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Evaluation of Arsenic pollution Ability in Soil, Water, Seed and Effects of Lime on The Arsenic Uptake and Yield of Mung Beans

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Abstract

The arsenic (As) contaminated soil and irrigation water of crops that has existed for a long time in An Phu district, An Giang province, Vietnam reduced the crop yield and was harmful to people's health. Application of inorganic manures combined with the lime amendment, which is the best way to decrease the As absorption and raise yield of mungbean was carried out the farm experiment during January to april of 2021. The field experiment, which was performed the same time designed with six treatments of three lime ratios: 0, 4 and 6 tons CaO per ha for the river water irrigation (L1, L2 and L3 treatment) and 0, 4 and 6 tons CaO per ha for the deep well water irrigation (L4, L5 and L6) and NPK fertilizer with four replications at An Phu district, An Giang. This study was shown that all deep wells were polluted by the high As concentration. Furthermore, local farmers irrigated their crops from these deep wells and its relationship with the movement and uptake in mungbean. The positive interaction among As contents of the deep well waters, crop soils, and seeds with The correlation coefficients. Four lime treatments (both irrigated waters) decreased As contents of stems (63.5%) and seeds (65.7%) and increased the yield of mungbean (33.3%) compared to the treatment of no lime and deep well water irrigation. The higher ratio of lime amended, the lower As concentration of stems and seeds. Amendment of 6 tons CaO and river water irrigation produced the highest yield (2.70 t/ha) and lowest As contents of stems (416 ppb) and seeds (192 ppb).

Keywords: Arsenic, mungbean, lime, NPK, yield.

1. Introduction

Mung beans, which are an important role for contributing highly nutrion sources hold trace elements and diversified nutrients for humans (Chuong et al., 2021; Khan et al., 2018). The growth and productivity of mung beans has restricted by As polluted soils and irrigation water. Farmers used deep well waters contained the As hight content irrigated crops. The As content of irrigation water was absorbed in soils. Furthermore, plant roots, which were negative effects of As toxicant and uptake of plants (Saldaña-Robles et al., 2018; Kramar et al., 2015; Dixit et al., 2016). Mung beans, which could absorb As high contents in soils are the As hyperaccumulation (Rosas et al., 2016). Application of inorganic fertilizers combined with lime amendment, which could be the best way for the As immobilization of polluted soils has significantly used to reduce the As absorption and raise yield of mung beans (Heeraman et al., 2001, Chuong et al., 2021). the main objective of this study has assessed impacts of four lime ratios on yield and As accumulation of mung bean in the nethouse and field conditions.

2. Materials And Methods

Sample Collection and Experimental design

Samples of deep well waters, soils, stems, seeds of mungbean were collected in An Phu district from october to december, 2020. Total samples were 120 samples (30 samples per the sample kind). The field experiment, which was performed at Phuoc Hung commune, An Phu district, Vietnam were established including six treatments: L1-control (NPK: 80kgN-50kgP_2O_5-40kg K_2O per ha); L2 (4.0 tons CaO/ ha + NPK); L3 (6.0 tons CaO/ ha + NPK) and L4-control (NPK:); L5 (4.0 tons CaO/ ha + NPK); L6 (6.0 tons CaO/ ha + NPK) four repeats (L1, L2 and L3 treatments irrigated the river water and deep well water for L4,L5 and L6 treatments). The field study was carried out inside the dyke and irrigated by deep well water. The whole areas of experiment were 240 m^2 (0.5 m in width x 20 m in length x 6 treatment x 4 repeats).

Data Recorded

The mungbean V94-208 was used during the experimental season with the plant spacing was 30 cm on January to april of 2021. The lime amendment combined with NPK was shown in Table 1. The cultivation method followed local cultivators. Each treatment was added different lime ratios. Application of lime was at the depth of 10 cm and before 15 days after sowing.

Table 1. NPK and lime treatments

Treatment	Amendments	Addition	Irrigation water
L1-Control	NPK	80kg N- 50kg P_2O_5 -40kg K_2O / ha	
L2	NPK + lime	4.0 tons CaO + NPK	River water
L3	NPK + lime	6.0 tons CaO + NPK	
L4	NPK	80kg N- 50kg P_2O_5 -40kg K_2O / ha	
L5	NPK+ lime	4.0 tons CaO + NPK	Deep well water
L6	NPK + lime	6.0 tons CaO + NPK	

Sampling and analysis

All samples, which were taken from fields of An Phu district were deep well waters, soils, stems and seeds of mungbeen. pH of soil and water samples were examined by pH meters. Physical and chemical properties of Soils and plants were examined by method of Soil and plant Analysis (Piper, 1950; Page et al. 1982). Arsenic concentrations of soil, water, stem and seed samples were determined by the AAS method (A.O.A.C., 2000).

Table 2. Characteristics of Soil and Water before the field experiment

Parameters	Value	Parameters	Value
Silt (%)	60.1	pH_{H2O}	5.01
Clay (%)	18.2	Total As (soil inside the dike), ppm	35.5
Sand	21.7	Total As (soil outside the dike), ppm	11.5
pH soil	5.54	Total As (deep well water), ppb	297
Textural class	Loam	Total As (river water), ppb	negative

Data Analysis: The figures were processed by Microsoft Excel software. Statgraphics 18 software was used to analyze variance, compare average different among treatments and regression analysis.

3. Results and Discussion

As concentration in deep well water

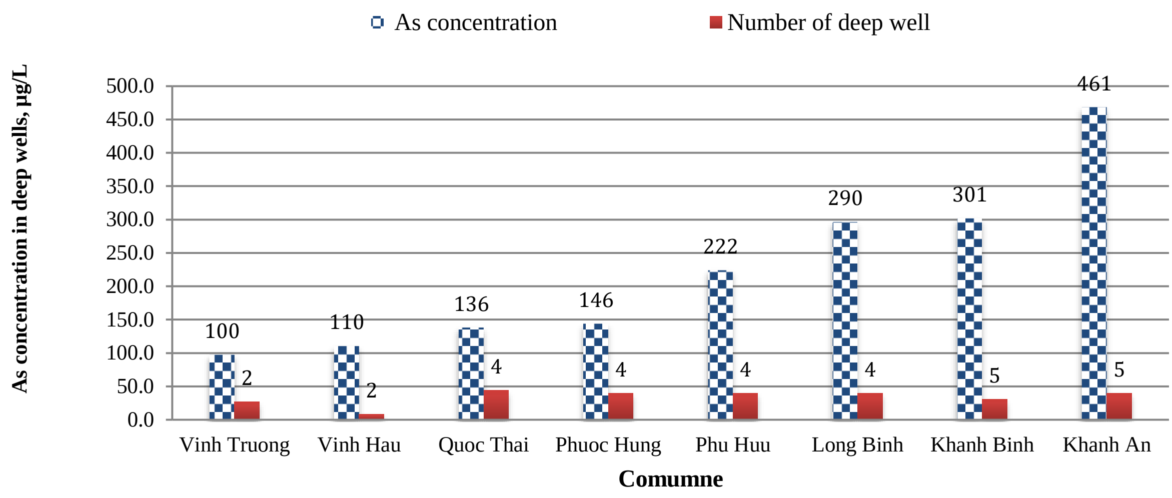

Fig.1: The As concentration of deep well water (n=30). October, 2020

Results in Fig. 1 showed that average As concentration of deep well water ranged from 100 to 461 µg/L. The highest and lowest As content reached 461 and 100 µg/L at Khanh An and Vinh Truong comumne, respectively. All deep well water samples of eight comunnes, which contained the high As content exceeded the allowed standard of WHO.

using irrigation water in crops

The local farmers have used As-contaminated water of deep wells to irrigate for their crops. The minimum rate (30%) reached at Phuoc Hung commune and the maximum rate (92.6%) for Quoc Thai commune (Figure 2). All study communes used the As polluted water of deep wells to water their crops.

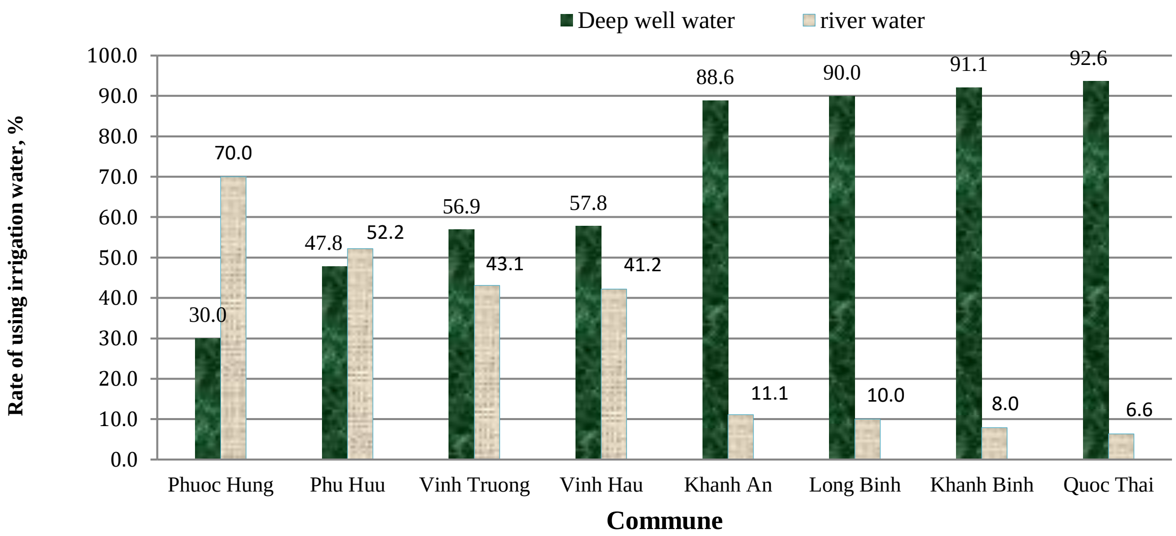

Fig.2 Irrigation water in crops in An Phu district , november 20201

Correlation between As contents of soil, deep well water and mung bean seed

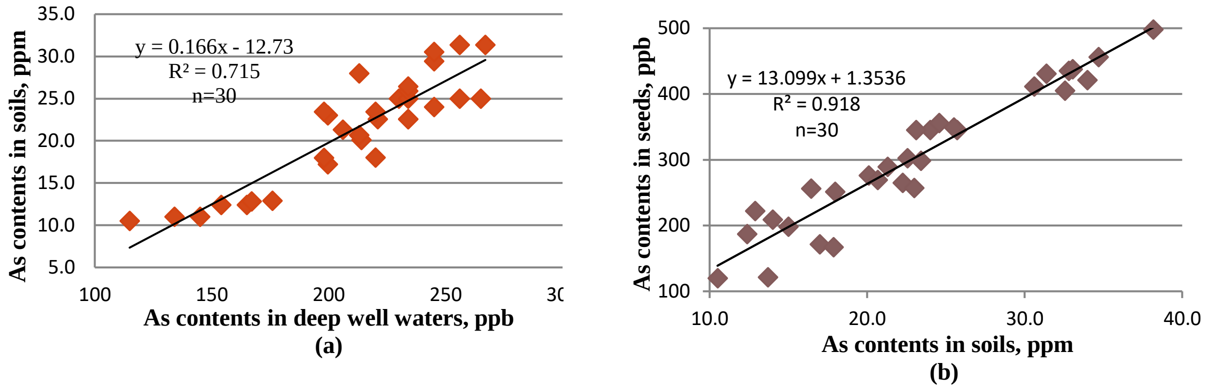

Fig.3 Correlation coefcients between: (a) soil As and deep well water As; (b) soil As and mungbean seeds

Arsenic concentrations of soil correlated positively to As concentrations of deep well water and correlation coefciens were quite high value (R^2= 0.715). As values of soil were higher when the irrigation water contained the high As concentration (Fig.3). According to prior study of Kabir et al., (2016) proved the use of arsenic polluted deep well water, which irrigated for crops could raise the As content of cultivated soils. The correlation coefficients that have significantly had the positive interrelationship of soil As with seed As were the significant relationship (Fig. 3). The above results may explain that higher content of seed As due to plants absorbed from the higher content of soil As. The crop soils may raise the As concentration due to the As polluted irrigation and finally uptake in stems and seeds of the plant (Kabir et al., 2016)

Effect of lime on the As uptake of mungbean

Table 3. yield and As content of mungbean

Treatment	Yield component and yield			As contents (ppb)	
	Biomass (t/ha)	100-seed weight (gr)	Yield (t/ha)	Stems	Seeds
L1	4.21^{b}	9.56^{b}	2.20^{c}	581^{c}	327^{e}
L2	4.69^{e}	9.82^{e}	2.60^{e}	526^{b}	222^{b}
L3	4.58^{d}	9.91^{f}	2.70^{f}	416^{a}	192^{a}
L4	3.67^{a}	7.23^{a}	1.80^{a}	1,140^{f}	559^{f}
L5	4.53^{c}	9.60^{c}	2.10^{b}	723^{e}	284^{d}
L6	4.72^{f}	9.75^{d}	2.32^{d}	623^{d}	224^{c}
F	**	**	**	**	**
CV (%)	8.50	10.3	13.5	35.3	41.9

** = Significant at p=.001

Biomass

The mungbean biomass obtained from 3.67 to 4.72 t/ha at all treatments. The highest Value of The mungbean biomass (4.72 t/ ha^{1}) that was reached at the L6 treatment irrigated by the As polluted water of the deep well and 6 tons CaO amendment for per ha. The lowest biomass was shown by 3.67 t/ ha (L4: Without lime with irrigated deep well water). There are significant differences, which was irrigated by the river water and deep well water supplied lime ratios for some treatments. The As contaminated soil of the first experiment, which contained to exceed allowed limits of crop soil was over two times (Table 2). The arsenic that is a toxic element damage to the roots, growth and yield of crops. The biomass of mungbean was reduced at treatments, which were planted on As contaminated soil and irigated water and non lime amendment (Kramar et al., 2015; Dixit et al., 2016).

100-seed weight and yield

The resulds of **Table 3 showed that** 100-seed weight of L1 with L4 treatment (irrigated river and deep well water, respectively; without lime (9.56 gr) were significant differences (P_{value} < 0.001). The 100-seed weights of L1 treatment for irrigating no As polluted water (were higher than that of L4 treatment (7.23 gr) for irrigating the As polluted water. Results in Table 3 indicated the highest 100-seed weight of mungbean was reached 9.91 gr at the 6 tons CaO amended treatment for irrigating the river water (L3) and the lowest obtained by 7.23 gr for the treatment of non lime amendment and deep well water irrigation (L4).

The use of deep well water, which was polluted the high As concentration for watering on crops reduced yield of mungbean (Table 3). Furthermore, there were low values of yield to be presented at treatments in which no lime amendment and high As contents in crop soils. Lime amendment could affect on the yield of mungbean had significant differences at p=0.01%. Productivity of mungbean that ranged from 1.80 to 2.70 t/ha was recorded the maximum value (2.70 t/ha) at the L3 treatment (application of 6.0 tons CaO/ha amended and river water irrigation) and the lowest reached in L4 (1.80 t/ha) in the treatment of no lime amendment and deep well irrigation. Interaction of lime rates and irrigation water in this study was significantly indicated during the experimental time (Table 3). The amendment of different lime ratios (0.0, 1.0 to 2.0 tons per ha) could bring beneficial effects on yield of crops. Specially, co-application of the lime combined with inorganic proved advantageous impacts on the growth and yield of crops where it was planted by As polluted soils. The lime supplementation, which raised soil pH, helpful micronutrients and hindered the As uptake of plants (Chuong, 2018; Lei *et al.*, 2018).

Arsenic concentration of stems and seeds

Application of NPK and lime amendment (4.0 and 6.0 t/ ha) that was irrigated two kinds of river and deep well water reduced As concentrations of mungbean at all lime amended treatments. Arsenic contents of stems and seeds ranged from 416 to 1,140 ppb and 192 to 559 ppb, espectively (Table 3). When lime ratios augmented from 0.0 t/ ha[1] (L1, L4) to 4.0 t/ ha (L2, L5) and 6.0 t /ha (L3, L6) significantly decreased As contents of stems and seeds from 28.4 to 41.3% for irrigating the river water and 45.4 to 59.9 % for irrigating the deep well water, respectively, when compared without lime amendment. The results of Table 3 were presented that As contents of stems and seeds in river water irrigation treatments were significantly lower than those of deep well water irrigation treatments. The L1 treament of no lime and river water irrigation contained the lower As level of stems (581 ppb) and seeds (327 ppb) than that of stems (1,140 ppb) and seeds (559 ppb) in the L4 treament of no lime and deep well water irrigation. In general, Co-application of NPK and lime amendment with river water irrigation reduced significantly the As uptake of mungbean compared to others. The lowest As concentration of stems (416 ppb) and seeds (192 ppb) was reached for 6.0 t/ ha (CaO) with river water at L3 and the highest As content of stems (1,140 ppb) and seeds (559 ppb) was by no lime amendment and deep well water irrigation treatment (Table 3). Many prior studies indicated the As immobilization of soil and reduced uptake of plants by lime, as well as impacts of As polluted irrigated water on the accumulation of soil and uptake of plants. The results proved that the arsenic immobility increased the concentration of lime supplementation raised. Moreover, the opposite relationship between lime contents and the immobilized As in soil (Chuong, 2018; Bustingorri et al., 2014)

4. Conclusion

The main source of arsenic in crop soils and mungbeans has come from deep wells. The As polluted water watering for plants, which has moved the As toxicity to soil and mungbean was the major source of this toxic element in agriculture. Application of NPK combined with the lime amendment and the river water irrigation, which had the lowest As concentration of stems and seeds of mungbean was the highest mungbean yield.

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