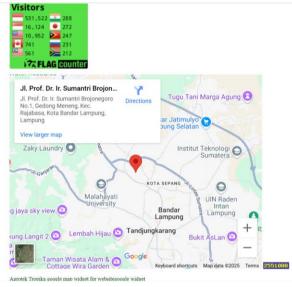
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Desister	JURNAL AGROTEK TROPIKA VOL 13, FEBRUARI 2025		SILLA
Register			Science and Technology Index
4 .	TABLE OF CONTENTS		SINTA ACCREDITATION
	ARTICLES		
Guidelines	KUALITAS INDEKS DAN KOMPOSISI LAHAN KERING DI KABUPATEN LABUHANBATU, INDONESIA Aust Novia	PDF 1 - 6	DOAJ DIRECTORY OF OPEN ACCESS JOURNALS
Author Guidelines	APLIKASI ZAT PEMACU KEMASAKAN TEBU SEBAGAI BAHAN BAKU AWAL GILING DI SUMATERA UTARA	PDF 7 - 14	
Author 🙈	Arinta Rury Puspitasari, Diana Ariyani, Rivandi Pranandita Putra		QUICK MENU
	Bela Ayu Prativi, Yusnita Yusnita, Dwi Hapsoro, Agus Karyanto, Sri Ramadiana		Reviewer
MOU	PEMANFAATAN LIMBAH AMPAS TAHU DAN BLOTONG KERING SEBAGAI MEDIA TANAM	PDF	Focus and Scope Author Guidelines
	TERHADAP PERTUMBUHAN JAMUR TIRAM PUTIH (Pleurotus ostreatus) Ias Marroha Doli Siregar, Christian Yosua Salomo	22 - 28	Publication Ethics
$\neg 2^{\nu}$	PHYLOGENETIC ANALYSIS OF ROBUSTA COFFEE (Coffin Camphora PIERRE EX FROCHNER) BASED ON MORPHOLOGICAL (CHARACTERISTIC AND CLASS PROXIMITY Sri Nurnayani, Muhamman Tahir, Wiwik indrawati, Bawon Mahhendra, Resti Paupa Katika Sari	PDF 29 - 37	Open Access Policy Peer Review Process Copyright Notice
	UJI ANTAGONIS Streptomyces spp. TERHADAP Sporisorium scitamineum PENYEBAB LUKA API SECARA IN VITRO Laksamma Agadhia Rabarjo	PDF 38 - 43	Online Submission Author Fees
Crossref	DAMPAK KOMBINASI JENIS TANAH, KOMPOS DAN Trichoderma sp. TERHADAP KERAPATAN SPORA Trichoderma sp.	PDF 44 - 51	
O sinta	Aprellia Sofiatul Subhan, Moch. Arifin, Fitri Wijayanti, Maroeto Maroeto, Safira Rizka Lestari		Journal Visitors Visitors
	GROWTH RESPONSE OF 3 ACCESSORIES OF PORANG (Amorphophallus muelleri Blume) ON VARIATION ORGANIC FERTILIZER DOSAGE Etik Wukir Tini, Khoerotun Nisa, Totok Agung Dwi Haryanto	PDF 52 - 58	531,522 288
Google	ANTIVITAS IAI, KUNOMIA IAI, KUNANGANG UTIAN JAWA ANTIVITAS PESITIK XILANASI BAKTERI TERMOFILIK AMOBIL SSA2 DENGAN VARIASI SUMBER KARBON Indawit Indawit, Zahara Nurfatihah, Z. Dwi Hidia Putri, Landa Advinda, Yuurizal Yuurizal	PDF 59 - 65	16,124 272 10,952 247 741 231
PKP INDEX	DAN PRODUKSI DUA VARIETAS JAGUNG PULUT (Zea mays ceratina kulesh) PADA DOSIS PUPUK NPK VANG BERBEDA	PDF 66 - 72	561 212
	Dian Yustisia, Ridha Alamsyah THE EFFECT OF ARBUSCULAR MYCORRHIZAL FUNGI (AMF) AND ORGANIC FERTILIZERS	PDF	
<mark>%nelitj</mark>	ON MOLER DISEASE AND SHALLOT PRODUCTIVITY IN PEAT SOIL Raki Warnian, Fadjar Rianto, Iwan Sasli	73 - 81	WRITING CHECK
	PENGARUH APLIKASI TIGA JENIS BIOCHAR DAN PUPUK FOSFOR TERHADAP KEBERADAAN FUNGI MIKORIZA ARBUSKULAR SERTA PERTUMBUHAN TANAMAN	92 - 105	
KEYWORDS	JAGUNG (Zea mays) DI LTPD UNILA Fairuz Nabila Sholihah, Sri Yusnaini, Maria Viva Rini, M. A. Syamsul Arif		MENDELEY grammarly
Adaptasi perubahan iklim, Fase fenologin, Orowing Degree Daya, Stroberi Agensia hayati, bonggol pisang, Fusarium oxysporum f. sp cubense, dan	THE IMPACT OF NITROGEN BALANCE AND LIQUID ORGANIC FERTILIZER FROM COW URINE ON THE GROWTH AND PRODUCTION OF PAKCOY PLANTS (Brassica Chimensis L.) IN	PDF 82 - 91	OPEN JOURNAL SYSTEMS
mikroorganisme lokal Air kolam budidaya udang vaname, hidroponik, konsorsium Trichoderma, pakcoi Allium ascalonicum Bactrooera, host rearing,	REGOSOL SOIL Khairul Anwar, Heny Alpandari, Tangguh Prakoso, Nia Herlina		NOTIFICATIONS
keanekaragaman, lalat buah, zeugodacus Bahan organik, FMA, Kacang hijau Beauveria bassiana, Aspergillus otyzae, Penicillium citrinum, Trichoderma	RESPON BEBERAPA VARIETAS PADI YANG DIBERI RIZOBAKTERI PADA TANAH SALIN Tantri Palupi, Dini Anggorovati, Siti Aprizkiyandari	PDF 106 - 113	NOTIFICATIONS View Subscribe
aspereilium, Spodoptera fragiperia J.E.Smith Benih, produksi, rasio, sistem tasam Bredenkamp, fisiologi benih, inpari, leikeringan, non parametnik Budidaya,	PHYSIOLOGICAL RESPONSES OF SHALLOT (Allium cepa L. Aggregatum group) IN DROUGHT	PDF 114 - 121	and the
mangrove, pandemi covid-19, panametas Dunasy a, mangrove, pandemi covid-19, upaya konservasi Cabai merah, oskanan kekerungan, in vitro, radiasi gamma Entomopatogen, formulasi, nematoda, patogen Erosi,	STRESS WITH THE APPLICATION OF SALICYLIC ACID AND BIOSILICA Lisa Dwifani Indarwati		JOURNAL CONTENT Search
guludan, pennpukan, singkong KCL Kata Kunci : Cabe, Covid-19, Pupik Kandang, Pertumbuhan, Vegetayif: Kombinasi pupuk,	PENGARUH GULUDAN DAN PEMUPUKAN TERHADAP KEHILANGAN HARA DAN C- ORGANIK AKIBAT EROSI PADA PERTANAMAN SINGKONG (MANIHOT ESCULANTA	PDF 122 - 128	Search Scope
Organonitrofos, Pemupukan, Produksi ubikayu, Serapan hara,	CRANTZ) TAHUN KEDELAPAN Muhammad Frayoga Janata, Irwan Sukri Banuwa, Septi Nurul Aini, Afandi Afandi, Nur Afni Afrianti		All V Search
Tanah ultisol, Ubikayu, serapan mara, Tanah ultisol, Ubikayu. Kompo TKKS Lidah baya, pupuk embo, pupuk kompo jagung. Pod, pasang mut, pemangkana, produktivita, pupuk	PENGGUNAAN MULSA PADA SISTEM BUDIDAYA EDAMAME Dulbari Dulbari, Destieka Ahyuni, Lina Budiarti	PDF 129 - 138	Browse
NPK Polyacrylamide dan dolomit, agregat tanah, indeks dispersi Tanaman padi, walang sangit, yuyu sawah	UTILIZATION OF ARDUNO MICROCONTROLLER FOR PRECISE WATER SUPPLY MANAGEMENT TO ENHANCE WATER SPINACH (Jpomose reptans Potr) (ROWTH Purds Saupya, R. A Dana Wilyatuti, Tumint Ratirian Mank, Nihub D Puvika	PDF 139 - 146	By Issue By Author By Title Other Journals
CURRENT ISSUE	PEMANFAATAN LIMBAH AGROINDUSTRI DALAM PERBANYAKAN BACILLUS THURINGIENSIS DAN YOKSISITASNYA TERHADAP LARVA Oryctes rhinoceros Maasa Submoth 'Nila Poinsath', Simormon SIF	PDF 147 - 156	
855 1.0	STUDI VIABILITAS BENIH KEDELAI (Glycine max [L-] Merril) PADA BERBAGAI PROPORSI KAPUR TOHOR DALAM DUA UKURAN WADAH SELAMA PENYIMPANAN 17 BULAN	157 - 164	
CURRENT ISSUE	MANAOEMENT TO ENHANCE WATER SPINACH (Ipomose reptans Peir) GROWTH Purba Sanjaya, R. A. Diana Widyatuti, Tumiar Katarian Manik, Niluh D. Punvika PEMANFAATAN LIMBAH AGROINDUSTRI DALAM PERBANYAKAN BACILLUS THURNOIENSIS DAN TOKSISITASNYA TERHADAP LARVA Oryctes rhinoceros Messa Syahputri, Yulai Pujaistuti, Suparman SHK STUDI YUABLITAS BENIH KEDELAI (Gheime max [L.] Merril) PADA BERBAGAI PROPORSI	PDF 147 - 156	By Title

RAKYAT LAMAKNEW SELATAN RAKYAT LAMAKNEW SELATAN Resti Fadilah, Mara D. A. Pitaloka, Maria Imelda Hamoen, Elesta Banamtuan, Maria Y. M. K. Leo, Suci Andewal, Julyo Grideon Rohi

EFEKTIFITAS FRAKSI METANOL BEBERAPA EKSTRAK TANAMAN UNTUK MENGENDALIKAN PENYAKIT BULAI (Peronosclerospora spp.)PADA TANAMAN JAGUNG (Zea mays L.) Fathia Ramadhani, Efri Efri, Suskandini Rath Dirmawati, Joko Prasetyo	PDF 172 - 177
SISTEM DETEKSI UNSUR HARA MIKRO ESSENSIAL F¢ DAN Ma PADA TANAH UNTUK PENGEMBANGAN SISTEM PERTANIAN CERDAS DAN PRESISI Rath Kumiah, Herk Sagen	PDF 178 - 188
LAJU KEMUNDURAN BENIH TIGA GENOTIPE SOROUM (Sorghum bicolor [L.] Moench) SELAMA PERIODE 2:3-24 BULAN DALAM RUANO BER-AC Bella Merlin, Eko Prumoo, Muhammad Kamal, Muhammad Syamoed Hadi	PDF 189 - 200
PENGARUH PERLAKUAN PENCHING DAN MATERI PEMECAH DORNANNI (KNO3 Dan BAP) TERHADA PERTUMBUHAN DAN PERKEMBANGAN TANAMAN JAMBU BIJI (Pudum guajava L.) YKBISTAL: RADhana Wafwandhi, Setvo Davi Uneno. Darwin H Pananbuan, Puda Saniava, Wida Asustin	PDF 201 - 212
MPLEMENTASH, ONSEP BETANILAN ORGANIK PADA PERANCANGAN LANSKAP PENGEMBANGAN TAMAN WISATA WONGSOTIRTO AGRO PARK DI TANUNG BINTANG LAMPUNG SELATAN Windh Haditya Rani, Setyo Widagdo, Sudiono Sudiono, Kus Hendarto	PDF 213 - 222
PENGARUH PUPUK HAYATI DAN PUPUK KANDANG TERHADAP INTENSITAS PENYAKIT MOLER (Pusarium oxyaporum) DAN PRODUKSI BAWANG MERAH BERPOLA TANAM OROANIK Khusmayouk Khusmayodi, Suskandini Ratih Dirmavati, Kus Hendarto, Muhammad Nurdin	PDF 223 - 231
PENGARUH APLIKASI KONSORSIUM ISOLAT BAKTERI TERPILIH DAN JENIS PUPUK TERHADAP PERTUMBUHAN DAN PRODUKSI TANAMAN CABAI MERAH (Capacum annum) Demiyah Demiyah, Mhahmang Fajar Isnail Navanon, Kasi Mendadayan Masilan Anf	PDF 232 - 239
KARAKTERISTIK DAN UJI ANTAGONIS BEBERAPA ISOLAT Trichoderma TERHADAP PENYEBAB PENYAKIT LAYU (Fusarium oxysporum) PADA TANAMAN TOMAT (Lycopersicum esculentum Mill) Angraim Subasari, Efri Efri, Lestari Wibowo, Titik Nur Aeny	PDF 240 - 245
INCREASING NITROGEN EFFICIENCY WITH MODIFIED UREA-HUMIC ACID-BIOCHAR (UAB) AND THEIR EFFECTS ON THE GROWTH OF CORE Ese Rabini Rabini, Marinan Marinan Maiiana Muliana Muliana Muliana	PDF 246 - 258



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EFFECT APPLICATION OF SELECTED BACTERIAL ISOLATE CONSORTIUM AND FERTILIZER TYPES ON THE GROWTH AND PRODUCTION OF RED CHILI PLANTS (*Capsicum annum*)

PENGARUH APLIKASI KONSORSIUM ISOLAT BAKTERI TERPILIH DAN JENIS PUPUK TERHADAP PERTUMBUHAN DAN PRODUKSI TANAMAN CABAI MERAH (Capsicum annum)

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KEYWORDS: Chili plant production, organonitrophos fertilizer, red chili plants selected,

bacterial isolates.

KATA KUNCI: Isolat bakteri terpilih, produksi tanaman cabai, pupuk organonitrofos, tanaman cabai merah.

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ABSTRACT

The low production of red chili is thought to be caused by suboptimal soil fertility. This soil fertility problem can be solved through fertilization, either using chemical or organic fertilizers. This study examines the effect of a consortium of selected bacterial isolates, types of fertilizers, and the interaction between the two in increasing the growth and production of red chili plants. This study used a 4x3 factorial Randomized Group Design with three replications. The first factor is the type of consortium of selected bacterial isolates: no consortium (K0), a consortium of bacterial isolates from pineapple rhizomes (PR) (K1), a consortium of Empty Fruit Bunches (EFB) (K2), and a combination of PR + EFB consortium (K3). The second factor was the type of fertilizer (P1), sterile organonitrophos fertilizer (P2), and non-sterile organonitrophos fertilizer (P3). The results showed that applying the selected bacterial isolate consortium did not significantly affect the growth and production, while non-sterile organonitrophos fertilizer gives the best results on plant growth and soil C-organic levels. No interaction was found between the application of the selected bacterial isolate consortium and the type of fertilizer on all observed variables.

ABSTRAK

Rendahnya produksi cabai merah diduga disebabkan oleh kesuburan tanah yang kurang optimal. Masalah kesuburan tanah ini dapat diatasi melalui pemupukan, baik menggunakan pupuk kimia maupun pupuk organik. Penelitian ini bertujuan untuk mengkaji pengaruh konsorsium isolat bakteri terpilih, jenis pupuk, serta interaksi antara keduanya dalam meningkatkan pertumbuhan dan produksi tanaman cabai merah. Penelitian ini menggunakan Rancangan Acak Kelompok (RAK) faktorial 4x3 dengan tiga kali pengulangan. Faktor pertama adalah jenis konsorsium isolat bakteri terpilih, yang terdiri dari: tanpa konsorsium (K0), konsorsium isolat bakteri dari rimpang nanas (K1), konsorsium TKKS (K2), dan kombinasi konsorsium RN+TKKS (K3). Faktor kedua adalah jenis pupuk, meliputi: pupuk kimia (P1), pupuk organonitrofos steril (P2), dan pupuk organonitrofos non-steril (P3). Hasil penelitian menunjukkan bahwa pemberian konsorsium isolat bakteri terpilih tidak memberikan pengaruh signifikan terhadap pertumbuhan dan produksi tanaman cabai merah. Pupuk organonitrofos steril memberikan hasil terbaik dalam meningkatkan produksi tanaman cabai merah, sedangkan pupuk organonitrofos non-steril memberikan hasil terbaik terhadap pertumbuhan tanaman dan kadar C-organik tanah. Tidak ditemukan interaksi antara aplikasi konsorsium isolat bakteri terpilih dan jenis pupuk terhadap semua variabel yang diamati.

1. INTRODUCTION

Curly red chili (*Capsicum annum*) is a plant that contains capsaicin, which gives its fruit a spicy flavor. In addition to capsaicin, this plant is rich in protein, calcium, fats, calories, vitamin A, vitamin B1, and vitamin C. Due to its distinctive spicy taste, curly red chili has become one of Indonesia's most sought-after commodities as a seasoning ingredient (Sastradihardja & Firmanto, 2011).

According to BPS data (2019), the production of red chili from 2014 to 2018 experienced a relatively small increase. In 2018, the production of red chili only rose by 0.04% compared to 2017. This insignificant increase in production raises concerns as the demand for red chili increases yearly. One of the reasons for the low production of chili is the less-than-optimal soil fertility conditions. One of the efforts that can be made to address this issue is through fertilization. Utomo et al. (2016) classified fertilizers into organic and chemical fertilizers. Each type of fertilizer has its advantages and disadvantages. Chemical fertilizers have a high nutrient content but low diversity, while organic fertilizers have high nutrient diversity but relatively low content.

The organic fertilizer used in this study is organonitrophos fertilizer. Organonitrophos fertilizer is a solid organic fertilizer produced from the composting process of various organic materials, such as cow manure, coconut husk, ash from burnt tofu, solid waste from the Monosodium Glutamate (MSG) industry, and empty fruit bunches. During the decomposition process, phosphate-solubilizing microorganisms (P) and nitrogen-fixing microorganisms (N) are added (Dermiyati, 2017). Additionally, there are biofertilizers, which are fertilizers that contain microorganisms. Biofertilizers can be in single or mixed forms, where mixed fertilizers contain more than one type of microorganism and are often referred to as microbial consortia. According to Okoh (2006), a consortium is a combination of various populations of microorganisms within a community that have mutually beneficial relationships. The associated members of this community are more effective in degrading chemical compounds than single microorganisms.

The selected bacterial isolate consortium used in this study was obtained from the suspension of pineapple rhizome extract (RN) and empty fruit bunches of oil palm (TKKS). RN and TKKS have the potential to produce phosphate-solubilizing bacteria (BPF) that can dissolve bound phosphate (P) in the soil. According to research by Dermiyati et al. (2019), four BPF isolates were found from the RN extract suspension and seven BPF isolates from the TKKS extract suspension, which can solubilize bound phosphate. The bacterial isolates from the TKKS extract suspension are also known to be hypovirulent and can function as Plant Growth Promoting Bacteria (PGPB) (Andayani, 2018).

The presence of nitrogen-fixing (N) and phosphate-solubilizing (P) microorganisms in organonitrophos fertilizer is expected to interact with the applied selected bacterial isolate consortium, thereby positively impacting the growth and production of red chili plants. The relationships among these microorganisms will not interfere with each other as long as the substrate conditions are met and may even enhance the efficiency of the decomposition process (Okoh, 2006).

Using chemical fertilizers and biofertilizers is also an interesting aspect to observe. Although chemical fertilizers cannot serve as substrates for soil microorganisms, their high nutrient content can influence their activity. Research by Lovitna et al., (2021) indicates that the application of BPF and inorganic phosphate fertilizers affects the population of BPF, the availability of P, and the dry weight of red chili plants.

This study aims to investigate the effects of the selected bacterial isolate consortium, the type of fertilizer, and the interaction between the two in enhancing the growth and production of red chili plants.

2. MATERIALS AND METHODS

2.1 Time and Place

This research was conducted at the Integrated Field Laboratory of the Faculty of Agriculture, University of Lampung. The selected bacterial isolate consortium was rejuvenated in the Biotechnology Laboratory of the Faculty of Agriculture, University of Lampung.

2.2 Research Design

This study employed a Factorial Randomized Block Design (RBBD) (4x3) with three groups for each treatment. The first factor is the type of selected bacterial isolate consortium, which consists of no consortium (K0), a consortium of bacterial isolates from pineapple rhizome (RN) (K1), consortium of bacterial isolates from empty fruit bunches of oil palm (TKKS) (K2), and consortium of bacterial isolates from the combination of RN+TKKS (K3). The second factor is the type of fertilizer, which includes chemical fertilizer NPK 15:15:15 at a dose of 0.25 tons ha⁻¹ (P1), sterilized organonitrophos fertilizer at a dose of 20 tons ha⁻¹ (P2), and non-sterilized organonitrophos fertilizer at a dose of 20 tons ha⁻¹ (P3). Data were analyzed using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT) at a significance level of 5%.

2.3 Implementation of Research

The soil used as the planting medium was obtained from the Integrated Field Laboratory of the Faculty of Agriculture, University of Lampung (Unila). The soil was sun-dried for one week, then sieved using a sand sieve and sterilized by steam heating for 4 hours. After sterilization, 7 kg of soil (air-dry weight with 40% moisture content) was placed into polybags. The seeds used were of the Kastilo F1 variety. The chili seeds were soaked in water for 3 hours, then planted in polybags containing 100 g of soil (air-dry weight) at a depth of 1 cm. Each polybag was filled with one seed and covered with soil. The polybags containing the seeds were kept in a dark place or away from sunlight for 3 days. Once the seeds began to sprout, the polybags were moved to a location exposed to sunlight.

The selected bacterial isolate consortium was rejuvenated using Potato Peptone Glucose Agar (PPGA) media in test tubes under aseptic conditions in a Laminar Air Flow (LAF) cabinet. A selected bacterial isolate consortium was taken using a sterile inoculating loop and streaked onto slanted PPGA media. Each type of bacterial isolate consortium was multiplied into 6 test tubes, with one tube reserved for rejuvenation the following week. Seedlings four weeks old were transferred to the prepared planting medium. The planting process was carried out carefully to prevent damage to the plants. The plants were moved by lifting the soil from the seedling media, avoiding direct contact with the stems or roots of the seedlings to prevent damage. The new planting medium was slightly dug to create a space for planting the seedlings. The soil around the plants was gently pressed to compact it, and the plants were watered.

The selected bacterial isolate consortium was applied three times, specifically in the first, second, and third weeks after planting. The bacterial isolate consortiums were prepared by harvesting the bacterial isolates using an inoculating loop. Then, they are placed into 10 ml of physiological solution and homogenized using a vortex mixer. This process was repeated until 90 ml of suspension solution was obtained for each isolate type. The suspension solution was then added to 2,150 ml of physiological solution, resulting in a total volume of 2,250 ml. For the mixed bacterial isolate consortium, 60 ml of suspension solution from both RN and TKKS isolates were combined, yielding 120 ml of suspension solution. This suspension was added to 2,130 ml of physiological solution.

Some of the organonitrophos fertilizer was sterilized by steam heating for 4 hours. The application of organonitrophos fertilizer was conducted one day before planting at a dose of 20 tons ha⁻¹. Chemical fertilization (NPK 15:15:15) was performed twice: two weeks after planting with a dose of 0.05 tons ha⁻¹ and eight weeks after planting with a dose of 0.2 tons ha⁻¹.

Plant care was performed daily, including watering, weeding, and pest and disease control. Watering was done every afternoon. Harvesting was conducted 95-100 days after planting (HST) by carefully picking the fruit from the stem to avoid breaking branches or twigs. The criteria for harvesting include intact, firm, and shiny dark red fruits. The soil analysis conducted in this study includes measurements of organic carbon content, total nitrogen, available phosphorus, and soil pH.

3. RESULTS AND DISCUSSION

The results of the study indicate that the application of selected bacterial isolate consortia from RN (K1), TKKS (K2), and the combination of RN+TKKS (K3) did not have a significant effect on all observed variables. Additionally, no interaction was found between the application of selected bacterial isolate consortia and the type of fertilizer.

Factors suspected to contribute to the ineffectiveness of the bacterial isolate consortia include the application dose and environmental conditions. According to the Decree of the Minister of Agriculture No. 261/KPTS/SR.310/M/4/2019 (Ministry of Agriculture, 2019), one genus in the bacterial consortium must have a minimum live cell count of $\ge 1 \times 10^7$ cfu g⁻¹, while other genera must have a minimum of $\ge 1 \times 10^5$ cfu g⁻¹. However, each genus was unknown in the applied bacterial isolate consortia, causing the consortium to fail to develop properly due to insufficient numbers and competition with other soil microorganisms.

Based on the DMRT test at a 5% significance level, treatments P2 (sterilized organonitrophos fertilizer) and P3 (non-sterilized organonitrophos fertilizer) showed the best results in terms of growth variables (Table 1), production (Table 2), and soil organic carbon content (Table 3). Meanwhile, treatment P1 (chemical fertilizer) did not yield the best results in all observed variables. This is suspected because chemical fertilizers only improve soil chemical properties. In contrast, in the short term, using chemical fertilizers shows low bacterial growth and basal respiration rates (Lazcano et al., 2013). Bacteria are known to be the most sensitive microorganisms to differences in fertilizers due to their shorter life cycle and ability to respond quickly to changes in soil environment (Kuzyakov, 2010).

Research by Septima et al., (2014) showed that applying chemical fertilizers at the recommended dose did not result in significant differences compared to applying organonitrophos fertilizer at 5,000 kg ha⁻¹ in terms of plant growth. In this study, the dose of organonitrophos fertilizer applied was higher, at 20,000 kg ha⁻¹, resulting in better performance of plants treated with organonitrophos fertilizer than those treated with chemical fertilizer (P1) at the recommended dose.

Treatment	PH (cm)	NL (helai tan ⁻¹)	PWW (g tan ^{- 1})	PDW (g tan ^{- 1})	WRW (g tan ⁻¹)	
Chemical Fertilizer (P1)	58.2 a	51 a	33.5 a	10.8 a	8.63 a	
Sterillised Organonitrofos (P2)	94.8 b	141 b	73.8 b	22.9 b	10.67 b	
Organonitrofos Fertilizer (P3)	99.5 b	148 c	83.5 c	21.2 b	13.28 b	

Table 1. Effects of Fertilizer Type on the Growth of Red Chili Plants.

Note: PH= Plant Height; NL= Number of Leaves; PWW= Plant Wet Weight; PDW= Plant Dry Weight; WWR= Wet Root Weight.

Treatment	FWW	FDW	FL
Treatment	(kg ha ⁻¹)	(kg ha ⁻¹)	(cm)
Chemical Fertilizer (P1)	73.1 a	14.0 a	11.11 a
Sterillized Organonitrofos (P2)	302.4 c	55.3 c	13.00 b
Organonitrofos Fertilizer (P3)	159.9 b	28.5 b	12.22 b

Table 2. Effect of Fertilizer Type on Red Chili Plant Production.

Note: FWW= Fruit Wet Weight; FDW= Fruit Dry Weight; FL= Fruit Length.

Table 3. Effect of Fertilizer Type on Soil Organic C.

Treatment	Organic C (%)
Chemical Fertilizer (P ₁)	1.11 a
Sterillized Organonitrofos Fertilizer (P ₂)	1.24 a
Organonitrofos Fertilizer (P3)	1.36 b

Note: Mean values followed by the same letter are not significantly different based on the 5% DMRT test.

Table 4. Correlation between Soil Chemical Variables and Yields of Red Chilli Plants Variables.

Variable	Coeficient C	Coeficient Correlation (r) and Significancy					
	PH	WRW	DRW	PWW	PDW	FD	
P-available	-0.004ns	0.620*	0.535 ns	0.028 ns	0.304 ns	-0.262 ns	
N-total	0.553 ns	0.582*	0.594*	0.641*	0.626*	-0.041 ns	
C-organic	-0.092 ns	-0.031 ns	0.085 ns	-0.082 ns	-0.254 ns	0.588*	
рН	0.98*	0.254 ns	0.352 ns	0.508 ns	0.284 ns	0.522 ns	

Note: *= Significant at 5% level; ns= not significance at 5% level; PH= Plant Height 6 WAP; WRW= Wet Root weight; DRW= Dry Root Weight; PWW= Plant Wet Weight; PDW= Plant Dry Weight; FD= Fruit Diameter.

The sterilization process applied to sterilized organonitrophos fertilizer is suspected to be the factor causing higher production of red chili plants compared to treatments with non-sterilized organonitrophos fertilizer and chemical fertilizer. This sterilization affects the life cycle of microorganisms. According to Maier (2009), the life cycle of microorganisms is divided into four phases: the lag phase, the log phase (exponential phase), the stationary phase, and the death phase. It is suspected that there is a difference in the growth rate of bacteria between treatments P2 and P3, where in treatment P3, the exponential phase of microorganisms occurs faster, as reflected in the higher plant growth variables observed in P3.

At this growth stage, microorganisms in treatment P2 are suspected to still be in the lag phase. However, when the plants enter the generative stage, microorganisms in treatment P2 begin to enter the exponential phase, resulting in higher observed values during the generative stage. The fruits produced from treatment P2 also showed greater length than those from treatments P1 and P3. This is supported by the results of soil organic carbon content observations at the end of the study, which showed that the organic carbon content in treatment P2 was lower than in P3, as microorganisms in P2 require more carbon as a substrate. Meanwhile, the soil organic carbon content in treatment P1 was relatively low due to the absence of organic matter added to the soil.

The correlation test results between soil chemical properties and the growth and production of red chili plants showed that soil chemical properties correlate with several growth and production variables (Table 4). The available phosphorus (P) content in the soil was found to have a positive correlation with root fresh weight. This is due to the positive influence of phosphorus on root morphology, which generally stimulates root growth (Williamson et al., 2001). Additionally, phosphorus also affects the diameter of the root collar (Hudai et al., 2007).

The total nitrogen (N) content in the soil has a positive correlation with fresh and dry root weight and fresh and dry shoot weight. Nitrogen plays a crucial role in plant metabolism, as all essential processes in plants are related to proteins, of which nitrogen is a key component (Leghari

et al., 2016). Nitrogen contributes to enhancing growth during the early stages of plant development, improving fruit quality, increasing leaf number, boosting protein content, and promoting the absorption and utilization of other nutrients such as potassium (K) and phosphorus (P) (Bloom, 2015). Nitrogen also stimulates the formation of photosynthetic pigments (chlorophyll) by increasing the number of stroma and thylakoids in leaves (Filho et al., 2011).

The organic carbon content in the soil has a positive correlation with the diameter of red chili fruits. The ability of the soil to provide nitrogen (N) is greatly influenced by the condition and amount of organic matter in the soil (Cookson et al., 2002). It is known that the organic carbon content in the soil affects the mobilization of N within the soil (de Graaff et al., 2010). Soil microorganisms require N to synthesize proteins, nucleic acids, and other cellular components (Geisseler et al., 2010). The quality of organic carbon can also influence the mobility of N in the soil (Cao, 2021). This is consistent with the findings of Gentile et al. (2008), Cheng et al. (2017), and Mehnaz et al. (2019), which report that the quality of organic matter controls N immobilization. The ability of organic matter to reduce N mobility is considered to impact the growth and production of plants, as the plants can utilize the immobilized N.

The soil pH positively correlates with the height of red chili plants. Research by Lubis et al. (2015) indicates that soil pH affects the number and weight of root nodules at the end of the vegetative phase and N absorption. Nitrogen stimulates plant growth, particularly in stems, branches, and leaves (Rusmana & Salim, 2003).

A significant difference in available phosphorus (P) content was found in the soil after harvest compared to the conditions before planting. The available P content in the soil after harvest was classified as high to very high, which is markedly different from the low available P content before planting. This may be due to the addition of organonitrophos fertilizer, which has a very high P content of 0.31% or equivalent to 3,100 ppm (Deviana et al., 2014). Additionally, the application of organic matter to acidic soils can enhance P absorption and corn yield, as the decomposition of organic matter produces nutrients such as N, P, and K, as well as humic and fulvic acids that play a crucial role in binding soluble Fe and Al in the soil, thereby increasing P availability (Hasanudin, 2003).

4. CONCLUSION

The application of selected bacterial isolate consortia did not significantly affect the growth and production of red chili plants, nor did it affect the soil's chemical properties. Sterilized organonitrophos fertilizer (P2) can increase the production of red chili plants compared to chemical fertilizer (P1) and non-sterilized organonitrophos fertilizer (P3). Meanwhile, non-sterilized organonitrophos fertilizer (P3) has been shown to enhance the growth of red chili plants and the organic carbon content in the soil better than chemical fertilizer (P1) and sterilized organonitrophos fertilizer (P2). No interaction was found between the selected bacterial isolate consortium and the type of fertilizer across all observed variables regarding the growth and production of red chili and the soil's chemical properties.

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