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LIME AND BIO-FERTILIZER RESPONSE TO SOIL NUTRIENTS AND GROWTH OF CHILI PLANT (CAPSICUM ANNUUM L.)

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Abstract

The aim of tillers is the high quality, productivity and gain from their crops. Positive effects of lime and bio-fertilizer application significantly improved the soil nutrient and raised plant yield. The main goal of this research found out impacts of lime, bio-organic combined with inorganic fertilizer on soil properties and chili yield. The study, which was designed in Chau Thanh district, An Giang province, Vietnam, consisted of five treatments of bio-fertilizer (1.0 ton Trichomix DT02/ ha), lime (3.0 tons $CaCO_3$/ha) and three inorganic fertilizer ratios of NPK:60-60-60 kg/ha were applied on soil properties and chili yield. As a result, the co-application of 3.0 tons $CaCO_3$/ha + 1.0 ton Trichomix DT02/ha+NPK remarkably raised the soil chemical constituents and chili yield in all treatments. Conversely, the co-application of 3.0 tons $CaCO_3$/ha and/or 1.0 ton Trichomix DT02/ha had the lower yields. The highest chili yield was significantly observed under the added treatment of lime, Trichomix DT02 and NPK. The soil chemical constituents such as total nitrogen, available phosphorus, exchangeable potassium and organic matter, which were significantly impacted by amendment treatments of lime, Trichomix DT02 and/or NPK fertilizer in differently amended levels. The added treatment of Lime, Trichomix DT02 and NPK obtained the maximum chili yield, which raised from 37.6% at C1 (NPK alone); 45.5% at C2 ($CaCO_3$ alone) and59.8% at C3 (Trichomix DT02 alone) and 23.5% at C4 when comparing to C5 (1.0 tons Trichomix DT02/ha + 3.0 tons $CaCO_3$/ha + NPK). From this research results, Co- application of lime, bio-fertilizers and inorganic fertilizers, which need to be recommended to famers to promote soil nutrients and plant yield.

Keywords: Chili; Trichomix DT02; NPK, Lime; Bio-Fertilizer; Yield.

I. INTRODUCTION

Chili (*Capsicum frutescens* L.), which is one popular food spice and brings highly economic value for tillers in An Giang, has cultivated widely around Mekong delta. The whole area of chili cultivation is 1.500 ha with an annual production of 7.46 tons yearly in An Giang (Chuong, 2019). The cultivated crop has increasingly depleted of nutrients due to abuse inorganic fertilizers and lack of technology for production. For these reasons, the chili yield and profit have been decreasing per annually (Chuong, 2019; Khaitov et al., 2019). Continuous and unscrupulous usage of inorganic fertilizers, without the co-application of organic manure especially cause environmental degradation in the soil, thereby affecting its fertility on long term basis (Adhikari et al., 2016). For maintaining optimum yield of the land and building up of soil fertility, the addition of organic manures to crops has been suggested. Further, the recent investigation found out the impacts of different sources of organic fertilizers along with different rates of lime on growth, fruit characters, and yield and quality improvement of chili (Vimala et al., 2007). Among the various factors affecting the growth and productivity of chili, the soil fertility is the prime

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consideration for increasing the crop production. Improvement in growth and yield can be brought about by the application of different doses of essential nutrients (Khaitov et al., 2019; Kareem et al., 2007). Poultry manure application had significantly increased on yield and yield components of the maize (Kareem et al., 2007). Most of the soil properties measured responded positively to applications of lime and vermicomposting either in combination or alone. Co-application of medium rates of lime (4 tons/ha), vermicomposting (5 tons/ha), and chemical P (40 kg/ ha) holds a lot of promise as an efficient alternative to amend soil acidity and increase soil nutrient availability (Abdissa et al., 2018). Many ways to increase the quality and quantity of chili pepper plant, one of them is by doing cultivation techniques improving. The co-application of lime and bio-organic fertilizer, which ameliorated soil texture as well as supply macro and micronutrients needed by the chili pepper, increased the yield of chili compared to the inorganic fertilizer application (Chuong, 2019). The paper presents the nutrient content and increases soil fertile responses of chili by lime, bio-organic and inorganic fertilizers, with the objective of obtained results on the fertilizer requirement for conventional as well as for co-application of bio-organic production of chili in Chau Thanh district, An Giang province, Viet Nam.

2. MATERIALS AND METHODS

2.1 Material

Chili TN 378 was collected from Trang Nong Company. Trichomix DT 02 was kindly taken from the Dien Trang Bio-fertilizer company, An Giang, Vietnam.

2.2. Experimental site

The field experiment was carried out in Chau Thanh district, An Giang province. The experiment was designed in a randomized complete block design (RCBD) with five treatments and four replications. Five experiment consisted of C1 (control treatment): applied belong to local famers (NPK: 60-60-60 kg/ ha), C2 (3.0 tons $CaCO_3$/ha+ 1.0 ton Trichomix DT02/ha), C3 (1.0 ton Trichomix DT02/ha), C4 (NPK+1.0 ton Trichomix DT02/ha) and C5 (3.0 tons $CaCO_3$/ ha + 1.0 ton Trichomix DT02/ha + NPK). Usage of river water watered during crop, with area of each replication of being equivalent to 24m^2 (2m x 12m), planted with distance of 60 cm x 40 cm (three seeds per hole), the distance between plants was 40 cm and row was 60 cm. The pots were applied with a basal dose of N, P and K at 60:60:60 kg/ha, respectively (Chuong, 2019). The NPK fertilizers used urea, KCl and single super phosphate. The lime, P, K and Trichomix DT02 were wholly applied fifteen days before sowing except urea, which was applied in two split doses. Fifty percent of the nitrogen quantity was applied 15 days after sowing and the rest was top dressed 60 days after sowing. Observations on growth of chili recorded at 20, 45, 65 days and harvest) such as plant height, number of branches and leaves per plant. Furthermore, of fresh fruits was counted by ton per hectare.

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2.3 Collection and analysis

The soil samples were taken from 20 cm in depth, which was taken twice (the first and end of the crop), collected using systemic sampling method. The soil sample was then air-dried at room temperature and sieved with a 2 mm sieve for determination of physical and soil chemical *constituents*. Particle size distribution was determined using Bouyoucos hydrometer method (Walkley and Black, 1934). Soil pH, 10 g of soil was mixed with distilled water at a ratio of 1:2.5, and the pH was measured with soil pH. The method of Walkley and Black (1934) was analyzed for organic matter. Modified KJeldahl distillation method determined soil total nitrogen. The available phosphorus (P_2O_5) in the soil was analyzed by the Lancaster method. Exchangeable potassium was eluted with 1 N-NH_4OAc and then measured with an Atomic Absorption Spectrometer (AAS).

Table 1: Chemical Properties of Soil at the First of the Experiment (n=5)

No.	Characters	Results
1	pH_{H20}	5.30
2	Total N (%)	0.122
3	Available P (ppm)	551
4	Available K(ppm)	248
5	OM (%)	2.28

3. RESULTS AND DISCUSSION

The result of soil pH_{H2O} (Table 1) was suitably for the chili grow (pH = 5.13-5.28) (Haynes & Naidu, 1998). The soil pH values after the experiment were significantly raised higher than those of soil pH before of the experiment, and significant differences at level 5%. The highest soil pH obtained 7.0 at C5 and lowest at C3 (5.47) after the experiment. According to (Santri et al., 2002), soil pH value raised with the application of lime at the certain rate due to soil neutralization process after lime addition. The reaction time of lime depends on the kind and size of the lime particles used. The pH increase of soil begins ten days after lime addition application in each treatment thank to the reaction of lime and soil particles. Treatments of lime, bio-fertilizers combined with NPK fertilizer significantly increased a pH value (about 1) 14 days after adding (Mkhonza et al., 2020; Chuong, 2019).

Table 2: pH and OM of soil before and after of the experiment

Treatment	pH		OM (%)	
	Before	After	Before	After
NPK:60-60-60 kg/ ha (C1-control)	5.16^{b}	5.67^{c}	2.15	2.14^{e}
3.0 tons $CaCO_3$/ha + 1.0 ton Trichomix DT02/ha(C2)	5.30^{a}	6.65^{b}	2.17	2.54^{c}
1.0 ton Trichomix DT02/ha (C3)	5.15^{b}	5.47^{c}	2.14	2.43^{d}
NPK + 1.0 ton Trichomix DT02/ha (C4)	5.25^{ab}	6.78^{ab}	2.15	2.63^{b}
3.0 tons $CaCO_3$/ha + 1.0 ton Trichomix DT02/ha +NPK (C5)	5.30^{a}	7.00^{a}	2.14	2.90^{a}
F_{test}	**	**	ns	**
CV (%)	11.6	12.5	12.5	13.5

**: significantly different at level 1 %; ns: insignificantly different at level 5 %;

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The results in Table 2 presented the maximum organic matter content of soil (2.90%) at harvest, which was obtained by co-application of the lime combined with Trichomix DT02 and NPK fertilizer, and significantly different at level 1% among all other treatments, while the lowest percent value of OM (2.314%) was the control treatment (Table 2). The soil organic matter valued from 2.14% to 2.17% before the experiment and was insignificantly different among treatments. However, the reaction among lime and bio-fertilizer was significant differences ($p \leq 0.01$) at harvest (Table 2). The highest OM percentage (2.90%) was reached at the C5 treatment having 3.0 tons $CaCO_3$/ha + 1.0 ton Trichomix DT02/ ha + NPK followed by C4 (NPK+1.0 ton Trichomix DT02/ ha). The organic matter all the lime and Trichomix DT02 management was almost raised except control treatment (C1). Many studies have proved that soil organic matter is a nutrient source closely related to soil fertility, especially in hot and humid tropical conditions (Zao et al., 2020). The bio-organic or organic fertilization (BF and OF) significantly enriched soil fertility, as the soil organic matter increased by 55–75% (Prasad et al., 2009).

The plant yield is wholly determined by nitrogen, which is a nutrient element to promote the crop growth. Each N type of soil depends on the soil organic level. The soils content the high level of humus, which could contain such a Nitrogen (Prasad et al., 2009). The result in Table 3 showed that soil total N contents after of the experiment range from 0.110% (C1) to 0.139% in C5. The highest total nitrogen (0.139%), which obtained C5 treatment at harvest, was the best treatment of lime, Trichomix DT02 and NPN combination for the soil nitrogen. The lowest total N concentration was 0.110% in the treatment C1 (NPK application alone). The impacts of lime and bio-fertilizers on nitrogen mineralization and P availability may be magnified in the highly humid soils. The lime amendment for crop soil was higher Nitrate-N content than other treatments (Mkhonza et al., 2020).

Table 3: Soil N, P, K Contents Before and after of the Experiment

Treatments	Total N (%)		Available P (ppm)		Exchangeable K (ppm)	
	Before	After	Before	After	Before	After
C1 (Control)	0.113	0.110^{c}	376^{c}	320^{e}	240^{a}	280^{d}
C2	0.115	0.135^{b}	465^{a}	727^{c}	230^{bc}	310^{b}
C3	0.112	0.133^{b}	370^{c}	404^{d}	240^{ab}	268^{e}
C4	0.115	0.133^{b}	414^{b}	872^{b}	232^{bc}	377^{a}
C5	0.114	0.139^{a}	405^{b}	914^{a}	212^{d}	292^{d}
F_{test}	ns	**	*	*	*	*
CV (%)	12.4	13.6	4.04	12.9	6.49	11.5

**, **: are significantly different according to LSD at 5 and 1%*; *ns: are not different*

Soil available P was significant differences according to LSD at level 5% before and after of the experimental (Table 3). Available P, which raised all treatments at harvest, ranged from 520 to 914 ppm. There was a higher increase of available P in treatments, which were co-application of NPK, lime and/or Trichomix DT02 (C2, C3, C4, and C5), except for C1. The available P content after of experiment in C5 was the highest compared to other treatments. Many prior studies showed that P content of bio-fertilizer affected

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available P of soil during a long period of time. Because, when mineralized organic matter could release P into soil solution, reduce P adsorption and increase available P in crop soil (Abdissa et al., 2018; Zhao et al., 2020).

Exchangeable K in soil samples before and after of the experiment, which were significant differences among treatments at level 5%, ranged from 212 to 240 ppm and 280 to 377 ppm, respectively. After of the experiment, the treatment C4 had the maximum exchangeable K (377 ppm). Conversely, the minimum exchangeable K (268 ppm) was recorded by using Trichomix DT02 alone (C3), and significant difference when compared to other treatments (Table 3). The exchangeable K is often related with the K uptake by plants. According to prior studies of Rivera, (2021); Prasad et al., (2009), discovered that bio-organic and organic fertilizers are natural resources of humic for plants and soils. The humic soils have existed in almost all soil types in the small forms of potassium humate, potassium fulvates and humins. Naturally occurring humic soils from low charcoal grey are the best fertilizer, which is used such as organic fertilizer leads to risk of xenobiotic compound (Ullah et al., 2020; Meena et al., 2020; Brtnicky et al., 2019). In genaral, the co-application of organic fertilizers increased K, P, and N contents at all environmental condition. Especially in the greenhouse condition with significant differences. The co-application of lime, bio-organic and organic fertilizers raised strongly the soil nutrient content in all experiments (Chuong and Trai, 2021; Khaitov et al., 2019).

Table 4: Chili Height during the Growth Time

Treatments	Plant height (cm)			
	20 DAS	45 DAS	65 DAS	Harvest
C1	15.0c	34.0b	42.2bc	58.0b
C2	14.9c	31.0c	32.9c	41.0c
C3	11.9d	22.1d	29.8d	37.2d
C4	17.4b	34.1b	47.7b	57.9b
C5	19.0a	37.1a	63.2a	71.6a
F	*	*	*	*
CV (%)	16.5	15.5	19.4	14.8

*DAS: days after sowing, *: significantly different according to LSD at 5 %.*

Table 5: Number of Chili leaves as affected by NPK, Trichomix DT02 and lime

Treatment	No. of chili leaves (leaves/plant)			
	20 DAS	45 DAS	65 DAS	Harvest
C1	15.0b	49.0c	166b	205b
C2	15.0b	33.3d	102c	161c
C3	13.2c	22.6e	100c	102d
C4	20.8a	53.7b	167b	261a
C5	21.0a	58.2a	251a	264a
F	*	*	*	*
CV (%)	16.4	14.8	11.5	18.2

**: significantly different according to LSD at 5 %.*

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The results in Table 4 presented that application of lime combined with Trichomix DT02 promoted to the chili height, which raised by combining with the different rates of lime and Trichomix DT02. In the treatment C5, the maximum chili height was 19.0, 37.1, 63.2 and 71.6 cm in 20, 45, 65 DAS and harvest, respectively. On the contrary, lime combined with Trichomix DT02 in C3 (Without NPK), chili height was the minimum value, which observed 11.9, 22.1, 29.8 and 37.2 cm in 20, 45, 65 DAS and harvest, respectively.

Number of chili leaves and branches significantly affected by all different rates of Trichomix DT02, lime and NPK fertilizers as showed in Table 5 & 6. The chili grown in C5 obtained the maximum plant height, number of branches and number of leaves per plant compared with others (Table 4, 5 and 6). The plants in C3 (Trichomix DT02 alone) had the shortest plant height, the number of branches and leaves of chili were the lowest during the growth time compared with others (Table 4, 5 and 6).

Results in Table 4, 5 & 6 presented the chili growth and yield of treatment C5 (NPK combined with Trichomix DT02 and liming) were best agronomy values compared to other treatments. There were significantly different from treatment C2 combining with Trichomix DT02 and lime except plant height, number of branches and leaves/plant. However, leaf number and plant height only raised slightly more the Trichomix DT02 application alone than those with others (Table 4, 5 and 6). The same study results of Ajeng et al., (2020).

Table 6: Number of Chili branches as affected by NPK, Trichomix DT02 and lime

Treatment	No. of branches / plant			
	20 DAS	45 DAS	65 DAS	Harvest
C1	1.32c	14.0c	26.1b	31.8c
C2	1.22cd	12.0d	16.0c	20.2d
C3	1.02d	7.70e	12.2c	15.0e
C4	1.62b	18.0b	30.0b	40.3b
C5	2.02a	25.5a	36.2a	46.0a
F	*	*	*	*
CV (%)	9.25	7.77	13.5	6.93

** Significantly different according to LSD at 5 %.*

The better growth of plants was as natural fertilizer with pesticide substance, which protects plant roots from nematodes, soil grubs and ants and performs as a nutrition inhibitor and prolongs the availability of nitrogen to short duration as well as long duration crops. Beside these, it promotes the soil nutrients considerably and protects the soil during the droughts. The bio-fertilizer manure provided soil nutrients to the plants and may improve edaphic climax, which promotes in higher chili growth parameters if combining with NPK and liming (Table 4,5 and 6). These studied results were in good agreement with the discoveries of scientists, who found out that bio-organic manures increased the plant growth and yield effectively (Kramany et al., 2007; Bade et al., 2017)

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Table 7: Effect of NPK, Trichomix DT 02 and lime on chili yield

Treatment	Fresh yield (ton/ha)
C1	7.11[c]
C2	6.21[d]
C3	4.58[e]
C4	8.71[b]
C5	11.4[a]
F	**
CV (%)	13.8

***, are significantly different according to LSD at 1 %l*.

Results in Table 7, the different rates of lime, Trichomix DT02 and NPK were significantly different at level 1% in the fresh chili productivity. The application of 3.0 tons CaCO3/ha + 1.0 ton Trichomix DT 02/ ha +NPK obtained the maximum yield of fresh chili (11.4 tons/ ha). Whereas, the minimum yield of fresh chili (4.58 tons/ ha) was observed at the treatment C3, which was applied 3.0 tons Trichomix DT 02 per ha. The flowing low chili yield was 6.21 tons/ha (NT2), which was applied by 3.0 tons CaCO3/ha. The prior study result of Shree et al., (2018) had similarity with this study result. Combination usage of vermicomposting and NPK fertilizer raised significant in case of number of nodes to first female flower, No. of fruits per pod, fruit weight (kg) per pod, yield (ton per ha). The chili growth was significantly developed under application of NPK, lime combined with bio-fertilizer, which increased higher number of fruits per plant and average fruit weight. The highest fruit yield per ha was attained under the combined usage of lime, organic and inorganic fertilizer (Afiya et al., 2021; Jadczak et al., 2010; Chuong, 2019).

4. CONCLUSION

The positive influences of lime, bio-fertilizer combined with NPK fertilizer were discovered to promote higher efficiency in improving the soil fertility and plant yield. The application of 3.0 tons $CaCO_3$/ ha + 1.0 ton Trichomix DT 02/ ha + NPK fertilizer raised chemical nutrition of soil and yield at all treatments. Whereas, the application of 3 tons $CaCO_3$/ ha or 1.0 ton Trichomix DT 02/ ha exhibited a lower yield. Therefore, the co-application of lime, bio-fertilizer and inorganic fertilizer should be considered one of the optimum options for increasing soil nutrients such as the N, available P, exchangeable K and organic matter.

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