oko, S. (2021). Pemanfaatan cangkang kerang hijau sebagai adsorben untuk menurunkan kadar besi (Fe2+)dalam air. Prosiding Seminar Nasional Penelitian & Pengabdian Kepada Masyarakat. 5. 13–16.https://jurnal.poliupg.ac.id/index.php/snp2m/article/view/3229/2761

Arlingga, Buyung, Syakur, Abd, Mas'ud, & Hidayati. (2014). Pengaruh persentase naungan dan dosis pupuk organik cair terhadap pertumbuhan tanaman seledri (*Apium graveolens* L.). Jurnal Agrotekbis, 2(6), 611–619.

Arintoko, A. N., Maryani, Y., & Pamungkas, D. H. (2023). Effect of inorganic fertilizer on growth and results of green beans (*Vigna radiata* L.) Vima 1 and Demak varieties. *Jurnal Ilmiah Agroust*, *7*(1), 13–25. https://doi.org/https://jurnal.ustjogja.ac.id/index.php/agroust/article/view/14707

Aryanti, E., Novlina, H., & Saragih, R. (2016). Effect of azolla pinata compost with different doses for macro fertility of peat soil and it's application in plant growth kale (*Ipomea reptans* Poir). *Jurnal Agroteknologi*, *6*(2), 31. https://doi.org/https://doi.org/10.24014/ja.v6i2.2238

Elfarisna, Mahfudin Budiawan, Nurul Fitriah, Erlina Rahmayuni, Welly Herman, & Kurniati. (2024). efek aplikasi cangkang kerang hijau terhadap pertumbuhan dan produksi tanaman jagung manis (Zea mays saccharata Sturt). Jurnal Cemara, 21(2). https://doi.org/10.24929/fp.v21i2.3869

Elfarisna; Kismawati, D. Salsabila., & Sumiahadi, A. (2023a). The effect of green mussel shells on the growth and production of edamame. *Journal of the Austrian Society of Agricultural Economics*, *19*(02), 1445–1454.https://www.sagepublisher.com/art icle/the-effect-of-green-mussel- shells-on-the-growth-and- production-of-edamame-soybeans

Elfarisna; Rahmayuni, E., & Gustia, H. (2023b). Ameliorant Effects on Growth and Production of Sweet Corn Plants. *Jurnal Ilmu Pertanian Indonesia*, *28*(4), 660–666. https://doi.org/10.18343/jipi.28.4.660

Elfarisna. (2023). *Limbah Cangkang Kerang Hijau* (Pertama). Nuta Media. Yogyakarta

Ganti, N. W. S. L. S., Ginting, S., & Leomo, S. (2023.). Pengaruh pemberian pupuk organik terhadap sifat kimia tanah masam dan hasil tanaman jagung (*Zea mays* L.). *Berkala Penelitian Agronomi*, *11*(1), 23–34. https://doi.org/https://doi.org/10.33772/bpa.v11i1.400

Hidayah, I. (2023). Kerang hijau, potensi ekonomi dan tantangan budidaya di Indonesia. Detik.edu. https://www.detik.com/edu/detikpedia/d-6635667/kerang-hijau-potensi-ekonomi-dan-tantangan-budidaya-di-indonesia?utm_source=chatgpt.com. [22 desember 2024].

Indriyati, L. T. (2018). Effectiveness of Organic and Inorganic Fertilizers on the Growth and Yield of Broccoli (*Brassica oleracea* var . Italica)). Jurnal Ilmu Pertanian Indonesia, 23(3), 196–202. https://doi.org/10.18343/jipi.23.3.196

Ismanto, S. D. (2016). Identification of waste from the button factory made from lola shells in Padang (In Indonesian). *Jurnal Teknologi Pertanian Andalas*, *20*(1), 1410–1920.

Lawing, Y. H. (2015). Kajian pemanfaatan lahan bekas tambang dalam upaya reklamasi berdasarkan kaidah good mining practice pada Pt. Anugrah Bara Kaltim Kabupaten Kutai Kartanegara Provinsi Kalimantan Timur. JGP (Jurnal Geologi Pertambangan), 2(18), 41–49.https://doi.org/10.53640/jgp.v2i18.202

Lesmanasari, M., & Barunawati, N. (2022). Respon pertumbuhan dan hasil tanaman seledri (Apium graveolens L.) pada pemberian dosis nitrogen dan bahan organik. Journal Produksi Tanaman, 10(10), 562–569. https://doi.org/10.21776/ub.protan.2022.010.10.05

Panjaitan, R. M. P., Perangin-angin, J. D., Syahputra, D. A., Saragih, H. D. B., Simbolon, R. A., Pratama, J., Pulungan, M. A., Ginting, M. S., & Maisarah. (2023). Pengaruh pupuk organik dan anorganik terhadap sifat kimia tanah pada perkebunan. Madani : Jurnal Ilmiah Multidisiplin, 1(9), 483–488.

Perwira, A. (2022). Pengaruh Penggunaan Pupuk Organik Dan Anorganik Terhadap Perkembangan Tanaman Ubi Jalar Ungu (Ipomoea batatas) Sebagai Peluang Bisnis Ahmad Perwira Prodi Pendidikan Biologi Universitas Muhammadiyah Surabaya. PEDAGO_BIOLOGI Jurnal Pendidikan Dan Pembelajaran Biologi, 12(1), 13–17. https://doi.org/10.30651/pbjppb.v12i1.18829

Prihanto, A., Muryanto, S., Ismail, R., Jamari, J., & Bayuseno, A. P. (2020). *No Title Utilization of green mussel shell waste for calcium carbonate synthesis through the carbonation method with temperature variation.* 1098. https://doi.org/DOI 10.1088/1755-1315/1098/1/012022

Rahmayuni, E., Septiawan, D., Herman, W., Elfarisa, Putri, E. L., dan Kurniati(2023). Efek Pemberian Kompos Ampas Tahu terhadap Pertumbuhan dan Produksi Tanaman Cabai Merah Keriting *(Capsicum annum L .)*. Jurnal Agrosains dan Teknologi *8*(2), 69–75. https://doi.org/10.24853/jat.8.2.69-75

Santi, A., Undadraja, B., Tinggi, S., Pertanian, I., Wacana, D., Metro, K., & Author, C. (2023). Response of celery (*Apium graveolens* L) to applicable dosage of NPK in fertilizer ' KSM ' at various. 11(2), 275–280. https://doi.org/10.23960/jat.v11i2.6256

Setyowati, M., & Chairudin. (2016). Study of shell waste as an alternative ameliorant material in peatlands (In Indonesian). *Jurnal Agrotek Lestari*, *2*(1), 59–64. https://doi.org/https://doi.org/10.35308/jal.v2i1.496

Sulaminingsih. (2024). Evaluasi efektivitas pupuk organik dan anorganik terhadap pertumbuhan tanaman padi. Jurnal Review Pendidikan Dan Pengajaran, 3(4), 11877–11883.https://doi.org/10.31004/jrpp.v7i3.33018

Wakhidah, A. Z. (2021). Review : Seledri (*Apium graveolens* L.) : Botani, ekologi, fitokimia, bioaktivitas dan Pemanfaatan. *Journal Pro-Life*, *8*(2), 156–167. https://doi.org/https://doi.org/10.33541/pro-life.v8i2.3208

Tangkeallo, Y. P. 2019. Pupuk kalsium memperkuat daya tahan tanaman terhadap serangan penyakit. http://cybex.pertanian.go.id/mobile/artikel/72710/Pupuk-Kalsium-Memperkuat-Daya-Tahan-Tanaman-Terhadap-Serangan-Penyakit/. [22 desember 2024].

Wirayuda, B., & Koesriharti. (2020). Pengaruh pemberian pupuk organik dan pupuk anorganik terhadap pertumbuhan dan hasil tanaman jagung manis (*Zea mays* L. var. saccharata). Jurnal Produksi Tanaman, 8(2), 201–209.