RESPONSE OF TOBACCO PLANT GROWTH AND YIELD TO COMBINATION DOSES OF ZA FERTILIZER AND COCONUT SHELL BIOCHAR

Furqan Mubarak Djula[1]*, Santi Rosniawaty[2], Intan Ratna Dewi Anjarsari[2]
[1]Study Program of Agrotechnology, Faculty of Agriculture, Universitas Padjadjaran, Sumedang 45363, Indonesia
[2]Department of Agronomy, Faculty of Agriculture, Universitas Padjadjaran, Sumedang 45363, Indonesia
*Correspondence: djulafurqan@gmail.com

ABSTRACT

Tobacco plants require nitrogen and sulfur elements to enhance their yield and quality. The primary source of N and S elements is typically from ZA fertilizer. The availability of ZA fertilizer is limited; therefore, an alternative material containing N and S as a complementary material is required. A material that can be used as a complementary for ZA fertilizer is coconut shell biochar. This research aims to identify tobacco plants' growth and yield response and determine the best dose combination of ZA fertilizer and coconut shell biochar on the growth and yields of tobacco plants. The method used is experimental by design Randomized Block Design consisting of six treatments and four repetitions: 0 g ZA fertilizer + 375 g coconut shell biochar/plant, 6 g ZA fertilizer + 375 g coconut shell biochar/plant, 12 g ZA fertilizer + 375 g coconut shell biochar/plant, 0 g ZA fertilizer + 563 g coconut shell biochar/plant, 6 g ZA fertilizer + 563 g coconut shell biochar/plant, and 12 g ZA fertilizer + 563 g coconut shell biochar/plant. The research was conducted from April to July 2024 at Kebun Percobaan Ciparanje, Faculty of Agriculture, Universitas Padjadjaran. The experiment results indicated a significant response in tobacco plant growth and yield to applying ZA fertilizer and coconut shell biochar. The treatment of 12 g ZA fertilizer + 375 g coconut shell biochar/plant had the best results for tobacco plants' growth and yield variables.

Keywords: N Fertilizer; Organic Matter; S Fertilizer

Submitted : 14 October 2024
Accepted : 12 November 2024
Published : 15 November 2024

INTRODUCTION

Tobacco plants hold high economic value and can be processed into various products, including cigarettes, pesticides, biofuels, and cosmetics. Tobacco cultivation significantly impacts Indonesia's economy, mainly through the Tobacco Excise Tax and by providing employment opportunities for laborers in tobacco-growing regions (Rachmat, 2016). According to WHO (2018), the area used for tobacco plantation globally was 3.5 million hectares, with the production declining from 2015 to 2018 at around 7 million tonnes in 2015 to around 6.5 million tonnes in 2018. The decline of production and the importance of tobacco on an economic aspect highlight the need for increased production

Activities like irrigation, watering, weeding, fertilization, and pruning are crucial to enhance tobacco yields. Proper fertilizer application is a pivotal strategy to boost productivity (Febrian et al., 2011). Applying fertilizers with appropriate doses, types, and methods is essential. Strategies include optimizing efficiency through techniques like the "five right principles" (right type, dose, time, location, and method), balancing macro and micronutrient applications during fertilizing processes, and utilizing plant analysis results along with fertilizer recommendations to determine optimal dosages (Mansyur et al., 2021). ZA fertilizer is one of the most commonly used fertilizers for tobacco (Soemarah et al., 2020).

ZA fertilizer is a fertilizer that contains nitrogen and sulfur. Its usage in tobacco farming is based on its lower nitrogen content than urea. Excessive nitrogen can prolong leaf drying times, complicate harvesting and drying processes, delay maturity, leading to immature dry leaves, cause leaf brittleness, and affect flavor preferences negatively (Sholeh et al., 2000; Tirtosastro & Murdiyati, 2010; North Carolina State University, 2014). Nitrogen deficiency leads to reduced leaf quality, while excessive amounts may contaminate soils due to nitrogen dissolving quickly (North Carolina State University, 2014). The sulfur acts as a secondary macro element within ZA fertilizer, improving tobacco leaves' combustibility by enhancing flexibility, coloration, aroma retention, and increasing leaf quantity (Soemarah et al., 2020). Mukhlid (2017) stated that sulfur deficiency could hinder protein synthesis, causing chlorosis, which affects organ quality. Therefore, the availability of ZA fertilizer is essential for tobacco cultivation.

The availability of ZA fertilizer has become an issue for farmers. According to Peraturan Menteri Pertanian No. 01 (2024), ZA does not qualify as subsidized agricultural inputs. Rising prices coupled with shortages make it challenging for farmers. Suryana et al. (2016) stated that ZA fertilizer shortages remain a recurring problem each year.

Tobacco farmers need alternative materials to solve that problem and fulfill growth requirements. Adding nutrients via biochar derived from coconut shells offers potential solutions by improving physical, chemical, and biological conditions, thereby boosting land fertility levels (Rahayu et al., 2019). Given Indonesia's abundant resources, biochars made from coconuts show significant ameliorative effects, including reducing acidity levels while maintaining long-lasting carbon storage capabilities comparable only slightly better than organic residues themselves (Jayyidah et al., 2023). Applying coconut shell biochar to soil can reduce soil acidity, enhancing crop yields. This biochar has a stable carbon content that can persist in the soil for extended periods (Putri et al., 2023). The carbon from coconut shell biochar remains in the soil longer than carbon derived from plant residues and manure (Adekiya et al., 2020).

Coconut shell biochar can only partially replace the role of ZA fertilizer due to its deficient nitrogen (N) and sulfur (S) content. According to Sukartono and Utomo (2012), coconut shell biochar contains N 0.25-0.34% and S 0.02%. This finding aligns with research conducted by Purnomo et al. (2023), which demonstrated that tobacco cultivation relying solely on organic materials without ZA fertilizer resulted in the lowest outcomes across all growth and yield variables. Therefore, incorporating coconut shell biochar as a supplementary material can be effectively combined with ZA fertilizer at appropriate dosages to optimize the growth and yield of tobacco plants.

The precise dosage of fertilizer significantly affects the growth of tobacco plants. According to research conducted by Bastian (2007), nitrogen (N) fertilization doses have a notable impact on the weight and quality of tobacco leaves. As a critical criterion in fertilization practices, fertilizer dosage also directly influences soil productivity through improvements in its physical, chemical, and biological properties (Purba et al., 2021). High soil productivity can enhance crop production, thereby improving tobacco farmers' quality of life and income and increasing the area planted and the overall tobacco production in West Java.

Optimal fertilization doses significantly influence nutrient absorption efficiency in plants. Nitrogen fertilization using ZA fertilizer is a common practice in tobacco cultivation. Additionally, coconut shell biochar can enhance soil productivity and support tobacco growth. However, more research is needed on the most practical combination of ZA fertilizer and coconut shell biochar for tobacco plant growth. Therefore, studies are needed to investigate the combination of ZA fertilizer dosages with the addition of coconut shell biochar to improve the growth and yield of tobacco plants. The appropriate use of coconut shell biochar is expected to reduce the reliance on ZA fertilizer.

MATERIALS AND METHODS

The experiment was conducted at Ciparanje Experimental Station, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor. The research was conducted from April to July 2024. The altitude of the field is ±760 m above sea level with an average temperature of 23,3°C and an average humidity level of 88.3 % with a C type of rainfall based on Schmidt and Ferguson rainfall classification. The soil ordo is Inceptisol.

The materials used in this research were Temangi variety tobacco seedlings, cow manure as a primary fertilizer, polybags size 40 cm x 40 cm with a media capacity of 15 kg, fungicide with an active ingredient of carbofuran, insecticide with the active ingredients of abamectin and imidacloprid, ZA fertilizer, SP-36 fertilizer, KCl fertilizer, and coconut shell biochar. The tools used in this research were a ruler, digital vernier caliper, labels, and documentation equipment. The results of an initial analysis of coconut shell biochar content are as follows (Table 1).

Table 1. Coconut Shell Biochar Content Analysis

No.	Parameter	Result
1.	Moisture Content	8.29%
2.	Organic-C	2.59 %
3.	Total-N	0.55 %
4.	C/N Ratio	13
5.	S	86.22 ppm

The experiments used a Randomized Block Design with six treatments and four replications. The treatments were: 0 g ZA fertilizer + 375 g coconut shell biochar/plant (A), 6 g ZA fertilizer + 375 g coconut shell biochar/plant (B), 12 g ZA fertilizer + 375 g coconut shell biochar/plant (C), 0 g ZA fertilizer + 563 g coconut shell biochar/plant (D), 6 g ZA fertilizer + 563 g coconut shell biochar/plant (E), and 12 g ZA fertilizer + 563 g coconut shell biochar/plant (F). The data collected from the experiment were analyzed using ANOVA at a significant level of 5%. The analysis would be continued using Duncan's Multiple Range Test (DMRT) at a significant level of 5%. All responses were analyzed statistically using SmartStatXL.

The experiment was conducted on a field of 300 cm x 400 cm, where each replication consisted of 18 plants, and the spacing between replication was 150 cm. The plant spacing was regulated by 100 x 50 cm. The total number of samples was 72 samples.

The polybag used for planting was 40 x 40 cm with a soil capacity of 15 kg. The soil was air-dried for three days before filling the polybags to remove weeds. The mixture was 10 kg of soil and 250 g of cow manure. Seven g/plants of P and K fertilizers were then applied at 1 WAP. The plant was watered every day except on rainy days. Pest, disease, and weed control were carried out using two primary methods: mechanical and chemical. The mechanical method involves removing the pest that interferes with plant growth, while the chemical method involves using pesticides.

The growth and yield responses that were observed were plant height (cm), stem diameter (mm), number of leaves, and leaf area (cm^2). All responses were observed 3 -7 Weeks After Planting (WAP).

RESULTS AND DISCUSSION

Results

The responses of tobacco plants were measured at the ages of 3, 5, 7, 9, and 11 Weeks After Planting (WAP). The analysis results are as follows (Table 2-5).

Table 1 showed that Treatment F produced a significant plant response compared to Treatments A at 5-11 WAP and compared to Treatments B and D at 5 and 7 WAP. Based on the experimental results in Table 2, treatment F resulted in significantly different stem diameter responses compared to treatments A and D at 7, 9, and 11 WAP. It also showed differences between treatment B at 5 and 11 WAP and treatment C, precisely at 9 WAP. Table 3 presented that Treatments C and F produced a significantly different number of leaf responses compared to Treatments A and D at 5, 7, and 11

WAP. However, no significant differences were observed with Treatment E during any of the observation weeks. For the variable of tobacco number of leaves, Treatments C and F did not show significant differences from Treatment E compared to Treatments C and F. The experimental results regarding the leaf shown in Table 4 indicate that Treatments C and F generated significant responses when compared to Treatments A and D across all stages of observation.

Discussion

Pahlevi et al. (2017) noted that combining nitrogen fertilizers with biochar resulted in taller plants than those without. Studies conducted by Wasis et al. (2019) found that Acacia trees grown with coconut shell biochar achieved the highest heights compared to just NPK fertilization or only coconut shell biochar alone.

Table 2. Plant Height Response by the Application of ZA Fertilizer with Coconut Shell Biochar Dose Combinations

Treatment	Plant Height (cm)				
	3 WAP	5 WAP	7 WAP	9 WAP	11 WAP
A	28.5 a	42.8 a	51.1 a	64.7 a	79.7 a
B	27.9 a	44.3 ab	59.6 b	72.8 ab	89.2 ab
C	28.2 a	47.5 bc	67.7 cd	80.6 b	94.9 b
D	26.8 a	43.4 a	58.8 b	74.7 ab	87.2 ab
E	27.5 a	47.4 bc	66.2 c	80.3 b	94.6 b
F	30.2 a	49.1 c	73.2 d	82.5 b	96.8 b

Notes: The average number marked with the same letter in the same column differed significantly according to Duncan’s Multiple Range Test at a 5 % significance level.

Table 3. Stem Diameter Response by the Application of ZA Fertilizer with Coconut Shell Biochar Dose Combinations

Treatment	Stem Diameter (mm)				
	3 WAP	5 WAP	7 WAP	9 WAP	11 WAP
A	6.7 a	9.0 a	11.3 a	11.5 a	12.2 a
B	6.5 a	9.7 ab	12.5 b	13.3 bc	13.3 b
C	6.8 a	10.2 bc	13.0 b	13.0 b	14.3 bc
D	6.2 a	9.4 ab	11.4 a	12.3 ab	13.5 b
E	7.0 a	9.9 abc	12.4 b	13.4 bc	14.2 bc
F	7.6 a	10.9 c	13.0 b	14.2 c	15.0 c

Notes: The average number marked with the same letter in the same column differed significantly according to Duncan’s Multiple Range Test at a 5 % significance level.

Table 4. Number of Leaves Response by the Application of ZA Fertilizer with Coconut Shell Biochar Dose Combinations

Treatment	Number of Leaves (sheets)				
	3 WAP	5 WAP	7 WAP	9 WAP	11 WAP
A	5.4 a	6.9 a	8.4 a	10.8 a	13.2 a
B	5.3 a	7.3 ab	10.3 bc	12.7 ab	15.3 b
C	5.7 a	8.2 c	11.3 c	13.3 b	16.6 b
D	5.1 a	6.9 a	8.9 ab	11.3 ab	13.2 a
E	5.3 a	7.8 bc	11.1 c	13.1 b	16.3 b
F	5.8 a	8.1 bc	11.5 c	13.4 b	16.3 b

Notes: The average number marked with the same letter in the same column differed significantly according to Duncan’s Multiple Range Test at a 5 % significance level.

Table 5. Leaf Area Response by the Application of ZA Fertilizer with Coconut Shell Biochar Dose Combinations

Treatment	Leaf Area (cm^2)				
	3 WAP	5 WAP	7 WAP	9 WAP	11 WAP
A	72.9 a	99.1 a	117.9 a	137.4 a	166.9 a
B	117.6 b	173.9 bc	203.4 bc	234.4 bc	270.1 bc
C	166.4 c	210.7 c	236.8 c	271.0 c	308.2 c
D	83.7 ab	143.5 ab	170.4 ab	193.2 ab	222.3 ab
E	119.8 b	169.6 bc	205.2 bc	227.9 bc	259.6 bc
F	161.0 c	223.3 c	253.9 c	273.4 c	282.9 bc

Notes: The average number marked with the same letter in the same column differed significantly according to Duncan's Multiple Range Test at a 5 % significance level.

Adding coconut shell biochar can aid in the efficient uptake of essential nutrients by plants. According to Laurenze et al. (2023), incorporating coconut shell biochar into the soil enhances microbial populations, facilitating plant nutrient uptake due to its high organic carbon content. Furthermore, the presence of sulfur in coconut shell biochar helps optimize nitrogen utilization in crops. Jamal et al. (2010) stated that sulfur is crucial in nitrate reductase enzyme activities, regulating nitrogen assimilation processes. Zenda et al. (2021) emphasized that nitrogen and sulfur are essential elements involved in protein synthesis; thus, insufficient sulfur levels reduce the effectiveness of nitrogen use in plants.

Cigarette plant growth is influenced by stem diameter. As reported by Sun et al. (2019), the value of stem diameter correlates with biomass present in leaves, affecting the physiological properties of the leaves and plant growth. Stem diameter growth can be enhanced by macronutrients such as nitrogen (Simatupang, 2019). Nitrogen application supports stem diameter growth, increasing cell expansion and plant tissue development (Belay et al., 2023). Phosphate-based fertilizer also contains sulfur. This element participates in biological nitrogen fixation processes, increasing nitrogen usage efficiency through phosphate-based fertilizer applications (Narayan et al., 2023).

Treatment E (6 g ZA fertilizer + 563 g of coconut shell biochar per plant) represents one of the most effective dosages for enhancing stem diameter growth despite having less ZA fertilizer than Treatment F E (12 g ZA fertilizer + 563 g of coconut shell biochar per plant), yet producing non-significant differences. Coconut shell biochar helps with plants' nutrient uptake through its high Cation Exchange Capacity (CEC) and Water Holding Capacity (WHC) (Ajien et al., 2022). Research by Ren et al. (2021) indicates that applying biochar to tobacco plants boosts photosynthetic rates and total biomass production. Cellular division occurs only when sufficient accumulated energy reaches critical sizes necessary for splitting cells (Moulager et al., 2007). Therefore, based on this understanding, biochar promotes stem diameter growth by providing energy for plant cellular divisions.

The number of leaves is one of the essential components in the growth of tobacco plants. Plant growth requirements are greatly influenced by the availability of nutrients that can be utilized by the plants (Syariyah et al., 2024). Regarding tobacco leaf counts, treatments C and F produced non-significant responses relative to treatment E, presumably due to higher nitrogen efficiency in treatment E compared to treatments C and F. This aligns with Astuti et al. (2023) statement that nutrient efficiency decreases as fertilizer dosage increases. Regarding this point, adding biochar to the soil can enhance cation exchange capacity (CEC), allowing for optimal nutrient absorption. Pahlevi et al. (2017) mentioned that adding biochar increases CEC in the soil, leading to improved nutrient uptake by plants and promoting plant growth.

Biochar can elevate nutritional availability and soil quality for plant growth. Biochar enhances soil water retention and microbial activity and reduces soil erosion, supporting plant metabolic processes and imparting alkaline effects that provide macro and micronutrients to plants (Al-Hayali, 2022; Fageria & Moreira, 2011). Coconut shell biochar contains macronutrients that contribute to increased leaf numbers. Sukartono and Utomo (2012) reported that coconut shell biochar contains approximately 8.4% potassium, influencing leaf counts through various plant metabolic processes. Potassium supports cell elongation and regulates osmotic pressure in plant cells, impacting stomatal activity.

Leaf area affects the yield of tobacco plants. According to Rochman and Hamida (2017), the length and width of tobacco leaves positively influence the dry yield of tobacco shreds. The role of nitrogen in increasing leaf area cannot be entirely replaced by coconut shell biochar. Nitrogen aids cell division and enlargement, supporting leaf length and width (Syariyah et al., 2024). According to Chowdhury et al. (2020), an increase in sulfur addition aligns with rapid growth in plants' leaf area.

Treatments B (6 g of ZA fertilizer + 375 g of coconut shell biochar per plant) and E (6 g of ZA fertilizer + 563 g of coconut shell biochar per plant), which used lower doses of ZA, produced responses that were not significantly different from treatments C (12 g of ZA fertilizer + 375 g of coconut shell biochar per plant) and F (12 g of ZA fertilizer + 563 g of coconut shell biochar per plant) at ages 5, 7, 9, and 11 WAP. Coconut shell biochar affects soil quality in supporting the growth of tobacco plants. According to Yang et al. (2024), applying biochar can improve soil porosity and reduce bulk density, facilitating root penetration and helping roots access to water and various nutrients in the soil, which influences the enhancement of growth parameters such as leaf area.

Research by Adekiya et al. (2020) indicates that the application of biochar can improve physical properties such as porosity and bulk density, as well as chemical properties like nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and cation exchange capacity (CEC).

CONCLUSION

Applying ZA fertilizer and coconut shell biochar significantly affected tobacco plants' growth and yield. The treatment of 12 g ZA fertilizer + 375 g coconut shell biochar produced the best results in increasing tobacco plant growth and yield responses.

REFERENCES

Adekiya, A. O., Agbede, T. M., Olayanju, A., Ejue, W. S., Adekanye, T. A., Adenusi, T. T., Ayeni, J. F. Effect of Biochar on Soil Properties, Soil Loss, and Cocoyam Yield on a Tropical Sandy Loam Alfisol. *Scientifical World Journal*, 1-9. doi: https://doi.org/10.1155%2F2020%2F9391630

Ajien, A., Idris, J., Sofwan, M. M., Husen, R., and Seli, H. 2022. Coconut shell and husk biochar: A review of production and activation technology, economic, financial aspect and application. *Waste Management & Research*, *41*(1), 37-51.

Al-Hayali, M., Khalid, A., Abdelsalam, N. R., Ghareeb, R., & Emaish, H. (2022). Preparation and Characterization of Biochar and Their Effect on Cell Division. *Egyptian Academic Journal of Biological Sciences*, *13*(2), 79–90. doi: http://dx.doi.org/10.21608/eajbsh.2022.257675

Astuti, Y., Lubis, I., Junedi, A. (2023). Penentuan Dosis Pupuk Nitrogen, Fosfor, dan Kalium Optimum untuk Padi Sawah Varietas Bioemas Agritan. *Jurnal Agro*, *10*(1), 16-29. doi: https://doi.org/https://doi.org/10.15575/23187

Bastian, A. 2007. Pengaruh Dosis Pemupukan Nitrogen Terhadap Pertumbuhan dan Hasil Tembakau pada Tanaman Tembakau Cerutu.

Belay, T., Alemayehu, M., Belay, F. (2023). Effects of nitrogen application and intra-row spacing on growth and yield of baby corn in north-west Ethiopia. *Journal of Agriculture and Food Research*, *13*, 1-8.

Chowdhury, M. A. H., Sultana, T., Rahman, M. A., Saha, B. K., Chowdhury, T., Tarafder, S. (2023). Sulphur fertilization enhanced yield, its uptake, use efficient and economic returns of *Aloe vera* L. *Heliyon*, *6*(12), 1–5.

Fageria, N. K., Moreira, A. (2011). Chapter Four - The Role of Mineral Nutrition on Root Growth of Crop Plants. *Advances in Agronomy*, *110*, 251-331. doi https://doi.org/10.1016/B978-0-12-385531-2.00004-9.

Febrian, I. F., Muryono, M., Hendryana, F. (2011). *Pengaruh Pupuk Nitrogen terhadap Pertumbuhan dan Produktivitas Tembakau (Nicotiana tabacum L.) Varietas Prancak pada Kepadatan Populasi 360000/Ha di Kabupaten Pamekasan, Jawa Timur*. Institut Teknologi Sepuluh Nopember, Jurusan Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam. Jawa Timur: Repository Institut Teknologi Sepuluh Nopember.

Jamal, A., Moon, Y., Abdin, M. Z. (2010). Sulphur - a General Overview and

Interaction with Nitrogen. *Australian Journal of Crop Science, 4*(7), 523-529.

Jayyidah, U. M., Rosniawaty, S., Suherman, C. (2023). Respons Bibit Batang Bawah Kemiri Sunan Terhadap Campuran Media Tanam Subsoil dan Biochar. *Jurnal Agroplantae, 12*(1), 49-56.

Laurenze, R., Alaa, A., Saleh, I. R. (2023). Application of Coconut Shell Biochar and Rhizobacteria Consortium to Increase Cocoa Production. *Pelita Perkebunan, 39*(2), 119-128. doi: 10.22302/iccri.jur.pelitaperkebunan.v39i2.545

Mansyur, N. I., Pudjiwati, E. H., Murtilaksono, A. (2021). *Pupuk dan Pemupukan*. (Z. Hanum, Ed.) Banda Aceh, Aceh, Indonesia: Syiah Kuala University Press. Retrieved from https://books.google.co.id/books?hl=endanlr=danid=eiwyEAAAQBAJdanoi=fnddanpg=PP1dandq=pemupukandanots=TCwb0zbewpdansig=JMZmVMxLBopbQtEh1NuW6gD0Jvkdanredir_esc=y#v=onepagedanq=pemupukandanf=true

Menteri Pertanian Republik Indonesia. 2024. Peraturan Menteri Pertanian Republik Indonesia Nomor 01 Tahun 2024 tentang Perubahan atas Peraturan Menteri Pertanian Nomor 10 Tahun 2022 tentang Tata Cara Penetapan Alokasi dan Harga Eceran tertinggi Pupuk Bersubsidi Sektor Pertanian.

Moulager, M., Monnier, A., Jesson, B., Bouvet, R., Mosser, J., Schwartz, C., Garnier, L., Corellou, F., Bouget, F.Y. 2007. Light Dependent Regulation of Cell Division in Ostreococcus: Evidence for a Major Transcriptional Input. *Plant Physiology, 144*, 1360-1369.

Narayan, O. P., Kumar, P., Yadav, B., Dua, M., Johri, A. K. 2023. Sulfur Nutrition and its Role in Plant Growth and Development. *Plant Signal and Behavior, 18*(1), 1-11. doi: https://doi.org/10.1080%2F15592324.2022.2030082

North Carolina State University. (2014). NC State Extension. Retrieved from Fertility - Nutrients: https://tobacco.ces.ncsu.edu/tobacco-fertility-nutrients/

Pahlevi, R. W., Susilo, B., Dalimartha, L. N., Wiguna, E. C., Isdiantoni, Koentjoro, M. P., Prasetiyo, E. N. (2017). Pengaruh Formulasi Penambahan Biochar terhadap Produksi Tanaman Tembakau Varietas K326 Cross Creek Seed USA di Lahan Kering Kabupaten Bojonegoro. *Proceeding Biology Education Conference, 14*(1), 171-176.

Purba, T., Ningsih, H., Purwaningsih, Junaedi, A. S., Gunawan, B., Junairiah, Arsi. (2021). *Tanah dan Nutrisi Tanaman*. (A. Karim, Ed.) Yayasan Kita Menulis.

Purnomo, T., Zudri, F., Putrina, M., Fefriyanti, D. S., Enati, N. P. (2023). Pengaruh Berbagai Dosis Pupuk Kimia and Pupuk Organik terhadap pertumbuhan dan Produksi Tanaman Tembakau Payakumbuh (Nicotiana tabacum L.). *Agrohita Jurnal Agroteknologi, 8*(1), 255-262.

Putri, D. K., Mumtazah, Z., Jannah, D. P., Abdullah, L. K. (2023). Pemberdayaan Petani Melalui Inovasi Biochar sebagai Solusi Pengganti Pupuk Kimia di Desa Grenden Kecamatan Puger Kabupaten Jember. *Jurnal Pengabdian Kepada Masyarakat, 7*(5), 716-723. doi:https://doi.org/10.12962/j26139960.v7i5.565

Rachmat, M. (2016). Pengembangan Ekonomi Tembakau Nasional: Kebijakan Negara Maju dan Pembelajaran Bagi Indonesia. *Analisis Kebijakan Pertanian, 8*(1), 67-83. Retrieved from https://epublikasi.pertanian.go.id/berkala/akp/article/view/761

Rahayu, Saidi, D., Herlambang, S. 2019. Pengaruh Biochar Tempurung Kelapa dan Pupuk Kandang Sapi Terhadap Sifat Kimia Tanah dan Produksi Tanaman Sawi pada Tanah Pasir Pantai. *Jurnal Tanah dan Air, 16*(2), 69-78.

Ren, T., Wang, H., Yuan, Y., Feeng, H., Wang, B., Kuang, G., Wei, Y., Gao, W., Shi, H., Liu, G. 2021. Biochar increases tobacco yield by promoting root growth based on a three-year field application. *Scientific Reports, 11*(1), 1-10. doi:https://doi.org/10.1038/s41598-021-01426-9

Rochman, F., Hamida, R. (2017). Keragaan Karakter Morfologi, Stomata, dan Klorofil Enam Varietas Tembakau Lokal Tulungagung. *Buletin Tanaman Tembakau, Serat, dan Minyak, 9*(1), 15-23.

Schmidt, & Ferguson. (1951). *Rainfall thypes based on wet and dry period ratios for indonesian with western nem guinee*. Jawatan Meteorologi dan Geofisika. Jakarta

Sholeh, M., Rachman, A., Mahfudz, M. (2000). Pengaruh Komposisi Pupuk KS, ZA, dan Urea, Serta Dosis N terhadap Mutu

Tembakau Besuki No. *Industrial Crops Research Journal*, *6*(3), 80-87.

Simatupang, B. (2019). Pengaruh Jenis Klon dan Aplikasi Pupuk Pelengkap Cair Gandasil D Terhadap Pertumbuhan Diameter Batang Bibit Okulasi Karet (Hevea brasiliensis Muell Arg). *Jurnal AgroSainTa*, *3*(1), 21-28.

Soemarah, T. K., Supriyadi, T., Suprapti, E., Haryuni. (2020). Pengaruh Jenis Pupuk Terhadap Produksi Daun Tembakau (Nicotiana tabacum). *Agrineca*, *20*(1), 64-71. doi:https://dx.doi.org/10.36728/afp.v20i1.999

Sukartono, Utomo, W. H. (2012). Peranan Biochar Sebagai Pembenah Tanah pada Pertanaman Jagung di Tanah Lempung Berpasir (Sandy Loam) Semiarid Tropis Lombok Utara. *Buana Sains*, *12*(1), 91-98.

Sun, J., Wang, M., Lyu, M., Niklas, K. J., Zhong, Q., Li, M. and Cheng, D. (2019). Stem Diameter (and Not Length) Limits Twig Leaf Biomass. *Front Plant Science*, *10*(185), 1–10. doi: https://doi.org/10.3389/fpls.2019.00185

Suryana, A., Agustian, A., Yofa, R. D. (2016). Alternatif Kebijakan Penyaluran Subsidi Pupuk bagi Petani Pangan. *Analisis Kebijakan Pertanian*, *14*(1), 35-54.

Syariyah, A., Rohman, N., Sidqi, M. S., Asman, A., Mukhlis, Syafrison, Eviza, A. (2024). Responses of Tobacco Plant (Nicotiana tabacumL.) Payakumbuh Rudau Gadang Variety to The Application of Tomato Liquid Organic Fertilizer. *International Journal of Life Science and Agriculture Research*, *3*(2), 88-94. doi: https://doi.org/10.55677/ijlsar/V03I2Y2024-06

Tirtosastro, Murdiyati. (2010). Kandungan Kimia Tembakau dan Rokok. *Buletin Tanaman Tembakau. Serat, dan Minyak Industri*, *2*(1), 33-43. Retrieved from https://media.neliti.com/media/publications/53962-ID-kandungan-kimia-tembakau-dan-rokok.pdf

Wasis, B., Ghaida, S. H., Winata, B. 2019. Application of Coconut Shell Charcoal and NPK Fertilizer toward Acacia mangium Growth on the Soil of Ex-Limestone Mining in Bogor, Indonesia. *Archives of Agriculture and Environmental Science*, *4*(1), 75-82. doi: http://dx.doi.org/10.26832/24566632.2019.0401012

[WHO]. 2018. Tobacco Production & Trade Global Infographic.

Yang, X., Zhang, K., Qi, Z., Shaghaleh, H., Gao, C., Chang, T., Zhang, J., & Hamoud, Y. A. (2024). Field Examinations on the Applications of Novel Biochar-Based Microbial Fertilizer on Degraded Soils and Growth Response of Flue-Cured Tobacco (Nicotiana tabacum L.). *Plants*, *13*(10), 1–18. doi: https://doi.org/10.3390/plants13101328

Zenda, T., Liu, S., Dong, A, and Duan, H. 2021. Revisiting Sulphur - The Once Neglected Nutrient: It is Roles in Plant Growth, Metabolism, Stress Tolerance, and Crop Production. *Agriculture*, *11*(7), 626. doi: https://doi.org/10.3390/agriculture11070626