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Effect of Polyhalite on Tea Productivity and Quality on Basaltic Soil in Lam Dong, Vietnam

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Abstract: ***Tea plants have high demand of potassium (K), calcium (Ca), magnesium (Mg) and sulphur (S), but in Lam Dong tea mainly grown on basaltic soil (rhodic ferrasols) which poor in these elements. Polyhalite is introduced as the new 4-in-1 fertilizer, which contain 48% SO_3, 14% K_2O, 6% MgO and 17% CaO. This is research on effect of polyhalite to tea productivity and quality in Lam Dong province, Vietnam. An experiment with 5 treatments of 0, 200, 400, 600 and 800 kg polyhalite ha^{-1} with background of 750N in urea, 250 P_2O_5 in fused* magnesium phosphate and 240 K_2O in KCl or polyhalite *was conducted on basaltic soil in Lam Dong province of Vietnam during 2015-2016. The trials were designed to Randomized Complete Bock (RCB) with 4 replications and plot area of 180 m^2. The results showed that polyhalite demonstrated the ability to supply plant K, Ca, Mg and S requirements, enhanced the density, weight and size of tea buds, thus increasing tea productivity by 3.3-6.0 t ha^{-1}, corresponding 11.6-19.8% in comparison with control. Also, polyhalite slightly improved tea quality parameters such as dry matter content and the concentrations of soluble substances, tannins and caffeine. Polyhalite dose gave highest tea yield was 600 kg ha^{-1}, with tea productivity of 3.95 t ha^{-1}.***

Keywords: basaltic soil; polyhalite; quality parameters; productivity; tea

1. Introduction

Vietnam is considered to be one of the cradles of the world's tea plants. With a 3,000 year history, the local is known as one of the most ancient homes of tea. The tea industry in Vietnam plays a vital role in income improvement and poverty alleviation in rural areas [4]. The tea area of Vietnam had reached 130,000 ha and the dried tea output 170,000 tons. Vietnam tea has found its way to more than 80 nations. Lam Dong is the largest tea growing province in Vietnam, with area of 22,000 ha [5]. The climate and soil in Lam Dong are suitable for high-quality aromatic tea.

The young vegetative buds of the tea plant are repeatedly harvested, thus maintenance of continuous new growth is essential. In addition to suitable ranges of temperature and air humidity, and water availability [11], tea requirements for soil mineral nutrition must be carefully met [10]. Moreover, the mineral composition of the leaves affects produce quality and depends very much on local soil properties and nutritional status [3], [2]. Due to the low soil pH and the appropriate nutrient regime in tea growing regions has become a concern [12].

Tea plants has high demand ofpotassium, calcium, magnesium and sulphur, but Lam Dong tea mainly grown on basaltic soil (Rhodic ferrasols) which poor in these elements. In basaltic soil of Lam Dong, potash content is under 0.1%, exchangeable calcium and magnesium below 20 meq kg^{-1} [8].

Polyhalite (dehydrate) is a single crystal complex with 2 molecules of water of crystallization. It is not a mixture of salts. The chemical formula is $K_2Ca_2Mg(SO_4)_4.2(H_2O)$. Polyhalite is introduced as the new 4-in-1 fertilizer which contain 48% SO_3 as sulphate (19.2% S), 14% K_2O as potassium sulphate (11.6% K), 6% MgO as magnesium sulphate (3.6% Mg) and 17% CaO as calcium suphate (12% Ca). It is recognized as an effective crop fertilizer.

To promote the use of polyhalite for main crops in Vietnam, through demonstrating the positive agronomic efficiency of polyhalite, the study on effect of polyhalite on tea productivity and quality was conducted during 2015 - 2016 in Lam Dong province, Vietnam.

2. Materials and Methods

2.1 Study site

Lam Dong is a mountainous province located in Central Highlands of Vietnam (Figure 1), with natural area of 965,969 ha. Ferralsols is a main soil group, occupies 25% area of the province. The soil was formed by the process of creating low active minerals and accumulating iron and aluminum oxide. The province belongs to monsoon tropical climate. On the whole territory, due to complex terrain, it has differences of height and cover rate of vegetation. However, Lam Dong has temperate climate, it is warm around year and rarely change yearly.

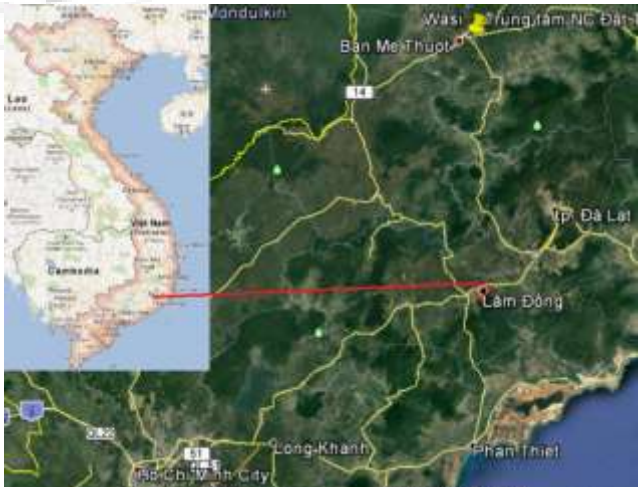

Figure 1: Stusy site

2.2 Materials

Species of tea in the experiment is TB 14 (Shan Tran Ninh) which was chose from Blao commune, Bao Loc district, Lam Dong Province, Vietnam. Fertilizers of urea (46%N), fused magnesium phosphate (15% P_2O_5), potassium chloride (60% K_2O) and polyhalite (48% SO_3, 14% K_2O, 6% MgO and 17% CaO) were used. The soil for experiment is rhodic ferralsols which has low bulk density and quite high porosity, is rich in organic carbon, nitrogen and phosphorus, but poor in potassium, calcium, magnesium and sulphur.

2.3 Methods

An experiment with 5 treatments was implemented on basaltic soil in Lam Dong province, Vietnam . The trial was designed to Randomized Complete Bock (RCB) with 4 replications and plot area of 180 m^2. The background consisted 750N in urea, 250 P_2O_5 in fused magnesium phosphate and 240 K_2O in KCl or polyhalite (Table 1).

Table 1: Experimental treatments

Treatment	*Polyhalite*	*KCl*	*Total of K_2O*
	(kg ha^{-1})		
T1	0	400	240
T2	200	535.3	240
T3	400	306.7	240
T4	600	293.3	240
T5	800	213.3	240

3. Results and Discussion

According to [6] in normal tea leaves there are 3.0-3.5% N; 0.15-0.17% P; 1.2-1.5% K. Optimal content of Ca, Mg and S in tea leaves were higher 0.4, 0.2 and 0.15%, respectively [1], over 0,8% for Ca and Mg and 0,37% for S are excess [7]. The content of N, P, K, Ca, Mg and S in tea leaves before aplication of fertilizer were lower than requirement. It is necessary time to apply fertilizer to the crop. The influence of the different fertilization treatments on nutrient content in the leaves was examined shortly. After the fertilizer application nitrogen content increased from 2.95-2.98 to roughly 3.32-3.41% of dry leaf weight, however, no differences occurred among treatments. Similarly, contents of P and K increased remarkably, from 0.144-0.149 to 0.162-0.167 %, and from 1.16-1.18 to 1.15-1.38%, respectively, with no significant effect of treatments (Table 2 and Table 3). These results also expressed that rate of potasium was uptook from KCl and polihalit were the same, in spite of employing different types of fertilizer. The response of Ca, Mg, and S was different between control (T1) and other treatments because Ca, Mg, S were supplied through polihalite (T2, T3, T4 and T5).

Table 2: Nutrient content in leaf before applying fertilizer (%)

Element	*T1*	*T2*	*T3*	*T4*	*T5*
N	2.97	2.95	2.98	2.96	2.98
P	0.148	0.144	0.146	0.149	0.147
K	1.18	1.16	1.16	1.18	1.17
Ca	0.38	0.40	0.39	0.35	0.37
Mg	0.19	0.17	0.18	0.16	0.16
S	0.14	0.15	0.14	0.15	0.14

Table 3. Nutrient content in leaf after applying fertilizer (%)

Element	*T1*	*T2*	*T3*	*T4*	*T5*
N	3.38	3.41	3.37	3.35	3.32
P	0.167	0.163	0.166	0.162	0.164
K	1.15	1.23	1.23	1.38	1.43
Ca	0.33	0.40	0.53	0.58	0.61
Mg	0.17	0.21	0.33	0.36	0.40
S	0.13	0.16	0.21	0.25	0.31

Bud density increased by 8.6-18.8% under using 200-800 kg of polyhalite. Bud weight, which was more responsive in the treatments with polihalite, increased by 4.0-7.9%. In contrast, bud length was more responsive in doses of 200-400 kg polyhalite, where it increased by 11.8-27.5% (Table 4). Thus, applying polihalite displayed much higher bud density, weight and length compared to that of control. There were dramatic differences in yield components such as bud density, weight and length among the treatments.

Table 4: The effect of the fertilizer to yield components

Treatment	*Bud density*		*Bud weight*		*Bud length*	
	(bud m^2)	*(%)*	*(g100 bud $^{-1}$)*	*(%)*	*(cm)*	*(%)*
T1	3,122 a	100.0	87.3 a	100.0	5.1 a	100.0
T2	3,389 b	108.6	90.8 b	104.0	5.7 b	111.8
T3	3,557 c	113.9	92.5 c	106.0	6.1 c	119.6
T4	3,671 d	117.6	93.9 d	107.6	6.4 d	125.5
T5	3,705 d	118.7	94.2 de	107.9	6.5 d	127.5

Means with the same letter are not different, $p < 0.05$

The tea productivity in the experiment ranged in 30.3-36.3 t ha-1. Using polyhalit increased tea productivity by 3.3-6.0 t ha^{-1}, corresponding 11.6-19.8% in comparison with control. There were significant differences in tea yield among treatments..

These results suggest that the common tea fertilization practice in these regions of Vietnam may be considerably improved using additional Ca, Mg and S fertilizers, although the exact role of this element in tea plants is still obscure [9]. The availability of nutrients, such as Ca, Mg and S appears to be significant for tea crop production and their increased application should be considered. However, tea yield inceased significatly in polihalite rate of 200- 600 kg ha^{-1}. The difference of productivity between traeatments of 600 (T4) and 800 kg ha^{-1} (T5) was insignifinatly (Table 5).

Table 5: The effect of the fertilizer to tea productivity

Treatment	*Productivity (t ha^{-1})*	*Ratio (%)*
T1	30.3 a	100.0
T2	33.8 b	111.6
T3	35.2 c	116.2
T4	36.1 d	119.1
T5	36.3 d	119.8

Means with the same letter are not different, $p < 0.05$

The data from Table 6 indicated that the lack of Ca, Mg and S appears to influence green tea quality parameters. T1 consistently obtained lower rates of dry matter content, soluble fraction, tannins, and caffeine, compared to CT2, T3, T4 and T5. Conversely, T4 and T5 displayed the highest rates for these parameters and there was no difference of dry matter content, soluble fraction, tannins, and caffeine

between these treatments. Polyhalite, comprising Ca, Mg, K and S seems to provide the most profitable solution, particularly due to significant tea quality improvement.

Table 6: The effect of the fertilizer to tea quality

Treatment	*dry matter (%)*	*soluble fraction (%)*	*Tannins (%)*	*Caffeine (%)*
T1	69.62 a	38.37 a	21.53 a	2.71 a
T2	72.77 b	41.64 b	23.26 b	2.88 b
T3	73.50 c	42.90 c	24.79 c	2.92 c
T4	74.25 d	43.53 d	25.24 d	3.01 d
T5	74.43 de	43.85 de	25.57 d	3.06 d

Means with the same letter are not different, $p < 0.05$

4. Conclusion

Polyhalite, added to a systematic K fertilization for tea plants on basaltic soil in Lam Dong, Vietnam, enhanced the density, weight and size of tea buds, thus increasing tea productivity by 3.3-6.0 t ha^{-1}, corresponding 11.6-19.8% in comparison with control. Also, Polyhalite slightly improved tea quality parameters such as dry matter content and the concentrations of soluble substances, tannins, and caffeine. Polyhalite demonstrated the ability to supply plant Ca, Mg and S requirements, while supporting better crop, compared to the fertilization without these elements. The treatment gave highest tea yield was 600 kg of polyhalite ha^{-1}, with tea productivity of 3.95 t ha^{-1}.

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