International Journal of Agriculture and Biosciences 2024 13(4): 596-602.
https://doi.org/10.47278/journal.ijab/2024.145

RESEARCH ARTICLE
eISSN: 2306-3599; pISSN: 2305-6622

Enhancing Soil Fertilizer and Peanut Output by Utilizing Endophytic Bacteria and Vermicompost on Arsenic-Contaminated Soil

Nguyen V. Chuong * and Tran L. K. Tri

An Giang University, Long Xuyen City, An Giang province – VNU-HCM City, Vietnam
*Corresponding author: nvchuong@agu.edu.vn

ABSTRACT

The primary objective of this research is to enhance soil fertility, peanut yield, and quality by implementing bio-nitrogen-fixing microorganisms in combination with organic manures. The study evaluated the effectiveness of Enterobacter asburiae strain RA5.MM (EA strain RA5.MM) and vermicompost (VT) in conjunction with two types of irrigation water (IW) [river water (RW) and deep well water (DWW)] on soil properties, plant growth, yield, quality, and arsenic (As) accumulation in peanuts. The field study was conducted in An Phu District, An Giang Province, Vietnam, and involved three factors: (1) two VT application rates (0.0 and 10 t ha^-1); (2) two inoculation methods for EA strain RA5.MM (inoculated and non-inoculated); and (3) two irrigation water types (RW and DWW), with four replications. The results of the research indicated that inoculating with EA strain RA5.MM and applying 10 t ha^{-1} of VT and RW irrigation enhanced soil fertility and improved peanut yield components. The study also showed that EA strain RA5.MM reduced arsenic absorption in peanut plants and decreased arsenic accumulation in peanut stems and grains. Specifically, the fresh pod productivity of peanuts was higher with the 10 t ha^{-1} VT application, EA strain RA5.MM inoculation and RW irrigation, compared to treatments without EA strain RA5.MM inoculation and DWW irrigation, by 11.0, 14.3, and 23.4%, respectively. Additionally, the arsenic content in the 10 t ha^{-1} VT application, EA strain RA5.MM inoculation and RW irrigation treatments were reduced by 9.96, 12.4, and 39.2% in stems, and 12.9, 15.7, and 30.2% in seeds, respectively, compared to treatments without VT application, EA strain RA5.MM inoculation and DWW irrigation. The EA strain RA5.MM effectively reduced arsenic uptake in peanut stems and seeds, improved soil fertility, and promoted peanut growth, yield, and quality. Its resistance to arsenic is increasingly linked to the addition of vermicompost and arsenic-free irrigation water, which are promising techniques for cultivating crops in arsenic-contaminated conditions. Furthermore, EA strain RA5.MM has the potential to develop bio-organic fertilizers for future crop production.

Keywords: Arsenic, Peanut, *EA* strain RA5. MM, Vermicompost, Deep well water, River water

Article History
Article # 24-706
Received: 16-Jul-24
Revised: 13-Aug-24
Accepted: 29-Aug-24
Online First: 04-Sep-24

INTRODUCTION

Peanuts (Arachis hypogaea L.) are an oilseed and an important industrial crop worldwide (Sobolev et al., 2013). Various bacteria that reside in the roots and interact peanuts are commonly associated with nitrogen fixation and alleviating plant stress (Chen et al., 2019). Several fungal and bacterial diseases, which include leaf spot, stem and pod rot, root rot, and wilt, commonly occur in peanut cultivation. It is thought that rhizosphere endophytic bacteria (REB) in plant roots are a great source of biofertilizers and great biocontrol agents for farming (Wang and Liang, 2014; Jiang et al., 2017; Sobolev et al., 2017). They are not only involved in promoting plant growth and health, but can also transmit these benefits from one plant generation to the next (Huang & Pang 2017; Chen et al., 2019). Researchers have already found that certain bacteria, like Enterobacter sp., Bacillus spp., Curtobacter spp., and Paenibacillus spp., can help plants grow and fix nitrogen (Chen et al., 2019; Prestes et al., 2019; Mazoyon et al., 2023). Rhizosphere endophytic bacteria influence plant growth and defense by producing

Cite this Article as: Chuong NV and Tri TLK, 2024. Enhancing soil fertilizer and peanut output by utilizing endophytic bacteria and vermicompost on arsenic-contaminated soil. International Journal of Agriculture and Biosciences 13(4): 596-602. https://doi.org/10.47278/journal.ijab/2024.145

A Publication of Unique Scientific Publishers

a variety of phytohormones (Bouwmeester et al., 2019). When vermicompost (VT) and EA were added to low-nutrient soil, the yield, quality and yield components all went up significantly in an outside net house at the AGU Experimental Center. The study revealed the effect of EA species on nodule number and peanut yield in the prior crop. In the next crop, the previously experimental VC application and EA inoculation plots significantly increased plant height, biomass, number of pods, nodules, yield, and peanut seed quality compared to no VC application and no EA inoculation in the prior crop (Chuong, 2023). Arsenic (As) pollution in agricultural soil and irrigation water is a critical environmental, agricultural, and human health concern. Even low-level exposure to As can alter plant morphology, physiology, and biochemistry (Abbas et al., 2018). Peanut and other crop yields have significantly declined in recent years in An Phu district, An Giang province, Vietnam, primarily due to infertile soil and high As content in soil and water (Chuong, 2021; Chuong et al., 2021). The main cause of reduced peanut profitability for local farmers was the excessive use of chemical fertilizers and high fertilizer prices, coupled with low peanut yields. Therefore, improving this issue involves applying organic fertilizers in combination with REB strains to enhance peanut quality and yield (Chuong, 2023). REB has the ability to fix nitrogen from the air in the root zone (Massawe et al., 2017). Vermicompost application has been shown to increase peanut yield and improve soil fertility (Uko et al., 2018; Getachew et al., 2019; Peter & Michael, 2023). Using organic manures to immobilize As toxins in contaminated soil has been a well-established and widely used technology. The application of inorganic and organic amendments, which can immobilize heavy metals and As toxicology in soil, leads to increased crop yield and soil fertility (Lwin et al., 2018; Coulibaly et al., 2024). Through fertilization and adding VT, increasing peanut yield and lowering As levels in the soil can help improve soil organic matter and microbial activity (Ferreira dos Santos et al., 2024; Dourado et al., 2022). This study aimed to assess the impact of vermicompost and EA strain RA5. MM inoculation on soil fertility and peanut yield in As-contaminated agricultural systems. The research findings can provide valuable insights into the potential of these practices to improve soil health, enhance crop productivity, and reduce arsenic contamination in food. Local farmers can use this information to encourage the adoption of sustainable agricultural practices.

MATERIALS & METHODS

Isolation and Molecular Identification of EA Strain RA5. MM

EA strain RA5. MM species that isolated from peanut nodules in the farmer's fields in Phuoc Hung, An Phu at 65 days after sowing (DAS) (Hossain et al., 2023). After cleaning all fifty selected nodules from five plants (ten nodules per plant) with fresh water to remove soil, we meticulously rewashed the nodule's surface with 70% alcohol, repeatedly rinsed it with sterile distilled water, and finally soaked it in 5% NaCl for a minute. We took the cleaned nodules in 1 mL of sterilized phosphate buffer and streaked them on YMA agar plates. We diluted the YMA plates at various rates and incubated the streaked YMA plates at 28ºC for 4–5 days. We selected the pure colonies for molecular identification.

Molecular Identification of EA Strain R A5. MM

Enterobacter asburiae strain R A5. MM was extracted to collect DNA from pure colonies for 16S rRNA gene analysis to compare with the similarity of previously designed bacterial sequences. EA strain R A5. MM was isolated in the laboratory of An Giang University (Fig. 1). We amplified the 16S rRNA gene from these isolates using the 27F and 1492R primer pairs in three PCR cycles. We also found that these isolates' DNA sequences were similar to nodulose bacteria sequences that had already been published (Cardoso et al., 2018). We used NCBI BLAST technology to interpret the Sanger sequencing results, revealing a high similarity of up to 100% between the selected isolate branch and the *Enterobacter asburiae* species based on the sequencing results and phylogenetic tree (Fig. 1). We sufficiently increased the population of EA strain R A5. MM to 10^8 CFU mL^{-1} five days before sowing, followed by co-inoculation with peanut seeds and soaking in liquid YMA medium for 8–12 hours before sowing (Etesami, 2022).

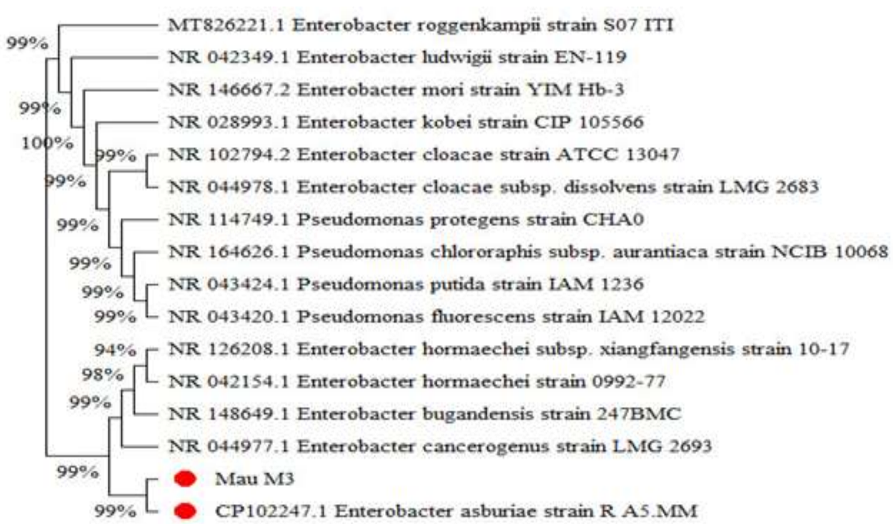

Fig. 1: Phylogenetic tree of EA strain R A5. MM

Experimental Design and Location

Phu District is located on an island with a total area of 225.3km^2 with a population of up to 200,000. It shares a border with Cambodia. The annual rainfall ranges from 500 to 650mm, with 60 to 70% falling between June and October. The average temperature ranges from 27 to 38 °C during the summer and 20 to 32°C in the winter. The field experiment in Phuoc Hung commune, Phu district, and Giang province contained eight treatments, which were organized in a completely randomized block design with four replications. We coded the eight treatments as follows: (1) no EA strain R A5 inoculation. MM, no VT amendment, and DWW irrigation; (2) no EA strain R A5. MM inoculation, no VC amendment, and RW irrigation; (3) no EA strain R A5. MM inoculation, 10t VT ha-1 amendment, and RW irrigation; (4) no EA strain R A5. MM inoculation, no VT amendment, and RW irrigation; (6) EA strain R A5. MM inoculation, no VC amendment, and DWW irrigation; (7) EA strain RA5. MM inoculation, 10t VT ha^{-1}. Three factors consisted of (factor 1) EA strain R A5. MM (inoculation and no inoculation); (factor 2) irrigation water types (RW and DWW); (factor 3) 10 t VT ha-1 amendment and no 10 t VT ha^{-1} amendment.

We used chemical fertilizers, specifically urea, superphosphate, and potassium chloride. We then converted the amounts of these fertilizers into kilograms of nitrogen, phosphorus, and potassium per hectare, using 40N:60P:60K kgha^{-1} for the eight experimental treatments. Nongnghieppho Company in Vietnam gathered vermicompost, which had total compositions of N (0.98%), P (1.05%), Kali (0.29), Ca (1.18%), and Mg (0.27). The complete experiment covered 640 m^2 (1 m wide × 20 m long × 8 plots × 4 replications). We separated two plots by 0.5m and planted them in single rows with a 25cm spacing between each plant (two seeds per hole). After achieving a maximum of three leaves, we chose one healthy plant from each hole for ongoing monitoring throughout the trial. The initial chemical characteristics of the RW were pH (5.7), whereas the DWW was pH (4.7). DWW contained 697μg L^{-1} of arsenic (As), which was not identified in RW. The WHO guidelines for arsenic in irrigation water are 50 μg/L. The WHO recommendation for arsenic level in irrigation water is 50μg/L. As a result, the arsenic concentration in the research area's DWW was ten times higher than the WHO recommendation. Long-term droughts caused by climate change have produced in a shortage of RW for crop irrigation in Phu, Giang, and Vietnam. Local farmers have been forced to irrigate their crops with DWW, which contains a high As concentration, resulting in a considerable decrease in agricultural yields and quality (Chuong & Hung, 2021). The baseline soil parameters included pH (4.97), CEC (2.627 cmol+ kg-1), soil organic matter (SOM:1.24%), total nitrogen (N:0.125%), accessible phosphorus (P:25.4mg.kg^{-1}), and exchangeable potassium (K:75.14mg.kg^{-1}). The arsenic concentration in the soil was 84.55 mg/kg (within the dike). The USDA (2019) classified the experimental soil texture as a silt sandy loam with 35.1% silt, 58.5% sand, and 6.4% lay and deemed it favorable for peanut cultivation (Rajendran et al., 2012).

Data Collection

The plant height, total chlorophyll content, available shoots, and leaf numbers were averaged for each plant at 20, 45, and 65 DAS. We selected ten plants for each treatment, observing growth and yield traits such as the number of nodules, the weight of fresh nodulose and biomass, the number of full and empty pods, the weight of 1,000 seeds, and the fresh pod yield.

Analysis Methods

We used Statgraphite XV software for the variance analysis (ANOVA). The mean comparison between variables was performed by Duncan's test with a significant difference at a P≤0.05. We calculated the data for each treatment based on three factors to determine the interaction between the experiments and these factors.

RESULTS

The Influences of EA Strain R A5. MM, VT and Two Irrigation Water Types on Soil Chemical Traits at Harvest

Research results' Table 1 proclaimed that 10 t VT ha-1 had highly significant differences (p ≤0.01) on soil pH, CEC, SOM, total N, and available P. The chemical traits of the farmland were significantly higher in the 10 t VT ha-1 fertilization treatments compared to the control treatments. Similarly, the EA strain R A5. MM inoculum made all of the soil's nutrients higher at harvest time compared to the non-bacterial inoculum, except for total nitrogen. These differences were very important (P≤0.01). When As-contaminated DWW was used to water peanut plants, the soil had fewer nutrients than when RW irrigation was used. These differences were statistically significant (P≤0.01). Meanwhile, plots of VT application, EA strain R. A5. MM inoculum, and two irrigation water types had very large interactions between them (P≤0.01). The total N did not interact with the EA strain R A5. MM inoculum in any of the experiments. Furthermore, the total N amount was insignificantly different between the VT application and the EA strain R. A5. MM inoculum (Table 1).

VT, EA strain R A5, MM inoculation, and irrigation water types all affected the soil pH, which ranged from 5.14 to 6.10 during the harvest season. All of the soil pH values in 10 t of VT, EA strain R A5, MM inoculation, and RW irrigation were higher than others. The CEC, SOM, total nitrogen, and available phosphorus levels were all higher in the experiments with 10 t VT ha-1, EA strain R A5. MM inoculation, and RW irrigation compared to the treatments without VT application, EA strain R A5. MM inoculation, and As-contaminated DWW irrigation. However, the value of total nitrogen was not statistically different between no EA strain R A5. MM inoculation and EA strain R A5. MM inoculation. The VT application (factor A), EA strain R A5, MM inoculation (factor B), and IW type (factor C) all had a very big impact (P≤0.01) on the chemical makeup of the soil. The factors also had an impact when they interacted with each other (P≤0.01).

Table 1: Chemical properties of soil at harvest season

Factors	pH	CEC (cmol⁺/kg)	SOM (%)	Total N (%)	P (mg/100g)
Vermicompost (A)					
0.0 t ha^{-1}	5.14±0.033b	6.09±0.036b	1.18±0.016b	0.09±0.008b	20.8±0.082b
10 t ha^{-1}	5.90±0.082a	6.61±0.008a	2.10±0.081a	0.14±0.032a	32.9±0.082a
EA strain R A5. MM (B)					
Yes	6.00±0.408a	7.56±0.035a	1.59±0.008a	0.11±0.008	29.6±0.163a
No	5.24±0.032b	5.05±0.041b	1.50±0.082b	0.10±0.400	25.9±0.082b
Irrigation water types (C)					
DWW	5.34±0.032b	5.23±0.025b	1.99±0.082b	0.08±0.008b	30.5±0.408b
RW	6.10±0.082a	7.98±0.008a	2.21±0.082a	0.18±0.065a	35.2±0.163a
F (AxB)	**	**	**	ns	**
F (AxC)	**	**	**	**	**
F (BxC)	**	**	**	**	**
F(AxBxC)	**	**	**	**	**

Different letters indicate significant (P≤0.01) differences in the values (mean±SD) of the same substance between different treatments. **Significant interaction between treatments. ns: Non-significant.

Table 2: Effect of VT, EA strain R A5. MM and irrigation water on the yield traits at harvest

Factors	Biomass (gr plant^{-1})	No. of full pods (pod plant^{-1})	full pod Wt. (gr plant^{-1})	Nodulose No. (nodules plant^{-1})	fresh Wt. of nodules (gr plant^{-1})	Wt. of 1,000 seeds (gr)
Vermicompost (A)						
0.0 t ha^{-1}	244±2.0b	63.8±0.653b	158±1.63b	235±4.08a	0.96±0.016b	860±8.16b
10 t ha^{-1}	282±1.63a	78.3±0.245a	176±0.957a	175±4.08b	1.27±0.016a	1,050±4.08a
EA strain R A5. MM (B)						
Yes	296±1.63a	80.8±0.653a	175±0.816a	257±1.63a	1.39±0.008a	1,050±4.08a
No	228±1.63b	64.9±0.081b	135±0.816b	155±4.08b	1.22±0.016b	840±8.16b
Irrigation water types (C)						
DWW	244±3.26	78.3±0.245	131±0.816b	181±0.817b	0.90±0.081b	870±4.08b
RW	260±4.08	76.5±0.408	171±0.816a	307±1.63a	1.70±0.081a	925±2.88a
F (AxB)	**	**	**	**	**	**
F (AxC)	**	**	**	ns	ns	**
F (BxC)	ns	**	**	**	**	**
F (AxBxC)	**	**	**	**	**	**

Different letters indicate significant (P≤0.01) differences in the values (mean±SD) of the same substance between different treatments. **Significant interaction between treatments. ns: Non-significant.

Table 3: Influences of VT, endophytic bacteria and IW on peanut yield and seed quality

Factors	Humidity	lipid	Protein	Pod yield	As contents (µg kg^{-1})	
	(%)	(%)	(%)	(t ha^{-1})	Stems	Seeds
Vermicompost (A)						
0.0 t ha^{-1}	30.0**±0.81b	25.3**±0.245b	17.3±0.245	6.53±0.025b	1,064±3.27a	116±0.816a
10 t ha^{-1}	32.0**±0.81a	25.9**±0.082a	17.4±0.245	7.34±0.033a	958±1.63b	101±0.816b
EA strain R A5. MM (B)						
Yes	32.8**±0.163a	25.8ns±0.163	17.3±0.244	7.47±0.016a	944±3.27b	99.5±0.408b
No	29.2**±0.163b	25.4ns±0.326	17.4±0.326	6.40±0.081b	1,077±1.63a	118±1.63a
Irrigation water types (C)						
DWW	30.0**±0.816b	23.5**±0.408b	15.2±0.163b	6.03±0.024b	1,260±4.98a	128±1.63a
RW	32.1**±0.081a	27.7**±0.163a	19.1±0.081a	7.87±0.057a	766±4.89b	89.3±0.244b
F (AxB)	ns	ns	ns	ns	ns	**
F (AxC)	ns	ns	ns	ns	ns	**
F (BxC)	ns	ns	**	ns	ns	**
F (AxBxC)	ns	ns	ns	ns	ns	**

Different letters indicate significant (P≤0.01) differences in the values (mean±SD) of the same substance between different treatments. **Significant interaction between treatments. ns: Non-significant.

Peanut Yield Traits

Application of VT and EA strain R A5. MM at the 1% level [expect factor (C)] water changed the peanut biomass (Table 2). The application of VT combined with the EA strain R A5. MM inoculum resulted in higher peanut biomass in all treatments, compared to the control treatments [expect Factor (C).] The interaction between the experimental factors and peanut biomass was significantly different at the 1% level [expect factor (BxC)]. The EA strain R A5. MM inoculation yielded the highest biomass (296 gr plant-1), while the treatment that solely applied NPK and As-contaminated irrigation had the lowest biomass value (244 gr plant-1) (Table 3). The number and weight of full pods and nodules made up of factor A (VT), factor B (EA strain R A5. MM), and factor C (types of irrigation water) were very different between treatments at the 1% level (P≤0.01). Additionally, significant statistical differences were observed at the 1% level among their interactions, specifically F(AxC) at the number and weight of peanut nodules. A significant statistical difference was observed at the 1% level for the weight of 1,000 seeds, specifically at F (AxBxC). Treatments with VC application, EA strain R A5. MM inoculation, and RW irrigation resulted in a higher weight of 1,000 seeds than the control treatment without VT application, no EA strain R A5. MM inoculation, and DWW irrigation. At the 1% level, Table 2's results showed a significant interaction between three factors (VT EA strain R A5. MM and irrigation water types).

Nutrition Composition and As Content of Peanut Seeds

The humidity percentage of peanut seeds significantly influenced the various VT rates (Table 3). The plots with VT application (32%) had a higher moisture content than those without VT application (30%), while the EA strain R A5. MM inoculation (32.8%) had a higher humidity percentage compared to the non-EA strain R A5. MM inoculation (29.2%). Similarly, the percentage of seed moisture in treatments with irrigating deep well water (30%) was lower than the percentage of seed humidity in RW irrigation (32.1%). There were significant differences among treatments at the 1% level in three factors, and their interactions were insignificant. The application of 10 t VT ha-1 resulted in a higher lipid content (25.9%) compared to the lipid content without VT application, which was 25.3% (control). These differences were significant at the 1% level. There wasn't a big difference between the treatments of factor B (EA strain R A5. MM inoculation) when it came to the amount of lipids present. However, the RW irrigation treatment yielded a higher lipid content than the DWW irrigation treatment. Their interactions of A×B, A×C, B×C, and A×B×C did not differ based on peanut seed lipid contents (Table 3). The interaction among the three factors showed insignificant differences [the expected F(BxC) was different at the 1% level]. The impact of the different factors was insufficient on the protein percentage of peanut seeds in factors A and B, with factor C being the most significant. DWW irrigation had a lower peanut seed protein content (15.2%) than RW irrigation (19.1%), and there were significant differences at level 1% (Table 3). Peanuts' nitrogen-fixing ability can meet the majority of their nitrogen requirements through a symbiotic relationship with REB. The fresh pod yield of three factors ranged from 6.03 to 7.87 t ha-1, with RW irrigation yielding the highest fresh pod yield and DWW irrigation yielding the lowest. At a significance level of 1%, the fresh pod yields of treatments with 10 t VT ha-1 application, EA strain R A5. MM inoculation, and RW irrigation were higher than those with non-VT application, non-EA strain R A5. MM inoculation, and DWW irrigation. However, the interaction of the experimental factors on the peanut yield was not statistically significant at the 5% level (Table 3).

Results in Table 3 showed that the application of 10 t VT per ha had a highly significant effect (P≤0.01) on the As uptake of peanut stems and seeds. The average As the concentration of peanut stems and seeds at 10 t VT ha-1 application was lower than the control treatments (without VT application). In the same way, factor B (EA strain R A5. MM inoculum) was lower in peanut stems and seeds at harvest compared to non-EA strain R A5. MM inoculation, and this difference was significant (P≤0.01). When looking at the different types of irrigation water, using DWW irrigation (As-contaminated water) led to more As building up in the stems and seeds than RW irrigation, which was statistically significant (P≤0.01). Meanwhile, plots of VT application, EA strain R A5, MM inoculum, and irrigation water types did not interact with each other in the accumulation of peanut stems. However, their interactions of A×B, A×C, B×C, and A×B×C were insignificantly different on the As contents of peanut seeds (Table 3).

DISCUSSION

The use of arsenic-contaminated water for crop irrigation resulted in a decrease in soil pH at the experimental end. This was due to adding H^+ ions from As-contaminated water to the farmland, which released H^+ ions from soil acids into a free form (Chuong & Cuong, 2021). However, the combined application of organic manures raised soil pH significantly compared to the control treatment (Chuong, 2024). We should add organic manures to As-contaminated soils to mitigate the harmful effects of heavy metals and ensure optimal plant growth and fertilizer utilization (Chuong, 2023). Adding well-decomposed organic matter and REB to arsenic-contaminated soils on a regular basis improves the soil's ability to buffer and stops sudden changes in pH. This makes it easier for plants to take in phosphorus and reduce Fe and Al levels in acidic soils (He et al., 2022; Gao et al., 2023). The integrated use of REB inoculation with organic manures is officially considered a promising approach for sustainable crop production on As-contaminated soils (Catherine et al., 2019; Chuong, 2023). This means that the plants grew taller after VT application, EA strain R A5. MM inoculation, and RW irrigation (non-As-contaminated water) than they did before VT application, EA strain R A5. MM inoculation, and DWW irrigation (As-contaminated water) (Jain et al., 2017; Chalwe et al., 2019). Li et al. (2023) attributeD these results in Table 3 to the advantageous relationship between VT application, EA strain R A5, MM inoculation, and RW irrigation with soil nutritional addition. Combining animal manure application with REB inoculation significantly increased the growth and biomass of peanuts (Yang et al., 2023). Vadthe & Umesha (2022) and Zheng et al. (2022) found in their previous research that the combination of organic manure fertilization and REB inoculation significantly increased the components and yield of peanuts. Applying VT alone or in combination with REB inoculation led to a higher weight of 1,000 peanut seeds compared to the control group (Sijilmassi et al., 2020; Vadthe & Umesha, 2022). The study's results demonstrated a significant two-way interaction between farming types and factors that enhance the quality and yield of peanut plants, including VT, nitrogen-fixing bacteria strains, and heavy metal-free irrigation water (Gao et al., 2022). The application of inorganic fertilizer combined with organic fertilizer, REB inoculation, and non-contaminated irrigation water, which help to increase the root and shoot biomass of peanuts, led to the release of readily available nutrients to the plants. Studies on other crops have shown that the use of chemical fertilizers combined with organic fertilizers has contributed significantly to increasing crop yield and quality (Sijilmassi et al., 2020; Chuong, 2024). The soil As content decreased significantly when applying organic fertilizers to peanut plants due to the lower As content in the organic manures compared to the soil, which reduced As uptake by peanut trees and seeds. We can reduce the risk of As contamination in heavily contaminated soil-plant systems by continuously applying clean organic manures (Li et al., 2019). When the right species of E. asburiae are introduced to peanut farms, the results showed that they can control how much As is absorbed and stored in plant tissues (Zhu et al., 2018). Application of organic manures, combined with REB inoculum and As-free irrigation water, helped peanut plants produce more effective shoots, leaves, flowers, and fruit (Massawe et al., 2017).

Conclusion

This study showed that using 10 tons of VT ha-1, EA strain RA5.MM inoculation, and As-free irrigation together greatly improved the fertility of the soil, peanut yield, and quality. Moreover, this approach effectively reduced As accumulation in peanut plants. In comparison to the control treatment, the yield of peanuts increased by up to 23.4%, while the concentration of As in both stems and seeds decreased by up to 30.2%. These results show that using vermicompost, biofertilizers, and clean irrigation water together might help lessen the bad effects of arsenic contamination on food security and crop yield.

Acknowledgement

This research is funded by Vietnam National University HoChiMinh City (VNU-HCM) under grant number C2023-16-04

REFERENCES

Abbas, G., Murtaza, B., Bibi, I., Shahid, M., Niazi, N.K., Khan, M.I., Amjad, M., & Hussain, M. (2018). Natasha. Arsenic Uptake, Toxicity, Detoxification, and Speciation in Plants: Physiological, Biochemical, and Molecular Aspects. *International Journal of Environmental Reserch Public Health,* 15(1),59. https://doi:10.3390/ijerph15010059

Bouwmeester, H., Schuurink, R.C., Bleeker, P.M., & Schiestl, F. (2019). The role of volatiles in plant communication. *Plant Journal,*100(5), 892-907. https://doi:10.1111/tpj.14496

Cardoso, P., Alves, A., Silveira, P., Sá, C., Fidalgo, C., Freitas, R., & Figueira, E. (2018). Bacteria from nodules of wild legume species: Phylogenetic diversity, plant growth promotion abilities and osmotolerance. *Science of Total Environment, 15*, 645,1094-1102. https://doi:10.1016/j.scitotenv.2018.06.399

Catherine, M., Moses, T., Cargele, M., Joseph, G., & Bernard, V. (2019). Variability of soybean response to rhizobia inoculant, vermicompost, and a legume-specific fertilizer blend in Siaya County of Kenya. *Soil and Tillage Research*, *194,*104290. https://doi.org/10.1016/j.still.2019.06.007

Chalwe, H. M., Lungu, O. I., Mweetwa, A. M., Phiri, E., Njoroge, S. M. C. Brandenburg, R. L., & Jordan, D. L. (2019). Effects of Compost Manure on Soil Microbial Respiration, Plant-Available-Water, Peanut (*Arachis hypogaea* L.) Yield and Pre-Harvest Aflatoxin Contamination. *Peanut Science*, *46*,42-49. https://doi.org/10.3146/PS18-6.1

Chen, L., Shi, Heng, J., Wang, D., & Bian, K. (2019). Antimicrobial, plant growth-promoting and genomic properties of the peanut endophyte Bacillus velezensis LDO$_2$. *Microbiological Research,* 218, 41–48. https://doi.org/10.1016/j.micres.2018.10.002

Chuong, N.V, Nghiep, H.X., & Loan, L.T.T. (2021). Influences of lime and irrigation water on arsenic accumulation of rice, maize and mungbean in the nethouse condition," *Nat. Volatiles & Essential Oils,* 8, 4019-4027.

Chuong, N.V. (2021). The influences of lime and irrigation water on arsenic accumulation of rice, maize and mungbean in the nethouse condition. *Communications in Science and Technology*, 6(2), 101-106. https://doi.org/10.21924/cst.6.2.2021.515

Chuong, N.V. (2023). Response of peanut quality and yield to chicken manure combined with Rhizobium inoculation in sandy soil. *Communications in Science and Technology, 8*(1), 31-37. https://doi.org/10.21924/cst.8.1.2023.1082

Chuong, N.V. (2023). The impact of *Klebsiella quasipneumoniae* inoculation with nitrogen fertilization on baby corn yield and cob quality. *Eurasian Journal of Soil Science*, *13*(2), 133-138. https://doi.org/10.18393/ejss.1408090

Chuong, N.V. (2024). Effect of Three Different Nitrogen Rates and Three Rhizosphere N2- Fixing Bacteria on Growth, Yield and Quality of Peanuts. *Trends in Sciences*, 21(3), 7281. https://doi.org/10.48048/tis.2024.7281

Chuong, N.V. (2024). Three new species of endophytic nitrogen fixing bacteria and their effects on soil fertility, baby corn yield and their chemical nitrogen fertilizer use. *Kexue Tongbao/Chinese Science Bulletin (CSB), 1*, (2), 963-975.

Chuong, N.V., & Hung, H.T. (2021). Evaluation of arsenic pollution ability in soil, water, seed and effects of lime on the arsenic uptake and yield of mung beans. *Turkish Online Journal of Qualitative Inquiry*, *12 (*6), 061 – 1066.

Coulibaly, K., Sako, A., Bloor, M., & Liu, Y. T. (2024). Geostatistical modelling of physico-chemical properties of soils impacted by artisanal gold mining and farming: implications for soil environmental quality assessment. *Sustainable Environment,* 10(1). https://doi.org/10.1080/27658511.2024.2333631

Dourado, P.R.M., Souza, E.R., Santos, M.A.D., Lin, C,M,T,, Monteiro, D.R., Paulino, M.K.S.S., & Schaffer, B. (2022). Stomatal Regulation and Osmotic Adjustment in Sorghum in Response to Salinity. *Agriculture*, 12(5), 658; https://doi.org/10.3390/agriculture12050658

Etesami, H. (2022). Root Nodules of Legumes: A Suitable Ecological Niche for Isolating Non-Rhizobial Bacteria with Biotechnological Potential in Agriculture. *Current Research in Biotechnology,* 4,78–86. https://doi.org/10.1016/j.crbiot.2022.01.003

Ferreira dos Santos, M., Filho, P.F.M., Gomes de Sousa, G., Henrique da Costa Freire, M., Eduardo da Silva Lopes, B., Bezerra da Silva, E., Nunes da Luz, L., Prudêncio de Araújo Pereira, A., Vanessa Pires de Souza, M. (2024). Inoculation of nitrogen-fixing bacteria to mitigate the negative effect of brackish water on peanuts. *Australian Journal of Crop Science*, 18(06), 299-304. https://doi.org/10.21475/ajcs.24.18.06.pne41

Gao, F. Li, H., Mu, X., Gao, H., Zhang, Y., Li, R., Cao, K., & Ye, L. (2023). Effects of Organic Fertilizer Application on Tomato Yield and Quality: A Meta-Analysis. *Applied Science*, 13, 2184. https://doi.org/10.3390/app13042184

Gao, T., Wang, H., Li, C., Zuo, M., Wang, X., Liu, Y., Yang, Y., Xu, D., Liu, Y., & Fang, X. (2022). Effects of Heavy Metal Stress on Physiology, Hydraulics, and Anatomy of Three Desert Plants in the Jinchang Mining Area, China. *International Journal of Environmental Research Public Health, 19*(23), 15873. https://doi: 10.3390/ijerph192315873

Getachew, B., Birhanu, T., & Terefe, F. (2019). Effects of nitrogen, phosphorus and vermicompost on groundnut yield in Babile District, eastern Ethiopia. *Oil Crop Science,* 4, 75-89. https://doi.org/10.1016/j.ocsci.2023.07.001

He, H., Feng, Y., Wang, H., Wang, B., Xie, W., Chen, S., Lu, Q., Feng, Y., & Xue, L. (2022). Waste-based hydrothermal carbonization aqueous phase substitutes urea for rice paddy return: Improved soil fertility and grain yield. *Journal of Cleaner Production,* 344, 31135. https://doi.org/10.1016/j.jclepro.2022.131135

Hossain, M.S., DeLaune, P.B., & Gentry, T.J. (2023). Microbiome analysis revealed distinct microbial communities occupying different sized nodules in field-grown peanut. *Frontiers in Microbioloy*, *2*(14), 1075575. https://doi:10.3389/fmicb.2023.1075575

Huang, S., & Pang, F. (2017). Biocontrol Agents for Controlling Wheat Rust. *Methods in Molecular Biology*, 1659:277-288. https://doi.org/10.1007/978-1-4939-7249-4_24

Jain, N. K., Meena, H. N., & Bhaduri, D. (2017). Improvement in Productivity, Water-Use Efficiency, and Soil Nutrient Dynamics of Summer Peanut (*Arachis hypogaea* L.) through Use of Polythene Mulch, Hydrogel, and Nutrient Management. *Communications in Soil Science and Plant Analysis, 48*(5), 549–564. https://doi.org/10.1080/00103624.2016.1269792

Jiang, G., Wei, Z., Xu,J., Chen, H., Zhang, Y., & She, X. (2017). Bacterial wilt in China: history, current status, and future perspectives. *Frontiers in Plant Science*, 8, 1549. https://doi:10.3389/fpls.2017.01549

Li, L., Zhang, Z., Pan, S., Li, L., & Li, X. (2019). Characterization and Metabolism Effect of seed endophytic bacteria associated with peanut grown in South China. *Frontiers in Microbiology, 13*;10,2659. https://doi:10.3389/fmicb.2019.02659

Li, X., Jiang, T., Wu, C., Kong, Y., Ma, Y., Wu, J., Xie, X., Zhang, J., & Ruan, Z. (2023). Molecular epidemiology and genomic characterization of a plasmid-mediated mcr-10 and blaNDM-1 co-harboring multidrug-resistant *Enterobacter asburiae. Computational and Structural Biotechnology Journal, 28*, 3885-3893. https://doi.org/10.1016/j.csbj.2023.08.004

Lwin, C.S., Seo, B.H., Kim, H.U., Owens, G., & Kim, K.R. (2018). Application of soil amendments to contaminated soils for heavy metal immobilization and improved soil quality-a critical review. *Soil Science and Plant Nutrition*, 64(2), 156–167. https://doi.org/10.1080/

00380768.2018.1440938

Massawe, I., Prosper, Mtei, M., Kelvin, Munishi K., Linus, Ndakidemi, & Patrick, A. (2017). Effects of Rhizobium inoculation and cropping systems on macronutrients uptake and partitioning in two legumes (Common bean and Lablab). *Indian Journal of Agricultural Research,* 51(3), 206-213. https://doi:10.18805/ijare.v51i03

Mazoyon, C., Hirel, B., Pecourt, A., Catterou, M., Gutierrez, L., Sarazin, V., Dubois, F., & Duclercq, J. (2023). Sphingomonas sediminicola Is an Endosymbiotic Bacterium Able to Induce the Formation of Root Nodules in Pea (Pisum sativum L.) and to Enhance Plant Biomass Production. *Microorganisms,* 11(1):199. https://doi:10.3390/microorganisms11010199

Peter, T.M, & Michael, P.S. (2023). Sweet potato is a strategic root crop in Oceania: A synthesis of the pastresearch and future direction [Review]. *Sains Tanah Journal of Soil Science and Agroclimatology*, 20(1), 51-65. https://dx.doi.org/10.20961/stjssa.v20i1.66319

Prestes, F.S., Pereira, A.A.M., Silva, A.C.M., & Pena ,P.O., (2019). Nascimento M.S."Effects of peanut drying and blanching on Salmonella spp. *Food Research International*, 119, 411-416. https://doi.org/10.1016/j.foodres.2019.02.017

Rajendran, G., Patel, M.H., & Joshi, S.J. (2012). Isolation and characterization of nodule-associated *Exiguobacterium* sp. from the root nodules of fenugreek (*Trigonella foenum-graecum*) and their possible role in plant growth promotion. *International Journal of Microbiology,* 2012, 693982. https://doi:10.1155/2012/693982

Sijilmassi, B., Filali-Maltouf, A., Boulahyaoui, H., Kricha, A., Boubekri, K., Udupa, S., Kumar, S., & Amri, A. (2020). Assessment of Genetic Diversity and Symbiotic Efficiency of Selected Rhizobia Strains Nodulating Lentil (*Lens culinaris Medik*.). *Plants (Basel)*, *10* (1), 15. https://doi:10.3390/plants10010015

Sobolev, V., Arias, R., Goodman, K., Walk, T., Orner, V., & Faustinelli, P. (2017). Suppression of aflatoxin production in Aspergillus species by selected peanut (Arachis hypogaea) stilbenoids. *Journal of Agricultural and Food Chemistry*, 66,118–126. https://doi:10.1021/acs.jafc.7b04542

Sobolev, V.S., Orner, V.A., & Arias, R.S. (2013). Distribution of bacterial endophytes in peanut seeds obtained from axenic and control plant material under field conditions. *Plant Soil,* 371, 367–376. https://doi.10.1007/s11104-013-1692-2

Uko, A.E., Effa, E.B., & Isong, A.I. (2018). Tillage Methods and Poultry Manure Application Effects on the Growth and Yield of Groundnut (*Arachis hypogaea* L.) in Calabar, Nigeria. *Journal of Agronomy,* 17, 188-197. https://doi:10.3923/ja.2018.188.197

USDA, (2019). *A Basic System of Soil Classification for Making Sand Interpreting Soil Surveys* (Handbook 436). Washington, DC: Natural Resources Conservation Service, U.S. *Department of Agriculture*, 2019.

Vadthe, J. N., & Umesha, C. (2022). Effect of organic manures and bio-fertilizers on growth and yield of Groundnut (*Arachis hypogaea* L.). *The Pharma Innovation Journal*, 11(5), 1249-1251.

Wang, X., & Liang, G. (2014). Control efficacy of an endophytic Bacillus amyloliquefaciens strain BZ6-1 against peanut bacterial Wilt, Ralstonia solanacearum. *Biomed Research International*, 2014, 465435. https://doi:10.1155/2014/465435

Yang, W. T., Li, G. D., Li, J. N., Zhang, X. M., & Zhang, A. L. (2023). Comparative analysis of rhizosphere and endophytic microbial communities between root rot and healthy root of *Psammosilene tunicoides*. *Current Microbiology, 80*, 215. https://doi.org/10.1007/s00284-023-03290-4

Zheng, Y., Lin, L., Wenjuan, Z., Siyuan, X., Siyu, C., Jing, L. Q. X., Feng, G., & Shile, L. (2022). Nitrogen fertilizer amount has minimal effect on rhizosphere bacterial diversity during different growth stages of peanut. *The Journal of Life and Environment Science, 10,* e13962. https://doi:10.7717/peerj.13962

Zhu, T., Yang, C., Wang, J., Zeng, S., Liu, M., Yang, J., Bai, B., Cao, J., & Chen, X. (2018). Bacterivore nematodes stimulate soil gross N transformation rates depending on their species. *Biology and Fertility of Soils,* 54(1), 107-118. https://doi.org/10.1007/s00374-017-1244-7