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EFFECTS OF RICE HUSK BIOCHAR, SAWDUST AND PRIESTIA ARYABHATTAI M2C ON THE PRODUCTIVITY AND ARSENIC ACCUMULATION OF SOYBEANS

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Abstract

Association of rice husk biochar, sawdust and Priestia aryabhattai M2C inoculant can impact on soil chemical compositions, yield components and the yield and arsenic accumulation of the soybean. The experimental design had all five treatments, which consisted of SB1(20N-30P-40K kg/ha); SB2 (20N-30P-40K kg/ha+Priestia aryabhattai M2C inoculant); SB3 (20N-30P-40K kg/ha+ Priestia aryabhattai M2C inoculant + 10 tons sawdust/ha); SB4 (20N-30P-40K kg/ha + Priestia aryabhattai M2C inoculant + 10 tons rice husk biochar /ha) and SB5 (20N-30P-40K kg/ha+ Priestia aryabhattai M2C inoculant + 5.0 tons rice husk biochar /ha +5.0 tons sawdust/ha) and four replications. Studied results showed that application of the rice husk biochar, sawdust amendment combined with Priestia aryabhattai M2C inoculant drastically raised the soil pH and lessened soil acidity. Furthermore, results also proved that amended treatments of rice husk biochar, sawdust combined with Priestia aryabhattai M2C inoculant significantly raised the agronomy and lessened the As uptake of soybean. In three amended treatments (SB3, SB4 and SB5) of Priestia aryabhattai M2C inoculant combined with rice husk and/or sawdust biochar was better in plant hights, tillers; pod number, pod weight, biomass and weight of 1,000 seeds. Yield and as uptake of soybean were also significantly affected by rice husk biochar, sawdust biochar application and Priestia aryabhattai M2C inoculant at five trials. Amendment of SB5, which produced the highest value of yield (2.15 tons/ha), was higher 25.1% than that of SB1 treatment (1.6 tons/ha). The sawdust amendment treatment (SB3) was the minimum as accumulation of roots, sterms and seeds in soybean in five trials. In general, addition of Priestia aryabhattai M2C inoculant (SB2) was better than SB1 (NPK application only) in all properties of cultivation soil and growth, yield, as accumulation in soybean.

Keywords: Arsenic, Priestia aryabhattai M2C, rice husk biochar, sawdust, soybean.

1. INTRODUCTION

In the natural environment, the relationship between plants and other organisms in the soil, which forms a flora and soil fauna. These relationships determine the diversity of the soil microbiota, although not all of these relations are positive for the plants. Rhizobium bacteria, which has found in the rhizosphere of crops colonize and interacted with crop roots. Although symbiotic species of rhizobium exist, the term “rhizobacteria” has used only in the context of mutually positive and symbiotic associations in which the bacteria assist in the development of crop. That is reason why these bacteria are named plant growth promoting rhizobia (PGPR) (Vessey, 2003; Lugtenberg & Kamilova, 2009).

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Promoting crop growth could conduct the direct promotion of phytohormonal activity, raising root surface, raising tolerance to crop diseases (Lucy et al., 2004; Dodd, et al., 2010). These phenomena, which have been found out in PGPR relations with main plants such as canola (Bertrand, (Lucy et al., 2001), pepper (Kokalis-Burelle et al., 2006), tomato (Porcel et al., 2014), cereals and legumes (Perez-Montano et al., 2014), and forest trees (Chanway, 1997; Garcia et al., 2004). plant growth promoting rhizobia have been applied for phytore-mediation of polluted soils (Huang et al., 2004). Their positive effects in growth promoting have been studied during a variety of stress conditions such as salinity (Lugtenberg and Kamilova, 2009; Karlidag et al., 2013), drought (Vurukonda, et al., 2016), heat stress (Meena et al., 2015), metal toxicity (Islam et al., 2014). For these reasons, PGPR are now applied as bio-fertilizers, soil additon, and rhizoremediators (Bohme and Bohme, 2006). Although useful impacts of PGPR on the growth and yield of plants have been found out for decades, the promotion mechanisms of plant growth have not been studied in depth (Babalola , 2010). Priestia aryabhattai was isolated from rhizosphere soil around the world such as South Korea (Lee et al., 2012), India (Lee et al., 2015), and Tibet (Yan et al., 2016). The plant growth promoting activity of P. aryabhattai was firstly found by Lee et al., (2012), who proved that P.aryabhattai promoted the growth of Xanthium italicum (Lee et al., 2012) in the recent years, it has been discovered zinc solubility of P. aryabhattai raises the growth of soybean by raising the mobilization and bio-fortification of zinc. Priestia aryabhattai strains have also been found for other positive abilities, such as the phosphatase solubility (Selim, 2015).

Rice husk biochar (RHB), which could be raised the agricultural soil fertility, is produced from rice straw. Rice husk biochar improved the soil pH, CEC and nutrient availability (Cui et al., 2011; Liu et al., 2014; Li et al., 2019), and reduced loss of nitrate (Ghorbani et al., 2019). The RHB addition combined with lime were remarkably decreased Arsenic, Cd and Pb mobility and uptake in peanuts and rices from a As, Cd and Pb pollution soils (Nguyen Van Chuong, 2019; Jiang et al., 2012; Li et al., 2016; Sui et al., 2020). Further, rice shoot Si contents significantly raised after biochar addition, and raised the rice yield has been found in poor soils after rice husk ash amendment of (Rambo et al., 2011). However, the positive effects of biochar as a soil supplementation to ameliorate soil characteristic is remarkably affected by soil types.

Application of sawdust and organic manures has been applied to the soil (Tanee and Akonye, 2009) in order to improve the need of the soil matrix to support biologically positive water and nutritions to soil microorganism, which are capability of degrading the goal components. In addition, the sawdust and organic manures additions reduce as toxicity of the polluted soil, thereby helping microorganisms to survive in soils containing very high as contens. According to Babalola et al., (2015), showed that impacts of sawdust on the growth of Solanum esculentum Linn raised height, number of leaves and number of branches compared to control. Therefore, Sawdust is needed to recommend as a good option for polluted soils. The prior study Chuong et al., (2021) showed that lime combined with sawdust application raised soil nutrients and lessened arsenic uptake of mung beans to 32.0% in the stems and 49.0% in the seeds. The mung beans yield raised

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to 22.5% comparison with control (without lime and sawdust application). In this research, we evaluated effects of rice husk biochar, sawdust and Priestia aryabhattai M2C on the growth, yield and as uptake of soybean, which was planted on high as pollution soil.

2. MATERIALS AND METHODS

2. 1. Bacteria

The root soil and nodule samples were taken from the soybeans, which were planted on high as pollution soils of the agricultural fields of An Phu district, An Giang province, Vietnam. Priestia aryabhattai M2C, which was isolated by obtaining pure YEMA culture from the root soil and nodule samples of soybeans in the central laboratory of An Giang University, was used during this study. Priestia aryabhattai M2C was identified through sequencing of 16S rRNA. The phylogenetic position of Priestia aryabhattai M2C was analysed by blasting the 16S rRNA sequence on NCBI. Phylogenetic analysis presented 100% similarity of the 16S rRNA sequence of our target bacterium to Priestia aryabhattai M2C.

2.2. Experimental design

Field experiment was carried out at An Phu district from Oct. to Dec. of 2022. Physical and chemical properties of the initially experimental Soil was analysed according to Tian et al., (2008). Results of soil characteristics are shownd in Table 1. Soybean seeds were sown in the rate of 25 seeds per m^2; Area per each treament was $10m^2$ (0.5 m in width × 20 m in length) included four replications; distance of 02 plots was $1m^2$. All pathogens and insects were treated by pesticides according to guide of manufacturer. Further, the As concentration of the soil samples outside the dike, which contained 34.1 ppm exceeded about 2.5 times compared with allowed standard of agricultural soil (12.0 ppm). Soybean seeds, which were collected from DUNG HA Company, Vietnam, were used during the experiment. The cultivated technique was studied from local tillers and harvested in December of 2022. Soil samples were collected from 0 to 20 cm in the depth at 15 days before taking the experiment in order to determine soil properties (Table 2.1). Stem and seed Samples of soybean were taken to analyse the as content at the harvest. Ratios of sawdust, rice husk biochar and Priestia aryabhattai M2C were applied in Table 2.2.

Table 2.1: Soil property of the initially experimental Soil (0-20 cm in depth)

Soil analysis		Value	Soil analysis		Value
Mechanics	Sand (%)	10.5	Soil nutrition	Total N (%)	0.134
	Clay (%)	60.5		Available P (ppm)	52.5
	Silt (%)	29.0		Exchangeble K (ppm)	623
	Texture	Silt clay loam		$CaCO_3$ (%)	2.50
Chemical	$pH_{\text{soil outside the dike}}$	6.1	Total As	River water (µg/L)	undetective
	$pH_{\text{river water}}$	5.2		Soil outside dike (ppm)	34.1

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Table 2.2: Experimental design *

Treatment	Priestia aryabhattai M2C (10^8CFU/g)	Sawdust (t/ha)	Rice husk biochar (t/ha)	N,P,K (kg/ha)
SB1 (control)	No	0.00	0.00	20-30-40
SB2	inoculum	0.00	0.00	
SB3	inoculum	10.00	0.00	
SB4	inoculum	0.00	10.0	
SB5	inoculum	5.00	5.00	

(*)experiment was irrigated by the river water (no As pollution)

Fig. 2.1: Priestia aryabhattai M2C on YEM culture

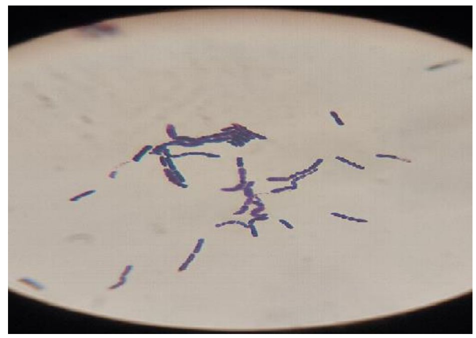

Fig. 2.2: The pure Priestia aryabhattai M2C

The experimental area was 200 m^2 (0.5m x 20m x 04 replications x 5 treaments). The soil pH, total nitrogen, available phosphorus, exchangeable potassium and soil texture were determined by Carterand and Gregorich, (2007). Total As of soil, water and plant samples were analysed by Atomic Absorption Spectrophotometric. The agronomy property and Yield of soybean was determined during the mature time of plants such as biomass, height and bud number, number of pods/ plant, fresh weight of fill and unfill pods per plant (g). The actual yield was counted by tons/ha for fresh pods. Experimental soil texture was the Silt clay loam. pH of soil and irrigation water was 6.1 and 5.2, respectively. Soil nutritions were the total nitrogen (0.134%) and the available phosphorus was quite rich (52.5 ppm).The exchangeble potassium and CaCO3 in soil were 623 ppm and 2.50%, respectively. Rates of phosphorus, potassium and CaCO3 was suitable for the growth of Priestia aryabhattai M2C and soybean.

2.3 Data Analysis

Data of soil pH, agronomics, yield components, yield and as concentration of soybean stems and seeds were determined by analysis of variance and a Duncan multiple-range test significant differences at level 5%

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3. RESULTS AND DISCUSSION

3.1 Soil pH

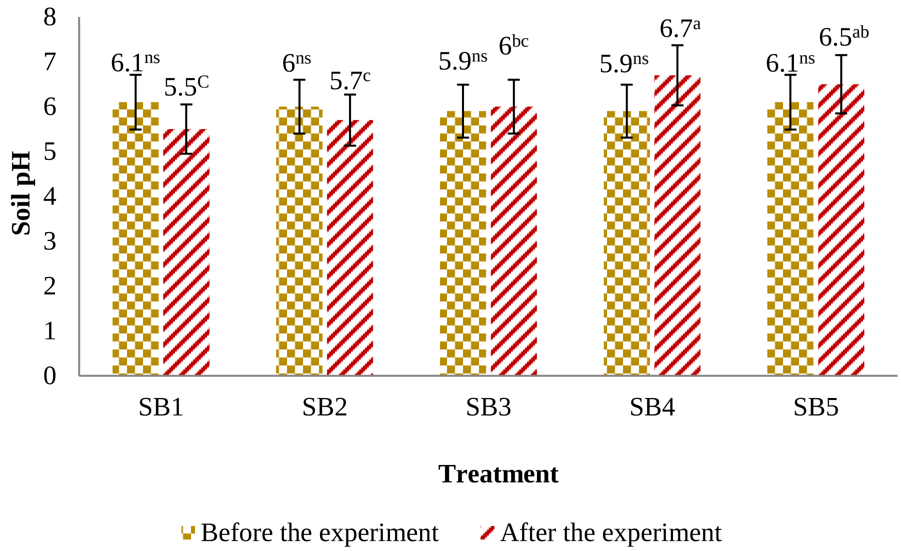

Figure 3.1: Soil pH before and after of the field experiment

There were signiflcantly different at level 5% of soil pH among treatments before the experiment (Fig. 3.1). However, soil pH ranged from 5.5 to 6.7 after the experiment and were sufficient diferrences at level 1%. The maximum soil pH (6.7) obtained at SB4 treatment, which added 10.0 tons rice husk biochar combined with NPK fertilizer and Priestia aryabhattai strain M2C inoculum. On the contrary, the minimum pH value (5.5) observed at the control treatment (SB1) (Fig. 3.1).

Soil pH of treatments of rice husk biochar amendment (SB4 and SB5 treatment) after the experiment was always higher than those of treatments before the experiment. In contrast, the soil pH of the treatments without rice husk biochar and sawdust supplementation, which slightly decreased at harvest (SB1 and SB2) compared with the soil pH before the experiment.

Especially, Co-application of sawdust amendment and NPK fertilizer did not change in soil pH. According to the prior study of Nurah et al., (2022) presented that inorganic fertilizer application reduced pH and OM of soil but raised total nitrogen and available Phosporous. Furthermore, the soil of pH was remarkably reduced by application of inorganic fertilizer, which could be released ion H+ from using the inorganic fertilizers (Rós et al., 2020).

Conversely, the amendment of organic fertilizers to raise soil pH was researched by Duruigbo et al. (2007), who proved that the attendance of cations existed in these organic fertilizers. Besides, application of rice husk biochar (3 tons/ha) significantly raised soil pH and nutrients to peanuts planted in acid soils (Nottidge et al., 2009). The prior study of

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Akinyemi and Adewale, (1985) showed that treatments of the sawdust amendment were no significant effects on soil pH compared to control (without sawdust amendment).

3.2 The agronomy of soybean

3.2.1. Plant height

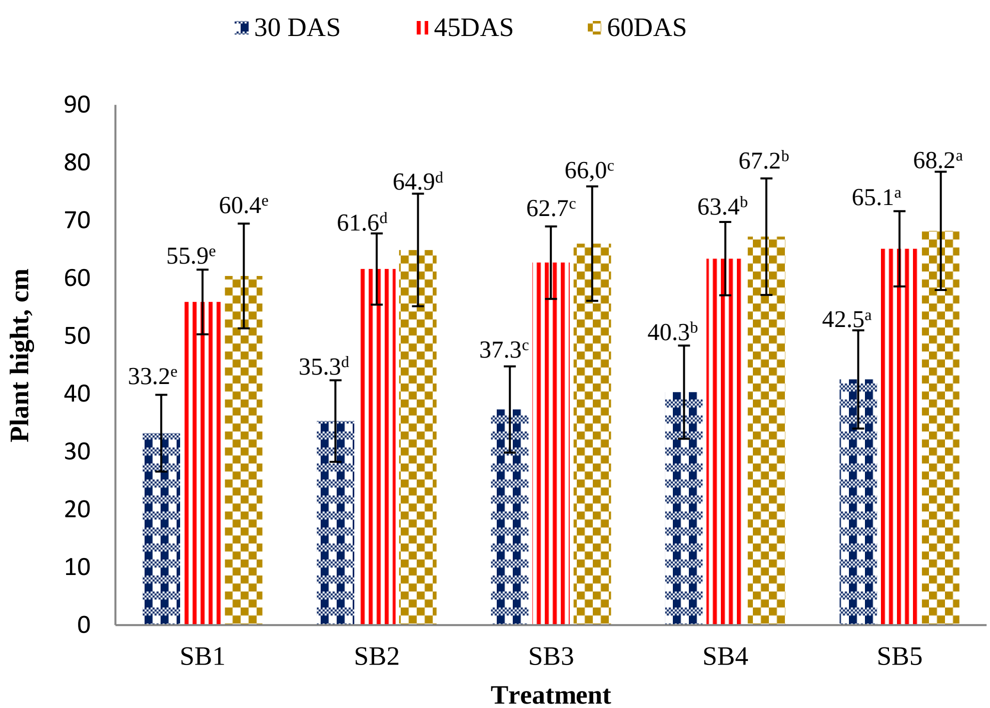

Figure 3.2: The height of soybeans

Impacts of rice husk biochar, sawdust and Priestia aryabhattai M2C on the soybean height (Fig. 3.2) were significant difference at level 1% among experimental treatments. The maximum plant height (68.2 cm) of SB5 treatment (20kgN-30kgP-40kgK/ha + 5.0 tons rice husk biochar/ha + 5.0 tons sawdust/ha and Priestia aryabhattai M2C inoculant) and minimum plant hight (60.4 cm) of SB1 treatment (20kgN-30kgP-40kgK/ha) at 60DAS. The soybean heights were significantly impacted by the rice husk biochar, sawdust and Priestia aryabhattai M2C inoculant. The prior studies were proved that positive effects of rice husk biochar, sawdust and Priestia aryabhattai remarkably raised on the growth of crops such as height and effective tillers (Oludare et al., 2018; Abukari, 2014; Agegnehu et al., 2016).

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3.2.2. Available tillers of soybeans

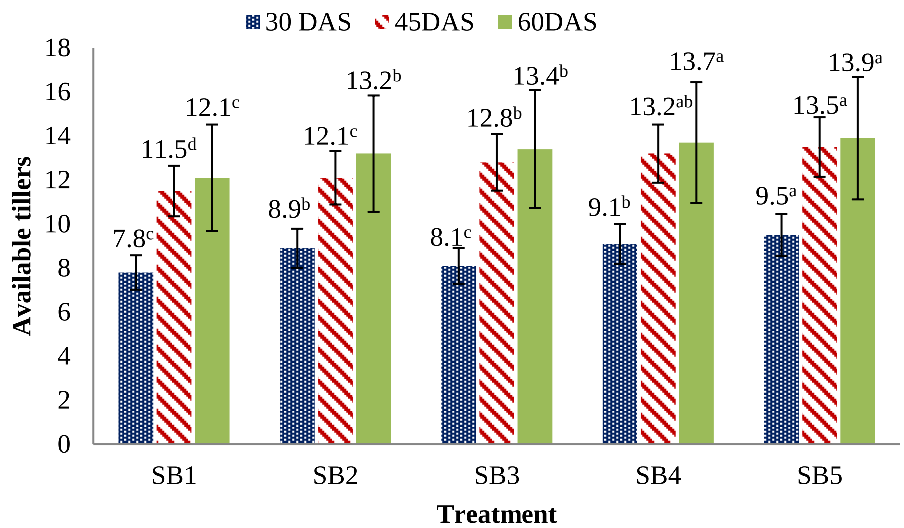

Figure 3.3: Available tillers of soybeans

Available tillers of soybeans in all experimental treatments were sufficiently different at LSD ≤ 0.01 during the growth. Values of available tillers of soybeans regularly raised from 7.8 to 13.9 tillers at 30, 45 and 60 DAS in the all treatments (Fig. 3.3). The greatest number of soybean tiller (13.9 tillers) of NPK + rice husk biochar + sawdust and Priestia aryabhattai M2C inoculant (SB5) and lowest tiller number (12.1 tillers) of NPK alone (SB1 treatment) in 60 DAS. The number of available tillers of soybeans were significantly impacted by the rice husk biochar, sawdust and Priestia aryabhattai M2C inoculant. According to the studies of Oludare et al., (2018); Abukari, (2014); Agegnehu et al., (2016) showed that available tillers remarkably increased in amended treatments of rice husk biochar, sawdust and Priestia aryabhattai remarkably during the growth of plants. These results were in agree with prior results of Arf et al., (2021); Nascente et al., (2012), demonstrated that bio-organic matters increased the crop hight and number of available tiller compared to the control. The amendment of the rice husk biochar, sawdust and Priestia aryabhattai M2C inoculant remarkably affected on the number and weight of pods, biomass and the weight of 1,000 seeds of soybean, which obtained the maximum values in amended treatments of the rice husk biochar, sawdust and Priestia aryabhattai M2C inoculant and were significant variousness among experimental treatments (Table 3.1). The highest values of number and weight of pods, biomass and weight of 1,000 seeds (48.7 pods, 468g, 670g and 151g, respectively) obtained in the amendment of the rice husk biochar, sawdust and Priestia aryabhattai M2C inoculant (SB5). Conversely, the lowest values of number and weight of pods, biomass and weight of 1,000 seeds (37.2 pods, 382g, 475g and 135g, respectively) and significant differences at level 5% and 1% among experimental treatments (Table 3.1).

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Table 3.1: The soybean yield attributes

Treatment	Yield attributes			
	No. of pods/plant	Wt. of pod/plant (g)	Biomass (g/plant)	Wt. of 1,000 seeds (g)
SB1	37.2^{e}	382^{e}	475^{e}	135^{b}
SB2	40.3^{d}	408^{d}	585^{d}	135^{b}
SB3	42.6^{c}	446^{c}	636^{c}	140^{b}
SB4	45.6^{b}	455^{b}	655^{b}	145^{ab}
SB5	48.7^{a}	468^{a}	670^{a}	151^{a}
F	**	**	**	*
CV (%)	9.62	7.65	11.2	6.31
*, **: significant differences at 5 and 1%, respectively.				

Table 3.2: The soybean yield and as concentrations

Parameters per plant						
Treatment	Yield (t/ha)	As concentration (ppm)				
		Roots	Stems	Seeds	Experimental Soil	
		At harvest			Before	After
SB1 (control)	1.61^{d}	1.25^{a}	1.23^{a}	0.11^{a}	34.1	30.5^{c}
SB2	1.74^{c}	1.12^{b}	1.02^{b}	0.10^{a}	34.0	32.1^{b}
SB3	1.81^{bc}	0.836^{e}	0.83^{d}	0.06^{b}	34.2	33.1^{b}
SB4	1.86^{b}	1.07^{c}	0.98^{bc}	0.09^{ab}	34.2	32.5^{a}
SB5	2.15^{a}	0.936^{d}	0.93^{c}	0.08^{ab}	34.2	32.6^{ab}
F_{test}	**	**	**	*	ns	**
CV (%)	13.9	7.50	14.0	23.3	11.09	13.0
(ns,*,**) insignificant difference, significant difference 5 and 1%, respectively.						

The soybean yields of five experimental treatments ranged from 1.61 to 2.15 tons/ha and were adequately differences at level 5%. The maximum productivity of SB5 treatment (20N-30P-40K kg/ha + 5.0 tons sawdust/ha + 5.0 tons the rice husk biochar/ha and Priestia aryabhattai M2C inoculant) obtained 2.15 tons/ha. Inversely, the control treatment of 20N-30P-40K kg/ha alone had the minimum soybean yield of 1.61 tons/ ha. The following high values of soybean yield were obtained by applying 20N-30P-40K kg/ha and Priestia aryabhattai M2C inoculant (SB2:1.74 tons/ha), Priestia aryabhattai M2C inoculant + 10.0 tons sawdust 20N-30P-40K kg/ha (SB3:1.81 tons/ha) and +10.0 tons rice husk biochar/ha and Priestia aryabhattai M2C inoculant (SB4:1.86 tons/ha) (Table 3.2). Soil addition with rice-husk biochar and sawdust remarkably promoted growth, nutrition uptake and dry matter store. This could be raised productivity of maize. Amendment of rice husk biorchar and sawdust with 120 g/pot promoted the drastic growth of maize compared to addition of 60g per pot (Emmanuel et al., 2016). Further, According to of Mohammad et al., (2022) showed that inoculum of Priestia aryabhattai in agricultural soils may promote overall growth and yield of plants, raise the nutrients of cultivated soils. From above results, co- application of rice-husk biochar, sawdust, NPK fertilizer and Priestia aryabhattai M2C inoculant increased on yield attributes as and yield of soybeans (Table 3.1 & 3.2).

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The As accumulation of soybean roots, stems and seeds ranged from 0.836 to 1.25 ppm, 0.83 to 1.23 and 0.06 to 0.11 ppm, respectively. The maximum As contents of soybean roots (1.25 ppm), stems (1.23 ppm) and seeds (0.11ppm) in the control treatment and minimum values of soybean roots (SB3: 0.836 ppm), stems (SB5: 0.936 ppm) and seeds (SB3:0.06 mg/kg) in the applying of rice-husk biochar, sawdust, NPK fertilizer and Priestia aryabhattai M2C inoculant. There was not noticeably different at level 5% among treatments of soil as contents before the experiment (Table 3.2). However, the as contents of soils after experiment were significant differences at level 1%. Arsenic contents of crop soil before and after experiment valued from 34.0 to 34.2 ppm and 30.5 to 33.1 ppm, respectively. The highest contents of soils after experimental was 30.5 ppm in the application of 20N-30P-40K kg/ha + 10.0 tons sawdust/ha and Priestia aryabhattai M2C inoculant (SB3) was 33.1 ppm. Conversely, the lowest as contents of soils after experimental was 30.5 ppm in application of NPK alone (SB1). All soybean parameters of yield attributes, yield and as concentrations of root, stem and seed of SB1 (only NPK) were lower than those of SB2 (NPK and Priestia aryabhattai M2C inoculant). These results of Table 4 showed that added treaments of rice-husk biochar, sawdust and Priestia aryabhattai M2C inoculant may decrease the As store and yield increase of soybean. According to prior study of Xing et al., (2022) showed that Priestia aryabhattai inoculant promoted the nitrogen fixation efficiency and yield of soybean. Furthermore, the soil microbial community increased in the treatments, which had Priestia aryabhattai inoculant. The effects of rice husk biochar decreased as store in rice and mungbean (Chuong et al., 2019).

4. CONCLUSION

Association of rice husk biochar, sawdust and Priestia aryabhattai M2C inoculant remarkably raised soil chemical compositions, yield components and the yield and reduced as accumulation of the soybean. The rice husk biochar and sawdust amendment considerably raised the soil pH and lessened soil acidity due to apply inorganic fertilizers. Application of rice husk biochar, sawdust combined with Priestia aryabhattai M2C inoculant also significantly raised the agronomy and lessened the as uptake of soybean. Application of rice husk biochar, sawdust combined with Priestia aryabhattai M2C inoculant generally inhibited the as uptake of soybean from the crop soil and decreased root damage caused by as toxicology in the cultivation soil. The yield and quality increase of soybean, thereby, planted on as pollution soils. Further, Priestia aryabhattai M2C inoculant was also raised the different population of soil microorganism.

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