The effect of *Trichoderma*-enriched biofertilizer application on total nitrogen, organic carbon, and peanut (*Arachis hypogaea* L.) yield in Inceptisols

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Abstract. The addition of N, P, and K nutrients through the application of fertilizer that is not in accordance with recommendation dosage still happening nowadays. One of the efforts to minimize this problem is the use of biofertilizer. This research aimed to study the effect of *Trichoderma*-enriched biofertilizer (T-EB) application on total nitrogen, organic carbon, and peanut (*Arachis hypogaea* L.) yield in Inceptisols. The research was conducted at The Laboratory of Soil Chemistry and Plant Nutrition, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor from May to October 2022. The design used was randomized block design (RBD) with nine treatments and three replications: (A)Control, (B)NPK Standard, (C) ½(T-EB)+1NPK, (D) ¾ (T-EB) + 1NPK, (E) 1(T-EB) + 1NPK, (F)1½(T-EB) + 1NPK, (G)1(T-EB) + ¾NPK, (H)1(T-EB) + ½NPK, (I)1(T-EB) + ¼ NPK. The results showed that the use of *Trichoderma*-enriched biofertilizer had a significant effect on soil total nitrogen, soil organic carbon, and peanut yield components compared to the control (without fertilizer) and NPK standard. A single dose of (T-EB) (2 kg/ha) effectively increased peanut yield when mixed with the NPK dose of standard fertilizer at ¾ (37.5 kg/ha). The use of (T-EB) at that dose can also reduce NPK usage in Inceptisols.

1 Introduction

Peanut (*Arachis hypogaea* L.) is one of the largest legume crops worldwide, containing carbohydrates, minerals, and vitamins. Compared to other nuts, peanut is richer in protein material [6,13]. Peanuts are consumed worldwide and have become part of various snacks and recipes in different countries. As one of Indonesia's main commodities for vegetable protein, peanut can enhance national food security [4]. With its high economic value and significant opportunities in the domestic and international market, peanut has the potential for further development.

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There is a report about the application of inorganic fertilizers that influence peanuts yield [1]. The continuous use of inorganic fertilizers could lead to environmental pollution, including soil fertility and groundwater contamination [12]. To overcome these issues, there is a current effort to adopt the use of environmentally friendly and cost-effective organic materials. Organic fertilizers can be conjoined with the inorganic fertilizers in Rates down the suggested amount for the continued peanut production [7,15]. Biofertilizer products contain various types of microbial cells as significant components of integrated nutrient supply, resulting in increased quality and yield of crops. One of them is *Trichoderma*. *Trichoderma*, a fungus utilized globally as a biofertilizer, has been reported to enhance plant growth and nutrient utilization efficiency [7, 2, 11].

The impacts of biofertilizers enriched with Trichoderma on plant development and yield have been thoroughly examined in controlled settings such as greenhouses or pots. *Trichoderma* species exhibit effectiveness as biological control agents capable of suppressing soilborne pathogens while also stimulating plant growth [9, 20]. The indicators used to assess soil fertility effectiveness are total nitrogen and organic carbon. Nitrogen existed as an important point at the soil as it is an essential nutrient for plants, particularly for building blocks in protein synthesis [8]. Organic carbon in the soil helps maintain soil chemical and biological balance and enhance soil and plant productivity [5,16]. The objectives of this study are (1) to determine the effect of *Trichoderma*-enriched biofertilizer on peanut yield and (2) to identify the optimal dosage of the biofertilizer that can positively influence peanut yield.

2 Method and Material

The research here was held on the experimental garden in Faculty of Agriculture, Universitas Padjadjaran, Jatinangor since May to October 2022. The study employed a RBD with the nine different medication and each of that was replicated thrice leading to 27 experimental plot as indicated in the Table 1. Data analysis involved the utilization of the DMRT of Duncan's Multiple Range Test and F test.

Table 1. Combination of *Trichoderma*-enriched Biofertilizer (T-EB) Treatment with N-P-K on Peanut Plants.

Code	Treatments	*Trichoderma*-enriched Biofertilizer (kg/ha)	NPK (kg/ha)		
			Urea	SP-36	KCl
A	Control	0	0	0	0
B	NPK Standard	0	50	100	50
C	½ T-EB+ 1 NPK	1	50	100	50
D	¾ T-EB + 1 NPK	1.5	50	100	50
E	1 T-EB + 1 NPK	2	50	100	50
F	1½ T-EB + 1 NPK	3	50	100	50
G	1 T-EB + ¾ NPK	2	37.5	75	37.5
H	1 T-EB + ½ NPK	2	25	50	25
I	1 T-EB + ¼ NPK	2	12.5	25	12.5

Description:

a) The control group received no "*Trichoderma*-enriched Biofertilizer" treatment and no NPK fertilizers.
b) The standard NPK fertilizer treatment consisted of locally recommended inorganic fertilizers does for peanut plants (50 kg Urea, 100 kg SP-36, and 50 kg KCl per hectare)
c) The recommended dose of "*Trichoderma*-Enriched Biofertilizer" treatment was applied at a rate of 2 kg/ha. The form *Trichoderma*-enriched biofertilizer was in powder. The fertilizer was soluble in the water of 1 liter per gram ratio of fertilizer per plant.

The study implementation includes land preparation, seed preparation, fertilization of *Trichoderma*-enriched Biofertilizer (at the beginning of planting), fertilization of NPK (7 day after planting, 21 days after planting, 35 days after planting), and plant maintenance. Plant maintenance consisted of watering, replanting, pest control, observation, sampling, laboratory analysis, and calculation of yields.

The materials used in this study are Inceptisol soil from Jatinangor Regency, peanut seeds (*Arachis hypogaea* L.) variety "Litbang Garuda 5", *Trichoderma*-enriched biofertilizer, and single inorganic fertilizers (Urea (45% N), SP-36 (36% P2O5), and KCl (60% K2O)). The observed responses were dry weight of pods per plant (g), dry weight of pods per plot (kg), dry weight of pods per ha (ton), and soil analysis (total nitrogen and carbon organic). The total nitrogen analysis was conducted implementing Kjeldahl'z technique and the organic carbon analysis is conducted applicating the Walkley and Black method. Subsoil used has the following characteristics: slightly acidic pH, very low organic carbon content (0.79 %) with a low C/N ratio (5.64), low N-total (0.14%), well as some low micro-content (Table 2).

Table 2. Result of Soil Analysis Before Treatments (Inceptisol)

No.	Parameter	Unit	Result	Criteria*)
1	pH : H_2O	-	6.02	Slightly acidic
2	pH : KCl 1 N	-	5.05	-
3	C-Organic	%	0.79	Low
4	N Total	%	0.14	Low
5	C/N	-	5.64	Low
6	P_2O_5 HCl 25 %	mg/100 g	56.21	High
7	P_2O_5 (Bray I)	ppm P	11.14	High
8	K_2O HCl 25 %	mg/100 g	31.88	Medium
9	Cation exchange capacity (CEC)	cmol/kg	20	Medium
10	Basic Cations:			
	K-dd	cmol/kg	0.28	Low
	Na-dd	cmol/kg	0.15	Low
	Ca-dd	cmol/kg	6.35	Medium
	Mg-dd	cmol/kg	1.93	Medium
11	Base Saturation	%	43.55	Medium
12	Al-dd	cmol/kg	0.22	-
13	H-dd	cmol/kg	0.35	-
14	Al-saturation	%	2.37	Poor
15	Texture			
	Sand	%	12	Silty Clay Loam
	Silt	%	56	
	Clay	%	32	

Notes : *) Result of Soil Analysis from Laboratory of Soil Chemistry and Plant Nutrition, Faculty of Agriculture, Universitas Padjadjaran (2022).

3 Results and Discussion

3.1. Soil Analysis

Soil analysis as an important thing in soil fertility to determine the levels of soil nutrients. Some of the main nutrients that need to be known are total of nitrogen and also organic carbon [17]. In general, the application of *Trichoderm*a-enriched biofertilizer affects the values of total nitrogen and organic carbon (Table 3).

Table 3. The Effect of *Trichoderma*-Enriched Biofertilizer (T-EB) Application on Total Nitrogen and Organic Carbon of Soil in "Litbang Garuda 5" Peanut Plants

Code	Treatment	Total Nitrogen (%)	Organic Carbon (%)
A	Control	0.14^{a}	0.73^{a}
B	NPK Standard	0.20^{b}	1.19^{b}
C	½ T-EB+ 1 NPK	0.23^{bc}	2.55^{c}
D	¾ T-EB + 1 NPK	0.27^{cd}	2.64^{d}
E	1 T-EB + 1 NPK	0.28^{cd}	2.66^{d}
F	1½ T-EB + 1 NPK	0.26^{c}	2.61^{cd}
G	1 T-EB + ¾ NPK	0.29^{cd}	2.68^{d}
H	1 T-EB + ½ NPK	0.22^{b}	2.53^{c}
I	1 T-EB + ¼ NPK	0.24^{bc}	2.56^{c}

Description:

Numbers followed by the same letter are not significantly different based on Duncan's multiple distance tests at the 0.05 level.

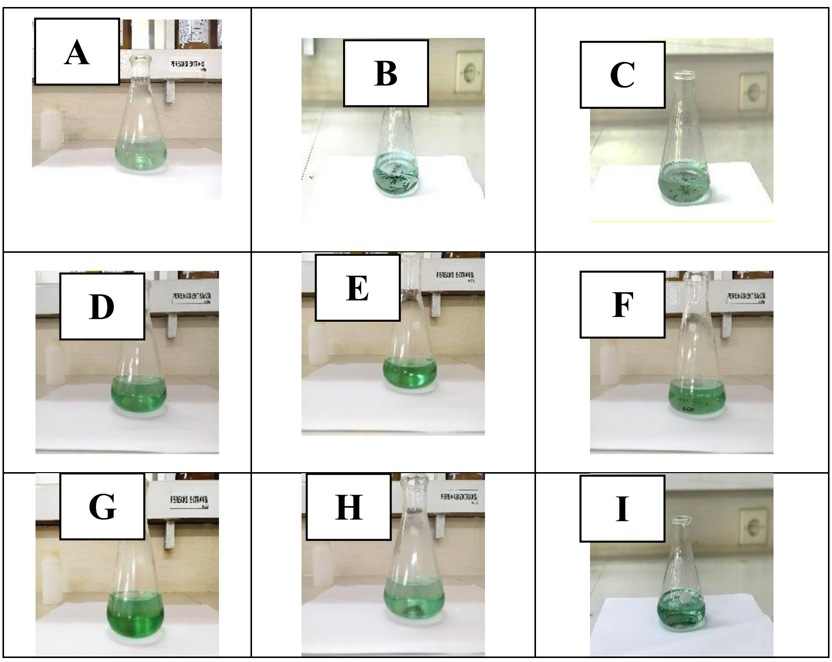

Fig. 1. Nitrogen content of soil in various treatments

Based on Table 3, the observation and statistical analysis data showed that all treatments of total nitrogen and organic carbon content provide significantly different results. Control (without fertilizer) (A) had the lowest organic carbon and total nitrogen content compared to all treatments. The total soil nitrogen and organic carbon in treatment G (1 *Trichoderma*-enriched biofertilizer + ¾ standard NPK) indicate higher results compared to control (A), NPK standard (B) and has significant results. This suggests the potential influence of *Trichoderma*-enriched biofertilizer application, which can optimize legume root potential with symbiotic bacteria in N fixation processes[18], as well as better organic material decomposition processes; compared to treatments without *Trichoderma*-enriched biofertilizer. In Figure 1, it can be observed that the nitrogen content in the soil varies among all treatments, exhibiting different shades of green. The darker the green color, the higher the nitrogen yield value produced. In treatment G (1 *Trichoderma*-enriched biofertilizer + ¾ standard NPK) the color appears noticeably greener compared to the other treatments.

Organic carbon in soil can improve soil fertility by enhancing soil water-holding capacity, increasing soil aggregation, and nutrient storage. It can stimulate plant growth by colonizing root surfaces and inducing significant metabolic changes in plants. *Trichoderma* can also produce organic acids that can decompose soil organic substances [9]. The utility of *Trichoderma* sp. into the soil can enhance the speed of organic matter decomposition due to the production of three enzymes: 1) cellobiohydrolase enzyme, which effectively degrades native cellulose; 2) endoglucanase enzyme, which effectively down the dissolved cellilose and also 3) glucoside enzyme that hydrolyze the cellobiose unit asctively Yo the flucose molecule. These enzymes collaborate synergistically, resulting in a more rapid and profound decomposition process [10]. Organic matter serves directly as a supplier of plant nutrients and simultaneously exerts an indirect impact on the physical and chemical properties[14].

3.2. Peanut Harvest Yield

The application of *Trichoderma*-enriched biofertilizer plus with NPK influences the dry weight of pods per plant (g), dry weight of pods per plot (kg), dry weight of pods per ha (ton). The result data of peanut crop yield components of Garuda 5 variety can be seen in Table 4. Visual lengths and diameters can be seen in Figure 2.

Table 4. The Effect of *Trichoderma*-enriched Biofertilizer (T-EB) Application on the yield of "Litbang Garuda 5" Peanut Plants

Code	Treatment	DWPP (g)	DWPPL (kg)	WPP (ton)
A	Control	$26^{a\ 1}$	3.41^{a}	3.6^{a}
B	NPK Standard	$30^{b\ 2}$	4.02^{b}	4.4^{b}
C	½ T-EB+ 1 NPK	$32^{bc\ 4}$	4.78^{bc}	6.7^{bc}
D	¾ T-EB + 1 NPK	$35^{cd\ 7}$	5.79^{c}	8.1^{d}
E	1 T-EB + 1 NPK	$36^{d\ 8}$	5.83^{c}	8.2^{d}
F	1½ T-EB + 1 NPK	$34^{cd\ 6}$	4.97^{bc}	7.3^{cd}
G	1 T-EB + ¾ NPK	$37^{d\ 9}$	5.87^{c}	8.3^{d}
H	1 T-EB + ½ NPK	$31^{b\ 3}$	4.39^{bc}	6.5^{bc}
I	1 T-EB + ¼ NPK	$33^{bc\ 5}$	4.89^{bc}	7.0^{bc}

Description:

a) Numbers followed by the same letter are not significantly different based on Duncan's multiple distance tests at the 0,05 level.

b) DWPP = dry weight of pods per plant (g)

c) DWPPL = dry weight of pods per plot (kg)

d) WPP = weight of pods per ha (ton)

The different doses of *Trichoderma*-enriched biofertilizer applied in each treatment resulted in varying yields. The higher yield for the dry weight of pods per plant was found in treatments G (1 T-EB + ¾ NPK) and E (1 T-EB + 1 NPK). Restoring the chemical properties of soil allowed sufficient nutrient availability to be absorbed by plants. Increasing organic carbon content and nitrogen on the soil due to above treatments affected the optimum peanut yield. The peanut increased along with the increasing chemical properties of the soil.

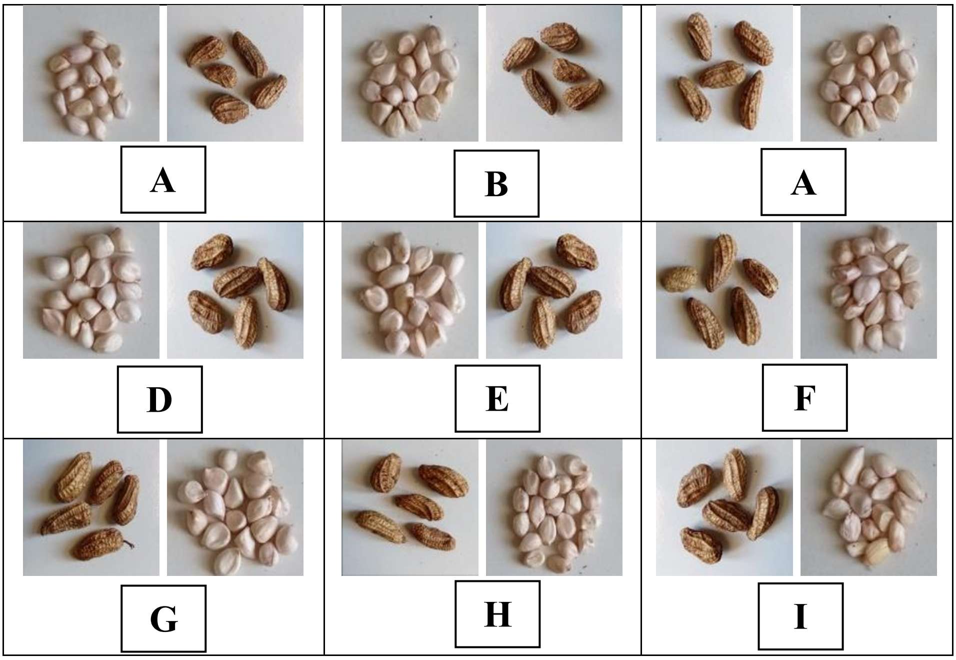

Fig. 2. Sample of peanuts from various treatment

4 Conclusion

Based on the experimental of *Trichoderma*-enriched biofertilizer of the Trichoderma-enriched at the result from "Litbang Garuda 5" variety peanut (*Arachis hypogaea,* L.), the conclusion is that the use of *Trichoderma*-enriched (T-EB) biofertilizer as a complement fertilizer shows significant results in soil total nitrogen, soil organic carbon, and peanut yield components compared to control (without fertilizer) and NPK standard. The application of *Trichoderma*-enriched biofertilizer which is 1 dose (2 kg/ha) is effective in increasing peanut yield mixed with NPK dose of standard fertilizer ¾ (37.5 kg/ha). *Trichoderma*-enriched biofertilizer with that dose can reduce NPK usage on inceptisols.

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