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EFFECTS OF BACTERIUM BS1897 AND SAWDUST ON YIELD AND ARSENIC UPTAKE OF MUNG BEAN PLANTS

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Abstract

A field experiment was designed with six treatments and four replicates with the main goal of ascertaining the impacts of sawdust and Bacterium BS1897 on soil properties, arsenic accumulation and yield of mung beans. The results showed that the Bacterium BS1897 inoculation combined with sawdust application, increased the soil nutrients and reduced arsenic content of mung bean. Arsenic content in stems (96.3 µg/kg) and in seeds (7.37 µg/kg) of the mung beans in treatment of 10-ton sawdust/ ha was lower than that of the control by 24.2% and 41.0%, respectively. The Bacterium BS1897–sawdust treatment increased pH, OM, total N, available P, exchangeable K and CEC in the soil, and the mung bean Yield in both sawdust application and Bacterium BS1897 inoculation was higher than that of the control treatment by 17.5% in sawdust addition group and 6.39% in Bacterium BS1897 group, respectively. The application of The Bacterium BS1897–sawdust reduced the uptake of arsenic and increased the soil fertility and yield of the mung beans. The greatest results were obtained from use of 10 ton sawdust/ha + 40 kg N+60 kg P + 60 kg K per ha and Bacterium BS1897.

Keywords: *Arsenic, Bacterium BS1897, mung bean, sawdust, yield*

1. INTRODUCTION

Mung bean (*Vigna radiate)* is an available food source for humans, which contains highly nutritional ingredients. Mung beans that are legumes, have the ability to fix nitrogen and beneficial to the soil. Its positively effects bring the fertility of the soil and the yield of the following crops (*Khan et al.,* 2018). Further, nutritional ingredients of mung bean contain twice as much nitrogen as other cereals and help to reduce a number of diseases such as anemia and ailments related to old age, including heart disease, cancer, diabetes and obesity. (Itoh et al., 2006; Anwar et al. 2007). Relationship between Food safety and environmental food, which need to be more care towards bio-fertilizer and bio-pesticides agriculture sector around the world. Plant growth promoting *rhizobacteria* (PGPR) are functional group of bacteria having immense potential as bio-fertilizers and bio-pesticides. Depending upon their function, they may serve as partial replacements for chemical fertilizer or pesticides as an eco-friendly and cost-effective alternative as compared to their synthetic counterparts. Therefore, isolation, characterization and practical evaluation of PGPRs having multifaceted beneficial characteristics, are essentially required. This study describes the detailed of Bacillus sp. S4 and S8 PHA accumulating bacterial isolates having plant growth promoting traits (Khan *et al.,* 2018). Plants have been restricted and stressed by very high arsenic (As) concentration in the crop soil, which lessens food quality and plant yield. Arsenic accumulation levels of soil and irrigation water have seriously increased and reduced the yield and quality of many different plants (Bailey-Serres *et al.,* 2012). Arsenic toxicology affects to human's health, plants and exists in agricultural soil, irrigation water and air environments

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around the world (Alam *et al.,* 2011). According to prior studies of Trai and Chuong, (2022, showed that tillers used As polluted deep well water to irrigate their crops, and As accumulation in the soil from As polluted water poses a serious threat to sustainable agricultural systems (Gillispie *et al.,* 2015). 69.6 % of tillers in An Phu district, who have been using a deep well water to irrigate their crops (Chuong and Hung, 2021). Co-application of lime with rice husk ash reduced the uptake of As and raised the soybean yield. The treatment of the lime–rice husk ash application raised pH and EC in the soil and the reduced as content of soybean stems and seeds were 81.0 and 27.0 µg/kg, respectively. Added application of lime with rice husk ash raised the maximum yield (7.59 tons/ha), in comparison with the minimum yield (4.63 tons/ha) in the control treatment (Chuong and Chinh, 2018). The sawdust, which is a biological absorbent, is derived from plants, and has a removing capable of toxic metals from pollution water. The sawdust uptake mechanism that was mainly related to ion exchange reactions between arsenate and arsenide ions, was trapped on the surface by the positively charged ions present in the sawdust (Trang and Nguyen, 2023). 90.2% of as concentration was mainly removed by ion exchange of three algal biomass (Christobel and Lipton, 2015). PGPR plays a important role in disintegrating organic matter and forming humic soil of positive microorganisms in soil and raising to improve soil nutrients, and these substances are responsible for providing carbon to the soil and are essential for almost beneficial microorganisms that live in soil. Reducing As content of crop soil and irrigation water by the sawdust could help plants to grow well and increase yield in as polluted soil and irrigation water (Trang and Nguyen, 2023). Therefore, sawdust addition and *Bacterium* BS1897 are an indispensable technology that reduces the soil as content, raises higher yield and enhances soil quality (Kamaruzzaman *et al*., 2014).

2. MATERIALS AND METHODS

2.1. Description of the experimental location and design

The field experiment, which was designed in Quoc Thai, An Phu, An Giang province, Vietnam, consisted of six treatments (Table 1): MB1-(NPK:40N-60P-60K kg/ha without sawdust and no *Bacterium* BS1897 inoculant), MB2 (NPK without sawdust and *Bacterium* BS1897 inoculant); MB3 (NPK + 5.0 tons sawdust/ha and no *Bacterium* BS1897 inoculant), MB4 (NPK + 5.0 tons sawdust/ha and *Bacterium* BS1897 inoculant), MB5 (NPK + 10.0 tons sawdust/ha and no *Bacterium* BS1897 inoculant) and MB6 (NPK+10.0 tons sawdust/ha and *Bacterium* BS1897 inoculant), four repeats in soil inside the dyke. Usage of deep well water watering during the crop, with the whole experimental area equivalent to 192 m^2 (2 m in width × 4 m in length x 6 treatments x 4 replications), planted with a distance of 50 cm × 30 cm (three seeds/hole) in a single row.

2.2. Sample collection

Soil samples were collected before the experimental design and at harvest on each repeat and treatment, agronomy composition were observed during the growth time of mung beans. The yield and yield composition of the mung beans were collected at harvest, and as content was analyzed by the atomic absorption method.

Table 1: Application and *Bacterium* BS1897 inoculation of experimental treatmants

Treatment	Bacterium BS1897 (10^8 CFU/g)	sawdust (ton/ha)	N,P,K (kg/ha)
MB1	uninoculated	0	40-60-60
MB2	inoculated	0	
MB3	uninoculated	5.0	
MB4	inoculated	5.0	
MB5	uninoculated	10.0	
MB6	inoculated	10.0	

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Table 2: Soil chemical properties at the first of the experiment (n=15 and 0-20 cm in depth)

Properties	Value	Properties	Value
Sand (%)	31.1	Total N (mg/ kg)	114
Clay (%)	37.0	Available P (mg/ kg)	493
Silt (%)	31.9	Available K (mg/ kg)	612
Soil pH	6.39	Total Ca (%)	11.0
OOM (%)	2.26	As in soil (mg/kg)	56.1
CEC ($cmol^+$/kg)	4,79	As in deep well water (µg/ kg)	379

2.3. Statistical analysis

Study data were statistically analyzed by least significant differences (LSD) tests at the 5% level of significance according to procedures outlined by using the Statgraphics xv program.

3. RESULTS AND DISCUSSION

3.1. Soil properties

The results in Table 3 showed that the soil pH after the experiment had significant differences among treatments at the level 1%. After the experiment, the soil pH value had an increase in the treatments compared to the soil pH before the experiment (6.39), and ranged from 6.46 to 7.90. Treatment of Bacterium BS1897 inoculation and 5.0 ton sawdust /ha with the highest soil pH of 7.90, the application of sawdust at the level of 5.0 tons/ha raised the soil pH quite high (7.9) compared to the appropriate pH threshold for growth. When strains (7.37) or no strains (7.14) Rhizobium sp. both increase soil pH. However, when combined with 10 tons sawdust/ha with *Bacterium* BS1897 inoculation (6.8) or fertilizing 10 tons sawdust/ha alone (6.68) helped increase suitable soil for plants growth (6.1 – 7.0) (Van & Nguyen, 2021). Soil after adding sawdust and *Bacterium* BS1897 inoculation was a soil pH increase in soil pH. This result is also found in the study of Hirtha et al., (2009) showed that the treatments applied with microbial organic fertilizers increased soil pH.

The CEC content after the experiment ranged from 4.86 to 7.98 $cmol^+$/kg. There were significantly statistical differences among treatments at level 1%. Sawdust application at the level of 10 tons/ha had the highest CEC increase (6.61 $cmol^{+/}$kg) compared to CEC before the experiment (4.79 $cmol^+$/kg). Besides, the addition of *Bacterium* BS1897 inoculation also increased CEC (7.56 $cmol^+$/kg). Through the statistical results of Table 3, the interaction of sawdust and *Bacterium* BS1897 inoculation at the level 1%. The results also showed that the treatment of *Bacterium* BS1897 inoculation and fertilizing 10.0 tons of sawdust per ha had the highest CEC index (7.98 $cmol^+$/kg) and all treatments had a higher CEC index than the initial CEC index of experiment. The treatment of *Bacterium* BS1897 inoculation and fertilizing 10.0 tons of sawdust per ha had was the highest CEC (7.98 $cmol^+$/kg) and lowest CEC in the treatment with only NPK (4.86 $cmol^+$/kg). After the experiment, all treatments increased the CEC index in the soil compared to the control treatment (4.79 $cmol^+$/kg) and there was a statistical difference between the treatments at the 1% significance level. According to research by (Emerson Nafziger, 2016) that the higher the CEC index in the soil, the higher the ability to retain N in the soil. The application of 10.0 tons of sawdust and the *Bacterium* BS1897 inoculation. It helps the soil have a high CEC and helps plants reduce N loss through leaching and denitrification.

The average organic matter (OM) of soil valued from 1.17 to 2.10% at three sawdust rates of 0.0, 5.0 and 10.0 tons/ha, and significantly different at level 1% among the treatments. The maximum average value of OM (2.10%) was obtained by the co-application of sawdust (MB5 & MB6). In contrast, the average OM content without sawdust amendment (1.18%) resulted in the lowest value. The OM

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content in the soil after the experiment almost increased when the fertilizer contained biochar, lime and NPK (Chuong, 2019). Furthermore, different types and rates of OM and different rates also affected the levels of organic matter in the soil. The application of organic manure may increase soil organic carbon content because organic manure contained the soil Carbon element (Adônis and Nand, 2010).

Table 3: pH, CEC and OM of soil at harvest

FACTOR	Soil pH	CEC ($cmol^+/kg$)	OM (%)
Sawdust ton/ha (A)			
S1: 0	7.11^b	6.06^c	1.18^c
S2: 5	7.87^a	6.19^b	1.35^b
S3: 10	6.71^c	6.58^a	2.10^a
***Bacterium* BS1897 (B)**			
IN: inoculation	7.34^a	7.52^a	1.59^a
NO: No inoculation	7.11^b	5.01^b	1.50^b
F (A)	**	**	**
F (B)	**	**	**
F (AxB)	**	**	**
CV (%)	11.8	11.1	12.5

(**) significantly different at level 1%

The average total N of soil valued from 168 to 181 mg/kg at three sawdust rates of 0.0, 5.0 and 10.0 tons/ha, and insignificantly different at level 5% among three groups. Similarly, the average value of N at two groups (*Bacterium* BS1897 inoculation and no *Bacterium* BS1897 inoculation) ranged from 172 to 179 mg/kg and insignificantly different at level 5% between two groups (Table 4).

Results of the average available P, which identically resulted the average total N of soil, valued from 280 to 300 mg/kg at three sawdust rates of 0.0, 5.0 and 10.0 tons/ha, and insignificantly different at level 5% among the treatments. (Table 4). The average value of available P at two *Bacterium* BS1897 groups (inoculation and no inoculation) ranged from 280 to 300 mg/kg and insignificantly different at level 5% between two groups (Table 4). Application of sawdust did not increase total N and available phosphorous in high As polluted soils (Trang and Nguyen, 2023). The results in Table 4 show that application of sawdust and *Bacterium* BS1897 inoculation increased the soil exchangeable K content. The highest potassium (410 mg/kg) was obtained in the group S3, the lowest available potassium of group S2 (380 mg/kg) was found in amendment of 5.0-ton sawdust and and insignificantly different at level 1% among three groups (Table 4). However, the average value of available P at two *Bacterium* BS1897 groups (inoculation and no inoculation) ranged from 390 to 400 mg/kg and insignificantly different at level 5% between two groups. Chuong and Chinh (2019), likewise, proved that the highest available potassium was present in soil that had added the sawdust and lime as fertilizer. The above results proved that co-application of sawdust combined with *Bacterium* BS1897 inoculation could both increase available K and reduce K leaching in soil.

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Table 4: Total N, available P and exchangeable K of at harvest

FACTOR	Total N	Available P	Exchangeable K
	(mg/kg)		
Sawdust ton/ha (A)			
S1: 0	181	280	400[a]
S2: 5	177	290	370[b]
S3: 10	168	300	410[a]
***Bacterium* BS1897 (B)**			
IN: inoculation	172	300	390
NO: No inoculation	179	280	400
F (A)	ns	ns	**
F (B)	ns	ns	ns
F (AxB)	ns	ns	**
CV (%)	12.8	10.1	15.3

(**) significantly different at level 1%, ns: insignificant difference at level 5%.

3.2. Yield and as contents of stems and seeds of mung bean

Results in Table 5 showed that the average As concentration or mung bean stems and seeds valued from 96.3 to 127 µg/kg and 7.37 to 11.5 µg/kg at three sawdust rates of 0.0, 5.0 and 10.0 tons/ha, respectively, and significantly different at level 1% among the treatments. (Table 4). The highest As concentration of stems and seeds was 127 and 11.5 µg/kg, respectively, in the group S1 (without sawdust) and lowest As value of stems (96.3 µg/kg) and seeds (7.37 µg/kg) in the group S3 (sawdust application: 10 tons /ha). Furthermore, the average As value of stems and seeds at two *Bacterium* BS1897 groups (inoculation and no inoculation) ranged from 103 to 114 µg/kg and 9.51 to 10.6 µg/kg, respectively, and significantly different at level 1% between two groups. The As concentration of stems and seeds in the *Bacterium* BS1897 inoculation treatments was lower than without *Bacterium* BS1897 treatments from 9.7 to 10.3 %, respectively. Bush and Chuong (2023) discovered that treatment of sawdust amendment and *Priestia aryabhattai* M2C inoculation reduced the As absorption of mung bean stems and seeds, so As toxicology was retained more in the soil than in the control treatments. Long-term usage of contaminated water in order to irrigate for crops raised as store in the agricultural soil Brammer and Ravenscroft, 2009).

Table 5: As contents in seeds and stems and yield of mung bean

FACTOR	Arsenic concentration (µg/kg)		Yield (ton/ha)
	stems	seeds	
Sawdust ton/ha (A)			
S1: 0	127[a]	12.5[a]	1.94[c]
S2: 5	104[b]	10.4[b]	2.09[b]
S3: 10	96.3[c]	7.37[c]	2.35[a]
***Bacterium* BS1897 (B)**			
IN: inoculation	103[b]	9.51[b]	2.19[a]
NO: No inoculation	114[a]	10.6[a]	2.05[b]
F (A)	**	**	**
F (B)	**	**	**
F (A x B)	**	**	*
CV (%)	15.0	22.6	9.1

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(*,**) significantly different at level 5 and 1%.

Table 5 demonstrates that there were significant effects of sawdust and *Bacterium* BS1897 inoculation treatments on mung bean yield. The mung bean yield value from 1.94 to 2.35 tons/ha at three group of sawdust rates of 0.0, 5.0 and 10.0 tons/ha, and insignificantly different at level 1% among the treatments. The highest yield was 2.35 tons/ha in the group S3 (10 tons of sawdust) and lowest yield (1.94 tons/ha) in the group S1 (without sawdust). Furthermore, the average yield of mung bean at no *Bacterium* BS1897 inoculation group (NO) (2.05 tons/ha) was lower 7.76% than *Bacterium* BS1897 inoculation group (IN:2.19 tons/ha) and significantly different at level 1% between two groups. Amendment of 10-ton chicken manure/ha and *Rhizobium* inoculum promoted soil fertility and decreased as store of mung bean seeds (55.1%) compared with only NPK. The mung bean yield increased 23.4% to compare with control treatment (Le Ngoc Tuan and Nguyen Van Chuong, 2022). In generally, all composition such as pH, CEC, OM, available P, exchangeable K in soil, yield, As (stems and seeds) of mung bean were interaction between sawdust and *Bacterium* BS1897 from 5 to 1% except total nitrogen

4. CONCLUSION

Application of sawdust combined with *Bacterium* BS1897 inoculum improved soil nutrients and decreased as accumulation in the stems and the seeds of mung beans. The yield of mung beans increased by 17.5 and 11.1% to compare without sawdust and 5.0-ton sawdust/ ha application, respectively. *Bacterium* BS1897 inoculum had had higher mung bean yield than no *Bacterium* BS1897 inoculum and positively interacted with sawdust application.

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