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Quality And Yield Improvement Of Edamame In Arsenic Contamination Soil And Irrigation Water With Application Of Lime

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Abstract

The effective discovery of liming, earthworm manure and Rhizobia on Arsenic (As) uptake and yield of edamames planted on the As contamination soil and irrigation water was designed at Phuoc Hung village in the Summer- Autumn season of 2021 with the soil inside the dike. Five treatments included: AD1 (NPK-40N-60P-60K kg per ha); AD2 (NPK + Rhizobia); AD3 (NPK + 10t earthworm manure/ha + Rhizobia); AD4 (NPK + 1.5t $CaCO_3$/ha + Rhizobia and AD5 (NPK + 1.5t $CaCO_3$/ha+10t earthworm manure/ha + Rhizobia) and four replications. The high yield and yield constituents of edamames obtained at amended treatments of the earthworm manure and liming alone or mixture during the edamame season. Great influences of earthworm manure alone or associate with liming cum Rhizobia increased the edammame yield from 9.50% (NPK+ 10 t earthworm manure/ha), 11.3% (NPK+ 1.5 t $CaCO_3$/ha) to 21.8% (NPK+ 10 t earthworm manure/ha+1.5 t $CaCO_3$/ha cum Rhizobia) compared to AD1 (NPK alone) and AD2 (NPK cum Rhizobia). The average As content of edamame stems and seeds of RV3 was lower than 44.8 % in stems and 33.3% in seeds compared to without liming or earthworm manure. the As store of edamame stems and seeds decreased remarkably when amended liming, organic manures to agricultural soils.

Key words:

Arsenic, edamame, liming, Rhizobia, earthworm

Introduction

Vegetable soybean (edamame) is an annual self-pollinating diploid plant and and is planting a popularity and potentially exportable market [1]. The yield of edamame, which obtained 3.5 t/ ha higher than other soybeans only had an average yield from 1.7 ton 3.2 t/ ha. Japan imports 100,000 tons edamame/year and the US to 7,000 tons Edamame/year. Edamame has strongly been a potential opportunity of global export markets. China and Taiwan supply to the 97% needs of Japan's market [2]. Furthermore, market need for edamame raised in the recent years thank to be aware of nutrition benefits and change modern life towards safer healthy foodstuff [3]. The nutritional composition of Edamame may satisfy with decresing lack of human health [4]. However, Arsenic-contaminated soil and irrigation water have significantly reduced crop yields and increased the As accumulation of stems and seeds of corn, mungbean and rice [5]. The As contaminated soil and irrigation water reduced the soil pH, which caused to raise the mobility of iron and aluminum toxins due to decreas the crop growth. the poor soil of organic manures and positive biologies reduced the yield of groundnut [6]. Almost none of Agricultural soils a adequacy of essential nutritions for crops such as nitrogen [7]. From above problems, the best way to overcome obstacles and difficulties are the amendment of lime, organic manure and Rhizobium inoculum [8]. Rhizobium inoculant has really been the potential way to take a nitrogen from the air for legume [9]. The application of earthworm manure may augment the great growth and yield of legume which enrich the fertility of the soil in the nutrient poor soil [10]. The liming, animal manure with Rhizobia has popularly used to augment the soil nutrition properties and crop yields [11]. the lime supply of agricultural soil that may reduce the As mobility in soils is the best method. The co-appliaction of liming, organic matter and possitive biologies supply, which could augment the As uptake reaise yield of crops and soil nutritions [12]. The r research target find out new points of lime, earthworm manure and Rhizobium inoculum on (i) the nitrogen fixation ability of Rhizobium on As pollution soil and irrigation water; (ii) reducing As accumulation and raising yield of Edamame. The research results may help local tillers, who can have positive informations from this study apply for their cultivation.

Materials and methods

Five Treatments that were carried out in the Phuoc Hung village of An Phu town from April to August of 2021 irrigated by the deep well water from automatic watering system. Studied soils were the poor nutrient. Phuoc Hung village located nerby the border with cambodia in the Mekong river. The average rainfall obtains from 60 to 70 percent per year . The weather is quite hot in the summer and warm the winter which fluctuates from 20 to 37^{o}C. Rhizobium bacterium was isolated from root soils of edamame at the central laboratory of An Giang university. Rhizobium spp. was mixed with edamame seeds before sowed seeds (Fig.1). This field research had five treatments for one crop and watered by As polluted water (deep well). Main goals of study are : (i) assessment of adaptability of Rhizobia on the soil and irrigated water of the As contamination; (ii) impacts of liming, earthworm manure, Rhizobium bacterium on As uptake and production of peanuts. The organic and inorganic fertilizers were applied by NH_4NO_3, DAP, KCl, $CaCO_3$ and Rhizobium bacteria (Table

1). The experimental area was 200 m^2 (0.5 m x 20m x 04 replications x 05 treaments). Collecton samples of soil and water were taken in the soil depth of 0 - 20 cm for soils water of used deep well for analysing properties before and after the experiment. Methods were used to determine physical and chemical characteristics of soil and irrigation water such as pH, total nitrogen, available phosphorus, exchangeable potasium and texture. Total As values of all samples were analysed by Atomic Absorption Spectrophotometric [17]. Yield components were determined by the mature time of edamames which included height and biomass of plant, number of shoot, pods, fill and empty pods per the plant. The fresh yield of Edamame was counted by tons per ha for fresh pods. Soil samples before the experiment were the sandy loam and low pH of soil and deep well water (5.5 and 4.8, respectively), total N (0.110%), the available phosporus was quite rich (2.44 ppm). One of macronutrients, which is very important nutrient of Rhizobia and edamame helps for the matureness of its life. However, exchangeble potassium was the low contentration (78.0 ppm). The deep well water sample contained a large rate of As toxicology (0.536 ppm) which exceeded quite high compared to WHO standard. The As content of Soil samples in research sites exceeded the allowable limits for agricultural soils (83.1 mg/kg). The peanut seeds, which was collected from Golden Season Plant Seed Joint Stock Company. The farming technique followed by local farmers and used the soil inside the diky for the field experiment. The soil samples were taken in the depth (0-20 cm) to analyse the physical and chemical properties. It was collected from fifteen days before the designable experiment. Soil samples were collected before and after the experiment per the treatment. Seeds and stems of edamame were collected at the harvest to determine the As content.

Table 1 Application of liming, earthworm manure, combined with Rhizobia*

Treatment	Rhizobium (10^8CFU/g)	$CaCO_3$ (t/ha)	Earthworm manure (t/ha)	NPK (kg/ha)
AD1 (control)	No	0.00	0.00	40-60-60
AD2	inoculum	0.00	0.00	
AD3	inoculum	0.00	10.0	
AD4	inoculum	1.50	00.0	
AD5	inoculum	1.50	10.0	

(*)the deep well water (As pollution) used to water for experimental plants

The research data was counted by significantly different at LSD < 0.05 and 0.01 level. Statgraphics Centurion XIX was used for the variance analysis.

Results and discussion

a. Soil pH

The soil pH before the experiment which varried from 5.06 to 5.10 and insignificant diferrences at the level of 5%. There was significantly diferrent at the 1% level of soil pH after the experiment of treatments. Soil pH values ranged from 4.91 to 6.17. The highest pH value of AD5 was 6.17 and

the lowest pH (4.92) of AD1 and AD2. The soil pH of liming and earthworm manure amendment (AD3, AD4 and AD5) obtained sufficiently higher than no liming and earthworm application at the end of the experiment (AD1 and AD2). Furthermore, the soil pH values of AD1 and AD2 treatment after the experiment was lower than those of soil pH before the experiment. On contrary, the soil pH of AD3, AD4 and AD5 treatment at the experimental end, which raised sufficiently higher than those of soil pH at the first stage of the experiment applied the lime combined with earthworm manure or alone and significant differences at level of 1%. Calcium cations were amended the soil by $CaCO_3$, which increased soil pH to raise the agricultural soil nutrients.

Table 2 Impacts of earthworm manure, limimg, Rhizobia and water irrigation on soil pH

Treatment	experimental Soil pH	
	Before	**After**
AD1: 40kg N- 60kgP - 60kg K/ha(NPK)	5.07	4.92a
AD2: NPK +Rhizobium	5.09	4.92a
AD3: NPK +Rhizobium + 10t earthworm manure	5.10	5.45b
AD4: NPK +Rhizobium+1.5 t $CaCO_3$/ha	5.09	5.90^c
AD5: NPK +Rhizobium+1.5 t $CaCO_3$ +10t earthworm manure/ha	5.06	6.17^d
F_{test}	ns	**
CV(%)	6.95	9.61

Note: correlation is insignificant differences (ns); (**) significant at level of 1%

Further, the application of liming combined Earthworm manure not only increased soil pH but also increased the soil fertility [18]. Many prior researches proved that the amendment of liming associated with organic and inorganic fertilizers raised soil pH and nutrients compared to the control treament [19], [20].

b. Yield constituents of edamames

The results in Table 3 were presented that co-applicationg of liming, earthworm manure associated with Rhizobium inculant and As pollution water irrigation on the height of groundnuts (Table 3) and no significant difference of 5% level in all treatments but twenty Days after sowing was one exception. The highest shoot (7.25) and lowest value (6.0 cm) which achieved in AD5 (NPK + 1.5 t $CaCO_3$ + 10 t earthworm manure/ha and Rhizobium inoculant) and others at harvest. Furthermore, shoots of edamane regularly raised during the growth from 20 to harverst and significant difference at leval of 5 and 1% (Table 3). The useful effects of organic manure, liming, Rhizobia, which contributed to develop the growth of yield **constituents** such as heights and effective shoots of edamames [21], [22].

Table 3 Influences of earthworm manure, limimg, rhizobia on the height and shoot of edamame

Treatment	Plant height (cm)				No. of shoots (plant)			
	Day after sowing				Day after sowing			
	20	**45**	**65**	**Harvest**	**20**	**45**	**65**	**Harvest**
AD1	25.2[a]	33.2	34.6	34.7	1.25[a]	5.25[a]	6.00[a]	6.00[a]
AD2	27.2[b]	33.6	35.9	36.1	1.75[ab]	6.00[b]	6.00[a]	6.00[a]
AD3	25.8a[b]	33.0	34.3	34.4	2.00[b]	6.00[b]	6.00[a]	6.00[a]
AD4	24.6[a]	31.6	34.1	34.2	1.50[ab]	5.75[ab]	6.75[b]	6.75[b]
AD5	24.2[a]	31.1	34.9	35.0	1.50[ab]	5.75[ab]	7.25[c]	7.25[b]
F_{test}	*	ns	ns	ns	*	*	**	**
CV(%)	5.66	5.73	5.09	5.01	21.4	7.70	9.34	9.34

Note: Insignificant correlation at P < 0.05 (ns); significant correlation at P < 0.05 (*); P < 0.01 (**)

Table 4 The yield constituents and yield of edamames

Treatment	Yield constituents per plant					
	Biomass (kg)	No. of pods		Wt. of pods (g)		Wt. of 1,000 seeds (g)
		Full	Empty	Full	Empty	
AD1	5.0[b]	1,886[d]	420[e]	4,800[d]	560[d]	600[a]
AD2	4.2[a]	1,614[a]	205[b]	3,600[a]	215[a]	700[b]
AD3	5.0[b]	1,780[b]	227[d]	4,000[b]	250[b]	700[b]
AD4	5.0[b]	1,820[c]	219[c]	4,200[c]	250[b]	700[b]
AD5	5.2[c]	1,923[e]	200[a]	4,200[c]	320[c]	750[c]
F_{test}	**	**	**	**	**	**
CV(%)	7.91	6.13	23.7	9.85	7.31	7.52

(**) correlation is significant differences at level of 1%

The biomass of edamames were sufficiently influenced by co-application of liming, earthworm manure and Rhizobia (Table 4). The edamame biomass of AD5 treatment (5.2 kg/plant), which was applied by the liming, earthworm manure and Rhizobia obtained the highest biomass compared to others. The edamames biomass ranged from 4.2 to 5.2 kg/ plant. The AD2 treatment had the lowest biomass (4.2 kg/plant), it only applied by NPK and Rhizobium inoculant and significant differences at level of 1% among treatments (Table 4). This results of Table 4 could cause the positive relationship between earthworm manure and liming with soil fertility [23]. The growth and yield of edamames may increase completly when supplying organic manure combined with liming [24].

The maximum number and fresh weight of full pods obtained 1,923 and 4,200 g per plant, respectively in AD5 (liming, earthworm manure and Rhizobia and NPK application). On contrary, the minimum number and fresh weight of full pods were 1,614 and 3,600 g per plant, respectively in AD2 (Rhizobia inoculant and NPK application) and significant differences at level of 1%. (Table 4). The number and weight of full pods of the co-application of Rhizobia and NPK treament (AD2)

were lower than those of other treatments. On the contrary, the number and fresh weight of empty pods, which had the maximum number and weight were 420 and 560 g/plant, respectively in control treatment (AD1) and minimum worth of pod number (200) and fresh weight (320 g/plant) (Table 4). The average comparison of 1,000 seeds weight was significantly different among treatments at level of 1%. The results of Table 4 showed the highest weight of 1,000 seeds was 750 g/plant in AD5, followed in AD2, AD3, AD4 (700g/ plant) and minimum value of 1,000 seeds weight (600 g/plant) of RV1 (control treatment). The supplementation of organic manure alone or combined with liming raised higher 1,000 seeds weight of peanut than others [25].

c. Yield and As accumulation of edamame

The various effect was significant differences at the level of 1% in the theoretical yield of edamame pods, which ranged from 340 to 4.33 t/ha. The AD5 treatment obtained the highest yield (4.33 t/ha) and the lowest value of theoretical yield (340 t/ha) from AD1 and AD2 (Table 5). Similarly, the fresh pod yield of edamame was affected by the relationship between earthworm manure, liming with Rhizobia. The pod yield of edamame highly increased in the treament of earthworm manure, liming, Rhizobia combined with NPK (40N-60P-60K kg/ha). edamame yields raised higher than those of treatments of Rhizobium inoculant combined NPK or NPK alone. Results of Table 5 showed that the maximum fresh pod yield of edamame (3.90 t/ha) was obtained in AD5 (1.5 t $CaCO_3$/ha + 10 t earthworm manure/ha + 40N-60P-60K kg/ha cum Rhizobia inoculum). On contrary, the minimum pod yields of edamame (3.05 t/ ha) presented at AD1 (NPK alone) and AD2(NPK and Rhizobia). The following results of pod yield of edamame that were AD3 (3.37 t/ ha) and AD4 (3.44 t/ha) were significant differences at 1% (P value ≤ 0.01). This study was proved that positive effects of earthworm manure alone or combined with liming cum Rhizobia increased the edamame yield from 9.50% (NPK+ 10 t earthworm manure/ha), 11.3% (NPK+ 1.5 t CaCO3/ha) to 21.8% (NPK+ 10 t earthworm manure/ha+1.5 t CaCO3/ha cum Rhizobia) compared to AD1 (NPK alone) and AD2 (NPK cum Rhizobia). Application of NPK, liming and vermicompost increased a high peanut production compared to without vermicompost application [26], [27].

Table 5 Yield and as uptake of edamames

Treatments	Theoretical yield (ton/ha)	Fresh pod yield (ton/ha)	As contents	
			Stems (ppm)	Seeds (ppb)
AD1	3.40^{a}	3.05^{a}	1.83^{d}	50.0^{b}
AD2	3.40^{a}	3.05^{a}	1.58^{c}	60.0^{c}
AD3	3.74^{b}	3.37^{b}	1.01^{a}	40.0^{a}
AD4	3.82^{c}	3.44^{c}	1.94^{e}	40.0^{a}
AD5	4.33^{d}	3.90^{d}	1.36^{b}	50.0^{b}
F_{test}	**	**	**	**
CV(%)	9.47	9.59	22.2	16.2

(**)correlation is significant differences at level of 1%

The As concentration of stems and seeds of edamames that valued from 1.01 to 1.83 ppm and 40.0 to 60.0 ppb, respectively, was sufficient differences at level of 1%. The highest As concentration of edamame stems (1.83 ppm) in AD1 and seed (60 ppb) in AD2. Furthermore, the lowest As content of edamame stems (1.01 ppm) in AD3 and seed (40 ppb) of AD3 AND AD4 (Table 5). Furthermore, The average As concentration of edamame stems and seeds of RV3 (NPK+ 10 t earthworm manure/ha) was lower than 44.8 % in stems and 33.3% in seeds compared to without liming or earthworm manure. Generally, the As accumulation of edamame stems and seeds reduced remarkably in treatments which amended liming, organic manures to agricultural soils. The negtive relation between the soil pH and As accumulation of crops by liming and organic manures [28]. The amendment of lime and organic manures reduced the As uptake and incresse yield of crops [29].

Conclusion

The significant effects of the As pollution irrigation water and soil on the nitrogen fixation of Rhizobia, which did create the nodes of edamame when planting the As pollution irrigation water and soil was completely shown in this research . The pod yield of edamame reached the highest value of 40N-60P-60K kg/ha + 10 t earthworm manure/ha+1.5 t $CaCO_3$/ha cum Rhizobia. Furthermore, **Yield constituents of** edamames such as the biomass, number and weight of fill pods, weight of 1,000 seeds and fresh pod yield raised at treatments which were amended by liming, earthworm. The highest yield and lowest As accumulation of edamames obtained in the earthworm, liming alone or combinable treatments in the edamame experiment. The As uptake of edamames was significantly decreased by limimg and earthworm manure. This research results concluded in order to raise yield and reduce As accumulation of edamame by the application of liming and earthworm alone or mixture.

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