ALGEBRA : JURNAL PENDIDIKAN, SOSIAL DAN SAINS

ISSN : 2807-663X e-ISSN : 2807-629X
Journal Homepage : https://algebra.yana.or.id/index.php/ejournal/index
Volume 6 Number 3 (2026)

COCOPEAT-PETROBIO SYNERGY ENHANCES YIELD OF POLYBAG-GROWN CAPLAK CHILI

Cut Sheilla Damia[1], Dedi Kurniawan[2], Razali[3]
[12]Program Studi Agroteknologi, Fakultas Sains dan Teknologi, Universitas Tjut Nyak Dhien, Medan, Indonesia
[3]Program Studi Budidaya Perkebunan, Fakultas Sains dan Teknologi, Universitas Tjut Nyak Dhien, Medan, Indonesia
Correspondence Email: dedikurniawan@utnd.ac.id

ABSTRACT

Container cultivation offers a practical route for chili production where field land is limited, but yield depends on balancing the physical properties of the growing medium with nutrient supply. This study evaluated whether cocopeat proportion and Petrobio biofertilizer interact to improve the growth and yield of caplak chili (Capsicum frutescens L.) grown in polybags. A 3 × 3 factorial randomized block design with three replications was conducted in North Sumatra from May to September 2025. Cocopeat treatments were topsoil alone (C0), cocopeat:topsoil 1:1 (C1), and 2:1 (C2), while Petrobio was applied at 0 (P0), 2 (P1), or 4 g plant−1 (P2). Plant height, stem diameter, branch number, fruit number, fruit weight per plant, and fruit weight per plot were measured. Cocopeat significantly affected plant height at 2–6 weeks after planting, stem diameter at 2 weeks, branch number at 6–8 weeks, and all yield variables. Petrobio did not significantly alter vegetative traits but significantly affected yield. The interaction was significant only for reproductive variables after square-root transformation [sqrt(x+0.5)]. P2C1 produced the numerically highest raw fruit weight per plot (36.33 g), whereas P1C2 produced no harvested fruit in the two harvests. The results reveal a stage-specific response: a high cocopeat proportion favored early vegetative growth, while a moderate cocopeat proportion combined with the highest Petrobio dose provided the strongest yield response. This combination merits validation over longer harvest periods and larger production scales.

Keywords: biofertilizer; Capsicum frutescens; cocopeat; container cultivation; yield interaction.

Submited: 29 August 2026	***Accepted: 15 September 2026***	***Published: 27 September 2026***

INTRODUCTION

Caplak chili, a locally cultivated type of bird's eye chili (Capsicum frutescens L.), is an economically useful horticultural crop and is well suited to small-scale and household production systems. Its adaptability makes it relevant for cultivation in areas where productive land is constrained, including polybag-based systems (Sardianti, 2021; Siregar & Lubis, 2022). Container culture, however, changes the root environment: the limited volume makes water retention, aeration, nutrient buffering, and root-zone structure more decisive than in open-field soil. Studies on pot-grown cayenne pepper therefore emphasize that the composition of the growing medium can determine whether the root zone supports stable vegetative development and fruit production (Sofiarani & Ambarwati, 2020; Harahap, 2022).

Cocopeat is attractive as a renewable substrate because it has high water-holding capacity, relatively low bulk density, and a porous structure. These properties can improve root-zone moisture and aeration when cocopeat is used alone or mixed with mineral soil, although excessive proportions may alter nutrient concentration, drainage, or air-filled porosity. Reviews of horticultural container media highlight the importance of combining cocopeat with other components rather than assuming that a higher cocopeat proportion is always better (Agrawal et al., 2021). Empirical studies also show crop- and ratio-dependent responses. Cocopeat has supported pepper yield and nutritional quality under protected cultivation (Tuckeldoe et al., 2023), improved the potential of biodegradable coir-based containers for chili production (Iriany et al., 2020), and functioned as a substitute for topsoil in degraded media (Shafira et al., 2021). These findings suggest that the agronomic value of cocopeat is determined by the balance between water retention and the chemical and physical contribution of the co-substrate.

Biofertilizers provide a complementary strategy because beneficial microorganisms can contribute to nutrient acquisition, rhizosphere processes, and crop productivity. Plant growth-promoting rhizobacteria may increase nitrogen fixation, phosphorus solubilization, phytohormone production, or nutrient availability, but their effectiveness is context dependent and often differs between controlled and field conditions (Alzate Zuluaga et al., 2024). Pepper studies have reported positive responses to microbial inoculants and integrated nutrient management, including improved growth, nutrient status, or yield (Sharma et al., 2022; Dasgan et al., 2023; Lobato-Ureche et al., 2023). Local studies on Capsicum also confirm the biological-fertilizer potential of rhizobacteria and mycorrhiza-based inputs (Fallo et al., 2023; Sari et al., 2024; Cahya et al., 2023).

The critical question is not simply whether cocopeat or a biofertilizer is beneficial, but whether their combination creates a root environment that changes the crop response across growth stages. Previous studies have usually examined substrate composition or biological inputs as separate management components. Biofertilizer experiments in chili show that yield responses can occur even when vegetative responses are weak or inconsistent (Yahya et al., 2022; Camacho-Rodríguez et al., 2022). Likewise, recent factorial horticultural studies published in ALGEBRA demonstrate that treatment effects and interactions can differ among vegetative and reproductive variables (Hasibuan et al., 2024; Azhari et al., 2025). This creates a practical research gap for polybag-grown C. frutescens: the optimum medium for early growth may not be the optimum medium for fruit production, particularly when microbial nutrient inputs are added.

Accordingly, this study evaluated the main and interactive effects of three cocopeat:topsoil compositions and three Petrobio biofertilizer doses on caplak chili grown in polybags. The study tested three hypotheses: (1) cocopeat proportion affects vegetative growth and yield; (2) Petrobio dose affects vegetative growth and yield; and (3) cocopeat proportion and Petrobio dose interact to affect crop performance. The novelty of the analysis is its stage-specific interpretation of the factorial response, distinguishing the medium that maximizes early vegetative growth from the combination associated with reproductive yield, while reporting untransformed agronomic means separately from transformed inferential statistics.

RESEARCH METHODS

The experiment was conducted at UPTD BI Palawija Tanjung Selamat, North Sumatra, Indonesia, from May to September 2025. The plant material was Sigantung variety caplak/bird's eye chili (Capsicum frutescens L.). The main materials were topsoil, cocopeat, Petrobio biofertilizer, manure, burnt rice husk, water, and a basal NPK fertilizer. Seedlings were raised in trays containing a 1:1 mixture of topsoil and burnt rice husk and were transplanted to 5-kg polybags at two weeks of age.

A factorial randomized block design was used with two treatment factors and three replications. The first factor was the cocopeat growing-medium composition: C0 = topsoil only, C1 = cocopeat:topsoil at 1:1, and C2 = cocopeat:topsoil at 2:1. The second factor was Petrobio dose: P0 = 0 g plant−1, P1 = 2 g plant−1, and P2 = 4 g plant−1. The factorial combination produced nine treatments. With three blocks, the experiment contained 27 plots; each plot contained five plants, giving 135 plants in total. Plots were separated by 40 cm and blocks by 50 cm. Cocopeat was soaked in water for two days before mixing with topsoil.

Petrobio was applied seven days before transplanting by placing the assigned dose in the planting point. All experimental units received the same basal NPK management, prepared at 6 g L−1 of water and applied as a soil drench one week after transplanting. Irrigation was performed manually, generally twice daily when rainfall did not supply sufficient water. Weeds were removed as needed. Harvesting began at approximately 104–110 days after planting when fruits reached harvest maturity, and two harvests were included in the yield data.

Vegetative observations comprised plant height, stem diameter, and branch number. Plant height was measured from the substrate surface to the highest growing point at 2, 4, 6, and 8 weeks after planting (WAP). Stem diameter was measured approximately 3 cm above the stem base with a caliper at the same observation ages. Branch number was recorded during vegetative development. Reproductive observations were the number of fruits per plant, fruit weight per plant, and fruit weight per plot from the two harvests.

The statistical model was $Y_{ijk} = \mu + \rho_i + \alpha_j + \beta_k + (\alpha\beta)_{jk} + \varepsilon_{ijk}$, where ρ_i represents block effects, α_j the cocopeat effect, β_k the Petrobio effect, and $(\alpha\beta)_{jk}$ their interaction. Analysis of variance (ANOVA) was performed in SPSS, followed by Duncan's multiple range test (DMRT) at the 5% level when treatment effects were significant. The thesis appendices show that the raw reproductive variables contained large dispersion and a zero-yield treatment; therefore, inferential ANOVA and mean separation for fruit number and fruit-weight variables were based on the square-root transformation sqrt(x+0.5). To avoid the unit error present in the thesis narrative, this article reports raw arithmetic means in grams or fruit number for agronomic interpretation, while significance decisions are taken from the transformed analysis.

Table 1. Experimental treatment structure and design

Component	Code	Description
Cocopeat factor	C0	Topsoil only
Cocopeat factor	C1	Cocopeat : topsoil = 1:1
Cocopeat factor	C2	Cocopeat : topsoil = 2:1
Petrobio factor	P0	0 g plant−1
Petrobio factor	P1	2 g plant−1
Petrobio factor	P2	4 g plant−1
Design	-	3 × 3 factorial randomized block design; 3 replications
Experimental units	-	27 plots × 5 plants = 135 plants

Note. Petrobio was applied seven days before transplanting. Cocopeat was soaked for two days before media preparation.

RESULTS AND DISCUSSION

Stage-Specific Vegetative Response to Cocopeat

Cocopeat composition significantly affected plant height from 2 to 6 WAP, but the effect disappeared at 8 WAP. At 2 WAP, both C1 and C2 produced taller plants than C0; by 4 WAP, C2 produced the greatest height, followed by C1 and C0. The same pattern remained at 6 WAP, when C2 reached 24.70 cm and C1 reached 23.74 cm, compared with 21.57 cm in topsoil alone. Stem diameter showed a significant medium effect only at 2 WAP, with C2 producing the largest diameter (3.00 mm). These responses indicate that increasing cocopeat proportion improved the early root-zone environment sufficiently to accelerate initial shoot and stem development. Similar advantages of cocopeat-based media have been attributed to water retention and favorable physical structure in container production (Agrawal et al., 2021; Tuckeldoe et al., 2023).

Table 2. Selected vegetative responses to cocopeat growing-medium composition

Trait	Time	C0	C1	C2	ANOVA
Plant height (cm)	2 WAP	17.77b	20.12a	20.81a	Significant
Plant height (cm)	4 WAP	20.41c	22.54b	23.84a	Significant
Plant height (cm)	6 WAP	21.57b	23.74a	24.70a	Significant
Plant height (cm)	8 WAP	25.03	25.16	26.16	NS
Stem diameter (mm)	2 WAP	2.51c	2.68b	3.00a	Significant
Branches (no.)	6 WAP	3.56ab	3.70a	2.48b	Significant
Branches (no.)	8 WAP	4.26ab	4.56a	3.22b	Significant

Note. Means followed by different letters within a row differ at the 5% level by DMRT. NS = not significant; WAP = weeks after planting. Values are raw means.

The branch response differed from the height response. At 6 and 8 WAP, C1 produced the greatest branch numbers, while C2 was lower. This divergence is important because it shows that the highest cocopeat proportion did not provide a universal vegetative advantage. A 2:1 cocopeat:topsoil medium may have supplied adequate moisture for height elongation but a less favorable balance for later branching. This interpretation is consistent with the principle that container media require a balance of water, air, and nutrient buffering rather than maximum water-holding capacity alone (Sofiarani & Ambarwati, 2020; Shafira et al., 2021). Harahap (2022) likewise found that a particular cocopeat-based mixture, rather than cocopeat in any proportion, was most favorable for cayenne-pepper production.

Petrobio did not significantly affect plant height, stem diameter, or branch number at the observed vegetative stages, and no cocopeat × Petrobio interaction was detected for these traits. The absence of an early vegetative response does not imply biological inactivity. Microbial inoculants are strongly influenced by substrate conditions, nutrient availability, establishment in the rhizosphere, and crop developmental stage. Reviews of PGPR-based biofertilizers emphasize that positive nutrient-acquisition mechanisms do not always translate into immediate shoot differences under every production environment (Alzate Zuluaga et al., 2024). Pepper studies have similarly reported treatment-specific and stage-specific effects of microbial inputs (Ichwan et al., 2021; Sari et al., 2024).

The overall vegetative pattern therefore identifies an important agronomic trade-off: C2 favored early height and initial stem diameter, whereas C1 was more favorable for branch development later in the vegetative phase. The optimum substrate should consequently be judged against final yield rather than against a single early-growth indicator.

Yield Response and Cocopeat-Petrobio Interaction

In contrast with the vegetative results, both main factors significantly affected all three reproductive variables after transformation. P2 (4 g Petrobio plant−1) produced the highest Petrobio main-effect means for fruit number (3.82 fruits plant−1), fruit weight per plant (7.48 g), and fruit weight per plot (31.89 g). P1 was consistently lower than both P0 and P2. For the cocopeat main effect, C0 and C1 formed the higher-yield group, whereas C2 significantly reduced fruit number and fruit weight. Thus, the cocopeat proportion that maximized early height (C2) was not the proportion that sustained reproductive performance.

Table 3. Main-effect means for reproductive variables

Treatment	Fruits per plant	Fruit weight per plant (g)	Fruit weight per plot (g)
P0	3.41a	6.67a	26.00b
P1	2.15b	4.22b	17.89c
P2	3.82a	7.48a	31.89a
C0	3.81a	7.41a	31.78a
C1	3.52a	6.85a	28.56a
C2	2.04b	4.11b	15.44b

Note. Values are raw means. Letters reflect DMRT decisions based on sqrt(x+0.5)-transformed reproductive data. P0, P1, and P2 = 0, 2, and 4 g Petrobio plant−1; C0 = topsoil, C1 = 1:1 cocopeat:topsoil, C2 = 2:1 cocopeat:topsoil.

The reduction under C2 suggests that a high cocopeat proportion can become unfavorable during fruiting even when it supports early shoot expansion. This may reflect dilution of the mineral-soil fraction, altered nutrient-buffering capacity, or an overly wet root zone during part of the production cycle; the present experiment did not measure substrate pH, electrical conductivity, porosity, or nutrient concentration, so these mechanisms remain hypotheses rather than demonstrated causes. Nevertheless, the result agrees with the broader literature showing that coir

effects are ratio- and management-dependent. Iriany et al. (2020) demonstrated that coconut-coir composition affected chili performance, while Tuckeldoe et al. (2023) found that coir could support pepper yield under a carefully managed system. These studies reinforce the need to optimize the composition rather than simply maximize the coir fraction.

The Petrobio response emerged primarily in reproductive variables. This pattern is biologically plausible because microbial biofertilizers can improve nutrient acquisition and resource-use efficiency in ways that become more visible when nutrient demand rises during flowering and fruit filling. Positive pepper responses to biofertilizer or PGPR systems have been reported through enhanced nutrient status, growth, and productivity (Sharma et al., 2022; Camacho-Rodríguez et al., 2022; Lobato-Ureche et al., 2023). Dasgan et al. (2023) further showed that biofertilizer use can partially substitute mineral nutrition in soilless pepper systems, and Tashi et al. (2022) reported increased chili yield with locally prepared biofertilizers. At the same time, the lower performance of P1 compared with P0 and P2 in the present experiment illustrates the non-linearity of biological inputs and cautions against assuming a monotonic dose response.

Table 4. Raw reproductive means for cocopeat × Petrobio combinations

Combination	Fruits per plant	Fruit weight per plant (g)	Fruit weight per plot (g)
P0C0	4.44a	8.56a	36.00a
P0C1	3.22b	6.33b	23.67b
P0C2	2.56b	5.11c	18.33c
P1C0	3.33ab	6.56b	28.00b
P1C1	3.11b	6.11bc	25.67b
P1C2	0.00c	0.00d	0.00d
P2C0	3.67ab	7.11ab	31.33a
P2C1	4.22a	8.11a	36.33a
P2C2	3.56ab	7.22ab	28.00b

Note. Values are untransformed raw means and therefore retain their original agronomic units. Mean-separation letters correspond to the transformed-data analysis. P2C1 had the numerically highest raw fruit weight per plot (36.33 g), but it shared the same DMRT group as P0C0 and P2C0.

The interaction was significant for fruit number and fruit weight, but not for vegetative traits. P2C1 (4 g Petrobio plant−1 combined with 1:1 cocopeat:topsoil) produced 4.22 fruits plant−1, 8.11 g fruit plant−1, and the numerically highest plot fruit weight of 36.33 g. Importantly, P2C1 was not statistically superior to every alternative combination: P0C0 produced 36.00 g plot−1 and shared the same DMRT group for plot yield. The agronomic value of P2C1 is therefore that it maintained the high-yield group while incorporating a moderate cocopeat fraction and the highest Petrobio dose, not that it proved an absolute statistical maximum under all comparisons.

At the other extreme, P1C2 produced no harvested fruit during the two recorded harvests. This zero explains much of the dispersion in the raw reproductive data and should not be treated as evidence that the combination will always fail. The experiment did not record flower abortion, root health, microbial colonization, or plant-specific stress that could explain the zero yield. Similar variability in microbial-input responses has been recognized in the biofertilizer literature, where inoculant performance depends on the compatibility among microbial strains, substrate, nutrient regime, and environment (Alzate Zuluaga et al., 2024). Studies using rhizobacteria on pepper have also shown that strain selection and host response matter strongly (Fallo et al., 2023; Camacho-Rodríguez et al., 2022).

Table 5. ANOVA F-values for square-root-transformed reproductive variables

Source	Fruits per plant	Fruit weight per plant	Fruit weight per plot
Petrobio (P)	10.91**	13.22**	7.91**
Cocopeat (C)	12.55**	14.09**	11.79**
P × C	5.16**	7.00**	4.14*
CV (%)	20	24	49

*Note. Transformation = sqrt(x+0.5). * significant at 5%; ** highly significant at 1%. CV = coefficient of variation on the transformed scale. The raw plot-weight ANOVA had very high variability; the transformed analysis is therefore used for inference.*

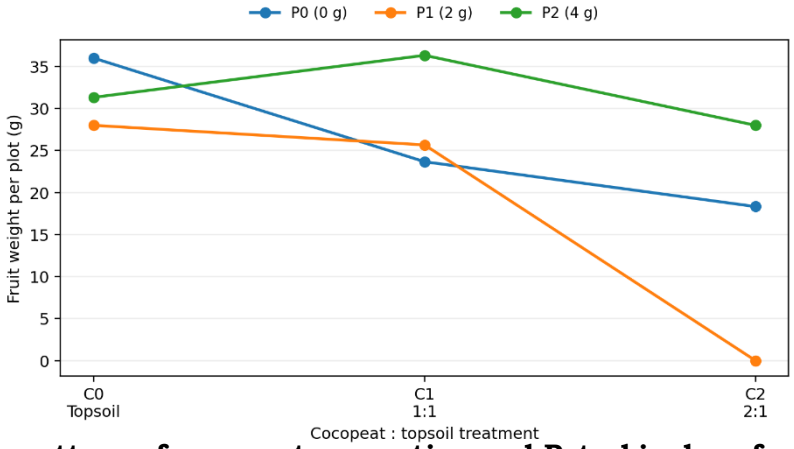


Figure 1. Interaction pattern of cocopeat proportion and Petrobio dose for raw fruit weight per plot.

The transformed ANOVA clarifies a numerical inconsistency in the original thesis. The square-root transformation used was sqrt(x+0.5). For P2C1, the three raw plot yields were 43, 39, and 27 g; transforming each replicate first and then averaging gives approximately 6.04. Thus, the value 6.04 reported in the thesis conclusion is a transformed-scale mean, not a fruit-weight value in grams. Likewise, P1C2 had raw values of 0, 0, and 0 g, which become approximately 0.71 after transformation because sqrt(0+0.5) ≈ 0.71. Reporting the raw means in Table 4 preserves the correct agronomic units, while Table 5 makes the transformed basis of significance explicit. This separation substantially improves the reproducibility and interpretability of the journal version.

From a crop-management perspective, the combined results support a stage-specific optimization concept. C2 was favorable for early height and stem diameter, but C1 maintained better branching and reproductive performance. P2 did not accelerate measurable vegetative growth, yet it was associated with the highest Petrobio main-effect yield. The P2C1 combination therefore represents a practical balance between a moderate renewable substrate proportion and biological nutrient support. This interpretation aligns with integrated-nutrient studies showing that microbial inputs can complement, rather than simply replace, the physical and chemical functions of the root medium (Thakur et al., 2023; Yahya et al., 2022).

The study also has limitations that should guide follow-up research. Yield was recorded from only two harvests, the experiment used five plants per plot and three blocks, and substrate chemical and physical properties were not measured. Microbial abundance or colonization after Petrobio application was also not quantified. Future experiments should extend harvesting to the full production cycle, measure pH, electrical conductivity, water-holding capacity, air-filled porosity, and available N and P, and include microbial indicators. Economic analysis is also needed to determine whether the additional Petrobio dose and cocopeat input are justified by marketable yield. Such validation would move the observed interaction from an experimental response toward an operational recommendation.

CONCLUSIONS

Cocopeat composition and Petrobio biofertilizer affected caplak chili in different growth phases. Increasing cocopeat to a 2:1 ratio with topsoil promoted early plant height and stem diameter, but this high cocopeat proportion reduced reproductive performance. The 1:1 cocopeat:topsoil medium produced a more balanced response, particularly for branching and yield. Petrobio had no significant effect on the measured vegetative traits, whereas the 4 g plant−1 dose (P2) produced the highest Petrobio main-effect yield. Cocopeat × Petrobio interaction was significant for fruit number and fruit weight after sqrt(x+0.5) transformation. P2C1 produced the numerically highest raw fruit weight per plot (36.33 g), although it was statistically grouped with other high-yield combinations. These findings support a stage-specific interpretation of substrate and biofertilizer management rather than selection based only on early vegetative growth. For recommendation-level evidence, P2C1 should be retested across a full harvest cycle, larger experimental units, and measured substrate and microbial conditions.

ACKNOWLEDGEMENTS
The authors acknowledge the Agrotechnology Study Program, Faculty of Science and Technology, Universitas Tjut Nyak Dhien, and UPTD BI Palawija Tanjung Selamat for supporting the implementation of the experiment.

BIBLIOGRAPHY

Agrawal, R. K., Tripathi, M. P., Verma, A., Sharma, G. L., & Khalkho, D. (2021). Effect on combinations of growing media for cultivation of horticultural crops in troughs, grow bag and pots: A review. *International Journal of Chemical Studies, 9*(1), 1545–1548. https://doi.org/10.22271/chemi.2021.v9.i1v.11444

Alzate Zuluaga, M. Y., Fattorini, R., Cesco, S., & Pii, Y. (2024). Plant-microbe interactions in the rhizosphere for smarter and more sustainable crop fertilization: The case of PGPR-based biofertilizers. *Frontiers in Microbiology, 15*, 1440978. https://doi.org/10.3389/fmicb.2024.1440978

Azhari, C. R., Kurniawan, D., & Berliana, Y. (2025). Response of giberellin and humic acid plants on the growth and yield of cherry tomato plants. *Algebra: Jurnal Pendidikan, Sosial dan Sains, 5*(1), 12–28. https://doi.org/10.58432/algebra.v5i1.1230

Cahya, S. D., Sugiarto, & Arfarita, N. (2023). Uji pengaruh pelet pupuk hayati VP3 dengan tambahan cangkang telur terhadap viabilitas bakteri fungsional dan bibit tanaman cabai (Capsicum frutescens L.). *Jurnal Produksi Tanaman, 11*(3), 191–198. https://doi.org/10.21776/ub.protan.2023.011.03.06

Camacho-Rodríguez, M., Almaraz-Suárez, J. J., Vázquez-Vázquez, C., Angulo-Castro, A., Ríos-Vega, M. E., & González-Mancilla, A. (2022). Effect of plant growth-promoting rhizobacteria on the growth and yield of jalapeño pepper. *Revista Mexicana de Ciencias Agrícolas, 13*(Special Issue 28), 185–196. https://doi.org/10.29312/remexca.v13i28.3273

Dasgan, H. Y., Yilmaz, M., Dere, S., Ikiz, B., & Gruda, N. S. (2023). Bio-fertilizers reduced the need for mineral fertilizers in soilless-grown capia pepper. *Horticulturae, 9*(2), 188. https://doi.org/10.3390/horticulturae9020188

Fallo, G., Tefa, A., & Pardosi, L. (2023). Selection of potential rhizobacteria as biological fertilizer and in vivo application against red chili seed germination in North Central Timor Regency, Indonesia. *Trends in Sciences, 20*(11), 6753. https://doi.org/10.48048/tis.2023.6753

Harahap, P. (2022). Efektivitas media tumbuh cocopeat terhadap produksi tanaman cabai rawit (Capsicum frutescens L.) dalam pot. *Jurnal Agroplasma, 9*(2), 239–244. https://doi.org/10.36987/agroplasma.v9i2.3335

Hasibuan, A. S., Berliana, Y., Kurniawan, D., & Razali. (2024). Growth and production response of beet plants (Beta vulgaris L.) to several concentrations and application methods of paclobutrazole. *Algebra: Jurnal Pendidikan, Sosial dan Sains, 4*(4), 153–167. https://doi.org/10.58432/algebra.v4i4.1158

Ichwan, B., Eliyanti, E., & Zulkarnain, Z. (2021). Influence of biostimulants and media compositions on growth and yield of Capsicum annuum L. under drought stress conditions. *Advances in Horticultural Science, 35*(2), 129–137. https://doi.org/10.36253/ahsc-8354

Iriany, A., Wulan Sari, O. A., & Hasanah, F. (2020). Optimization of BioPot compositions made from water hyacinth and coconut coir for improving the growth and yield of chili (Capsicum annum L.). *International Journal of Recycling of Organic Waste in Agriculture, 9*(3), 287–296. https://doi.org/10.30486/ijrowa.2020.1894411.1048

Lobato-Ureche, M. A., Pérez-Rodriguez, M. M., Segura, D., Monasterio, R., & Cohen, A. C. (2023). Pseudomonas 42P4 and Cellulosimicrobium 60I1 as a sustainable approach to increase growth, development, and productivity in pepper plants. *Frontiers in Sustainable Food Systems, 6*, 1111573. https://doi.org/10.3389/fsufs.2022.1111573

Sardianti, A. L. (2021). Hubungan input terhadap produksi usahatani cabai rawit di Kecamatan Tilamuta Kabupaten Boalemo. *Journal of Agritech Science, 5*(2), 65–75. https://doi.org/10.30869/jasc.v5i02.784

Sari, N. M., Rokhim, S., & Faizah, H. (2024). The effect of mycorrhizal biofertilizer with the addition of rice washing water and eggshells on the growth of cayenne pepper plant (Capsicum frutescens L.). *Agrovigor: Jurnal Agroekoteknologi, 17*(1), 6–20. https://doi.org/10.21107/agrovigor.v17i1.21768

Shafira, W., Akbar, A. A., & Saziati, O. (2021). Penggunaan cocopeat sebagai pengganti topsoil dalam upaya perbaikan kualitas lingkungan di lahan pascatambang di Desa Toba, Kabupaten Sanggau. *Jurnal Ilmu Lingkungan, 19*(2), 432–443. https://doi.org/10.14710/jil.19.2.432-443

Sharma, M., Sharma, V., Delta, A. K., & Kaushik, P. (2022). Rhizophagus irregularis and nitrogen fixing Azotobacter with a reduced rate of chemical fertilizer application enhances pepper growth along with fruits biochemical and mineral composition. *Sustainability, 14*(9), 5653. https://doi.org/10.3390/su14095653

Siregar, A. L. Z., & Lubis, N. M. (2022). Budidaya tanaman cabai caplak guna meningkatkan perekonomian masyarakat pesisir Dusun II Desa Percut Sei Tuan. *Martabe: Jurnal Pengabdian Masyarakat, 5*(6), 2331–2337. https://doi.org/10.31604/jpm.v5i6.2331-2337

Sofiarani, F. N., & Ambarwati, E. (2020). Pertumbuhan dan hasil cabai rawit (Capsicum frutescens L.) pada berbagai komposisi media tanam dalam skala pot. *Vegetalika, 9*(1), 292–304. https://doi.org/10.22146/veg.44996

Tashi, S., Wangchuk, K., Udas, E., Gaki, S., & Aryal, K. (2022). A solution at the doorsteps: Improved biofertilizer enhances soil fertility and yield of chili (Capsicum annuum L.) in Bhutan. *International Journal of Recycling of Organic Waste in Agriculture, 12*(2), 259–267. https://doi.org/10.30486/ijrowa.2022.1952686.1416

Thakur, S., Sharma, A. K., Thakur, K., Sharma, S., Gudeta, K., Hashem, A., Avila-Quezada, G. D., Moubayed, N. M. S., & Abd_Allah, E. F. (2023). Differential responses to integrated nutrient management of cabbage–capsicum–radish cropping sequence with fertilizers and plant-growth-promoting rhizobacteria. *Agronomy, 13*(7), 1789. https://doi.org/10.3390/agronomy13071789

Tuckeldoe, R. B., Maluleke, M. K., & Adriaanse, P. (2023). The effect of coconut coir substrate on the yield and nutritional quality of sweet peppers (Capsicum annuum) varieties. *Scientific Reports, 13*, 2742. https://doi.org/10.1038/s41598-023-29914-0

Yahya, D. P. A., Hendarto, K., Yelli, F., & Widyastuti, R. D. (2022). Response of biofertilizer application and alkali supplement fertilizer on the growth and yield of curly red chili (Capsicum annuum L.). *Jurnal Teknik Pertanian Lampung, 11*(1), 15–23. https://doi.org/10.23960/jtep-l.v11i1.15-23