Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 7, 1989 –1993

Great Influences Of Various Lime Ratios On Yield And Accumulation Of Maize In Arsenic Contamination Soils And Irrigation Water

Le Mong Trai[1] , Nguyen Van Chuong[2]

[1]*Master student of crop science, An Giang University, Vietnam-Vietnam National University, Ho Chi Minh City, Vietnam, 18 Ung Van Khiem St., Long Xuyen city, An Giang province 880000, Vietnam*

[2*]*Department of Crop Science, Faculty of Agricultural, An Giang University-Vietnam National University, Ho Chi Minh City, Vietnam, 18 Ung Van Khiem St., Long Xuyen city, An Giang province 880000, Vietnam*

***Corresponding Author:** - Nguyen Van Chuong

**Department of Crop Science, Faculty of Agricultural, An Giang University-Vietnam National University, Ho Chi Minh City, Vietnam, 18 Ung Van Khiem St., Long Xuyen city, An Giang province 880000, Vietnam, email: nvchuong@agu.edu.vn*

Abstract

The objective of this study asserted lime influences on the As absorbability and yield of maize. The field experiment was carried out with five treatments to be included five different liming rates: 0, 1,2,3 and 4 t $CaCO_3$/ha (M0, M1, M2, M3 and M4) and NPK fertilizer with four replications. The positive relation between As contents of the deep well waters and maize soils (r=0.69515**), maize seeds with maize soils (r=0.674**) were high correlation coefficients. Arsenic contents of maize stems in lime added treatments were lower than control treament (M0) from 15.2% to 74.2%. The fresh maize yields of M1, M2, M3 and M4 (1, 2, 3 and 4 t $CaCO_3$/ha) were higher than 2.20, 31.6, 44.0 and 52.0% compared to control treatment, respectively. The higher rates of liming addition were the lower As content in maize stems and without as accumulation in seeds. This study will promote to design lime addition methods to improve soil nutrients and thus ameliorated plant yield in agricultural systems.

Key words: Arsenic, maize, lime, different rates, deep well water

1. Introduction

Arsenic (As) contamination of soils and irragation water has really popularized in An Giang province, Vietnam and covered in a great region of An Phu Island [1]. In these as pollution conditions, there is a complex correlation between yield and lime determinants. Crop matureness could be remarkably decreased by as toxicity in agricultural soils and reduced mineralisation, nitrification, nitogen fixation of microbiologyin soil [2]. Furthermore, these crop soils consist of the gray soil and soil poor in nutrients such N and P [3]. According to Chuong & Hung, (2021) [4], showed that 30% of the irrigation water and crop soil are significantly contained by as toxicology and soils in farms are seriously N and P shortage. These negative conditions, yield of maize, the main food plant is very low, mean 4.0 tons per ha against a potentiality of about 7 tons per ha if crop soils were well cultivated by contributing the completely essential nutrients [5]. Essential efforts are much appreciated through improving the negative impacts of soil As toxicology have therefore been added by the exact determination to amend suitable liming rate for kinds of soils. Application of chemical fertilizer is rapidly seen its effecse for overcoming nutrient shortages of agricultural soil. However, in As pollution soil and irrigation water, which could reduce low pH of soil effect to chemical fertilizers could not react because of limitations caused by low pH. Application of lime combined with chemial is the best way and most effect practice to reduce negative effects of As toxicology and soil acidity [6, 7]. Optimal pH values of agricultural soils are from 5.5 to 6.5 for the good growth of most plants. Application of lime improves and maintains the soil pH at these values. Lime raises pH, Calcium , CEC. Further, Lime neutralizes soil acidity, reduces the toxic concentration of As, Al and Fe and increases availabe phosphorus [8, 9]. All chemico-physical reactions, contributed they are about a favorable value, raise seed yields and agricultural stabilizing [10, 11]. There are, presently, other kinds of lime are been using in Vietnam. These liming kinds differ from ingredient and nutrients or auxiliary elements combined with the lime agent. These properties could affect the effect of the lime material [12]. The popular lime materials on the

Vietnam market, which are calcium oxide (CaO) and calcium carbonate ($CaCO_3$) are in the powded form. These lime kinds increase to get in touch with surface area for faster reaction with the crop soil [13]. For the highest effect, liming have to be applied into the soil two weeks before sowing seeds. This research goal was to appreciate influences of five lime ratios, which amended alone or in association with NPK fertilizer on productivity and quality of maize.

2. Materials and methods

Research location

The field study was designed in Phuoc Hung village of An Phu town, An Giang-Vietnam for one Summer- Autumn crop of 2022. An Phu is a mean temperature of 27°C with a mean annual of rainfall 1,130 mm. The rainfall of research location is from March to August. The soils in Phuoc hung are a silt loam texture. The areas were choosed on having a low soil pH (Below 5.5). farms in the study area is small cultivated by local tillers. Maize is the most popular food plant grown in the As pollution area of soil and irrigated water with much chemical fertilizer and without lime iapplication.

Soil sampling and analysis

Deep well water, soil and plant samples from the the initial and final study locations were collected and analyzed for relevant physic - chemical properties using standard methods [14]. The soil pH was determined by 1:2.5 soil. The basic cations (Ca, Mg and K) were extracted using ammonium acetate at soil pH 7. Exchangeable K, total Ca and total As in the extract were analyzed by atomic absorption spectrophotometry (AAS), and exchangeable K, Ca by flame photometry. Organic matter was analyzed by Walkley and Black method [15]. Total N was analyzed by digesting 0.5 g of the soil sample in a mixture of H_2O_2 and H_2SO_4. The Nitrogen and P concentration were determined by the sample digestion. Total As contents of water, soil and plant samples were determined by AAS method.

Experimental design and agronomic procedures

This field sudy, which was designed by a randomized complete block included the five treatments and four replicates. The five treatments consisted of five lime ratios applied alone or with NPK fertilizers. Five treatments consisted of M0-Control treatment (NPK:40N-60P-60K kg/ha); M1 (NPK fertilizer + 1t $CaCO_3$ ha^{-1}); M2 (NPK fertilizer + 2t $CaCO_3$ ha^{-1}). M3 (NPK fertilizer + 3t $CaCO_3$ ha^{-1}); M4 (NPK fertilizer + 4t $CaCO_3$ ha^{-1}). The experimental lime, which contained %humidity <0.1; %MgO> 2.24; %c$CaCO_3$ > 90.1 was collected by Ba Dao company. The whole Lime was fertilized once at in the first crop for each treatment. After tilling, the total area of each replication of 0.5 m x20 m were 10 m^2 and 200 m^2 (10 m^2 x 5 treatments x 4 repeats = 200 m^2) for the whole experimental area. The spaces between rows were at 0.5 m. Lime ($CaCO_3$) is perfectly mixed by a hoe with the experimental soil in suitable plots, before planting at least 30 days in order to the soil has enough time to react. Maize NK4300 Bt/GT of Syngenta company in Vietnam was used during the experimental crop. The plant Space of 25 cm by 30 cm, within and between rows, respectively. Three seeds were sown in each holes and chose to one per hole after 2 weeks sowing. The management of weeding, pests and diseases was took good care of maize regularly. To prevent pollution from the contiguous plots, each replication was separately hoed. Yied components and grain yield determined at Harvest

Data analysis

The collected data was analyzed by variance (ANOVA) of the statgraphics centurion xv. Means were determined by significantly different at the P*value* < 0.05 level.

3. Results and discussion

Correlation coeffciens between As contents of soil, irrigation water and maize seed

There were significantly the great relationship between As contents of deep well water, soil and maize seeds. Arsenic contents of maize soil had the high correlation coeffciens with As contents of deep well water and maize seeds and the positively relationship (r=0.674** and r= 0.6951**, respectively). High concentrations of As in irrigation water will increase the concentration of arsenic in the soil. Furthermore, the high As concentration of agricultural soils could raise the As accumulation of maize seeds (Fig. 1a & 1b). According to prior study results proved that increase As content of corn seeds due to crops taken from the high As content of pollured soils. the As concentration of agricultural lands and crop parts could increase beceause of the As pollution irrigation water. The long use of As polluted deep well water for watering could raise the As content in the crop lands and finally uptake in stems and grains of the rice plants [4].

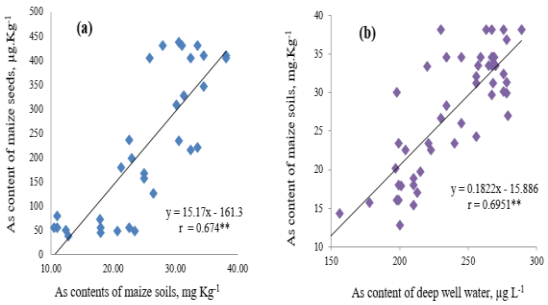

Fig.1 Relationship between As contents of maize soil and maize seeds (a); maize soil and deep well water (b)

Effect of lime on soil pH

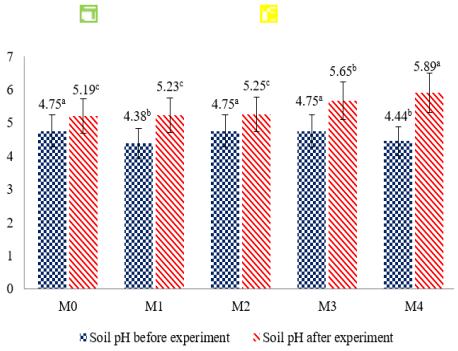

Fig. 2 Impacts of diffenrent lime rates on the soil pH of field experiment

Results in Fig.2 gives a observation for lime addition (t/ha) depended on the soil pH value, which was determined from an laboratory. Soil pH values of all treatments valued from 4.38 to 4.75 (pH < 5.5) and a quite low value, which were not suitable for the crop growth. On contrary, these soil pH made with soil As toxicology to become more movement (Fig. 2). pH values of the lime added treatments, which raised remarkably from 5.19 (the lowest pH) at M0 (control: without lime) to 5.89 (the highest pH) at M4 (added 4t $CaCO_3$/ ha). The different impacts of different lime rates on soil pH under are significantly shown in Fig. 2. In the field experiment, the $CaCO_3$ level of four tons per ha showed the best result for promoting soil pH with ΔpH = 1.45 (Fig. 2), while only applying NPK fertilizer obtained ΔpH = 0.44 a significantly lower impact than other treatments (Fig. 2). The main aim of lime addition is to raise soil pH, reduce As movement by neutralize H^+ ions from the solution of crop soil [15, 16]. According to prior study, different lime rates were the most important coposition for increasing values of soil pH to lime. A quadratic relation has also existed between soil pH and the lime rate, and the mode presentation more than 27% of the difference [17].

Effect of lime rates on growth , yield constituents of maize

Table 1. Liming effects on Plant height and yield constituents of maize

Treatment	Height per plant (cm) Days after sowing (DAS) 20	45	65	Haverst	yield constituents Biomass (kg/plant)	Wt. of 1,000 seeds (g)
M0-control (NPK:40N-60P-60K kg/ha)	27.3^{ab}	73.1^{e}	116^{c}	124^{c}	3.01^{c}	245^{c}
M1(NPK fertilizer + 1t $CaCO_3$/ ha)	25.9^{c}	77.2^{d}	121^{b}	130^{b}	3.11^{b}	259^{b}
M2(NPK fertilizer + 2t $CaCO_3$/ ha)	26.7^{b}	78.1^{c}	123^{b}	131^{b}	3.57^{ab}	261^{ab}
M3(NPK fertilizer + 3t $CaCO_3$/ ha)	27.5^{a}	79.2^{b}	129^{a}	137^{a}	3.59^{ab}	263^{ab}
M4(NPK fertilizer + 4t $CaCO_3$ /ha)	25.1^{d}	81.5^{a}	131^{a}	140^{a}	3.93^{a}	267^{a}
F	**	**	**	**	**	**
CV(%)	13.8	13.6	15.1	14.8	9,48	8.97

(**)significant difference ($p \leq 0.01$).

Influences of different lime rates on the height of corn plant (Table 1) presented that all treatments were sufficiently different at Pvalue<0.01(**). The maximum plant height (140 cm) of treatment M4 (NPK + 4 tons CaCO3/ ha) and minimum value (124 cm) of M0-control (NPK:40N-60P-60K kg/ha) at harvest. The fresh biomass of maize was remarkably affected by lime addition (Table 1). The fresh biomass ranged from 3.01 kg to 3.93kg per plant. The minimum biomass (3.01kg/plant) was only applied by NPK. Conversely, others valued from 3.11 to 393 kg/plant and the maximum biomass (3.93kg/ plant) at treatment M4 (Table 1). Maizes have requirements of suitable soil pH to be good growth [18] and most maize soils require range from 5.75 to 7.0 [19]. Therefore, application of lime and NPK fertilize is to raise higher pH value, which reduces directly negative effects on the maize growtth in order to promote the higher yield of the maize crop. The prior study of Alemu et al., (2022) [20], presented that maize yield raised 16% of the lime addition treatments comparision with control (without lime application) in acidity soil. Plant biomass bases on a genotype, which is changed by environmental and nutrient factors such as moisture and soil nutrients during growth stages of plants [21].

Weight of fresh thousand seeds at harvest under all treatments are presented in Table 2. The highest seed weight of maize (267g) was obtained towards M4, while the lowest (245 g) towards control treatment. The follow-up weight of fresh thousand seeds of maize is treatments M1(259g) and M2 (261g). Weight of seed Thousand of maize is an important role in the seed yield at haverst.The

results of Table 2 shoesd that the maximum weight of thousand-seeds was obtained towards M4, while minimum value towards control treatment. Effects of the lime addition on thousand - seeds weight were the significan presentation. More increase treatments with lime added a suitable environment for a maturity promotion, better root matureness and crop populations; it raised better yield than other methods without liming in the experiment [22].

Impacts of different lime rates on As uptake and yield of maize

The lime addition of the As pollution soil raised significantly higher seed yields compared with the control treatment. fresh seed yields of maize at harvest all experimental treatments are presented in Table 2. The greatest yield (9.17 t/ha) was towards M4 (NPK fertilizer + 4t $CaCO_3$ /ha), while the lowest yield (4.40 t/ha) had in control treatment (NPK application alone). Maize yields can be significantly raised by the application of lime on soil [23]. The As contents of maize seeds and stems in without lime treatment were always higher than application of 1, 2, 3 and 4 t $CaCO_3$/ha. The maximum As concentration of maize stems was 660 µg/kg in the control, while the minimum As level (170 µg/kg in stems) was had towards M4 (NPK fertilizer + 4t CaCO3 /ha). Similarly, treatments M1(NPK fertilizer + 1t $CaCO_3$/ ha), M2(NPK fertilizer + 2t $CaCO_3$/ ha) and M3 (NPK fertilizer + 3t $CaCO_3$/ ha) had resulted 560, 320 and 280 µg/kg in stems, respectively. However, all maize sample were undetected to contain As toxicology in seeds (Table 2).

Arsenic pollution soils may affect on the growth, yield and As uptake of maizes. Lime uses to neutralize in soil acidity and help to overcome the negative problems of soil to promote the growth, yield and reduce As uptake of plants [24, 25]. Liming ratios, which were significant affected on biomass, seed yield of corn may be the pH correction of soil by the lime application and improving the soil nutritions to maize roots [26].

Table 2. Impacts of different lime rates on As contents of stems, seeds and yield of maize

Treatment	As concentration (µg/kg)		Yield (t/ha)
	Stems	Seeds	
M0-control (NPK:40N-60P-60K kg/ha)	660^a	undetected	4.40^e
M1(NPK fertilizer + 1t $CaCO_3$/ ha)	560^b	undetected	4.50^d
M2(NPK fertilizer + 2t $CaCO_3$/ ha)	320^c	undetected	$6,43^c$
M3(NPK fertilizer + 3t $CaCO_3$/ ha)	280^c	undetected	7.86^b
M4(NPK fertilizer + 4t $CaCO_3$ /ha)	170^d	undetected	9.17^a
F	**	-	**
CV (%)	13.6	-	19.4

. ** significant difference ($p \leq 0.01$).

4. Conclusion

Co-application of lime and NPK fertilizers was positive effects on soil nutrients, yield and reduced As accumulation of the maize. The yield difference between the application of difference lime ratios and intercropped NPK fertilizers was remarkable results. Furthermore, the As concentration of maize stems in lime addition treatments were lower than that of the control treatment. Therefore, As concentrations in maize stems reduced in As pollution crop soils and raised yield and maize quality by lime application. Local farmers, who should not use well deep water to water their fields, apply lime to decrease As uptake of crops.

References

[1]. Chuong, N.V. Trung, L.T. (2021). Reducing Arsenic Absorption of corn (Zea mays L.) and its content in soil by lime and ferns (Pteris vittata). Annals of R.S.C.B., 25(4):12925–12932.

[2]. Dinkecha, K. & Tsegaye, D. (2017). Effects of Liming on Physicochemical Properties and Nutrient Availability of Acidic Soils in Welmera Woreda, Central Highlands of Ethiopia. Biochem. Mol. Biol., 2:102-109.

[3]. Chuong, N.V. & Chinh, N.T. (2018). Effects of lime and rice husk ash on total arsenic content in soybean grown inside the dike at An Phu district, An Giang province. Journal of Vietnam agriculture, science and technology. 7(92):26-30.

[4]. Chuong, N.V., Hung, H.T. (2021). Evaluation of Arsenic Pollution Ability in Soil, Water, Seed and Effects of Lime on The Arsenic Aptake and Yield of Mungbean. Annals of R.S.C.B. 12(6):1061-1066.

[5]. Ojiem, J.O. Palm, C.A.Okwosa, E.A. & Mudeheri, M.A. (2004). Effect of combining organic and inorganicP sources on maize grain yield in a humicnitisolinWestern Kenya. In A. Bationo (Ed.), Managing nutrient cycles to sustain soil fertility in sub-Saharan Africa. Academy Sciences Publishers, Nairobi, Kenya., pp. 346-356.

[6]. Fageria, N.K. (2008). Optimum soil acidity indices for common bean production on an Oxisol in no-tillage system. Comm. Soil Sci. Plant Anal., 39:845-857.

[7]. Goulding, K.W.T. (2016). Soil acidification and the importance of liming agricultural soils with particular reference to the United Kingdom. Soil Use and Manage, 32:390-399.

[8]. Jafer, D.G. & Hailu, G. (2017). Application of Lime for Acid Soil Amelioration and Better

Soybean Performance in SouthWestern Ethiopia. J. Biol. Agric.Health, 7:95-100.

[9]. Merino-Gergichevich, C.M. Alberdi, A.G. Ivanov, C. & Reyes-D'Ä±az, M. (2010). "Al3+-Ca2+ interaction in plants growing in acid soils: Al-phytotoxicity response to calcareous amendments," J. Soil Sci. Plant Nutr, 10:217-243.

[10]. Nduwumuremyi, A. (2013). Soil Acidification and Lime Quality: Sources of Soil Acidity, Effects on Plant Nutrients, Efficiency of Lime and Liming Requirements RRJAAS., 2:26-34.

[11]. Brady, N.C. & Weil, R.R. (2002). The Nature and Properties of Soil. 13th Edition, Prentice Hall, Upper Saddle River, New Jersey.

[12]. Bhargava, C.H. & Subramanian, K.S. (2017). Impact of Nano-liming materials on Biological Properties of Acid Soils Int. J. Curr. Microbiol. Appl. Sci., 6:451-457.

[13]. Anderson, J.M. & Ingram, J, S,I, (1993). Tropical Soil Biology and Fertility: A Handbook of Methods, CAB International, Wallingford, UK, 1993.

[14]. Kabir, M.S. Salam, M.A., Pau,l D.N.R. Hossain, M.I. Rahman, N.M.F. Abdullah Aziz & Latif, M.A. (2016). Spatial Variation of Arsenic in Soil, Irrigation Water and Plant Parts: A Microlevel Study. Scientific World Journal,1-14.

[15]. Bolan, N.S. Adriano, D.C. & Curtin, D. (2003). Soil acidification and liming interactions with nutrient and heavy metal transformation and bioavailability. Advances in agronomy. Academic Press, pp 215–272

[16]. Chuong, N.V. & Cuong, T.V. (2021). Reducing cadmium uptake and raising yield on rice by co-application of lime and inorganic fertilizer. Annals of R.S.C.B., 25(4):12933- 12941

[17]. Li, Y. Cui, S. Chang, S.X. et al. (2019). Liming effects on soil pH and crop yield depend on lime material type, application method and rate, and crop species: a global meta-analysis. J Soils Sediments, 19: 1393–1406. https://doi.org/10.1007/s11368-018-2120-2

[18]. FAO (Food and Agriculture Organization of the United States). (2015). Understanding Mountain Soils: A Contribution from Mountain Areas to the International Year of Soils. Mountain Partnership Secretariat 978-92-5-108804-3, Global Soil Partnership and University of Turinby, Rome, Italy .

[19]. Barrett, W. et al., (2017). Zwiep Agronomy Handbook Midwest Laboratories, INC. 13611 B Street, Omaha, NE 68144. 402-334-7770, USA

[20]. Alemu, E. Yihenew, G.S. & Birru, Y. (2022). Effect of lime on selected soil chemical properties, maize (Zea mays L.) yield and determination of rate and method of its application in northwestern Ethiopia. Elsevier, Heliyon, 8 (2022) e08657.

[21]. Fahad, S. et al., (2017). Crop production under drought and heat stress: Plant responses and management options. Front. Plant. Sci., 2017; 8, 1147

[22]. Dinkecha K, Tsegaye D (2017). Effects of Liming on Physicochemical Properties and Nutrient Availability of Acidic Soils in Welmera Woreda, Central Highlands of Ethiopia. Biochem. Mol. Biol. 2:102-109.

[23]. Bhargava, C.H. & Subramanian, K.S. (2017). Impact of Nano-liming materials on Biological Properties of Acid Soils Int. J. Curr. Microbiol. Appl. Sci 6:451-457.

[24]. Nanthi Bolan, S. Domy driano, C.A. & Denis Curtin. (2003). Soil acidification and liming interactions with nutrientand heavy metal transformationand bioavailability. Advances in Agronomy, 78: 215-272.

[25]. Abreha, K. Heluf, G. Tekalign, M. Kindie, T. (2013). Wheat crop response to liming materials and N and P fertilizers in acidic soils of tsegede highlands, northern Ethiopia, Agric. For. Fish. 2 (3):126–135.

[26]. Jafer, D. & Gebresilassie, H. (2017). Application of lime for acid soil amelioration and better soybean performance in South western Ethiopia. Jimma agricultural research center, J. Biol. Agri. Healthcare. 7 (5):95–100