Effectiveness Test of *Rhizobium* sp. Isolates on the Growth and Production of Peanut (*Arachis hypogaea* L.) in Inceptisol Land

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Abstract. The nitrogen requirement of legume plants can be optimized by utilizing *Rhizobium* so that it can ultimately increase the growth of peanut plants. *Rhizobium* can be found in the root nodules of legume plants such as *Mucuna bracteata* and acacia. This study aims to determine the type of *Rhizobium* sp. isolates Local Riau effective in symbiosis with peanuts (*Arachis hypogaea* L.) and its effect on the growth and production of peanut (*A. hypogaea* L.). The study was carried out experimentally and used a non-factorial completely randomized design (CRD) with one factor and four replications. The research treatment was *Rhizobium* sp. (R) consisting of: R_0: Control (commercial *Rhizobium* sp. with Superizogen trademark), R_1: Local *Rhizobium* isolate code $IIDA_5$, R_2: Local *Rhizobium* sp. isolate code $IIDM_1$, R_3: Local *Rhizobium* sp. isolate code $IIDM_2$, R_4: Local *Rhizobium* sp. isolate code $IIRA_2$, R_5: Local *Rhizobium* sp. isolate code $IIRM_1$, R_6: Local *Rhizobium* sp. isolate code $IIRM_4$. The results of research on the application of *Rhizobium* sp. to peanut plants showed that isolates of *Rhizobium* sp. Riau local with code $IIRM_4$ is *Rhizobium* sp. from the *M. bracteata* plant in Riau peatlands which is very effective in symbiosis with peanuts.

1 Introduction

Peanut (*Arachis hypogaea*) is a dicot plant and includes leguminosae (legumes) plants. This plant is one of the plants that plays an important role in meeting the increasing national food needs as the population increases. Peanut seeds contain 20-30% protein, 42-55% fat, and contain a small amount of vitamins A and B and can be used as raw materials for the food industry [1]. Based on data from [2], peanut production in 2021 was 541.12 t and lower than 2020, which was 575.81 t. Compared to its productivity, peanuts in Riau did not increase (9.57 q ha^{-1}). This is caused by a decrease in the area planted with peanuts, namely in 2020 covering an area of 594.8 ha to 567.20 ha in 2021. If the decrease in land area continues and productivity remains the same, it will have an impact on increasing peanut imports to meet public consumption needs. One effort that can be done is to increase the productivity of peanuts through the provision of *Rhizobium*. Applying *Rhizobium* inoculants represents one form of biological seed-coating technology. Inoculation of *Rhizobium* bacteria with 100 grams of inoculum and 400 ml of liquid gum for 1 kg of seeds increases the average number

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of root segments at the early and advanced stages, the number of pods per plant and can replace 50% of mineral fertilizers [3].

Peanut is a legume plant capable of interacting with *Rhizobium* to form root nodules. According to [4], *Rhizobium* is a bacterium capable of fixing atmospheric nitrogen and providing nutrients for plant growth. Nitrogen is one of the essential macronutrients required in large amounts, acting as a major component of proteins, hormones, chlorophyll, vitamins, and enzymes crucial for plant development. The use of *Rhizobium* as a biofertilizer not only enhances biological nitrogen fixation, but also contributes to sustainable soil management by improving soil fertility, increasing nitrogen use efficiency, and reducing dependency on synthetic nitrogen fertilizers. Consequently, this practice supports environmental preservation by minimizing chemical fertilizer inputs and mitigating their negative impacts on soil and water ecosystems.

Effective *Rhizobium* bacteria symbiotically interact with peanut roots, causing root hairs to branch and curl, which facilitates bacterial invasion. The bacteria then undergo cell division and multiplication, leading to the formation of swollen nodules called bacteroids. These bacteroids receive photosynthetic products from the host legume for respiration and nitrogen fixation. The fixed nitrogen, in the form of ammonia, is released from bacteroids to plant cells and transported as C–N compounds into the vascular system [5].

Soils with high acidity can inhibit nitrogen fixation and the development of *Rhizobium*. Meanwhile, Riau generally has acidic soils, thus requiring acid-tolerant *Rhizobium* strains. One type of acid soil in Riau is inceptisol, characterized by low organic matter and a relatively low pH. Based on the research by [6], four isolates belonging to the *Rhizobium* group were obtained from the root nodules of *Mucuna bracteata* and showed the ability to survive under low pH conditions. Therefore, to identify the most effective and adaptive *Rhizobium* strain for Riau's conditions, it is necessary to conduct inoculation trials on peanut plants.

2 Materials and Methods

This research activity was carried out at the Technical Implementation Unit of the Experimental Garden of the Faculty of Agriculture, University of Riau, Riau Province, Indonesia. The soil used in this study was classified as Inceptisol with the following chemical and physical characteristics: soil pH (H_2O) of 5.12 (acidic), organic carbon of 1.49%, total nitrogen of 0.14%, and a C/N ratio of 10.64. The materials used during the research activities were peanut seeds of the Talam-1 variety, isolates of local Riau bacteria *Rhizobium* sp. [6], *Rhizobium* sp. commercial, 70% alcohol, distilled water, yeast extract mannitol agar (YEMA), yeast extract mannitol broth (YEMB), urea fertilizer, SP-36 fertilizer, KCl fertilizer, insecticide Decis 2.5 EC, and Dithane M-45 fungicide. The seven *Rhizobium* sp. isolates (IIDA5, IIDM1, IIDM2, IIRA2, IIRM1, and IIRM4) were selected because they were previously isolated from the root nodules of locally adapted legume species that grow well in acidic peat and mineral soils, indicating their potential tolerance and adaptability to the low-pH conditions typical of Inceptisol soils in Riau.

The tools used during the research activities were pH meters, hot plates, loop needles, petri dishes, erlenmeyer, test tubes, entkas, magnetic stirrers, trays, hoes, machetes, meters, stakes, digital scales, gembor, buckets, shading net, oven, and labels. This research was carried out experimentally and used a non-factorial completely randomized design (CRD) with one factor and four replications. The research treatment was the administration of *Rhizobium* (R) consisting of, R_0: control (commercial *Rhizobium* Superizogen trademark), R_1: Local *Rhizobium* sp. isolate code $IIDA_5$, R_2: Local *Rhizobium* sp. isolate code $IIDM_1$, R_3: Local *Rhizobium* sp. isolate code $IIDM_2$, R_4: Local *Rhizobium* sp. isolate code $IIRA_2$, R_5: Isolate *Rhizobium* sp. local code $IIRM_1$, and R_6: Local *Rhizobium* sp. isolate local code $IIRM_4$. From these factors, 7 levels were obtained, each of which was repeated 4 times so that there were 28 experimental plots. Parameters observed were plant height, flowering age, number of effective root nodules, total number of root nodules, percentage of effective root nodules, harvest age, number pods per plant, number of fruitful pods, percentage of fruitful pods, seed weight, dry per plant, weight of 100 dry seeds, seed weight per 1.6 m^2, dry weight, and plant N uptake.

3 Results And Discussion

3.1 Plant Height

Based on the results of the analysis of variance, it was shown that the application of *Rhizobium* sp. had no significant effect on plant height. Peanut plant height following inoculation with *Rhizobium* sp. is shown in **Table 1**.

Table 1. Plant height of groundnut inoculated with *Rhizobium* sp.

Treatment of *Rhizobium* sp.	Plant Height (cm)
Control (commercial *Rhizobium*)	62.73 b
Local *Rhizobium* sp. isolate code $IIDA_5$	64.16 ab
Local *Rhizobium* sp. isolate code $IIDM_1$	65.35 ab
Local *Rhizobium* sp. isolate code $IIDM_2$	67.77 ab
Local *Rhizobium* sp.isolate code $IIRA_2$	68.15 ab
Local *Rhizobium* sp.isolate code $IIRM_1$	69.27 ab
Local Rhizobium sp. isolate code IIRM4	72.40 a

Note : Numbers followed by the same lowercase letters in the same column are not significantly different according to Duncan's test at the 5% level.

Table 1 shows that the administration of local *Rhizobium* sp. isolates coded $IIRM_4$ was significantly different from the control treatment, but not significantly different from the local *Rhizobium* sp. isolates coded $IIDA_5$, $IIDM_1$, $IIDM_2$, $IIRA_2$, and $IIRM_1$. According to [7], giving inoculation treatment to plants using the right rhizobia strain will help the plant growth process, because *Rhizobium* sp. is a nitrogen fixing bacteria capable of increasing the availability of nitrogen and meeting the nitrogen requirement of legume plants by up to 60-80%. However, if the rhizobia inoculation is not correct, it can inhibit the process of fixing N_2 in the air.

Several different *Rhizobium* sp. isolates will show different abilities to fix nitrogen. A study [8] showed that in general the *Rhizobium* sp. inoculants used in Indonesia are imported inoculants from outside so that the *Rhizobium* sp. isolates contained therein are not tolerant of certain land conditions, because they have to compete with indigenous *Rhizobium* and other bacteria or fungi that are antagonistic. This can cause *Rhizobium* to become less effective in fixing N and its host plants to become less responsive to the inoculant.

3.2 Flowering Age and Harvest Age

Based on the results of the analysis of variance, it was shown that the application of *Rhizobium* sp. had significant effect on the age of flowering plants and the age of crop harvest. Age of flowering and age of harvest of peanut plants inoculated with *Rhizobium* sp. based on Duncan's multiple range test at the 5% level can be seen in **Table 2**.

Table 2. Flowering age and harvest age of peanut plants inoculated with *Rhizobium* sp.

Treatment of *Rhizobium* sp.	**Flowering Age (days)**	**Age of Harvest (days)**
Control (commercial *Rhizobium*)	28.50 a	95.50 a
Local *Rhizobium* sp. isolate code $IIDA_5$	27.50 ab	95.25 a
Local *Rhizobium* sp. isolate code $IIDM_1$	27.00 b	94.50 ab
Local *Rhizobium* sp.isolate code $IIDM_2$	26.50 bc	93.75 bc
Local *Rhizobium* sp. isolate code $IIRA_2$	26.25 bc	93.25 cd
Local *Rhizobium* sp. isolate code $IIRM_1$	26.00 bc	93.25 cd
Local *Rhizobium* sp. isolate code $IIRM_4$	25.25 c	92.50 d

Note : Numbers followed by the same lowercase letters in the same column are not significantly different according to Duncan's test at the 5% level.

Based on **Table 2**, the administration of local *Rhizobium* sp. isolates coded $IIRM_4$ showed a faster flowering time compared to other treatments. Local *Rhizobium* sp. isolates coded $IIRM_4$ were significantly different from the treatments of local *Rhizobium* sp. isolates coded $IIDA_5$, code $IIDM_1$, and control, but not significantly different from the treatments of local *Rhizobium* sp. isolates coded $IIRM_1$, $IIRA_2$,and $IIDM_2$. **Table 2** also shows that the treatment of local *Rhizobium* sp. isolates coded $IIRM_4$ for harvesting was faster than the other treatments. The treatment of local *Rhizobium* sp. isolates coded $IIRM_4$ was significantly different from the treatments of local *Rhizobium* sp. isolates coded $IIDM_2$, $IIDM_1$, $IIDA_5$, and control, but not significantly different from the treatments of local *Rhizobium* sp. isolates coded $IIRM_1$ and $IIRA_2$.

The interaction between the local *Rhizobium* sp. Riau and its host plants is thought to have a suitable genetic match, making it easier for *Rhizobium* sp. to infect the roots of peanut plants in forming root nodules. This is in line with [9] who stated that the mechanism of *Rhizobium* bacteria as a nitrogen-fixing soil bacteria begins by infecting the root hairs to become curly. Assisted by the presence of auxin produced by the bacteria, it will form branches which cause the cortex tissue to enlarge so that it is seen as a root nodule. The effectiveness of *Rhizobium* bacteria depends on compatibility with the inoculum source and the host plant, if there is a match then the symbiosis that occurs will be effective.

3.3 Effective Root Nodule, Total Root Nodule, Percentage of Root Nodule

Based on the results of the analysis of variance, it was shown that the application of local *Rhizobium* sp. isolate significantly effects root nodules, total root nodule, and percentage of root nodule of plants. Effective number of root nodules of peanut plants inoculated with local *Rhizobium* sp. isolate based on Duncan's multiple range test at the 5% level can be seen in **Table 3**.

Table 3 shows that the parameter of the number of effective root nodules of peanut plants by administering local *Rhizobium* sp. isolate code $IIRM_4$ was significantly different from the control treatment and other Riau local *Rhizobium* sp. isolates. The mean number of effective root nodules was not significantly different between treatments, except for the administration of local *Rhizobium* isolate code $IIRM_4$. Treatment with local Riau *Rhizobium* sp. isolates showed a higher number of root nodules compared to the control treatment that the percentage of nodules on peanut plant roots in the control treatment was significantly different to the administration of local *Rhizobium* sp. isolates code $IIDM_2$, code $IIRA_2$, code $IIRM_1$, and code $IIRM_4$ but was not significantly different to the administration of local *Rhizobium* sp. isolate code $IIDA_5$ and local *Rhizobium* sp. isolate code $IIDM_1$.

Table 3. Effective root nodule, total root nodule, percentage of root nodule of peanut plants inoculated with *Rhizobium* sp.

Treatment of *Rhizobium* sp.	**Effective Root Nodule (nodule)**	**Total Root Nodule (nodule)**	**Percentage of Root Nodules (%)**
Control (commercial *Rhizobium*)	36.50 b	54.00 d	55,40 d
Local *Rhizobium* sp. isolate code IIDA$_5$	37.50 b	62.00 c	56.13 d
Local *Rhizobium* sp. isolate code IIDM$_1$	37.75 b	62.50 c	59.21 cd
Local *Rhizobium* sp.isolate code IIDM$_2$	38.00 b	62.75 c	63,24 c
Local *Rhizobium* sp. isolate code IIRA$_2$	39.00 b	66.00 bc	63.71 c
Local *Rhizobium* sp. isolate code IIRM$_1$	40.00 b	67.75 b	69.92 b
Local *Rhizobium* sp. isolate code IIRM$_4$	60.75 a	75.75 a	80.26 a

Note : Numbers followed by the same lowercase letters in the same column are not significantly different according to Duncan's test at the 5% level.

In addition to the quantitative differences presented in **Table 3**, the visual characteristics of root nodules formed under each treatment are illustrated in **Fig. 1**. The figure clearly shows that plants inoculated with local *Rhizobium* sp. isolates—particularly IIRM1 and IIRM4—developed a greater number of well-formed, pink, and active nodules compared to the control. The IIRM4 isolate, in particular, produced visibly larger and more abundant effective nodules, supporting the statistical results indicating its superior symbiotic performance. These visual observations further confirm the enhanced nodulation capacity induced by selected local isolates.

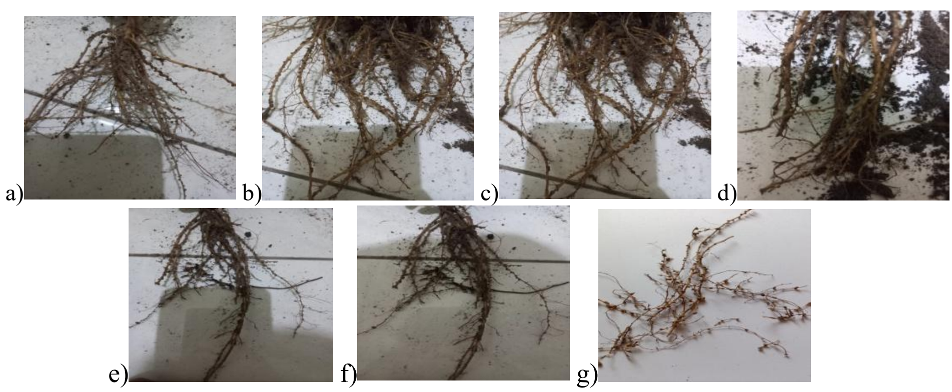

Fig. 1. Formation of Root Nodules in Different *Rhizobium* Isolates (a) Control, b) Local *Rhizobium* sp. isolate code IIDA$_5$, c) Local *Rhizobium* sp. isolate code IIDM$_1$, d) Local *Rhizobium* sp. isolate code IIDM$_2$, e) Local *Rhizobium* sp. isolate code IIRA$_2$, f) Local *Rhizobium* sp. isolate code IIRM$_1$, g) Local *Rhizobium* sp. isolate code IIRM$_4$)

The total nodules formed and the effective root nodules of peanut plants were higher than the controls. According to [7], Rhizobia inoculation on the host plant using an appropriate strain can increase the number of root nodules, thereby enhancing atmospheric nitrogen fixation and improving host plant growth. This is in accordance with the statement of [10] that organic matter given to the soil can also be used as an energy source for soil microorganisms so that it can help *Rhizobium* sp. activity in increasing the formation of root nodules.

3.4 Effects of *Rhizobium* sp. on Pod Formation and Pod Health

Based on the results of the analysis of variance, it was shown that the application of *Rhizobium* sp. had significant effect on the number of plant pods, number of healthy pods, and percentage of bernads pods. The number of peanut plant pods inoculated with *Rhizobium* sp. based on Duncan's multiple range test at the 5% level can be seen in **Table 4**. It indicates that the local *Rhizobium* sp. isolate coded IIRM4 resulted in the highest number of pods among all treatments. The treatment of local *Rhizobium* sp. isolates coded $IIRM_4$ was significantly different from the treatments of local *Rhizobium* sp. isolates coded $IIDM_2$, $IIDM_1$, $IIDA_5$, and control, but not significantly different from the treatments $IIRM_1$ and $IIRA_2$. The treatment of local *Rhizobium* sp. isolates coded $IIRM_4$ tended to produce the highest pods with full capacity compared to other treatments and was significantly different from the treatments of local *Rhizobium* sp. isolates coded $IIDM_2$, $IIDM_1$, $IIDA_5$, and control but not significantly different from the treatments of local *Rhizobium* sp. isolates coded $IIRM_1$ and $IIRA_2$. *Rhizobium* sp. isolate code $IIRM_4$ produced the highest percentage of fruitful pods, but was not significantly different from the control treatment and other isolates.

Table 4. Number of pods per plant, number of healthy pods, and percentage of bernads pods of peanut plants inoculated with *Rhizobium* sp.

Treatment of *Rhizobium* sp.	Number of pods (fruits)	Number of healthy pods (fruits)	Percentage of healthy pods (%)
Control (commercial *Rhizobium*)	29.19 c	24.87 b	83.60 a
Local *Rhizobium* sp. isolate code $IIDA_5$	30.19 bc	25.43 b	84.25 a
Local *Rhizobium* sp. isolate code $IIDM_1$	30.18 bc	26.56 b	84.99 a
Local *Rhizobium* sp.isolate code $IIDM_2$	31.00 bc	26.62b	85.31 a
Local *Rhizobium* sp. isolate code $IIRA_2$	37.38 ab	32.75 ab	85.58 a
Local *Rhizobium* sp. isolate code $IIRM_1$	41.56 a	35.56 a	85.93 a
Local *Rhizobium* sp. isolate code $IIRM_4$	44.13 a	38.62 a	87.30 a

Note : Numbers followed by the same lowercase letters in the same column are not significantly different according to Duncan's test at the 5% level.

Among isolates *Rhizobium* sp. from Riau, Riau local *Rhizobium* sp. isolates with codes $IIRM_4$ and $IIRM_1$ showed the highest yields, because they were able to increase the number of pods much higher than the isolates of *Rhizobium* sp. other Riau origin. This indicates that the two isolates belong to the type of *Rhizobium* sp. which is very effective, presumably because the *Rhizobium* sp. used is suitable for soil conditions that tend to be acidic. This is in accordance with the results of research by [11], who showed that *Rhizobium* sp. inoculation was effective in influencing the formation of pods which would occur after the fertilization process which formed a special organ, namely a gynophore. Furthermore, the gynophore will grow longer and increase the fruit containing embryo seeds to penetrate the soil. The *Rhizobium* sp. inoculation process will increase the number of root nodules so that it can affect the yield of the number of pods. The pods that have been formed will be filled with photosynthates to form seeds.

3.5 Seed Yield Response to *Rhizobium* sp. Inoculation

Based on the results of the analysis of variance, it was shown that the application of *Rhizobium* sp. had significant effect on the, weight of 100 dry seeds, and seed weight per 1.6 m^2. Dry weight of plant seeds inoculated with *Rhizobium* sp. based on Duncan's multiple range test at the 5% level can be seen in **Table 5**. **Table 5** shows that the parameter dry weight of plant seeds in the control treatment was significantly different from the treatment of local *Rhizobium* sp. isolates coded $IIRM_1$ and local *Rhizobium* sp. isolates coded $IIRM_4$, but not significantly different to the treatment of local *Rhizobium* sp. isolates coded $IIDA_5$, code $IIDM_1$, code $IIDM_1$, code $IIDM_2$, and code $IIRA_2$. Parameters for the weight of 100 dry peanut seeds in the control treatment were not significantly different between treatments except for the administration of local *Rhizobium* sp. isolate code $IIRM_4$. **Table 5** also shows that there were insignificant differences between treatments in the parameter of seed weight per plot. Administration of local *Rhizobium* sp. isolate code $IIRM_4$ had an effect on seed weight per plot and showed a significant difference with the control treatment, but not significantly different with other local isolates.

Table 5. Dry weight of plant seeds, weight of 100 dry seeds, and seed weight per 1.6 m^2 of peanut plants inoculated with *Rhizobium* sp.

Treatment of *Rhizobium* sp.	Dry weight of plant seeds (g)	Weight of 100 dry seeds (g)	Seed weight (g)
Control (commercial *Rhizobium*)	29.26 b	40.43 b	226.90 b
Local *Rhizobium* sp. isolate code $IIDA_5$	29.53 b	42.50 b	255.40 ab
Local *Rhizobium* sp. isolate code $IIDM_1$	30.02 b	43.05 b	257.08 ab
Local *Rhizobium* sp.isolate code $IIDM_2$	31.74 b	43.30 b	280.70 ab
Local *Rhizobium* sp. isolate code $IIRA_2$	37.34 ab	43.60 ab	229.85 ab
Local *Rhizobium* sp. isolate code $IIRM_1$	41.89 a	43.83 ab	306.65 ab
Local *Rhizobium* sp. isolate code $IIRM_4$	44.72 a	47.00 a	334.05 a

Note : Numbers followed by the same lowercase letters in the same column are not significantly different according to Duncan's test at the 5% level.

Parameters for the weight of 100 dry plant seeds were not significantly different between Riau local isolates and controls. This is in accordance with the opinion of [12], that adequate nutrient requirements and optimal growing media conditions will make it easier for ginophores to penetrate the soil so as to help form the optimal number of pods. According to [13], photosynthesis will produce photosynthate which will be translocated to seeds which are broken down to become assimilates with the help of respiration (C, H and O) and produce carbohydrates used for cell division which will affect the weight of 100 plant seeds.

According to [14], the amount of N fixed by *Rhizobium* sp. will increase during the flowering period (vegetative phase) and reach a maximum at the end of flowering and will decrease during the pod filling process. After the seed formation period has passed, the ability to fix N will decrease along with the increasing number of old root nodules and begin to be no longer active. This is what is thought to cause the plant stem weight to tend to be the same.

3.6 Plant Dry Weight and Plant N Uptake

Based on the results of the analysis of variance, it was shown that the application of *Rhizobium* sp. had significant effect on plant dry weight and plant N uptake. Dry weight of ground nut plants inoculated with *Rhizobium* sp. based on Duncan's multiple range test at the 5% level can be seen in **Table 6**. **Table 6** shows that the average value of dry weight loss on peanut plants in the control was significantly different to the administration of local *Rhizobium* sp. isolate code $IIRM_1$ and local *Rhizobium* sp. isolate code $IIRM_4$ but was not significantly different to the administration of local *Rhizobium* sp. isolate code $IIDA_5$, code $IIDM_1$, and code $IIDM_2$ whereas the administration of isolate local *Rhizobium* sp. code $IIRA_2$ was not significantly different from other *Rhizobium* sp. isolates. The results of N uptake of peanut plants in the $IIRM_4$ coded treatment were significantly different from those of other local *Rhizobium* sp. isolates and controls.

Table 6. Plant dry weight and plant N uptake of peanut plants inoculated with *Rhizobium* sp.

Treatment of *Rhizobium* sp.	Plant dry weight (g)	N uptake (%)
Control (commercial *Rhizobium*)	6.15 c	0.92 d
Local *Rhizobium* sp. isolate code $IIDA_5$	6.78 c	1.44 bc
Local *Rhizobium* sp. isolate code $IIDM_1$	6.85 c	1.15 d
Local *Rhizobium* sp.isolate code $IIDM_2$	8.00 bc	1.02 d
Local *Rhizobium* sp. isolate code $IIRA_2$	8.38 abc	1.25 bcd
Local *Rhizobium* sp. isolate code $IIRM_1$	9.48 ab	1.61 b
Local *Rhizobium* sp. isolate code $IIRM_4$	10.73 a	2.03 a

Note : Numbers followed by the same lowercase letters in the same column are not significantly different according to Duncan's test at the 5% level.

The results of N uptake of peanut plants in the $IIRM_4$ coded treatment were significantly different from those of other local *Rhizobium* sp. isolates and controls. The N content in the soil greatly affects the process of plant growth and production. The results of research by [15] showed that the process of increasing plant N concentrations was controlled by the soil's ability to supply N elements to the rhizosphere area for plant absorption. Uptake is influenced by conditions in the soil because before plants absorb nutrients, they will turn into ions so that the greater the plant's dry weight value and the higher the N content, the higher the N nutrient uptake will be. High plant N uptake indicates high crop production.

Recent studies have demonstrated that inoculation with *Rhizobium* significantly improved legume yield and nitrogen fixation: for example, a meta-analysis found that seed inoculation with *Rhizobium* increased grain legume yield by 40% on average compared to non-inoculated crops [16]. Moreover, field experiments on peanut (*Arachis hypogaea*) in Southeast China showed yield increases of 6.5 %–11.6 % when rhizobial inoculants were applied under conventional fertilization regimes [17]. These findings reinforce the importance of utilizing indigenous *Rhizobium* isolates adapted to acidic soils as an eco-friendly alternative to chemical nitrogen fertilizers. The application of locally adapted *Rhizobium* strains has the potential to enhance nitrogen fixation efficiency, support peanut cultivation on acid-prone lands, and promote sustainable agricultural systems through improved soil fertility and reduced dependency on synthetic inputs.

4 Conclusion

The results indicate that isolate *Rhizobium* sp. The Riau isolate coded IIRM4 is a *Rhizobium* sp. derived from the *Mucuna bracteata* plant in the Riau peatlands, and it is highly effective in forming symbiosis with peanut plants. Isolate *Rhizobium* sp. Riau local code $IIRM_4$ showed better growth and production compared to control *Rhizobium* sp.

Conflict of Interest
The authors declare no conflict of interest.

Data Availability
The data supporting this study are available upon reasonable request from the corresponding author.

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