Effect of the natural clay mineral illite on the enhanced growth of cherry tomato (*Lycopersicon esculentum Mill*) in the glass house

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Abstract
This study was performed to explore the effect of the natural clay mineral illite on the improvement of soil quality and plant growth. Cherry tomato was used as a model vegetable crop. The experiment was performed during two months in the glass house of the Chungbuk National University. Seedlings were pre-cultivated in the bed soil normally used for horticultural purpose. Of the seedlings cultured, the healthy and regular sized ones were selected and cultivated in pots with 7 cm diameter and 10 cm height. They were treated with two forms of illite, particulate (PA) and powder (PW), at the following application rates: standard application [P1(PA1, PW1), 1:30(w/w)], two times[P2(PA2, PW2), 1:15(w/w)], and four times[P4(PA4, PW4), 1:7.5(w/w)] application. Untreated (P0) soil was used as a control in the experiment. At four weeks of cultivation, growth length was greater in pots treated with P1 and P2 application of illite than in P0. At ten weeks of cultivation, growth lengths increased as the application rate increased with P0, P1, P2, and to P4 applications of illite, compared to the P0 at four weeks of cultivation. Their growth length was a little greater for the application of PW illite than for the PA illite. Based on analysis of leaf and stem parts of cherry tomato, the amounts of K, Ca, and Mg, correspondingly increased, as the application rate increased from P0, P1, P2, to P4 application. At the same application rate, amounts taken up in the respective two parts were a little higher for the application of PW illite than on the PA illite. Amounts of K were relatively evenly distributed leaf and stem, whereas, the amounts of Ca and Mg were higher in the leaf than in the stem. Consequently, it appears that the illite treatment, especially, the PW form of illite, enhanced the growth of cherry tomato in the glass house during the ten weeks of the experiment.

Key Words
Clay mineral, illite, soil conditioner, cherry tomato, growth, cations, K, Ca and Mg uptake.

Introduction
Illite is a 2:1 type of sheet clay mineral and is called illite, since it is originally discovered in the deep sediment of Illinois State in USA. It is well known that illite is in large reserved and distributed in Quebec of Canada, Illinois and Pennsylvania of USA, China, and Australia. In Korea, good quality of illite is reported occur as a massive amount in the Yeongdong area of Chungbuk province. It is frequently proposed that Illite can be utilized practically on a small scale in various fields, such as environmental, medical, cosmetic, architectural, and agricultural industries. Since the specific surface area of illite is relatively large, it can absorb the malodor, toxic chemicals, and heavy metals. In addition, it can improve soil quality and help the plant growth for agricultural purposes. However, very little information is available to support such reports. Therefore, in this study, explore growth of cherry tomato in the glass house as affected by forms and concentrations of illite.

Materials and Methods
Materials
Two forms of Illite, particulate and powder, which are produced in Yeongdong of Chungbuk province, in Korea were used as soil conditioners in this study. The cherry tomato(*Lycopersicon esculentum Mill*), was selected and cultivated as the target plant.

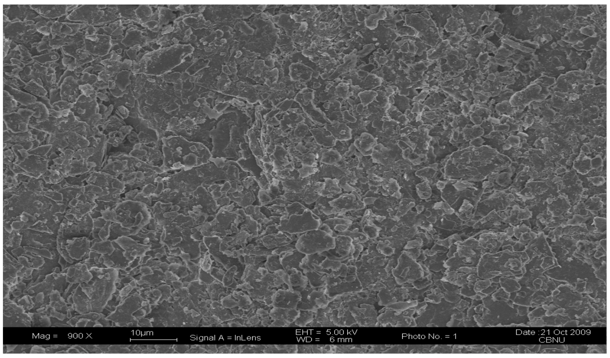
Cultivation and treatment
The seedlings of Cherry tomato were pre-cultivated in a 36 plug pot box with dimensions of 25cm X 25cm for two weeks packed with bed soil used for horticultural purposes. Then, the healthy seedlings were selected and transferred to cup pot with dimension of 7cm in diameter and 10 cm in height. Before they are

transferred, the particulate and powder forms of illite were mixed well in the cup pot as standard concentration (P1), two times (P2), and four times (P4) standard concentrations (Table 2).

Plant extraction
Plant extraction for the K, Ca, and Mg measurement were performed according to the plant analytical method (NAAS 2000).

Instrumental analysis
ICP (PerkinElmer, USA) was used for the analyses of K, Ca, and Mg.

Experimental Design and Data analysis
Seventy pots with 2 forms and 3 levels of illite including the control and 10 replications were arranged in a randomized block design. Data analysis was performed by Duncan’s multiple test using SAS at a significance level of 0.05.


SEM of particulate Illite

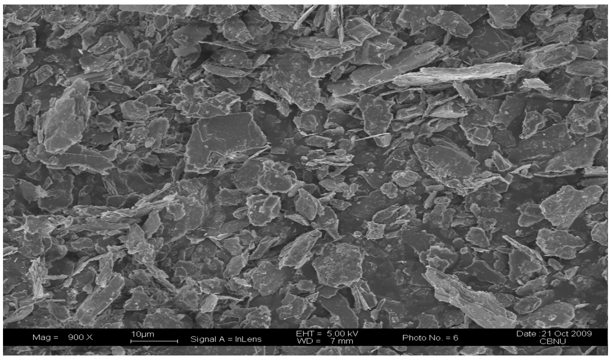

SEM of powder Illite

Figure 1. Scanning electron microscope (SEM) photograph of particulate and powder forms of illite.

Table 1. Physical and chemical properties of particulate and powder forms of illite.

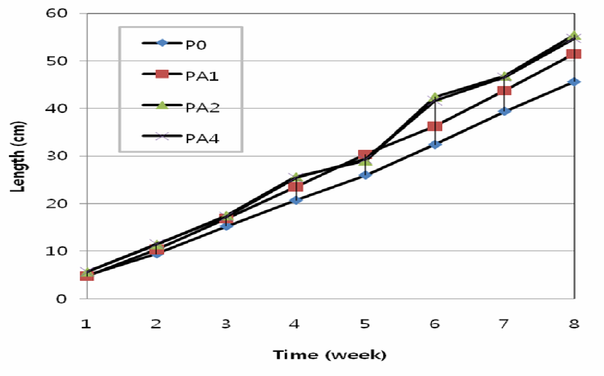
Class	pH	O.M	Exch. Cations($cmol_c$/kg)			EC
		(%)	K	Ca	Mg	(dS/m)
Particulate Illite	7.13	0.34	0.12	1.13	0.49	0.10
Powder Illite	7.14	0.52	0.45	1.55	0.69	0.13

Table 2. Application rate of particulate and powder forms of illite used in the study.

	Standard application P1(PA1, PW1) w/w	Two times applications P2(PA2, PW2) w/w	Four times application P4(PA4, PW4) w/w
Illite treatment	1:30	1:15	1:7.5

Results
Figures 2 and 3 showed the growth length of cherry tomato in the pots treated with the PA and PW illite and in untreated pots (control, P0). The growth lengths of cherry tomato were greater in the pots treated with both PA and PW illite than for P0. The growth lengths of cherry tomato treated with the PA illite were 10%, 16%, and 12% greater than that of P0, respectively. Growth lengths of cherry tomato treated with PW illite were 11%, 17%, and 15% greater than that of P0, respectively. Growth length was a little greater with PW illite than with PA illite.

Figures 4, 5, and 6 demonstrate the amounts of K, Ca, and Mg in the leaf and stem of cherry tomato as affected by the applications of PA and PW forms of illite. The results shown in the figures 4, 5, and 6, indicate that the amount of K, Ca, and Mg in the two parts of cherry tomato, leaf and stem were higher on applications of both PA and PW forms of illite than for the P0 treatment. The amounts of K were relatively evenly distributed in the two plant parts, but amounts of Ca and Mg were larger in the leaf than in stem.



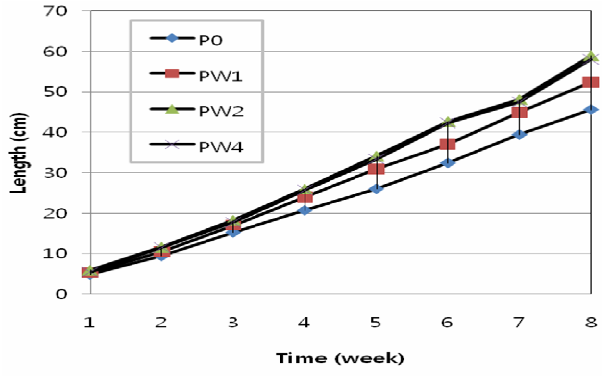


Figure 2. Growth of cherry tomatotreated with particulate illite as a function of time (week).

Figure 3. Growth of cherry tomato treated with powder illite as a function of time (week).

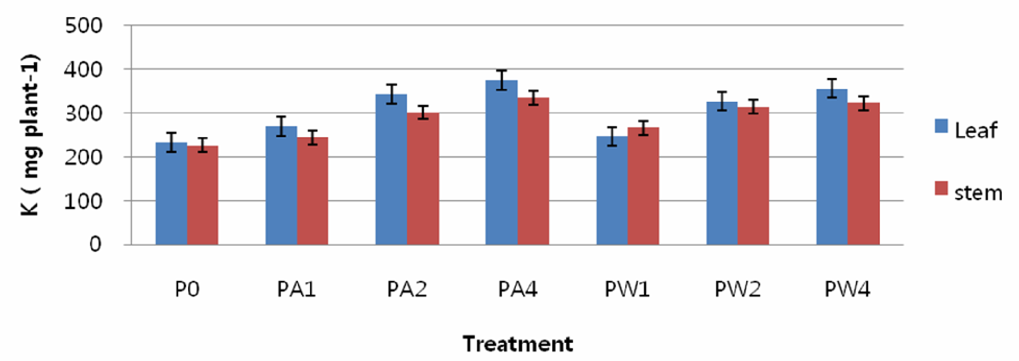


Figure 4. Amount of K in the leaf and stem as affected by the application rate of PA and PW illite.

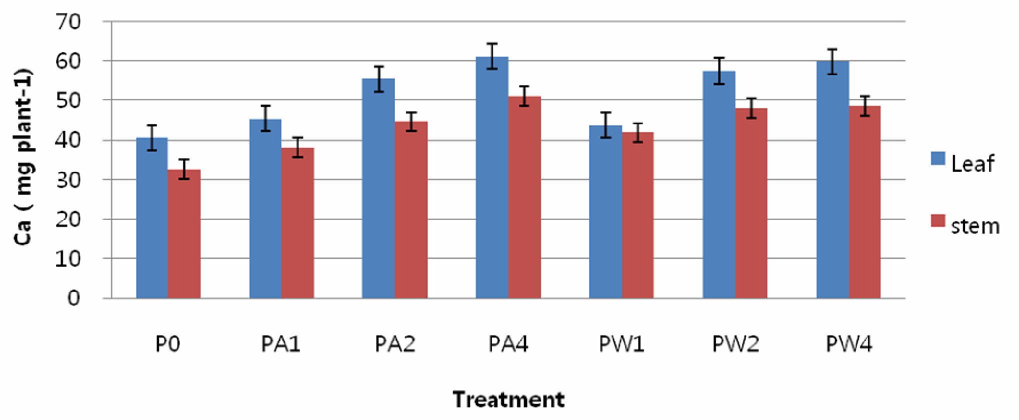


Figure 5. Amount of Ca in the leaf and stem as affected by the application rate of PA and PW illite.

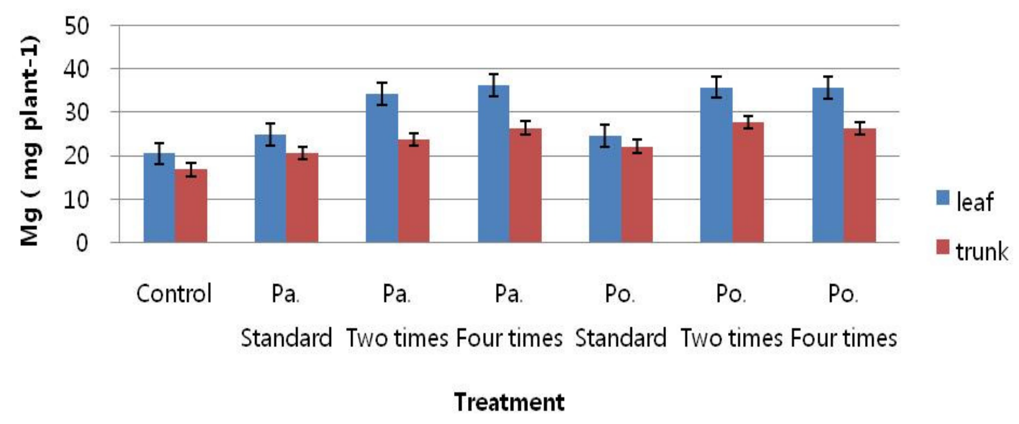


Figure 6. Amount of Mg in the leaf and stem as affected by the application rate of PA and PW illite.

Conclusion

This study showed that the growth length of cherry tomato was increased by the application of particulate (PA) and powder (PW) forms of illite. It demonstrated that the growth length of cherry tomato was 11-14% greater on the application of PA illite and 12-15% greater on the application of PW illite relative to the P0 for the three application rates (P1, P2, and P4) of illite during the ten weeks of cultivation. Their growth length was a little greater due the application of PW illite than PA illite. Under the same three application rates (P1, P2, and P4) of illite, the plant analysis for the leaf of cherry tomato showed that the amount of K was 10-36% on the application of the PA illite and 7-36% on the application of PW illite greater than values of P0. The increased in Ca was 8-26% on application of PA illite, 9-28% on application of PW illite relative to P0. Mg was 14-40% higher on application of PA illite and 18-44% on the application of PW relative to P0. For the stem of cherry tomato, the amount of K was 4-22% greater on application of the PA illite and 6-26% greater on application of PW illite relative to P0, that that of Ca was 5-26% on the application of PA illite, 7-29% on the application of PW illite relative to P0. The increase in Mg was 10-26% on application of PA illite and 10-33% on the application of PW illite relative to P0. The amount of K in the leaf on the application of PA and PW illite was similar to that of K in the stem, whereas, the amounts of Ca and Mg in the leaf were higher than in the stem on the applications of PA and PW forms of illite. The uptake amounts of cations were a little greater on the application of PW illite than for PA illite. Consequently, it appears that illite stimulates the growth of cherry tomato through the uptake of K, Ca, and Mg included in the natural clay mineral illite.

References

Choi JS, Cho SW, Kim TS, Cho K, Han SS, Kim HK, Woo SH, Chung KY (2008) Proteome analysis of greenhouse-cultured lettuce with the natural soil mineral conditioner illite. *Soil Biology and biochemistry* **40,** 1370-1378

Lee SS, Han SS, Choi GS, Ahn HJ, Kim HK, Chung KY, Woo SH, Lee CW (2005) Effect of the treatment and concentration of the natural soil mineral applied as the soil conditioner on the growth of lettuce in the glass house. In 'Proceedings of the Korean Society of Agriculture and Environment'.

Tisdale SL, Nelson WL, Beaton JD (1985) 'Soil Fertility and Fertilizers' 4th edn. (Macmillan Publishing)

Sparks DL (1995) 'Environmental Soil Chemistry'. (Academic Press: San Diego).

Sheng XF, He LY (2006) Solubilization of potassium-bearing minerals by a wild-type strain of *Bacillus edaphicus* and its mutants and increased potassium uptake by wheat. *Can. J. Microbiol.* **52,** 66-72.

Ministry of Agriculture and Forestry (2005) 'Agriculture and Forestry Statistical Year Book'. (Gwacheon: Korea).

Kang BK, Jeong IM, Kim JJ, Hong SD, Min KB (1997) Chemical characteristics of plastic film house soils in Chungbuk area. *J. Korean Soc.Soil Sci. Fert*. **30,** 265-271