ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

International Journal of Mechanical Engineering

Yield Component, Production and Arsenic Accumulation of Groundnuts as Swayed by Application of Lime, Vermicompost Combined with *Rhizobium* Inoculant

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Abstract - This study is aimed to find out impacts of lime, vermicompost, agricultural mulch and *Rhizobium* adaptability on As accumulation and yield of groundnuts on soil and water irrigation which was polluted As toxicology. The experiment was carried out April to August of 2021 in Phuoc Hung commun with the soil inside and deep well water irriagation. The experiment that had five treatments an four replications such as (RV1) NPK-40N-60P-60K kg/ha; NPK + using Agricultural mulch (RV2); NPK + 1t $CaCO_3$/ha+ *Rhizobium* inoculant (RV3); NPK +10 t vermicompost /ha^1 + *Rhizobium* inoculant (RV4) and NPK + 1t $CaCO_3$/ha+10 t vermicompost /ha^1+ *Rhizobium* inoculant (RV5) in RCB design. Results showed that the polythene mulch treatment obtained higher yield than without agricultural mulch treatment. The maximum yield and yield attributes were shown in the vermicompost alone or mixture treatments in the groundnut crop. This research was shown that great effects of vermicompost alone or combined with lime cum *Rhizobium* inoculant raised the groundnut yield from 36.6% (vermicompost alone) to 41.6% (vermicompost combined with lime cum *Rhizobium* inoculant) compared to NPK appliction alone.The As accumulation of groundnut stems and seeds was adequately reduced by lime, vermicompost or mixture. Furthermore, The As accumulation of groundnuts stems and seeds of RV2, RV4 and RV5 was lower than 25% in seeds when comparing to RV1 (control treatment). it could be concluded that higher production and lower As uptake of groundnut crop thank to the co-application of lime, vermicompost or mixture cum *Rhizobium* inoculant.

Index Terms - Arsenic, groundnut, lime, Rhizobium, vermicompost

INTRODUCTION

Peanut (*Arachis hypogaea* L.), which is an important role for providing the essential resource of nutrients for human contains from 40 to 50% oil, 20 to 30% protein and various vitamines [1]. It has been planted in all Asian regions to use as food for human and animal because of its high oil and protein [2]. The groundnut yield of the world was 1.74 tons /ha and 45.5 million tons of the production around the world [3]. However, the prior studies of Nguyen Van Chuong et al., [4], [5], [6] were shown that agricultural soils of Phuoc Hung which were both degraded soil and As contamination. Therefore, the yield and quality of the groundnut was significantly reduced by the poor fertility and As pollution of crop soils. the grey degraded soil and lack of nutritional supplementation reduced the yield of groundnut. However, most peannut soils are a lack of essential plant nutrients, especially nitrogen and phosphorus [7]. According to prior study of Ghulam et al., [8] showed that the As contamination of agricultural soil and irrigation water which has been the serious problem of the environment, agriculture and health's human due to its highly toxic and carcinogenic nature.The exposure of low As content to plants may change about the form, physiology and biochemistry of crops. Low peanut yields, which were reached by farmers in An Giang province were generally resulted by the needy soil fertility and high soil As [9]. Using the high price of chemical fertilizers coupled with the low yield of groundnuts lessened the profits of peanut farmers. Therefore, co-application of lime, organic manures and *Rhizobium* inoculation used to increase the yield aquality of peanut [10]. *Rhizobium* that has the potentiality to create nodules of peanut shoots and the nitrogen fixation from the air lives the symbiotic in leguminous plants [11]. The vermicompost amendment, which was proved the best maturity and production of groundnut enhanced the soil fertility and groundnut yield in the grey degraded soil [12], [13]. Co-application of lime and vermicompost with *Rhizobium* inoculant has been the popular use to improve the soil fertility and increase groundnut yields [14]. Using the lime amendment to immobilize the As toxicity soil that is the perfect and popular technology. The appliaction of lime, organic and inorganic amendments, which could immobilize the heavy metal and As toxicity in soils increased crop yields and soil fertility [15]. The raise in groundnut production and the reduction in As content in soil may be contributed to the amelioration in soil humus and soil microorganism operation raising from the lime and vermicompost application [16]. The main objective of this research tried to appraise impacts of lime, vermicompost, *Rhizobium* inoculum and As pollution irrigation water on the development and production of peanut and its As accumulation. The results of research that could

contribute for local farmers to related informations advised them to use of vermicompost, lime, *Rhizobium* combined with As unpolluted irrigation water for increasing groundnut yield and reducing the As level of peanut stems and seeds.

MATERIALS AND METHODS

The experimental location was carried out in Phuoc Hung commune of An Phu district, An Giang province, Vietnam during the Summer-Autumn season of 2021 under dripping-tube system of the deep well irrigation water. The research soils are the grey degraded soil sites, annual rainfall reaches 500–650 mm. An Phu is the border district of An Giang Province, which is contiguous to Campuchia in the Mekong Delta. The An Phu district, which had the total area of 225.3 square kilometres and over 191,328 people gets 90 km^2 far from Long Xuyen city. The rainfall raised from 60 to 70% between May and november. The average temperature ranges from 27 to 38ºC (the summer) and from 20 to 30ºC (the winter). *Rhizobium* sp., which collected from the biologic laboratory of An Giang university was isolated from groundnut nodules. Rhizobium was incubated we with groundnut seeds one day before sowing Seeds (Fig.1). The experimental location was carried out in Phuoc Hung commune of An Phu district, An Giang province (Fig 2). This field study was performed by the main harvest from April to August of 2021. This research included one experiment and five treatments. The experiment was irrigated by deep well water (Table 2). This main aims of experiment evaluated: (i) the nitrogen fixation capacity of *Rhizobium* bacteria on the soil and irrigation water of the As pollution; (ii) influences of lime, vermicompost, *Rhizobium* inoculation on As accumulation and yield of groundnuts when planing in the soil and irrigated water of the As pollution (Table 1 &2). The experimental materials, which were used by NPK fertilizers such as Ammonium nitrate (NH_4NO_3), DAP (Di-ammonium Phosphate), KCl (Potassium chloride), $CaCO^3$ and *Rhizobium* bacterium were shown in Table 2 & 3. The total area of field study was 400 m2 (0.5 m x 20 m x 04 repeats x 05 treaments x 02 experiments). Soil and water samples of early experiment were collected 0-20 cm in the soil depth of 0–20 cm for soils and deep well water for waters to analyse the soil properties and at three experimental locations. Methods of Carter & Gregoric, [17] were used to analyse the physical – chemical properties of soil such as pH, total N, total and available P, exchangeable K and texture. Total As contents of all soil, water and plant samples were determined by Atomic Absorption Spectrophotometric (AAS). Component Yield, which were counted by growth time of groundnut had height and shoot number of each plant, No. of pods per plant, number of biomass, number of nodule per plant, weight of fresh nodule, fresh weight of fill and empty pods per plant (g). The fresh yield was recorded by tons/ha for fresh pods. Results of the initial soil samples were the sandy loam, low pH of soil and deep well water (5.1 and 4.7, respectively), total nitrogen (0.120%), the Available phosphorus was quite rich (2.43 ppm). Phosphorus that is very essential nutrient of *Rhizobium* and grounduts helps for the growth of plants and *Rhizobium* life. The level of exchangeble K that had the low contents (79.0 ppm).

FIG.1 *RHIZOBIUM* ISOLATION

(a) *Rhizobium* isolation (b) purebred *Rhizobium*

FIG. 2 THE FIELD EXPERIMENT IN PHUOC HUNG COMMUNE.

The As concentration of deep well water sample (0.696 ppm) was quite high and negative for river water sample. The As concentration of soil sample in Phuoc Hung was so high (84.0 ppm) (Table 1). The groundnut seeds, which collected from Institute for the new variety of Loc Troi group, Vietnam had healthy, good disease resistance and high yield. The farm method was followed by local tillers and harvests the august end of 2021. The soil inside the dike were used during the experiment. Soil

samples were collected from 0 to 20 cm in the depth for analysing the physico-chemical properties. It was taken ten days before designing the experiment (Table 1). Soil samples were taken the initial and final experimental per the treatment and plant samples were taken at the harvest for determining the As concentration.

TABLE 1. CHEMICAL-PHYSICAL CHARACTERISTICS OF IRRIGATION WATER AND CROP SOIL AT THE INITIAL EXPERIMENT

Soil analysis		Value	Soil analysis		Value
Mechanics	Sand (%)	60.0	Soil nutrients	Total N (%)	0.120
	Clay (%)	4.50		Available P (ppm)	2.43
	Silt (%)	35.5		Exchangeble K (ppm)	79.0
	Texture	Sandy loam		$CaCO_3$ (%)	2.50
Chemical	pH_{soil}	5.1	Total As (ppm)	Deep well water	0.36
	$pH_{\text{deep well water}}$	4.7		Soil inside dike	86.1

TABLE 2. AMENDMENT OF LIME, VERMICOMPOST COMBINED WITH *RHIZOBIUM* INOCULUM

Treatment	Irrigation water*	Agricultural mulch	Rhizobium (10^8CFU/g)	$CaCO_3$ (ton/ha)	Vermicompost (ton/ha)	Chemical fertilizer (N-P-K, kg/ha)
RV1 (control)	Deep well	No	No	0.00	0.00	
RV2	Deep well	Yes	No	0.00	0.00	
RV3	Deep well	No	inoculum	1.00	0.00	40-60-60
RV4	Deep well	No	inoculum	0.00	10.0	
RV5	Deep well	No	inoculum	1.00	10.0	

(*) the irrigated water of experiment was the deep well water (As pollution)

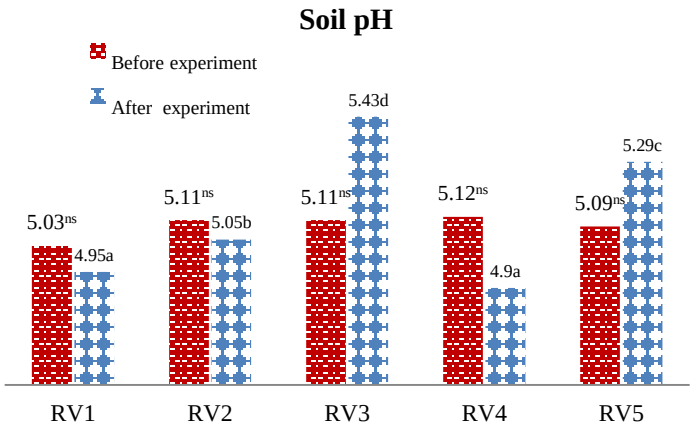
The experiment datum were analyzed statistically at significant difference at the 5% and 1% probability level. The analysis of variance was determinated by Statgraphics Centurion XIX.

RESULTS AND DISCUSSION.

3.1 The influence of Rhizobium, Vermicompost, lime and river water irrigation on Soil pH

The results in Figure 3 showed that soil pH values ranged from 5.03 to 5.12 before the experiment and inadequate diferrences at 5%. However, there had adequate diferrences among treatments after the experiment and pH values varried from 4.9 to 5.43. The maximum pH of RV3 (one ton $CaCO_3$ per ha) was 5.43 and the minimum value (4.9) of RV4 (10 tons vermicompost/ha). The soil pH values of lime supplement treatments (RV3 and RV5) were completely higher than without lime amendment treatments after the experiment (RV1, RV2 and RV4). The soil pH before the experiment that was lower than the soil pH after the experiment. The soil pH of RV1 treatment was lower than the RV2 treatment which was used the agricultural mulch and sufficient differences at 5%. These increase results of soil pH could cause the number of Ca^{2+} ions to be amended to the agricultural soil from $CaCO_3$ and Vermicompost. The prior study of Islam et al., [18] presented the soil pH increase was shown the application of lime, animal manure and chemical fertilizers when comparing to the control treament (without lime).

FIG. 3 SOIL PH BEFORE AND AFTER THE FIELD RESEARCH



3.2 Yield components of groundnuts

Influences of Vermicompost, lime, *Rhizobium* and water irrigation on the plant height of peanuts (Table 3) revealed that there was sufficient difference ($P<0.05$) among all treatments. The maximum plant height (111 cm) and minimum value (97.5 cm) that were obtained in treatment RV5 (NPK + 1 ton $CaCO_3$ + 10 tons vermicompost per ha and *Rhizobium* inoculum) and RV1 (only NPK application), respectively at harvest. Further, plant branches in stage of 45 and 65 DAS at RV5 raised higher number of effective branches in other treatment. However, effective branches, which were insufficient difference ($P<0.05$) at 20 DAS and harvest had sufficient increase during the growth time (Table 3). The prior study of Aipa and Michael, [12] was shown that

positive impacts of Vermicompost, lime, *Rhizobium*,which raised yield components such as plant heights and effective branches of peanuts.

TABLE 3. EFFECT OF VERMICOMPOST, LIME, *RHIZOBIUM* AND WATER IRRIGATION ON THE GROUNDNUT GROWTH AT HARVEST

Treatment	Plant height (cm)				No. of branches/ plant			
	20 DAS*	45 DAS	65 DAS	110DAS	20 DAS*	45 DAS	65 DAS	Harvest
RV1	12.4^{c}	31.3^{b}	55.4^{b}	97.5^{a}	4.0	11.0^{a}	28.0^{ab}	32.8
RV2	12.4^{c}	29.5^{ab}	52.6^{ab}	103^{b}	3.25	11.8^{ab}	28.5^{b}	30.3
RV3	9.85^{a}	29.85^{ab}	52.5^{ab}	103^{b}	3.75	12.3^{b}	27.5^{ab}	32.0
RV4	11.3^{bc}	29.4^{ab}	50.2^{a}	107^{bc}	4.25	11.8^{ab}	25.5^{a}	28.3
RV5	10.9^{ab}	28.7^{a}	48.5^{a}	111^{c}	4.25	11.0^{a}	28.3^{ab}	31.3
F_{test}	**	*	*	**	ns	*	*	ns
CV(%)	10.5	5.03	7.21	5.36	18.4	6.57	7.31	10.3

** DAS: Day after sowing;* ns : no significant differences;*,**: difference at $P_{value} \leq 0.05$ and 0.01%

TABLE 4. EFFECT OF VERMICOMPOST, LIME, *RHIZOBIUM* ON THE YIELD COMPONENTS AND YIELD OF GROUNDNUTS

Treatment	Parameters per plant							
	Biomass (g)	No. of pods		Wt. of pods (g)		No. of nodules	Wt. of nodules (g)	Wt. of 1,000 seeds (g)
		Full	Empty	Full	Empty			
RV1	765^{a}	54.1^{a}	2.45^{ab}	88.5^{a}	1.35^{a}	271^{ab}	5.39^{b}	80.0^{a}
RV2	$1,300^{b}$	83.9^{b}	2.43^{ab}	145^{b}	1.35^{a}	318^{b}	6.34^{d}	90.0^{b}
RV3	$1,145^{b}$	85.0^{b}	3.10^{bc}	143^{b}	2.05^{b}	382^{c}	7.60^{e}	80.0^{a}
RV4	$1,325^{b}$	105^{c}	3.45^{c}	193^{c}	2.85^{c}	288^{b}	5.74^{c}	90.0^{b}
RV5	$1,275^{b}$	114^{c}	2.38^{a}	204^{c}	1.27^{a}	230^{a}	4.57^{a}	90.0^{b}
F_{test}	**	**	*	**	**	**	**	**
CV(%)	20.2	21.9	21.7	23.0	19.7	20.5	17.6	7.20

,: significant difference at $P_{value} \leq 0.05$ and 0.01%*

The biomass of groundnuts was affected by application of vermicompost, lime, *Rhizobium* and agricultural mulch (Table 4). The groundnut biomass of all treatments that were used by Agricultural mulch and co-application of Vermicompost, lime with *Rhizobium* inoculant was higher than that of other treatments. The groundnut biomass raised from 765 to 1325 g per plant. The RV1 treatment that had the lowest biomass (765 g/plant) was only applied by NPK and significant variousness among all treatments (Table 4). Contrary to the RV1 treatment, other treatments were the higher biomass from 1,125 to 1,325 g/plant and insignificant differences at 5%. The results in Table 4 may cause the positive relation of vermicompost, lime and *Rhizobium* inoculant with soil nutritional amendment [19]. The growth and biomass of groundnuts could raised strongly when applying animal manure combined with *Rhizobium* inoculant [20].

The highest number and weight of full pods were 114 and 204 g/plant, respectively in RV5 with various differences to RV1 (control), vermicompost, lime and *Rhizobium* inoculant and NPK fertilizer application (Table 4). The results in Table 4 were also shown that all treatments with the amendment of vermicompost, lime, *Rhizobium* inoculant (alone application or mixture) and using and agricultural mulch were higher number and weight of full pods of the alone NPK application (RV1). Contrary to the number and weight of fill pods, the highest number and weight of empty pods were 3.45 and 2.85 g/plant, respectively in RV4 and lowest values of number (2.38) and weight (1.27 g/plant) of empty pods with significant differences (Table 4). The mean comparative of number, weight of nodules and weight of 1,000 seeds found out high adequate differences among groups at 1% ($p>0.01$). The minimum values of number and weight of nodules were 230 and 4.57 g/plant, respectively in RV5 (Table 4). The maximum values of number (3.82) and weight (7.60 g/plant) of RV3 (lime and *Rhizobium* inoculant and NPK fertilizer application). The prior research of Mbah and Dakora, [21] revealed that applying a lot of nitrogen fertilizer to bean soils can reduce the nitrogen fixation of *Rhizobium*. For this reason, the number of nodules of peanuts can be produced less than s where nitrogen fertilizer is not applied. Application of vermicompost alone or combined with lime or using agricultural mulch increased higher weight of 1,000 seeds of peanut than others [22].

3.3 Quality and Yield components of groundnuts

The different impacts was adequately at 1% in the percent of oil and protein of grounut seeds. The RV5 treatment had the highest protein (12.9%) and oil (55.2%) of groundnut seeds with the lowest contents of 10.7% protein and 48.4% oils attained from RV1 (application NPK alone) (Table4). The application of vermicompost alone or combined with lime cum *Rhizobium* inoculant also had a signficant effects on the protein and oils content of groundnut. The vermicompost and lime amendment cum *Rhizobium* inoculant in combination with NPK fertilizer (40N-60P-60K kg/ha) raised groundnut yields which were much higher than *Rhizobium* inoculant without P vermicompost or NPK application alone. Results in Table 4 proved that the highest fresh seed yield of grounuts (8,900 kg/ha) was observed in RV5 (1 ton$CaCO_3$/ha+10 tons vermicompost/ha+40N-60P-60K kg/ha cum *Rhizobium* inoculant). the RV5 contrary, groundnut Yield had not done completely in only without vermicompost treatments i.e. RV1 (5.200 kg/ha-NPK alone) obtaining the lowest production of groundnuts (compared to other treatments). This research was shown that great effects of vermicompost alone or combined with lime cum *Rhizobium* inoculant raised the groundnut yield from 36.6% (vermicompost alone) to 41.6% (vermicompost combined with lime cum *Rhizobium* inoculant) compared to RV1 (NPK alone). Specially,the groundnut yield of RV2 (using agricultural mulch) resulted to higher than 20% yield compared to RV2

(Using agricultural mulch). When co-application of NPK, lime and vermicompost raised a greater grounut production than without vermicompost treatments [23]. According to prior study of Hakeem et al., [24] proved that The polythene mulch used for peanut fields in Nigeria which helped to retain moisture and prevent weeds very effectively during the dry seasont increase both pod and seed yield of peanuts.

TABLE 5. EFFECT OF VERMICOMPOST, LIME, *RHIZOBIUM* ON THE QUALITY AND YIELD OF GROUNDNUT

Treatments	Parameters				
	Seed protein (%)	Oil content (%)	Fresh Seed yield (kg/ha)	As contents (mg/kg)	
				stems	seeds
RV1	10.7^{a}	48.4^{a}	$5{,}200^{a}$	1.33^{c}	0.12^{b}
RV2	11.4^{b}	53.7^{c}	$6{,}500^{c}$	0.85^{b}	0.09^{a}
RV3	11.3^{b}	53.1^{b}	$5{,}950^{b}$	1.33^{c}	0.08^{a}
RV4	11.8^{c}	54.2^{d}	$8{,}200^{d}$	0.72^{a}	0.16^{c}
RV5	12.9^{d}	55.2^{e}	$8{,}900^{e}$	0.70^{a}	0.09^{a}
F_{test}	**	**	**	**	**
CV(%)	6.53	4.58	20.5	24.5	21.5

***: significant difference at* $P_{value} \leq 0.01\%$

The As accumulation of stems and seeds of groundnuts, which ranged from 0.70 to 133 mg/kg and 0.09 to 0.16 mg/kg, respectively, was sufficiently different at 1%. The highest content of peanut stems (133 mg/kg) in RV1 and RV3 and peanut seeds (0.16 mg/kg) in RV3. Further, there were the lowest As content of peanut stem (0.70 mg/kg) and seed (0.09 mg/kg) of RV5 (Table 5). Furthermore, The As accumulation of groundnuts stems and seeds of RV2 (Using agricultural mulch) was lower than 36.1% in stems and 25% in seeds. In general, the lowest As uptake of stems (0.70 mg/kg) and seeds (0.09 mg/kg) was in RV5. However, the As concentration of groundnut seeds obtained the minimum value to belong to RV2 (0.09 mg/kg), RV3 (0.08 mg/kg) and RV5 (0.09 mg/kg). These results can explain that use of lime, polythene mulch and animal manures may reduce the As uptake of groundnuts due to the use of polythene mulch, lime and vermicompost. The negtive relationship between the pH and As uptake of plant increased soil pH values by lime [25]. According to prior resarch of Chuong et al., [26] revealed that co-application of lime and organic manures could reduce the As accumulation and incresse yield of crops.

CONCLUSION

This research presented the As polluted water irrigation was insignificant effect of the nitrogen fixation of *Rhizobium.* The groundnut yield of polythene mulch treatment was higher than that of without agricultural mulch treatment. Further, the biomass, number and weight of fill pods, weight of 1,000 seeds, protein and oill percent and fresh seed yield raised the highest value of the mixture treatment (1 ton$CaCO_3$/ha+10 tons vermicompost/ha+40N-60P-60K kg/ha cum *Rhizobium* inoculant). The maximum yield and yield attributes were shown in the vermicompost alone or mixture treatments in the groundnut crop. The As accumulation of groundnut stems and seeds was adequately reduced by lime, vermicompost or mixture. From the above resulds, it could be concluded that higher production and lower As uptake of groundnut crop thank to the co-application of lime, vermicompost or mixture cum *Rhizobium* inoculant.

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