COMMUNICATIONS IN SCIENCE AND TECHNOLOGY
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Response of peanut quality and yield to chicken manure combined with *Rhizobium* inoculation in sandy soil

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Article history:
Received: 27 December 2022 / Received in revised form: 16 May 2023 / Accepted: 30 May 2023

Abstract

Chemical fertilizers, which contain a nitrogen (N) element, has been intensively used to increase the peanut productivity. However, the unstable and high cost of N fertilizer, and the great demand for N fertilizer sources have strongly increased the strategical plan of nitrogen fixation (NF). Therefore, the field research was carried out to appraise the ability of *Rhizobium* sp. trains and chicken manure (CM) on the quality and yield of peanuts. This research has four ratios, which valued from 0.0, 2.0, 4.0 to 6.0 t CM per ha in the combination with the *Rhizobium* sp. inoculum, expect control treatment (without CM and *Rhizobium* sp.). Different rates of CM combined with *Rhizobium* sp. inoculation was added by using 6.0 tons CM/ ha, which had number of the highest peanut nodules. Research results observed that the inoculant of *Rhizobium* sp. strain combined with CM remarkably increased the yield components per plant such as biomass, number of nodules, weight of dry nodules, weight of fill and empty pods and fresh yield of groundnut. The highest yield and quality of peanut (7.60 t/ha), oil % (50.6%), seed protein percentage (26.8%), as well as NPK content in seed (4.32, 0.912 and 0.999%, respectively) were obtained under the application of NPK+6.0 t CM/ha+ *Rhizobium* sp. inoculation. Co-application of 6t CM/ha and *Rhizobium* sp. inoculation increased by 20.5% when compared without CM application and no *Rhizobium* sp. inoculation. The study showed that both possibility of nitrogen fixation of peanut and nitrogen uptake of the sandy soil were raised by field inoculant with effectiveness of *Rhizobium* sp. with animal manure application. In really, *Rhizobium* sp. inoculation and CM proved a great method to increase soil nutrients for subsequent crops and it helped to enhance the taking of nitrogen from the air into the crop soil.

Keywords: Chicken manure; peanut; quality; *Rhizobium*; yield

1. Introduction

Groundnut (*Arachis hypogaea* L.), which is a key seed legume, has been the popular cultivation in Vietnam [1]. Seeds of groundnut highly containt from 20 to 30% protein, 40 to 50% oil and many kinds of vitamin B, so that groundnut fields have been planting mainly for its grain harvest. Furthermore, stems, leaves and pods of groundnut are utilized as feeds for the livestocks and fertilizers for crops [2]). Local farmers in Tri Ton have seriously faced by lack of soil nutrient, low rainfall and long drought, which are some of the limitations in production [3]. However, The groundnut, which has the capacity to raise the soil fertility, when planted in rotational crop or in association with other agriculture plants. Positive results of rotational and/or intercropping season, groundnuts have been amended to raise productivities of next seasons in rotational crop or combination with other food plants in rotational systems. Rotational systems, which have significantly contributed to the action of soil microorganisms that raise yields and soil nutrients crop soils are a successfulness of their effectually nutrition cyclist, detoxified functions and unshakeable firmness of crop soils [4]. According to prior study of Xu & Wang, (2003) [5] presented that continuously cultivable regions of groundnuts remarkably reduced yields, agricultural soil quality and soil microorganic community [6]. The continuously cultivable fields of groundnut also decreased microorganism species and the number of bacterium, advantageous fungus and raised disadvantageous fungus in crop soils [6]. To raise the peanut yield and surmount these problems, the method change and technology innovation of peanut cultivation need to be immediately implemented for increasing yield and quality of peanut production [7]. Groundnut – *rhizobia* are a nitrogen-fixing plant and microbial interaction that is been using around the world to further crop growth. The rhizobia are the most isolation from nodules of peanut root [8]. *Rhizobium* Inoculant of groundnuts that is strongly promoted to the matureness and productivity of peanut and it has been applied popularly in order to replay for being quite costly of a chemical nitrogen fertilizer [9]. The *Rhizobium* bacteria could create the nodules of peanut roots from fixing air nitrogen in legumes [10]. Poultry manures play a important key in the unshakeable increase of soil nutrition and groundnut yields. Further, application of animal manures demonstrated the best matureness and productivity of groundnut was enhanced soil nutrition and peanut yield and/or maintained the peanut yield in grey soils [11].

Therefore, amendment of poultry manures has significantly used as the key demand to raise the plant yield. Crops use

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https://doi.org/10.21924/cst.8.1.2023.1082

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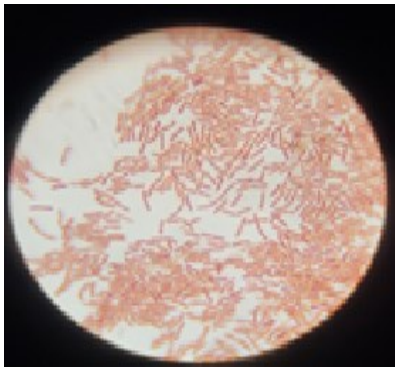
most of nutrition mostly from the planted soils. It has really known that the positive matureness of crops not only causes from the whole nutrients in the agricultural land but also affected by soil properties [12]. Inorganic fertilizers are used to bring beneficial production to be better crop yield, but higher dose inorganic fertilizers is combined with decrease land characteristics and plant yields over time [13]. On contrary, the animal manures such as chicken manure, cow manure…have positively affected in optimizing the land characteristics. In the recent years, local tillers have negatively tended to use more inorganic fertilizers for meeting the demands of crop nutrition. they are more gain, easy to apply and fast in reply. Opposite, poultry manure affects longer reply on plant productivities, although they have positively affected in optimizing the land characteristics. So, organic manures are an important role to use co-application of organic and inorganic fertilizer, which could maintain food quality without soil nutrient deterioration and yield. With above reasons, this research was therefore carried out to found out the impacts of co- application of chicken manure and NPK fertilizer combined with *Rhizobium* inoculation on quality and yield of groundnuts.

2. Materials and Methods

2.1 Microorganisms and inoculation

Rhizobia were isolated from nodules of peanut shoots at microbiology laboratory of the An Giang university (Figure 1). The bag was inoculated with peanut seeds in the dark. peanut Seeds were carefully shaken in liquid solution after diluting with ratio (1:1) of distilled water for half an hour before sowing.



(a)

(b)

Fig. 1. (a) *Rhizobium* picture (b) pure *Rhizobium strains, Rhizobium* isolation from groundnut noodles

2.2 Experimental design and treatments

The farm experiment was designed with four different treatments at Tri Ton town from April to July of 2022. Groundnut seeds (LDH 09) of ASISOV company were used during this experimental season to evaluate its matureness and productivity. The total area of experiment that included four treatments and four replications was covered 160 m^2 (20 m in length x 0.5 m in width x 4 repeats x 4 treatments). The irrigated water during crop was the deep well. The field experiment was designed in Randomized Complete Block Design (RCBD) with two factors i.e. *Rhizobium* and chicken manure. Four experimental treatments consisted of G0 (control - 0 CM and no *Rhizobium* sp. inoculum), G1 (2 t CM ha^{-1}+ *Rhizobium* sp. inoculum), G2 (4 t CM ha^{-1}+ *Rhizobium* sp. inoculum), G3 (6 t CM ha^{-1}+ *Rhizobium* sp. inoculum (Table 1).

Table 1. Amendment of CM combined with *Rhizobium* inoculum

* Treatment	*Rhizobium* sp. (10^8CFU/g)	Chicken manure (t/ha)	Chemical fertilizer (N-P-K, kg/ha)
G0 (control)	No	0.00	40-60-50
G1	inoculation	2.00	
G2	inoculation	4.00	
G3	inoculation	6.00	

Fig. 2. The field experiment of peanut in Tri Ton district, An Giang province

Table 2. Soil particle size distribution and chemical characteristics at the first of the experiment

Soil properties			
Soil depth (0 - 20cm)			
Sand (g/kg)	828	Total nitrogen (%)	0.124
Clay (g/kg)	189	Available P (mg/kg)	56.1
Silt (g/kg)	153	Exchangeable K (mg/kg)	624
Textural class	Sandy loam	Total Ca (%)	20.0
C (%)	1.49	pH	5.21
OM (%)	2.56	EC (µS/cm)	220

Soil samples that were taken from 0 to 20 cm in depth determined for physic-chemical ccharacteristics (Table 2). Groundnuts planted two grains per hole with the distance of between two plants and row was 25 cm and 50 cm,

respectively. The weight of NPK fertilizers was similarly used at 40kg N, 60 kg P and 50 kg K per ha for all treatments. Peanut seeds (LDH 09), which were collected from ASISOV company were sown in this field experiment during crop. Soil characters of the land before experiment presented in Table 1. The Textural class of soil was sandy loam, concentration of OM, C, total N, available P, exchangeable K, total Ca, and EC were lower according to the average standard of Hepperly *et al.,* (2009) [13]. The results in Table 1 indicated poor nutrients and acidity of planted soil. therefore, it will reduce crop yield production without improving soil nutrition.

2.3 Study parameterization and sample determination

Data of groundnut samples were continuously determined from their matureness to harvest. The research parameterization consisted of plant height, number (No.) of branches, plant Biomass, No. of Nodule, Weight (Wt.) of dry nodule, Wt. of fill pods, Wt. of empty Pods per plant and yield of fresh pods (ton per ha), which were counted at harvest. Plant samples of each replication were separately collected and dried to determine the peanut yield of pods and seeds. The seed sample was completely grinded and stored in dark bottles for the chemical determination. Methods of Piper (1950 [14] and Page et al. (1982) [15], were used to analyze soil samples. The A.O.A.C. [16] method were analyzed for the oil, protein and NPK in groundnut seeds. the raw protein content was counted by 6.25 of total nitrogen content.

2.4 Statistical analysis

Data was statistically showed by the impacts of different treatments on the studied parameters to see significant differences between treatments. Studied treatments were tested by STATGRAPHICS CENTURION XVI.

3. Results and Discussion

3.1 Effect of CM, Rhizobium sp. *and NPK fertilizer on soil pH*

The results in Figure 1 showed that different ratios of CM combined with *Rhizobium* inoculum and fertilization of NPK fertilizer on soil pH. The studied soil, which had low pH (below 5.5) and insignificant differences at 5% value from 5.02 to 5.18 before experiment (Figure 1). However, regard of CM and *Rhizobium* supplementation, soil pH gradually increased with the increase of CM rate (Figure 2). The increase trend of soil pH presented similarly in all additional soils and the rate of increase ranged from 0.0 to 6.0 t CM/ ha about at harvest. The results of Fig. 1 were remarkably differences among between soil pH of control and CM and *Rhizobium* sp. supplementation. Soil pH of CM supplemented treatments at harvest was higher than before the experiment. Further, the soil pH of the treatments with CM amendment was higher than that of inorganic fertilizer application at harvest. According to prior studies by [17, 18, 40] were proved that animal manures raised soil nutrients and soil pH due to reaction between available anions of animal manures and soil H^+ ion. Chicken manure remarkably raised the soil pH comparison with the control treatment thank to its lime effect. The high content of ammonium in the CM also increased soil pH [19]. Application of chemical fertilizers change soil pH, which negatively impacts the health of naturally benefit soil microorganisms. These acidity levels of the soil raises and eliminate the microorganisms that are beneficial to plant and soil nutrients as they help to improve the plants' natural defenses against pests and diseases [20].

3.2. Effect of CM, Rhizobium sp. *and NPK fertilizer on Plant height and branches*

Co-application of CM and NPK fertilizer obtained remarkable influences on plant height. Especially, the positive interaction among treatments had significant influences on plant height. in treatments of CM amendment, peanut plant heights raised according to increase CM weight. Among the highest rate of 6.0 tons CM per ha obtained the highest plant height. However, the lowest plant height showed control treatment (G0) without CM and *Rhizobium* (Table 3). From those results in Table 3 presented that lower weight to higher weight which had 2.0, 4.0, and 6.0 t CM/ha, could raise gradually the plant height and significantly differences among

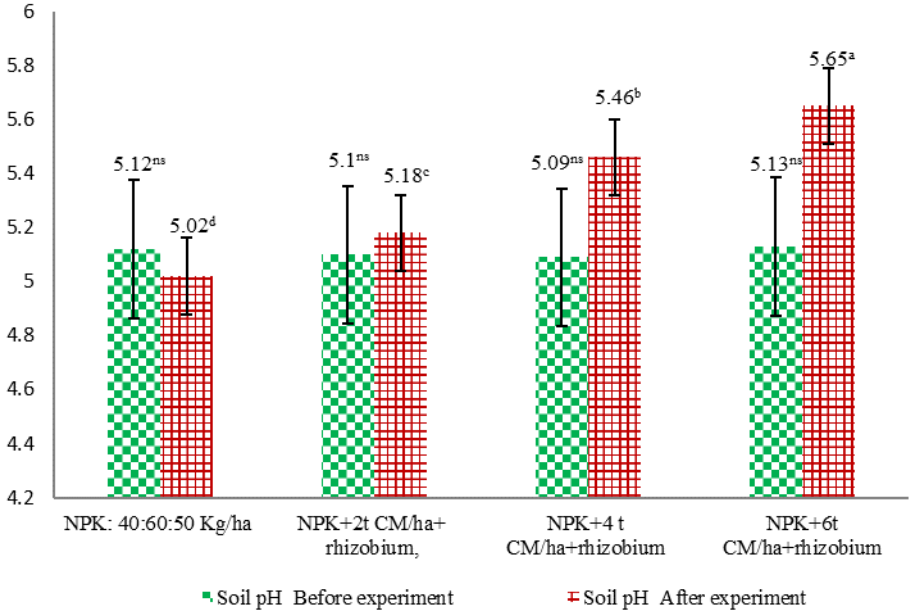


Fig. 3 Soil pH before and after experiment

treatments. The studied Data in Table 4 proved that number of branches were statistically at 1% (p >0.01) among treatments. Furthermore, number of branches were significantly higher in plants on CM amendment plots) when compared to control plots (NPK: 40:60:50 Kg/ha alone) and obtained the highest number of branches produced on plots of NPK+6t CM/ha + *Rhizobium* sp. application. The increase in number of branches with raising ratios of CM addition may be contributed to increase the concentration of nitrogen and other nutrition lessened by CM amendment.

Table 3. Effect of CM, *Rhizobium* sp. and NPK fertilizer on peanut plant height

Treatments	Plant height (cm) Days after sowing (DAS)			
	20	40	60	Harvest
NPK: 40:60:50 Kg/ha (Control)	19.5^{c}	37.8^{d}	50.3^{d}	62.1^{d}
NPK+2t CM/ha+ *Rhizobium* sp.	21.3^{b}	38.4^{c}	51.6^{c}	66.7^{c}
NPK+4 t CM/ha+ *Rhizobium* sp.	21.8^{b}	41.4^{b}	54.2^{b}	67.5^{b}
NPK+6t CM/ha+ *Rhizobium* sp.	22.7^{a}	44.4^{a}	56.7^{a}	68.2^{a}
F	**	**	**	**
CV(%)	6.02	6.80	4.83	3.74

Means followed by different letters in the same category are significantly different at (**, P ≤ 0.01)

Table 4. Effects of CM, NPK and *Rhizobium* sp. inoculum on peanut branches

Treatments	Number of branches /plan			
	20 DAS●	40 DAS	60 DAS	Harvest
NPK: 40:60:50 Kg/ha (Control)	2.13d	3.15^{d}	4.08^{c}	4.54^{c}
NPK+2t CM/ha+ *Rhizobium* sp.	2.25c	3.26^{c}	4.38^{b}	4.86^{b}
NPK+4 t CM/ha+ *Rhizobium* sp.	2.55b	3.78^{b}	4.45^{b}	4.97^{ab}
NPK+6t CM/ha+ *Rhizobium* sp.	2.85a	4.05^{a}	4.55^{a}	5.07^{a}
F	**	**	**	**
CV(%)	11.9	10.8	4.30	4.89

● DAS: Days after sowing; Means followed by different letters in the same category are significantly different at (**, P ≤ 0.01)

Prior studied results proved that positive effects of poultry manures combined with chemical fertilizer on plant height of rice-wheat cropping system [21] and soybean [22]. Generally, plant reached the height and matureness by co-application of organic and inorganic fertilizer treatments. The stable growth of plants was significantly reached by the co-application of both organic and inorganic source of essential nutrients. Raising ratios of CM led to remarkable amelioration in the whole height and branch of plants. Similar observation was made by Dwyer and Stewart (1986) [23].

Biomass in Table 5 was demonstrated statistically significant at 1% (P ≤ 0.01) due to various rates of CM comparison with control treatment (Table 4). Biomass of groundnut ranged from 125 to 138g per plant under different weight of CM amendment. It is proved that the increasing weight of CM raised the peanut biomass remarkably up to NPK+6t CM/ha+ *Rhizobium*. The maximum Biomass (138 g/ plant) was obtained with the application 6-ton CM per ha comparison with to 0.0, 2.0 and 4.0 t CM per ha. While the minimum weight of biomass (125 g/ plant^{1}) was presented by application of NPK application only. Groundnut nodules were remarkably affected CM, inorganic fertilizer combined with *Rhizobium* inoculum (Table 4). The greatest nodules (92.9 noodles/ plant) were obtained in the treatment of the maximum CM application (NPK+6t CM/ha + *Rhizobium*), while lowest number of nodules (58.3 nodules / plant) presented in the control treatment (NPK: 40:60:50 Kg/ha, alone).

Table 5. Effectiveness of CM, NPK fertilizer and *Rhizobium* on yield components of peanuts

Treatments	Character per plant						
	Biomass (g)	No. of Nodules	Wt. of dry nodules (g)	Wt. of fill pods (g)		Wt. of empty Pods (g)	
				fresh	dry	fresh	dry
NPK: 40:60:50 Kg/ha (Control)	125^{b}	58.3^{d}	0.430^{c}	54.8^{d}	31.8^{d}	2.07^{a}	1.19^{a}
NPK+2t CM/ha+ *Rhizobium* sp.	128^{b}	85.8^{c}	0.748^{b}	56.7^{c}	32.9^{c}	1.92^{b}	1.09^{b}
NPK+4 t CM/ha+ *Rhizobium* sp.	133^{ab}	88.9^{b}	0.765^{b}	58.9^{b}	35.5^{b}	1,88^{b}	1.05^{b}
NPK+6t CM/ha+ *Rhizobium* sp.	138^{a}	92.9^{a}	0.831^{a}	60.8^{a}	36.9^{a}	1.78^{c}	0.913^{c}
F	*	**	**	**	**	**	**
CV_A(%)	5.27	17.4	23.2	4.16	6.34	5.79	10.2

Means followed by different letters in the same category are significantly different at (*, P ≤ 0.05), (**, P ≤ 0.01)

Table 6. Effectiveness of CM, NPK fertilizer and *Rhizobium* sp. on yield and quality of peanuts

Treatments	Seed protein (%)	Seed Oil (%)	NPK content in seed (%)			Fresh Yield (t/ha)
			N	P	K	
NPK: 40:60:50 Kg/ha (Control)	23.2^{c}	45.8^{c}	3.20^{c}	0.820^{b}	0.790^{c}	6.04^{c}
NPK+2t CM/ha+ *Rhizobium* sp.	23.5^{c}	46.1^{c}	3.70^{bc}	0.850^{b}	0.830^{c}	6.62^{b}
NPK+4 t CM/ha+ *Rhizobium* sp.	24.9^{b}	48.8^{b}	3.81^{ab}	0.896^{a}	0.902^{b}	6.83^{b}
NPK+6t CM/ha+ *Rhizobium* sp.	26.8^{a}	50.6^{a}	4.32^{a}	0.912^{a}	0.999^{a}	7.60^{a}
F	**	**	**	**	**	**
CV(%)	6.29	4.39	14.1	4.90	10.1	9.11

Means followed by different letters in the same category are significantly different at (**, $P \leq 0.01$)

Results in Table 5 also showed that positive relations between CM, NPK fertilizer and *rhizobia* increased number of nodules per groundnut plant in the experimental crops. *Rhizobium* inoculation combination with CM raised the weight of dry nodules compared to NPK fertilizer alone. Weight of dry nodules valued from 0.430 to 0.831 g per plant[1]. The greatest value of dry nodule obtained at the treatment of highest CM rate (NPK+6t CM/ha + *Rhizobium*) combined with *Rhizobium* and NPK fertilizer (NT4: 0.831g/ plant), while the minimum weight presented 0.430 g per plant (control treatment) (Table 5). These results can explain that application of organic manure combined with *Rhizobium* inoculant, which could significantly raise the agronomy (plant heights and available branches), yield (biomass, weight and number of nodules, number of pods, weight of 1,000 seeds of peanuts) thank to increase the *Rhizobium* population of soil for raising nitrogen fixation and yield of the peanuts [23]. Furthermore, previous study of Basu et al. (2008) [24], showed that inorganic fertilizer application of 20:40:30 kg ha^{-1} NPK combined with animal manure at 2.5 t /ha was influential in raising the agronomy, nitrogen fixation, yield component and crop quality like oil concentration, protein concentration, mineral concentration and hydration coefficient of peanut crop. Amelioration of soil nutrients, which was amended by lime (2 $tCaCO_3$)/ ha combined with farmyard manure further increased the remarkable *Rhizobium* population of soil, which causes raise nitrogen fixation and yield of the peanuts.

These studied results could be the correlative cause between CM and *Rhizobium* inoculum with roots of previous groundnut crops [25]. Biomass and matureness of groundnuts were positively improved by Co-application of poultry manures, *Rhizobium* inoculum in the next crops [26]. Number of highest nodules observed in treatments with CM amendment which showed that N-fixation increased under organic nutrients as peanut tend to respond on fixed - N, when the CM rate may significantly depend on the nutrient contents of CM and other essential elements in crop soil [27]. Number of peanut nodules were significantly increased by the inoculation of five *Rhizobium* strains, which had influences of biosynthesis of rhizobia on the nodules creation of the groundnut [28]. The addition of poultry manure raised the high population of Rhizobia in crop soils over 23% comparison with application of chemical fertilizer alone [29]. Prior study proved that benefit impacts could promote the root growth to take easier nutrients and highly increase number of groundnut nodules [30]. According to prior research of Tu and Chuong, (2022) [31] showed *Rhizobium* inoculant association with NPK fertilizer reached the higher dry weight of nodules than that of control treatment (no *Rhizobium* inoculation). The soybean nodule weight of the *Rhizobium* inoculation treatments association with chemical fertilizers raised over 145% compared to without *Rhizobium* inoculation [32]. Similarly, the prior study of Raposeiras et al. (2006) [33], due to the lack of host peanuts and poor levels of crop soil fertility. Furthermore, soil characters such as organic matter, phosphorus and nutrition supply showed a significant effect on number and mass of the peanut nodules, and increased the high population of *Rhizobium*. Amendment of CM combined with *Rhizobium* inoculum was significantly raised on the fill pod weight and reduced the empty pod weight of peanuts [34].

Effectiveness of CM addition, *Rhizobium* inoculant association with NPK fertilizer clearly represented on fresh and dry weight of fill pods per peanut plant. The weight of peanut fill pods was significantly influenced by chicken manure amendment with *Rhizobium* inoculation and statistically significant at 1% (Table 4). Effect of CM and *Rhizobium* inoculum significantly affected on the dry and fresh weight of fill pods and significantly differences at 1% ($P \leq 0.01$) among experimental treatments. The results of Table 4 was shown for the maximum fresh and dry weight of fill pods (60.8g and 36.9g) and minimum fresh and dry weight of empty pods (1.78g and 0.913g) in the amended treatment of NPK+6t CM/ha+ *Rhizobium* sp. Conversely, the control treatment of NPK application alone had the opposite results, which were only the minimum fresh and dry weight of fill pods (54.8g and 31.8g), maximum fresh and dry weight of empty pods (2.07g and 1.19g) comparison with others. The oil, protein and NPK concentration of groundnut seeds significantly impacted by CM and chemical fertilizer application. The nutritional values of groundnuts such as oil, protein and NPK content in seeds remarkably influenced by poultry manure amendment treatments. The minimum concentration of oil (45.8%), protein (23,2%) and NPK (3.2%, 0.82% and 0.79%, respectively), were observed by control treatment (NPK application alone). Conversely, the maximum oil, protein (26.8% and 50.6%, respectively) and NPK content of groundnut seeds (4.32%, 0.912% and 0.999%, respectively) obtained from the added treatment of NPK+6t CM/ha+ *Rhizobium* sp.). More increasing ratio of CM combination with *Rhizobium* sp. inoculants was remarkably raised more seed quality by raising protein, oil and NPK contents.

The relations between competitiveness for nodule creation,

growth and/or nitrogen fixation were shown in Table 6. Yield production had positively related with all peanut parameters and had a strongly relation with the peanut quality such as oils, protein and NPK in seeds. The peanut productivity valued from 6.04 to 7.60 t/ha. The highest yield (7.60 t/ha) was obtained by the treatment of NPK+6t CM/ha+ *Rhizobium* sp. Conversely, the lowest yield (6.04 t/ha) was shown at the control treatment (application NPK, alone). The study results of Lindström & Mousavi (2020) [35] demonstrated that NPK concentration of peanut seeds was significantly increased in added treatments CM and *Rhizobium* sp. inoculants obtained the maximum content of oil, protein and NPK in peanut seeds. Bogino et al., (2006) [36] presented that potential growth of groundnuts thank to *Rhizobium* inoculant with poultry manure addition. Continuous addition of poultry manures and *Rhizobium* sp. inoculant during many seasons, which could promote the nodule creation and reduced the demand to inorganic fertilizer [37]. The *Rhizobium* sp. inoculation has significantly promoted on growth, yield and quality of peanuts. Application of organic combination with inorganic fertilizer reached yield of peanut in both crops [38]. Application of *Rhizobium* sp. inoculation combined with poultry manure and chemical fertilizer remarkably raised the yield of peanut at two experiment locations [39]. Positive effects of animal manures application combination with *Rhizobium* sp. that already stimulated the growth of peanut were grown in the field condition, increased yield components and yield of peanuts. Moreover, the number of nodules and the nutritional components such as NPK, protein and oil content of seeds were all increased compared without animal manures addition and *Rhizobium* sp. inoculants [40, 41]. According to recent study of Chuong, (2023) [42] proved that co-application of organic manures and *Rhizobium* sp. strains inoculation had the greatest mung bean yield (2.22 t/ha) was higher 32.4% than that of control (1.5 t/ha, NPK fertilize application alone).

4. Conclusion

Many prior studies significantly demonstrated that biological nitrogen fixation and organic manures amendment for peanut lands play an important role for the agricultural cultivation to promote peanut yield and soil quality. The abuse of inorganic fertilizers and no organic manure application could lead to lessen remarkably the positive microorganism's population of crop soils. Addition of organic manures combined with *Rhizobium* inoculant in order to gradually reduce inorganic fertilizer, which could promote the crop growth and agricultural soil health and increase farmer's profit. All peanut characters of CM addition and *Rhizobium* inoculant compared to the control treatment. Especially, fresh yield of added treatments of 4.0, 6.0 and 8.0 tons CM/ha increased from 8.76, 11.6 to 20.5%, respectively, comparison with the control treatment.

Acknowledgements

We thank you so much for Leaders of *AGU,* VNU-HCM for helping funds in order to complete this study.

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