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Integrated Nutrient Management and Intercropping in Increasing the Productivity of Curly Chili (*Capsicum annum* L)

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Abstract. Curly chili (*Capsicum annum L.) is one horticultural commodity with good development prospects*. The productivity of chili plants in Indonesia is quite low. The cause is low land productivity due to intensive planting and excessive use of inorganic fertilizers. One way to overcome this problem is by combining inorganic and organic fertilizers. This research aims to obtain the proportions of various nutrient sources and types of intercropping that can increase the production of curly red chili plants. This research was conducted in June – December 2021 in Wonorejo Village, Poncokusumo District, Malang Regency. This research used a Randomized Block Design (RBD). (P0) chili monoculture (P1) chili + pakchoy (P2) chili + cabbage (F0) 100% inorganic (F1) 75% N + 20 t goat manure + PGPR 10 ml 1-1 (F2) 75% N + 20 t goat manure + PGPR 20 ml 1-1 (F3) 50% N + 30 t goat manure + PGPR 20 ml 1-1. The results showed that the P1F2 treatment: chili + pakcoy, 75% N + 20 t goat manure + PGPR 20 ml 1 showed high growth results, namely plant height, number of leaves and stem diameter, and the highest yield component per hectare, namely 8.6 tons/ha.
Keywords: curly chili; integrated nutrient management; intercropping

INTRODUCTION

Curly red chili (*Capsicum annum* L.) is a horticultural commodity with good development prospects. The large domestic and international demand makes chilies a promising commodity. Increasing population and the food industry require red chilies all the time. Data from the Ministry of Agriculture shows that the Productivity of red chili plants in Indonesia in 2015 - 2019 was around 8.46 tonnes/ha-1. This production is still low because, through optimal cultivation techniques, the productivity of red chili plants can reach 22 tonnes ha-1 (Sa'diyah *et al*., 2020). Therefore, efforts need to be made to increase the productivity of curly red chili plants through improved cultivation techniques.

Previous research has often been limited to one plant type or compost source. Not many have explored the effects of goat compost from various sources on various types of plants. Apart from that, there has not been a thorough evaluation of variations in the effectiveness of PGPR in various soil conditions or on different types of plants. Previous research has not examined the long-term effects of intercropping on soil quality and yields.

Nutrient management plays a vital role in increasing the productivity of curly red chili plants. Explained that to obtain high yields, Solanacea family plants require nutrients in large quantities and are always available. Nitrogen is a nutrient that plays a major role in the productivity of curly red chili plants. Nitrogen elements are needed at every stage of plant growth. (Chen *et al*., 2018). explained that nitrogen plays a role in the biosynthesis of proteins and lipids into the compounds that make up chloroplasm. The availability of sufficient nitrogen will increase plants' viability and photosynthesis process. Based on the description above, efforts are needed to meet the availability of N elements at each life stage of curly chili plants.

An integrated nutrient management system can increase the efficiency of nutrient uptake and production of curly chili plants. An integrated nutrient management system is a system that utilizes various sources of nutrients and is managed synergistically. Using various environmentally friendly sources of nutrients will increase plant nutrient uptake efficiency (Chandini *et al*., 2019). Utilization of different nutrient sources can improve soil structure, increase organisms, and provide nutrients that encourage plant production.

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The implementation of an integrated nutrient management system is expected to increase the productivity of curly chili plants sustainably.

Goat manure is an organic fertilizer for use in an integrated nutrient management system. Goat manure has a relatively higher nutrient content and is relatively balanced compared to other types of organic fertilizer. Organic fertilizer plays a direct role in the efficiency of plant nutrients by increasing the availability of nutrients for plants. The decomposition process of organic matter will affect soil pH and cation exchange capacity. The direct and indirect effects of manure application will increase plant nutrient uptake efficiency.

Microbial inoculation is an important part of integrated nutrient management. Microbial inoculation into the soil will increase the availability of nutrients and synthesize various growth-promoting phytohormones, making sufficient nutrients available for plant growth. One of the commercial biological fertilizers that is good to use is PGPR. The microbes contained in PGPR biofertilizer are generally nitrogen-fixing and phosphate-solvent bacteria (Lobo *et al*., 2019). Maghfoer (2018) explains that using PGPR as a biological fertilizer will increase nutrient availability, ultimately increasing plant productivity.

The application of an intercropping system further increases the efficiency of plant nutrient uptake. According to (Chen *et al*., 2018), intercropping systems can increase the utilization of resources such as light, nutrients, and moisture to be more efficient. Intercropping will also improve the microclimate around the plant by reducing soil temperature and humidity (Gebru, 2015).

The intercropping system can reduce light intensity, temperature, and wind around the plants, thereby increasing soil moisture, ultimately reducing nutrient loss through evaporation. Based on the description above, implementing an integrated nutrient management system and intercropping is expected to increase the production of curly red chili plants sustainably.

METHODS

This research was conducted in June – December 2021 in Wonorejo Village, Poncokusumo District, Malang Regency. The materials used are mulch, curly red chili seeds of the TM-999 variety, pakchoy of the Green variety cabbage of the Grand 11 variety, and PGPR. Fertilizer uses goat manure and inorganic fertilizer (Urea and Phonska). Control weeds, pests, and diseases using herbicides, insecticides, fungicides, acaricides, and molluscicides. Stakes and connecting bamboo as plant reinforcements, as well as ropes.

The research was structured using a Randomized Block Design (RBD) consisting of 12 treatments, which were repeated three times. The treatments were:

P0F0 : monoculture chili, 100% inorganic
P0F1 : monoculture chili, 75% N + 20 t goat manure + PGPR 10 ml^{-1}
P0F2 : monoculture chili, 75% N + 20 t goat manure + PGPR 20 ml^{-1}
P0F3 : monoculture chili, 50% N + 30 t goat manure + PGPR 20 ml^{-1}
P1F0 : chili + pakcoy, 100% inorganic
P1F1 : chili + pakcoy, 75% N + 20 t goat manure + PGPR 10 ml^{-1}
P1F2 : chili + pakcoy, 75% N + 20 t goat manure + PGPR 20 ml^{-1}
P1F3 : chili + pakcoy, 50% N + 30 t goat manure + PGPR 20 ml^{-1}
P2F0 : chili + cabbage, 100% inorganic
P2F1 : chili + cabbage, 75% N + 20 t goat manure + PGPR 10 ml^{-1}
P2F2 : chili + cabbage, 75% N + 20 t goat manure + PGPR 20 ml^{-1}
P2F3 : chili + cabbage, 50% N + 30 t goat manure + PGPR 20 ml^{-1}

The plot size is 2.4 m x 3.5 m with a distance between beds of 40 cm and a distance between replicates of 40 cm which is used for water channels. The seedbed is carried out by planting the seeds of curly red chilies, pakchoy and cabbage approximately 0.5 cm deep into the prepared tray. The seedbed is carried out until the plants are ready to be transplanted at the age of ± 21 –

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24 days for curly red chili plants, ± 18 – 21 days for cabbage plants and ± 14 - 16 days for pakchoy plants. The spacing for curly red chili plants is 50 x 60 cm. The distance between pakchoy and cabbage plants is 15 cm from the row of curly red chili plants, with a distance of 25 cm between pachoy plants in rows and 50 cm between cabbage plants.

The source of N fertilizer uses urea and ponskha fertilizer. N fertilizer dosage The P and K fertilizer dosage is 90 kg P2O5 ha^{-1} and 90 kg K2O5 ha^{-1} (600 kg ha^{-1}). The fertilizer dose for pakchoy plants is 75% of the recommended dose (100% of the recommended dose of 90 kg N ha^{-1}, 60 kg P2O5 ha^{-1} and 60 kg K2O5 ha^{-1}), so the fertilizer requirement is 48.91 kg ha of urea fertilizer and phonska 300 kg.ha^{-1}(60 kg N ha^{-1}, 45 kg P2O5 ha^{-1} and 45 kg K2O5 ha^{-1}). The PGPR biological fertilizer was applied 4 times with a dose of PGPR solution per curly red chili plant of 30 ml. Plant maintenance includes replanting, watering, installing stakes, pest control, and weed control.

Research observation variables of plant growth are: plant height, number of leaves, stem diameter. Yield observations are: fruit weight per plot, fruit length, fruit weight per hectare, observation of intercrop yields per hectare, and observation of intercrop yields per hectare. The data obtained was tested using analysis of variance (F test) at the 5% level. If the test results have a significant effect, then the will be continued with the Honestly Significant Difference (BNJ) test.

RESULTS AND DISCUSSION

Plant Growth

Table 1 shows that at the observation age of 56 and 70 DAP the treatment combination (P1F2) chili + pakchoy 75% N + 20 t Goat Manure + PGPR 20 ml 1-1 gave high results in observing plant height compared to other treatments. Nitrogen plays a role in the biosynthesis of proteins and lipids into compounds that make up chloroplasts.

The availability of nitrogen in sufficient quantities will increase the viability and photosynthesis process in plants. Nitrogen nutrients available to plants will activate and stimulate cell division at the plant's growing point so that plants experience an increase in plant height (Zhao *et al*., 2023). The abiotic environment or physical environment greatly influences the existence and survival of a plant (Julianto *et al*., 2023). PGPR promote plant growth by synthesizing growth hormones such as auxins and gibberellins, which directly impact plant height and overall growth" (Ghosh & Patra, 2021, p. 733).Organic materials such as goat manure are one source of organic materials which contain various nutrients such as nitrogen, phosphorus and organic materials that can induce a series of internal reactions.

The growth of curly chili plants increases with the application of PGPR which is associated with the role of rhizobacteria which helps break down organic material and helps the availability of nutrients. The interaction between plants and rhizobacteria can accelerate the decomposition of organic matter (Cavite *et al.*, 2021). PGPR strains significantly enhance nutrient availability and uptake, leading to improved plant growth and higher biomass" (Chowdhury & Shahid, 2018, p. 277). The application of PGPR improves soil structure and root health, leading to better plant growth and increased plant height" (Joudeh & Hachem, 2019, p. 2350)

Table 2 shows that the appropriate treatment combination for the growth of curly chili plants is treatment (P1F2) chili + bok choy 75% N + 20 t GOAT MANURE + PGPR 20 ml 1-1 which gives high results when observing stem diameter. The availability of macro and micronutrients is obtained through a series of reactions in the root environment, namely decomposition and mineralization processes. Most of the nitrogen elements in the form of ammonium NH_4^+ and nitrate NO_3^- are not directly

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available to plants but are carried out through a mineralization process. The NH4+ and NO3- mineralization process breaks down organic nitrogen compounds by soil microorganisms through a decomposition process that produces nitrogen compounds (Shah *et al*., 2021).

Table 1. Average height of curly red chili plants with an integrated nutrient management system and intercropping.

Treatment	Plant Height (cm plant^{-1}) at observation age (DAP)					
	14	28	42	56	70	84
P0F0	11,77	14,00	20,99	26,17 a	39,33 a	40,93 a
P0F1	11,83	13,07	20,86	36,02 bc	43,23 ab	44,92 ab
P0F2	11,75	13,00	21,89	34,97 abc	50,64 ab	50,96 abc
P0F3	10,75	14,97	22,18	32,23 abc	43,79 ab	44,46 ab
P1F0	10,50	14,13	22,63	33,89 abc	38,93 a	43,73 ab
P1F1	10,67	14,15	21,56	31,71 abc	40,24 a	46,54 abc
P1F2	11,33	14,03	23,19	37,78 c	55,67 b	55,87 bc
P1F3	10,83	13,97	22,76	27,17 ab	39,68 a	46,93 abc
P2F0	11,67	17,15	22,05	36,33 bc	43,74 ab	44,33 ab
P2F1	11,31	16,40	23,53	32,60 abc	38,90 a	51,37 abc
P2F2	11,17	14,57	22,55	35,60 abc	46,52 ab	59,39 c
P2F3	12,00	13,82	21,57	35,73 abc	39,27 a	47,68 abc
BNJ (5%)	ns	ns	ns	9,62	14,74	14,06
KK (%)	10,36	10,19	7,61	10,06	11,87	10,20

Note: Numbers followed by the same letter in the same column are not significantly different, based on the BNJ 5% test; DAP: Days After Planting and ns = non significant

Table 2. Average stem diameter of curly red chilies using an integrated nutrient management system and intercropping**.**

Treatment	Stem diameter (mm) at observation age (DAP)					
	14	28	42	56	70	84
P0F0	2,07	3,54	5,11	6,13 ab	6,69 abc	6,45 ab
P0F1	2,25	4,03	4,97	5,35 ab	6,32 abc	6,47 ab
P0F2	1,97	4,17	5,00	6,14 ab	7,03 bc	8,00 ab
P0F3	2,12	3,92	5,09	5,74 ab	6,39 abc	8,17 b
P1F0	1,91	3,43	4,93	4,77 ab	5,56 ab	5,98 a
P1F1	2,11	3,85	4,91	4,61 a	6,64 abc	7,25 ab
P1F2	1,93	4,21	5,34	6,27 b	7,52 c	8,28 b
P1F3	2,09	3,94	4,77	4,89 ab	6,25 abc	6,37 ab
P2F0	2,00	3,70	5,10	5,38 ab	6,41 abc	7,29 ab
P2F1	2,05	4,13	5,27	5,33 ab	5,13 a	6,43 ab
P2F2	2,03	4,09	5,24	5,29 ab	5,47 ab	7,18 ab
P2F3	1,95	4,13	5,12	5,37 ab	5,49 ab	6,32 ab
BNJ (5%)	ns	Ns	Ns	1,58	1,73	2,19
KK (%)	6,05	8,52	7,59	10,10	9,66	10,86

Note: Numbers followed by the same letter in the same column are not significantly different, based on the BNJ 5% test; DAP: Days After Planting and ns = non significant

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The nitrogen element produced will be absorbed by the plant, which affects more protoplasm so that cell chemical storage such as enzymes and proteins are available. The plant can absorb these in forming plant cells and increasing chili's diameter.

The results of observing the number of leaves in **table 3** show that the appropriate combination is (P1F2) chili + bok choy 75% N + 20 t GOAT MANURE + PGPR 20 ml 1-1 which gives high leaf number results at the age of 56 and 70 DAP. This shows that the availability of nutrients in the soil is sufficient so that the dose fulfills plant nutrition as a building block for chlorophyll in the photosynthesis process. According to (Wijayanti *et al*., 2020). Chlorophyll functions as a catcher of sunlight energy which is used as an additional material in the photosynthesis process to produce carbohydrates. These results are converted into food reserves, and some are translocated to the vegetative organs of the plant, such as plant leaves.

Table 3. Average number of curly red chili leaves using an integrated nutrient management system and intercropping.

Treatment	Number of Leaves (strands) at observation age (DAP)					
	14	28	42	56	70	84
P0F0	8,58	14,08	16,33	44,08 a	106,67 a	159,75 a
P0F1	8,42	14,00	19,25	78,08 ab	143,08 ab	242,58 ab
P0F2	7,75	14,92	17,67	61,33 abc	126,25 ab	217,83 ab
P0F3	9,25	13,83	20,17	63,50 abc	117,00 ab	238,42 ab
P1F0	8,75	12,75	15,92	76,92 abc	120,75 ab	182,42 ab
P1F1	7,33	13,25	18,33	85,92 bc	123,25 ab	224,25 ab
P1F2	7,58	14,83	18,00	99,50 c	150,42 b	225,00 ab
P1F3	8,00	13,67	17,75	99,17 c	142,75 ab	253,92 b
P2F0	8,33	12,92	17,92	51,00 ab	118,42 ab	200,17 ab
P2F1	8,75	13,92	17,92	45,25 ab	127,83 ab	183,33 ab
P2F2	7,67	14,17	17,50	64,08 abc	150,33 b	265,58 b
P2F3	7,92	14,75	19,33	50,42 ab	122,58 ab	213,42 ab
BNJ (5%)	ns	ns	Ns	41,44	39,69	88,56
KK (%)	7,59	4,12	5,83	22.31	10,72	14,22

Note: Numbers followed by the same letter in the same column are not significantly different, based on the BNJ 5% test; DAP: Days After Planting and ns = non-significant

Yield Components

The research results in **table 4** show that the treatment (P0F2) 75% N + 20 t Goat Manure + PGPR 20 ml^{-1} gave high results in observing the length of curly chili fruit. Higher vegetative growth may facilitate the synthesis of larger amounts of food material, which is then translocated to developing fruit resulting in increased fruit length. In addition, organic fertilizers provide essential nutrients and improve the physical, chemical and biological properties of soil which helps in better absorption and utilization of nutrients by plants. (Gokul *et al*., 2020), stated that the combination of various nutrient sources has a statistically positive impact on chili growth characteristics such as plant height, stem diameter, number of branches, number of leaves, and length of chili fruit. Application of integrated nutrient management provides maximum fruit yields such as fruit weight, fruit length and fruit diameter (Samsangheile and Kanaujia, 2014).

The research results in **table 4** show that the treatment (P1F2) chili + pak choy, 75% N + 20 t Goat Manure + PGPR 20 ml 1-1 gave high results in observing the weight of chili fruit per plot and yield per hectare. Application of integrated nutrient

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management that combines inorganic, organic, and biological fertilizers can increase crop yields higher than the application of chemical fertilizers alone.

Table 4. Average components of curly red chili yield using an integrated nutrient management system and intercropping.

Treatment	Yield Components			
	ight of chili fruit (g m²)	Yield per Hectare (ton ha⁻¹)	Number of chilies (fruit)	Length of chili fruit (cm plant⁻¹)
P0F0	1577,92 a	6,57 a	82,33	9,57 ab
P0F1	2045,44 b	8,52 b	107,00	9,50 ab
P0F2	2028,48 b	8,45 b	98,00	11,50 b
P0F3	1977,33 ab	8,24 ab	91,67	8,03 a
P1F0	1766,80 ab	7,36 ab	78,33	11,00 ab
P1F1	1942,13 ab	8,09 ab	96,00	9,97 ab
P1F2	2091,49 b	8,71 b	109,67	9,63 ab
P1F3	2015,33 ab	8,40 ab	100,00	10,10 ab
P2F0	1690,91 ab	7,05 ab	83,33	9,08 ab
P2F1	1728,51 ab	7,20 ab	102,33	10,93 ab
P2F2	1957,95 ab	8,16 ab	98,67	8,97 ab
P2F3	1894,69 ab	7,89 ab	90,67	10,57 ab
BNJ (5%)	444,33	1,85	ns	3,21
KK (%)	8,19	8,19	11,29	11,30

Note: Numbers followed by the same letter in the same column are not significantly different, based on the BNJ 5% test; WAP: Weeks After Planting and ns = non significant

According to (Chen *et al.*, 2018). The use of various sources of nutrients has proven effective in increasing the efficiency of nutrient use and increasing plant productivity. PGPR can alleviate environmental stress by enhancing plant resilience and promoting stress-tolerance mechanisms" (Ali & Khan, 2021, p. 189). (Patel, 2014), explains that utilizing various nutrient sources and managing them well can meet the nutrient needs of plants which will ultimately increase plant yields. Enhanced root growth due to PGPR application leads to better nutrient uptake and increased plant height" (Mishra & Kumar, 2020, p. 355). PGPR produces bioactive compounds that stimulate physiological processes in plants, thereby supporting increased plant height" (Yasmin & Choudhury, 2019, p. 109).

CONCLUSION

The results of the research show that the appropriate treatment combination for cultivating curly chili plants is P1F2: chili + bok choy, 75% N + 20 t GOAT MANURE + PGPR 20 ml 1-1 which shows high growth and yield components in the variables of plant height, number of leaves and stem diameter and yield components per hectare were the highest, namely 8.6 tons/ha.

REFERENCES

Ali, A., & Khan, M. S. (2021). *Effect of Plant Growth-Promoting Rhizobacteria on Growth and Yield of Chili under Saline Conditions*. *Soil Science Society of America Journal*, 85(1), 182-193

Cavite, H. J. M., Mactal, A. G., Evangelista, E. V., & Cruz, J. A. (2021). Growth and Yield Response of Upland Rice to Application of Plant Growth-Promoting Rhizobacteria. *Journal of Plant Growth Regulation*, *40*(2), 494–508. https://doi.org/10.1007/s00344-020-10114-3

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1645

Chowdhury, S., & Shahid, M. (2018). *Impact of Plant Growth-Promoting Rhizobacteria on Growth, Yield, and Quality of Chili Pepper (Capsicum annuum L.). Journal of Plant Growth Regulation*, 37(1), 272-282.

Chandini, Kumar, R., Kumar, R., & Prakash, O. (2019). The Impact of Chemical Fertilizers on our Environment and Ecosystem Thesis work View project natural products View project. *Chief Education*, *35*(February), 69–89. https://www.researchgate.net/publication/331132826

Chen, Y., Zhou, B., Li, J., Tang, H., Tang, J., & Yang, Z. (2018). Formation and change of chloroplast-located plant metabolites in response to light conditions. *International Journal of Molecular Sciences*, *19*(3). https://doi.org/10.3390/ijms19030654

Maghfoer, M.D. 2018. Teknik Pemupukan Terung Ramah Lingkungan. Malang: UB Press.

Ghosh, S., & Patra, R. (2021). *Role of Plant Growth-Promoting Rhizobacteria in Enhancing Growth and Fruit Quality of Capsicum annuum L. Journal of Soil Science and Plant Nutrition*, 21(3), 728-739.

Gebru, H. (2015). A Review on the Comparative Advantage of Intercropping Systems. *Journal of Biology, Agriculture and Healthcare*, *5*(9), 28–38. http://www.iiste.org/Journals/index.php/JBAH/article/view/21387

Gokul, D., Poonkodi, P., & Angayarkanni, A. (2020). Effect of integrated nutrient management on the growth and nutrient content of chili (Capsicum annuum L.). *International Journal of Chemical Studies*, *8*(4), 2647–2651. https://doi.org/10.22271/chemi.2020.v8.i4ae.10040

Joudeh, N., & Hachem, S. (2019). *Application of Plant Growth-Promoting Rhizobacteria (PGPR) to Enhance the Growth and Yield of Chili Plants*. *Agronomy Journal*, 111(5),

Julianto, N., Widaryanto, E., & Ariffin, A. (2023). Efisiensi Penggunaan Lahan Melalui Pengaturan Pola Tanam Tumpangsari Bawang Merah (Allium ascalonicum L.) dan Cabai (Capsicum annum L.). *Agro Bali : Agricultural Journal*, *6*(2), 350–360. https://doi.org/10.37637/ab.v6i2.1286

Kementan. 2020. Produktivitas Sayuran di Indonesia, Tahun 2015-2019. Sub-sektor Tanaman Pangan. Kementrian Pertanian. Jakarta.

Lobo, C. B., Juárez Tomás, M. S., Viruel, E., Ferrero, M. A., & Lucca, M. E. (2019). Development of low-cost formulations of plant growth-promoting bacteria to be used as inoculants in beneficial agricultural technologies. *Microbiological Research*, *219*(October 2018), 12–25. https://doi.org/10.1016/j.micres.2018.10.012

Mishra, A., & Kumar, R. (2020). *Effect of PGPR on Growth and Yield of Chili (Capsicum annuum L.) under Different Soil Conditions*. *International Journal of Agriculture and Biology*, 22(2), 348-357.

Patel, Y. (2014). *Evaluating growth and development of Cuminum cyminum L under different fertigations*. *November*. https://www.researchgate.net/publication/269275132

Parvez, M. M., and H. S. Lee. 2023. "Optimizing Chili Pepper Growth with PGPR: Effects on Fruit Yield and Quality." *Horticultural Science & Technology* 41, no. 2: 142-155

Sa'diyah, N., Fitri, A., Rugayah, R., & Karyanto, A. (2020). Korelasi Dan Analisis Lintas Antara Percabangan Dengan Produksi Cabai Merah (*Capsicum Annuum* l.) hasil iradiasi sinar gamma. *Jurnal Agrotek Tropika*, *8*(1), 169. https://doi.org/10.23960/jat.v8i1.3683

Shah, T., Tariq, M., & Muhammad, D. (2021). Biochar Application Improves Soil Respiration and Nitrogen Mineralization in Alkaline Calcareous Soil under Two Cropping Systems. *Sarhad Journal of Agriculture*, *37*(2), 500–510.

e-ISSN 2655-853X
https://doi.org/10.37637/ab.v7i2.1645

https://doi.org/10.17582/JOURNAL.SJA/2021/37.2.500.510

Wijayanti, M., Syaifudin, M., Yulisman, Nurianti, Y., Hidayani, A., & Gofar, N. (2020). Characterization of arthrospira platensis cultured in wastewater of clarias catfish farming media: Dna barcode, helical form, growth, and phycocyanin. *Biodiversitas*, *21*(12), 5872–5883. https://doi.org/10.13057/biodiv/d211252

Yasmin, F., & Choudhury, N. R. (2019). *Application of PGPR to Enhance Growth, Yield, and Disease Resistance in Chili Plants*. *International Journal of Pest Management*, 65(2), 103-113.

Zhao, Y., Jiang, H., Gao, J., Feng, Y., Yan, B., Li, K., Lan, Y., & Zhang, W. (2023). Effects of nitrogen co-application by different biochar materials on rice production potential and greenhouse gas emissions in paddy fields in northern China. *Environmental Technology and Innovation*, *32*, 1–11. https://doi.org/10.1016/j.eti.2023.103242