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The Agricultural Soil Fertility and Yield of Mung Bean Improved as Addition of Lime, Chicken Manure and Rhizobium Inoculation

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Abstract

The objective of this study was to determine effects of lime, chicken manure and *Rhizobium* on the soil fertility, yield and quality of mung bean cultivated on the Arsenic polluted soil and irrigation. The field experiment was conducted at the in An Phu town, An Giang province from March to Jun of 2022. The experiment was laid out in a split plot design with four treatments and four replicates. The MB1 included 40 kg N-60 kgP-60kgK per ha (control); MB2 (NPK + 1.5 t $CaCO_3$ ha^{-1} cum *Rhizobium*);); MB3(NPK + 10 t chicken manure ha^{-1} cum *Rhizobium*); MB4 (NPK + 1.5 t $CaCO_3$ ha^{-1} + 10 t chicken manure ha^{-1} cum *Rhizobium*). The results showed that growth attributes, yield and Arsenic uptake were significantly affected by the addition of lime, chicken manure and *Rhizobium*. Co-application of 1.5 t $CaCO_3$/ha combined with 10 t chicken manure / ha and *Rhizobium* inoculum (10^8 CFU/g) raised soil fertility and lessened Arsenic uptake of mung bean (55.1%) in seeds compared with only NPK application. The dry yield of mung bean seeds increased by 23.4% over compared with the control treatment. The maximum yield constituents and the minimum As uptake of mung bean obtained at the mixture treatment of NPK + lime + chicken manure and *Rhizobia* inoculation. From above results, the addition of lime, chicken manure associated with *Rhizobium* inoculum is the best method to raise soil fertility, quality and yield of mung bean.

Key words: Arsenic, chicken manure, Deep well, lime, mung bean, Rhizobium.

1. Introduction

Green bean [*Vigna radiata* (L.)], which significantly contains the high composition of essential elements is one of the key plants grown in Vietnam. Its edible seeds are characterized by good digestibility, taste, high protein content and without any flatulence effect. Its seed is sufficiently describeb by good digestion, flavorous food and high protein concentration [1]. Degraded soils were impacted by soild properties including organic mater physics, chemical, and biology [2, 3]. Degraded soils is a big problem around the world, particularly in tropical regions [4]. In these dry areas, irrigation water lack, due to low rainfall and baking sun, raises the difficult cultivation in planting and raising crop productivity. Furthermore, crop yield is remarkably reduced by the As pollution soil and irrigated water. The As concentration of crop soil has seriously contained and uptake of stems and seeds of plants [5]. Animal manure is continually amended to raise the organic mater (OM) and availabe nutrients, to increase soil pH and to decrease the irrigation water. However, the animal manure often contains low mineral nutrients to apply plants [6]. Lime, which also contains the remarkable carbon level and organic carbon amendment increases the soil pH and crop yield [7, 8]. The green bean that is a useful plant such as taking nitrogen from the air to plant and agricultural soil by symbiotic nitrogen fixation [9,10,11]. Chuong et al., (2021) [12] proved the influences of grains inoculum with *Rhizobia*, lime and cow manure on nodule, matureness and yield compositions of peanuts and showed that the co-application of *Rhizobium* lime and cow manure, affected remarkably on the number of pods per plant, number of grains per pod and 1,000 grain weight of the peanut.Arsenic element, which is dangerous to humans's health and plant and is existing in soil, water and air everywhere[13]. Arsenic has high toxicity and dangerous to the growth of plant [14]. it harms crop roots and fosters the oxygenated process of lipide [15]. Prior of Chuong and Hung, (2021) [16] presented that local tillers used deep well water (As contamination) to water their plants. Phuoc Hung

is an agricultural commune and local tillers use As polluted water from deep wells (69,6%) to water their fields [17]. The repair of above problems, the field study of co- application of lime, chicken manure (CK) and *Rhizobia* on mung beans was conducted.

2. Materials and methods

2.1. Time and study site

The field experiment was designed at the Phuoc Hung, An Phu town, An Giang , Vietnam from March to Jun 2022.

2.2 Planting material

Mung been seeds (DX 208), which were collected by Loc Troi company. were treated with 0.5% chlorine for 30 minutes and incubated *Rizobiun* for one day before growing.

2.3 Fertilizers

Fertilizers used in the experiment included: Chicken manure (1.6% N, 0.6% P_2O_5, 0.85% K_2O); urea (46.3% N); superphosphate (16% P_2O_5, 10% S, 12 mg Cd/kg); potassium chloride (61% K_2O). Lime ($CaCO_3$) and Rizobium (10^8CFU/g).

Table 1. Physical and chemical properties of soil sample used in the experiment (n =4)

Texture (%)			pH_{H2O}	OM	Total N	Available P	Available K	As concentration (ppm)	
Clay	Silt	Sand	(1:2.5)	(%)	(%)	(mg/kg)	(mg/kg)	Deep well water	Soil
31.7	55.6	12.7	4.9	1.40	0.121	50.5	530	0.36	85.9

Characteristics of soil sample were shown in Table 1. The data showed that the soil is classified as clay silt texture [18], moderately acidic, low in soil organic matter, and low in total nitrogen, available phophorus and potassium [19]. However, As contents of crop soil and irrigation water is quite high level comparison with WHO standard (agricultural soil ≤ 12 mg kg^{-1} and fresh water ≤ 10 µg L^{-1}).

2.4 Experimental design

One factor experiment was laid out in split-plot design (SPD) with four replicates. Four treatments included : MB1 –control [NPK (kg/ha) 40 N: 60P: 60K]; MB2: (NPK +1.5 t $CaCO_3$/ha + *Rhizobium*); MB3: (NPK +10 t CK/ha + *Rhizobium*); MB4: (NPK +1.5 t $CaCO_3$/ha + +10 t CK/ha + *Rhizobium*). Entire amount of CK, lime were applied in respective plots as per treatment during the final soil preparation.

The repeated size was 10 m^2 (20 m in length, 0.5 m in width). The health seed of mung bean were planted at the distance of 25 cm x 20 cm. The spacing between blocks and plots were 0.5m with an the whle area experiment equivalent to 160 m^2 (10 m × 4 x 4), planted in a single row with a distance of 25 cm × 20 cm (three seeds were planted per hole); the distance between plants was 20 cm and between rows was 25 cm.

2.5 Data collection

Growth attributes were collected at 120 days after planting, while biomass (leaves, stem, roots, seeds), yield and yield component data were collected at harvest where plant leaves started by drying and withering. Growth attributes such as plant height, branches were recorded from ten randomly selected ten plants from each replication. The dry biomass data was determined after weighing separately fresh biomass data. Actual fresh yield was calculated from weight of fresh pod (g/m^2) and then the data expressed as ton/ha.

2.6 Statistical analysis

All variables were subjected to analysis of variance as using Mixed Models of statgraphics centurion xv. Differences between treatments were tested using the least significance difference (LSD) test at the probability of 0.05.

3. Results and discussion

3.1. Soil properties

Soil pH reached from 4.8 (MB1-control) to 6.0 (MB4) and significant variousness at 1% among treatments in the end of the experiment. The MB4 that amended lime combined with CK cum *Rhizobium* (NT4) yielded the maximum pH (6.0) (Table 2). This result in Table 2 also showed that fertilization of lime augmented pH thank to the carbonate concentration of lime [20]. The prior study proved that fertilization of lime reached in greater pH of soil comparision with the Control without liming at a depth of 0-20 cm [21]

The relationship between lime and electrolytic conductivity (EC**)** were significant differences and valued from 210 µS/cm to 231 µS/cm. the highest EC value obtained 231 µS/cm in the MB4 treatment of lime, CM application and *Rhizobium* inoculation and the lowest EC was 210 µS/cm in MB1 (Table 2). This result discovered that co-application of organic manures and lime raised the soil EC. The prior study of Han *et al.*, (2020) [22], the EC of agricultural soil after the amendmend of lime and CM (6 t ha^{-1}) raised from 0.99 µS/cm to 1.77 µS/cm.

The total N percentage obtained from 0.137% to 0.184% in the various rates of lime and CM application, (Table 2). The highest total nitrogen (0.184%) obtained in the MB4 treatment of NPK, 1.5 tons $CaCO_3$ and 10 tons CM per ha combined witth *Rhizobium* (MB4), and the lowest value was in the control (MB1). Above results further proved that addition of lime and CM increased the total N

percentage due to the great amendment of carbon and nitrogen, which existed in lime and CM. The total N increase was significantly proved by the study of Meena el al., *(*2015) [23], the addition of lime and CM had a increase in the total nitrogen-mineralization ratio.

Table 2. Chemical properties of soil sample at harvest*

Treatment	pH	EC (mS/cm)	Total N (%)	Available P (mg/kg)	Available K (mg/kg)	Total OM. (%)	Total Ca (%)
NPK:Control (MB1)	4.80^{a}	211^{c}	0.137^{d}	45.8^{d}	612^{d}	1.21^{c}	18.5^{b}
NPK+Lime+ *Rhizobium* (MB2)	5.80^{c}	210^{c}	0.157^{c}	60.5^{c}	625^{c}	1.25^{c}	20.5^{a}
NPK+CK+ *Rhizobium* (MB3)	5.60^{b}	221^{b}	0.167^{b}	78.5^{b}	658^{b}	1.46^{b}	18.7^{b}
NPK+Lime + CK + *Rhizobium* (MB4)	6.00^{d}	231^{a}	0.184^{a}	90.5^{a}	782^{a}	1.58^{a}	20.8^{a}
F	**	*	**	**	**	**	**
CV (%)	9.58	16.4	16.6	15.6	11.4	11.0	17.6

*Note: Within a group of means, values followed by a same letter are not significantly different at 5% level; **: significant at 1% level; CM: chicken manure.*

Application of lime, CM associated with Rhizobium significantly raised the soil potassium level as a result of the calcium ion in the soil. The maximum available potassium (90.5 mg/kg) obtained at the MB4, the minimum value of potassium (45.8 mg/kg) was presented in the control (MB1). According to Chuong, (2019) [20] found out the maximum value of soil available potassium (0.170 meq/100 g) was obtained when applying for 3.5 t $CaCO_3$ and 10 t cow manure per ha. These research results proved that application of lime associated with animal manures can increase exchangeble K and decrease K leaching of soil [21].

The organic matter (OM) of experimental soil valued from 1.21% to 1.58%, with significant differences among treatments. The maximum OM (1.58%) was shown by the amendment of lime, CM combined with *Rhizobium* (MB4). On contrary, the OM of the MB1 (1.21) had the minimum value. The OM concentration of the soil after the experiment reached in MB3 and MB4 when applying CM, lime and NPK [22]. Further, various kinds of animal manures and various levels of lime also affected the content of OM in the agricultural soil. The supplementation of lime and animal manure with *Rhizobium* inoculant may raise carbon concentration of crop soils because treatments of organic fertilizer and the lime application contained the carbon level higher than without lime treatments [23]. The calcium content ranged from 18.5% (MB1) to 20.8% (MB4), and the significantly different at 1%. Lime, which contributed cations of Ca^{2+} and Mg^{2+} for the crop soil significantly raised higher productivity of crops [24]. The available phosphorus contents ranged from 45.8 to 90.5 mg/kg and significant difference at 1%. The maximum available phosphorus was (90.5 mg/kg) in the MB4 (Table 2). On contrary, the minimum value of available phosphorus had 45.8 mg/kg in the MB1. Application of lime and CM associated with *Rhizobium* inoculant raised microbial activity and available phosphorous in highly acidic soils [25].

3.2. Yield and components yield

The plant height druring the growth (20 DAS to harvest) raised from15.2 to 68.9 cm and significant difference at 5 and 1% (Table 3). The maximun plant height obtained in the MB4 treatment and the minimum height of mungbean was in the control treatment. However, there were a significant growth thank to application of lime, CM and Rhizobium.

Table 3. Effects of lime, CM application and Rhizobium on the plant height of mungbean

Treatment	Plant height (cm)			
	20 DAS	45 DAS	60 DAS	Harvest
NPK:Control (MB1)	15.2^{b}	39.8^{b}	63.5^{c}	63.6^{c}
NPK+Lime+ *Rhizobium* (MB2)	16.2^{b}	47.5^{b}	64.6^{b}	64.7^{b}
NPK+CK+ *Rhizobium* (MB3)	16.9^{b}	48.1^{b}	66.8^{ab}	66.9^{ab}
NPK+Lime + CM + *Rhizobium* (MB4)	19.6^{a}	51.6^{a}	68.8^{a}	68.9^{a}
F	**	**	*	*
CV (%)	12.7	13.2	8.13	8.14

**Note: Within a group of means, values followed by a same letter are not significantly different at 5% level; **: significant at 1% level; ns: not significant at 5% level; CM: chicken manure,* DAS:days after sowing

Table 4. Effects of lime, CM application and *Rhizobium* on yield and yield components of mungbean

Treatment	1,000 seed weight (g)	No. of full pods plant^{-1}	No. of seeds pod^{-1}	Seed yield (ton ha^{-1})
NPK:Control (MB1)	82.1^{d}	19.5^{d}	6.00^{d}	1.70^{d}
NPK+Lime+ *Rhizobium* (MB2)	84.1^{c}	21.5^{b}	8.00^{b}	1.96^{c}
NPK+CK+ *Rhizobium* (MB3)	86.3^{b}	20.6^{c}	7.20^{c}	2.08^{b}
NPK+Lime + CM + *Rhizobium* (MB4)	89.5^{a}	23.5^{a}	9.00^{a}	2.22^{a}
F	**	**	**	**
CV (%)	13.4	17.3	16.9	14,8

(**) are significantly different according to LSD at 1% level.

Results in Table 4 showed that impacts of lime, CM application and *Rhizobium* on all traits of yield and yield components. All yield components raised remarkably in all amended treatments of lime and CM comparison with the control treatment. The MB5 treatment of NPK, lime, CM combined Rhizobium obtained the highest value of all traits such number of full pods plant^{-1} (23.5 pods), seeds

pod^{-1} (9.0), weight of seed ha^{-1} (2.22 t ha^{-1}) and 89.5 g/1,000 seeds.

The dried yield of mung bean obtained from 1.7 (MB1) to 2.22 t ha^{-1} (MB4); it was noteworthy noting that MB3 reasched in a yield production of 2.08 t ha^{-1} and higher slightly than that of MB1(1.70 t ha^{-1}) and MB2 (1.96 t ha^{-1}). Dinesh *et al.* (2017)[26], showed that The various productivities of mung beans in this research depended on the cultivated method. When application of 0.2 t $CaCO_3$ ha^{-1} and animal manure raised soil pH and yield of green beans.

3.3. Arsenic uptake

Results in Table 5 presented there were adequately different at 1% among experimental groups. As contents of the soil before and after the experiment valued from 85.9 to 86.8 mg kg^{-1} and 94.7 to 123 mg kg^{-1}, respectively. The maximum As content in soils before the experiment contained 86.8 mg kg^{-1} in MB2 and the minimum value (MB4) was 85.9 mg kg^{-1}. Results in Table 5 showed that the alarmingly toxic redundance of As in the agricultural soil in the study region. Futhermore, the As concentration of the crop soil at harvest was noticeable difference at 1%. The maximum As value at Harvest (123 mg kg^{-1}) was in MB1 and the lowest As content obtained in MB4 (94.7 mg kg^{-1}), and the contents for MB2 and MB3 were 95.6 mg/kg and 111 mg kg^{-1}, respectively.

Table 5. Effects of lime, CM application and *Rhizobium* on As accumulation of soil and mung bean

Treatments	As contents			
	Soil (mg kg^{-1})		Plant (µg kg^{-1})	
	before	after	stems	seeds
MB1	86.1^{b}	123^{a}	190^{c}	67.0^{a}
MB2	86.8^{a}	96.5^{c}	180^{d}	35.2^{c}
MB3	86.1^{b}	111^{b}	250^{a}	40.2^{b}
MB4	85.9^{c}	94.7^{c}	240^{b}	30.1^{d}
F_{test}	**	**	**	**
CV(%)	0.41	11.3	14.7	34.1

(**) significant differences at level of 1%

The As content of the stems of mung beans, which ranged from 180 to 250 µg kg^{-1} in ammended treatments of lime, CM and *Rhizobium* inoculum was higher lightly than that of the control treatment except MB2 (addition of lime + *Rhizobium* inoculum). The greatest As content (250 µg kg^{-1}) of mung bean stem was in treatment MB3 and lowest content of control treatment (190 µg kg^{-1}) (Table 5). Contrary to stems, the As concentration of mung beans seeds valued from 30.1 to 67.0 µg kg^{-1}. The maximum As concentration (67.0 µg kg^{-1}) in seeds resulted in treatment MB1 (only 40 N: 60P:60K kg per ha) and the lowest As content of MB4 (NPK +1.5 $CaCO_3$ t/ha + 10 t CM/ha cum *Rhizobium* inoculum) only contained 30.1 µg kg^{-1} (Table 5). In genaral, all treatments of lime, CM and *Rhizobium* addition (MB2, MB3 and MB4) contained lower As content of mung bean seeds than those of control treament from 47.5, 40.0 and 55.1% comparison with MB1 (control), respectively.

Prior researchs demonstrated that the co-application of lime and animal manures improved physical and chemical properties of agricultural soils and soil fertility. Many plant nutrients such as total N, available P and available K also increased after three applied months [27]. Lime and animal manures may be responsible for increasing EC in low pH of soils. EC and pH of soil remarkly raised by the existence of sodium and calcium ion when lime and animal manure were amended [28]. Reducing arsenic uptake of mung beans was up to 98.8% through addition of sawdust and lime [29]. The opposite correlation between the pH and As uptake of crops by addition of lime organic manures [30]. lime combined with vermicompost could reduce the As store and increased yield of crops [31].

4. Conclusion

Addition of 1.5 t $CaCO_3$/ha combined with 10 tCM/ ha and *Rhizobium* inoculum (10^8 CFU/g) raised agricultural soil nutrients and reduced arsenic accumulation of mung bean seeds (55.1%) comparison with control (only NPK). The seed yield raised by 23.4% over comparison with control treament. The highest yield constituents and the lowest As accumulation of mung bean were the highest value at treament of NPK + lime + CM and *Rhizobia* inoculation. From above results, the addition of lime, CM associated with *Rhizobium* inoculum is the best method to raise soil fertility, quality and yield of mung bean.

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