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Improving Chemical Properties of Inceptisol Media Applied with Calcite and Kiserite and its Effect on Yield and Mineral Content of Moringa Leaves (*Moringa oleifera* Lam.)

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ABSTRACT

This research is about the improvement of the chemical properties of Inceptisol media applied by Calcite and Kiserite and its effect on yield and mineral content of Moringa leaves (Moringa oleifera Lam.) was carried out to consider the importance of growth and productivity of Moringa plants on Inceptisol soils with high leaf Mg levels. This study aims to determine the effect of interaction and the main effect of Calcite and Kiserite treatment on improving the chemical properties of Inceptisol media, increasing the yield and mineral content of Moringa leaves. The research was conducted at Karen Nisrina Agro, Kampar Regency, with a 4x3x3 factorial Completely Randomized Design. The first factor is Calcite with 3 dose levels, 0.0 tons $ha^{-1.}$, 2.11 tons ha^{-1} and 4.22 tons ha^{-1}. The second factor is Kiserit with 4 levels, 0.0 tons $ha^{-1.}$, 0.35 tons $ha^{-1.}$,0.45 tons ha^{-1}, and 0.55 tons ha^{-1}. Observation parameters: chemical properties of the media (pH, Ca and Mg), leaf yield and stover, and leaf mineral content (Ca and Mg). Observational data were analyzed using analysis of variance at 5% significance level, followed by Duncan's multiple distance test at 5% significance level. On the chemical properties of the soil, the interaction of giving Calcite and Kiserite occurred at pH and Ca media. Calcite increases the pH and Ca media. Kieserite increases Mg and decreases Ca media. The application of Calcite and Kiserite significantly increased the yield of leaves and stover, but there was no interaction between them. For leaf mineral content, the interaction of giving Calcite and Kiserite was found in the Ca content of the leaves. Calcite and Kiserite application had no significant effect on the Ca and Mg levels of the leaves.
Keywords: Mineral nutrient, Media, Inceptisol, production, increasing

1. INTRODUCTION

For several centuries, Moringa has been known as a multipurpose plant rich in nutrients and medicinal properties (Kusnadi, 2015). The most widely used source of nutrients from the Moringa plant is its leaves. Moringa leaves are a complete source of nutrients, both minerals and vitamins. In some African countries, Moringa leaf powder is recommended to overcome the problem of mothers suffering from malnutrition (McBurney *et al.*, 2004; Lockett *et al.*, 2000).

More and more Indonesians are becoming aware of the exceptional benefits of Moringa through various media outlets. People are now more interested in growing Moringa due to this information. Moringa farming in Indonesia takes place on acidic mineral soils.

Inceptisol is an acid mineral soil with the potential for moringa plant development. In Indonesia, inceptisol soils cover around 70.5 million ha, or 37.5% of the total land area (Puslitbangtanah, 2003). Most Inceptisols in Sumatra and Kalimantan are formed from ancient sedimentary rocks and hence have low productivity. This circumstance makes growing moringa plants with good output and quality difficult.

Inceptisol has numerous limitations for Moringa cultivation. Low fertility, acidic soil responses, and easily leached surface layers characterize Inceptisol soils (Sudirja et al., 2017). As an acidic soil, Inceptisol contains limiting factors like nutrient shortages in N, P, K, Ca, and Mg (Nursyamsi *et al.,* 2002).

Many studies have demonstrated that liming and fertilization can help to solve the problem of Inceptisol soil acidity and low fertility. Liming is beneficial for increasing soil pH and introducing Ca and Mg elements. Calcite is one sort of liming that can be employed. The CaCO3 concentration of calcite lime is 90%. Calcite treatment with this CaCO3 percentage raises soil pH and nutrient availability and can reduce the solubility of hazardous components in plants (Wijanarko et al., 2004). Furthermore, Inceptisol soil is low in Mg, and high Mg levels indicate moringa leaf quality, so Mg elements must be added. Kiserit is a Mg-containing fertilizer with a high solubility.

Kiserit is a fertilizer with Mg and S nutrients. Kiserit has a solid crystal form with the chemical formula MgSO4.H2O, a secondary mineral easily soluble in water (Kasno and Nurjaya, 2011). Applying Kiserit fertilizer on Oxixols and Ultisols soils significantly increases the Magnesium content of soil and plants (Kasno and Nurjaya, 2011). Kiserit at a dose of 0.45 tons ha-1 gives the best effect to improve the uptake of Phosphorus, Potassium and Magnesium in vegetables (Huang *et al.*, 2017)

Calcite and Kiserite must be used simultaneously due to the acidic Inceptisol soil reaction and low Mg concentration. However, there is currently a lack of knowledge on the dose of Calcite and Kiserite that results in the interaction of increased chemical properties of Inceptisol media, high growth, and yield of moringa plants. Given the importance of moringa plant growth and production, as well as the high Mg content of moringa leaves in Inceptisol soil, research on improving the chemical properties of Inceptisol media applied with Calcite and Kiserite and its effect on yield and mineral content of moringa leaves (*Moringa oleifera* Lam.) is required. This study aimed to determine the interaction effect and the main effect of Calcite and Kiserite application on improving the chemical properties of Inceptisol soil media, plant physiology, increasing yield and mineral content of moringa leaves.

2. MATERIAL AND MHETODS

This research was conducted at Karen Nisrina Agro Nursery, Simalinyang Village, Kampar Kiri Tengah Subdistrict, Kampar Regency, Riau Province, with the geographical coordinates of the location are 0ᶱ 11' 57.1416" North Latitude and 101ᵉ 20' 45.0528" East Longitude. Analysis of moringa leaves' soil chemical properties and mineral content was carried out at the Chemistry Laboratory of PT Sarana Inti Pratama. The research was conducted for 6 months, starting from March 2020 to August 2020.

Tools used in the study include: Portable Photosynthesis System Li-6400XT, Chlorophyll meter, AAS (Atomic Absorption Spectrophotometer), Spectrometer, scales, pH meter, oven, measuring cup, furnace, hotplate, analytical balance, test tube, bucket sprinkler and stationery.

Materials used include moringa plants, Kiserit ($MgSO_4$-H_2O), Calcite ($CaCO_3$) fertilizers, polybags, Inceptisol soil media, single fertilizers (Urea, RP and MOP), polinet, wood, moringa leaf powder and chemicals.

This study was a 4 x 3 factorial experiment with 3 replications, which was placed according to a completely randomized design (CRD). Each experimental unit consisted of 3 plants, so there were 108 experimental plants. Factor 1: Calcite ($CaCO_3$) application consisting of 3 levels: Calcite dose of 0.0 tons $ha^{-1.}$ 2.11 tons ha^{-1} and C3: Calcite dose of 4.22 tons ha^{-1}. Factor 2: Kiserit ($MgSO_4.H_2O$) consisting of 4 levels: K1 : Kiserit dose of 0.0 tons $ha^{-1.}$ K2: Kiserit dose of 0.35 tons $ha^{-1.}$ K3: Kiserit dose of 0.45 tons ha^{-1} and K4: Kiserit dose of 0.55 tons ha^{-1}.

The data obtained were analyzed statistically using variance analysis at the 5% real level with a linear model: $Y_{ijk} = \mu + C_i + K_j + (CK)_{ij} + \varepsilon_{ijk.}$ Duncan's Multiple Range Test (DMRT) was conducted at a real level of 5% to determine the differences between treatments.

The parameters observed in this experiment include soil chemical properties (pH, Ca and Mg media), leaf and stalk yields and mineral content of moringa leaves (Ca and Mg leaves).

3. RESULT AND DISCUSSION

Chemical Properties of Inceptisol Media Before Treatment

Based on the results of the chemical properties analysis, it can be stated that the Inceptisol media used in this study has low fertility. This is indicated by the category of each soil chemical properties where this soil has an acidic soil reaction. Total N and Na contents are low, and K, Ca-dd, Mg-dd and CEC contents are very low. In the Inceptisol media used, only the available P content (P Bray) was high, C-Organic was moderate and Al saturation was very high. Similar results were reported by Idwar et al. (2014 and 2018) that Inceptisol soils in Riau have low fertility.

Chemical Properties of Inceptisol Media After Treatment

Acidity (pH) of Inceptisol Media

The analysis of variance showed that the Calcite treatment and the interaction of

Calcite and Calcite significantly affected the pH of Inceptisol media. In contrast, the Calcite treatment did not have a significant effect. The pH value of Inceptisol media treated with Calcite and Kiserite after Duncan's multiple range test is presented in Table 1.

Table 1. pH of Inceptisol media in Calcite and Kiserite treatments.

Calcite (ton/ha)	**Kiserite (ton/ha)**				
	0.0	0.35	0.45	0.55	Average
0.0	5.92e	5.84e	6.36cd	6.18ed	6.07C^{am}
2.11	6.94ab	7.01ab	6.67cb	6.93ab	6.89B^{n}
4.22	7.30a	7.26a	7.17a	7.14a	7.22A^{n}
Average	6.72A^{n}	6.70A^{n}	6.73A^{n}	6.75A^{n}	

Note: Numbers in rows and columns followed by the same capital letter and numbers in each combination followed by the same lowercase letter are not significantly different according to the Student's t-test. Each combination, followed by the same lowercase letter, is not significantly different according to the Duncan multiple range test at the 5% real level. Duncan's multiple range test at the 5% real level. am = slightly acidic, n = neutral.

The interaction that occurred in the change of Calcite dosage from 0 tons ha^{-1} to 2.11 tons ha^{-1} and Kiserite from 0.35 tons ha^{-1} to 0.45 tons ha^{-1} resulted in a reduction of pH value by 0.43. The interaction in the change of Calcite dosage from 0 tons ha^{-1} to 2.11 tons ha^{-1} and Kiserite from 0.45 tons ha-1 to 0.55 tons ha^{-1} increased in pH value of 0.22. The interaction value of the other 4 treatment combinations was ≤ 0.145, reducing and increasing the pH value. Table 1 also shows that the increasing dose of Calcite increased the pH. However, different amounts of Kiserite produced a pH that was not different.

The interaction of Calcite and Kiserite treatments on pH value is because Calcite contains Ca and CO_3, and Kiserite contains Mg and SO_4. Aryanti et al. (2016) stated that the increase in pH value is due to liming, because lime contains Ca and Mg elements. The elements of Ca and Mg shift the position of H^+ on the colloidal surface so that the H^+ cation binds to the remaining acid carried by Calcite and Kiserit. This reaction changes the acidic condition of the soil to neutral. An increase in pH due to the rise in Calcite dosage was also reported by many researchers (Wijanarko dan Taufik, 2004; Arini, 2011; Kubro *et al.*, 2017. Novitasari *et al.*, 2019 dan Janah *et al*., 2020).

Maftu'ah et al. (2013) stated that lime will supply OH- ions into the soil solution, which will react with water with existing H^+ ions. This reaction will cause a reduction in H^+ levels, increasing soil pH.

Calcium Content of Inceptisol Media

The analysis of variance showed that the provision of Calcite and Kiserite and the interaction of Calcite and Kiserite significantly affected the Calcium content of Inceptisol media. The Ca content of Inceptisol media treated with Calcite and

Kiserite after Duncan's multiple range test is presented in Table 2.

Table 2. Ca content of Incentisol media (me/100 g) in Kiserit and Calcite treatments.

Calcite (ton/ha)	Kiserite (ton/ha)				
	0.0	0.35	0.45	0.0	Average
0.0	0.807d	0.713d	1.223d	1.040d	0.946C^{sr}
2.11	6.750c	6.827c	7.250c	5.007cd	6.458B^{s}
4.22	18.217a	17.323ab	13.513b	8.667c	14.430A^{t}
Average	8.591A^{s}	8.288A^{s}	7.329AB^{s}	4.904B^{r}	

Note: Numbers in rows and columns followed by the same capital letter and numbers in each combination followed by the same lowercase letter are not significantly different according to Duncan's multiple range test at the 5% real level. sr = very low, r = low. s = medium, t = high.

The interaction occurred in changing the dosage of Calcite from 2.11 tons ha^{-1} to 4.22 tons ha^{-1} and Kiserite from 0.35 tons ha^{-1} to 0.45 tons ha^{-1}. There was a reduction in Ca content worth 2.12 me/100g. The interaction that occurred in changing the dose of Calcite from 2.11 tons ha^{-1} to 4.22 tons ha^{-1} and Kiserit from 0.45 tons ha^{-1} to 0.55 tons ha^{-1} there was a reduction in Ca content worth 1.30 me/100g. The interaction value of the other 4 treatment combinations was ≤ 1.03 me/100 g, reducing and increasing the Ca content of the media. This is thought to be because, at these doses, a balanced ratio of Ca from Calcite and Mg from Kiserit in the soil media affects the Ca content.

Table 2. shows that the more the Calcite dose increases, the more the Ca content of the media increases. Calcite (CaCO3), when applied to the soil will hydrolyze, releasing Ca, thus increasing the Ca of the media, and the more Calcite dose given, the more Ca in the soil media. Many references have investigated on the effect of liming on soil Ca content (Yunus, 2006; Hasibuan et al., 2018; Basuki and Sitompul, 2019; Novitasari et al., 2019). Conversely, increasing the dose of Kiserit decreased the Ca content of the soil media. Kiserit ($MgSO_4.H_2O$) in the soil and releasing Mg^+ also releases $SO_4^{-2.}$ The reaction between Ca^+ with SO_4^{-2} to become $CaSO_4$ can be thought to be the cause of the decrease in Ca content of the media.

Liming and raising soil pH also affects the increase of Ca compounds in the soil (Tisdale et al., 1985). Increasing soil Ca^{2+} content is one of several benefits obtained from liming (Krisnawati and Bowo, 2019). This condition proves that liming is very effective to be applied to acid mineral soils because by increasing the Ca^{2+} content of the soil, the Ca^{2+} needs of plants are met and the Ca^{2+} reserves from liming can still be stored in the soil so that they can be utilized in the next planting season.

The decrease in media Ca content due to the increase in Kiserit dosage levels aligns with the results of Putra & Hanum's research (2018). The results of this study state that there is antagonism or opposing properties between Calcium, Potassium and Magnesium nutrients in Inceptisol soil treated with manure, dolomite fertilizer and KCl fertilizer.

Magnesium Content of Inceptisol Media

The results of the analysis of variance showed that the Kiserit treatment had a significant effect on increasing the Mg content of Inceptisol media. In contrast, the Calcite treatment and the interaction of the treatment of Kiserit and Calcite did not have a significant impact on increasing the Mg content of Inceptisol media. The Mg content of Inceptisol media treated with Calcite and Kiserite after Duncan's multiple range test is presented in Table 3.

Table 3. Mg content of Incentisol media (me/100 g) in Kiserite and Calcite treatments.

Calcite (ton/ha)	Kiserite (ton/ha)				
	0.0	0.35	0.45	0.55	Average
0.0	0.463a	0.623a	1.123a	1.293a	0.876A^r
2.11	0.437a	0.863a	0.983a	1.707a	0.998A^r
4.22	0.493a	1.070a	1.217a	1.530a	1.078A^r
Average	0.464D^r	0.852C^r	1.108B^s	1.510A^s	

Note: Numbers in rows and columns followed by the same capital letter and numbers in each combination followed by the same lowercase letter, are not significantly different according to Duncan's multiple range test at the 5% real level. sr = very low, r = low. s = medium, t = high.

Table 3 shows that all treatment combinations produce interactions that are not different. The higher the dose of Kiserite, the higher the Mg content of the media. However, the provision of various doses of Calcite on Inceptisol media resulted in Mg levels that were not different.

Table 3 shows that the increased media Mg levels align with the rise in Kiserit dosage because Kiserite is a fertilizer containing Mg and SO4. Therefore, the increase in Kiserite dosage is followed by the rise in soil Mg levels. This result is in line with the statement of Kasno and Nurjaya (2011) that Mg nutrient levels in soil and plants significantly increased due to the addition of Kiserit fertilizer in Ultisols and Oxisols soils. Kiserit increases the proportion of Mg and can neutralize Al in the soil (Rodriguez et al., 2009). However, different results were reported by Nurmahdy (2015), that the content of Mg elements in the soil after the Kiserit fertilization experiment decreased from moderate criteria (1.49 me 100 g^{-1}) to very low.

Giving various doses of Calcite on Inceptisol media produces Mg levels that are not different. This result aligns with the statement of Novitasari et al. (2019) that applying suspension and granule Calcite fertilizers at various dosage levels produces low criteria for soil Mg availability. This is due to the suspension of Calcite, and granule Calcite fertilizers contain few Mg elements. The results of this study are certainly logical, because Calcite given to the soil only adds Ca and CO_3.

Leaf and Stover Yield (g)

The results of the analysis of variance showed that the provision of Calcite and Kiserite had a significant effect on the weight of leaf and stalk yields, while the interaction of Calcite and Kiserite had no significant effect on the weight of leaf and stalk yields of Moringa plants. The weight of leaf and stalk yields treated with Calcite and Kiserite after Duncan's multiple range test is presented in Table 4.

Table 4. Leaf and Stem Yield of Moringa Plants (g) in Calcite and Kiserite Treatments.

Calcite (ton/ha)	Kiserite (ton/ha)				
	0.0	0.35	0.45	0.55	Average
0.0	16.70a	19.80a	73.90a	40.25a	35.33B
2.11	16.40a	210.10a	143.55a	333.00a	175.76A
4.22	72.67a	217.67a	161.07a	199.20a	162.65A
Average	37.61B	158.97A	131.16AB	192.01A	

Note: Numbers in rows and columns followed by the same capital letter and numbers in each combination followed by the same lowercase letter are not significantly different according to Duncan's multiple range test at the 5% real level.

Table 4. shows that all treatment combinations produce interactions that are not different. The more the dosage of Calcite and Kiserite increases, the more the weight of leaf yield and moringa plant stalks increase.

The increase influenced the increase in yield weight in the Calcite treatment in Ca content of Inceptisol media, where there was a strong correlation between media Ca and leaf and stover yield weight with a value of r = 0.74. Lime amelioration at a dose of 2 tons ha^{-1} increased the biomass yield of Muccuna sp, mung beans and corn (Yunus, 2006). The success of lime and organic matter application will cause residual effects that benefit soil fertility and increase crop productivity.

In the Kiserite treatment, the increase in yield weight was influenced by the increase in Mg content of Inceptisol media, where there was a very strong correlation between media Mg and yield weight (r = 0.88). These results are consistent with the findings of Kasno and Nurjaya (2011), who found that fertilization of oil palm seedlings with Mg nutrients significantly increased wet and dry stem weight.

The interaction effect between the application of Kiserit and Calcite on the weight of leaf and stalk yields was not different because no interaction response between the application of Kiserit and Calcite supported each other between the two treatments, where each treatment only gave a single effect on the productivity of stalk and leaves (Sirait, 2018).

According to Leone et al. (2015), in addition to the influence of fertilization, another major factor affecting moringa plants' productivity is the availability of superior plant varieties that can adapt to local environmental conditions. Meanwhile, according to Mitariastini (2016), another factor affecting moringa plants' productivity is the number of branches formed on the plant.

Calcium Content of Moringa Leaf

The analysis of variance showed that the interaction of Calcite and Kiserite treatments had a significant effect on the Calcium content of Moringa leaves. In contrast, the Calcite and Kiserite treatments had no significant impact. The Ca content of Moringa leaves treated with Calcite and Kiserite is presented in Table 5.

Table 5. Calcium Content of Moringa Leaves (%) in Calcite and Kiserite Treatments.

Calcite (ton/ha)	**Kiserite (ton/ha)**				
	0.0	0.35	0.45	0.55	Average
0.0	0.320c	1.033ab	0.450cb	0.467cb	0.604A
2.11	0.767cb	0.800cb	0.900cb	0.800cb	0.818A
4.22	1.550a	0.833cb	0.800cb	0.700cb	0.918A
Average	0.863A	0.900A	0.750A	0.656A	

Note: Numbers in rows and columns followed by the same capital letter and numbers in each combination followed by the same lowercase letter, are not significantly different according to Duncan's multiple range test at the 5% real level.

The interaction analysis results showed that the interaction of all treatment combinations was very small. Increasing the dose of Calcite increased leaf Ca levels, but the increase's nature was not significantly different. Giving Kiserit with different doses produced leaf Ca levels that were not different.

This condition is different from the results of research by Ispandi and Munip (2005) which stated that liming can increase the Ca content in plants. Calcium nutrient uptake will increase to the optimum limit of the dose of fertilizer given, then if fertilization continues to be done at a higher dose, it will result in the uptake of Calcium nutrients in soybean plants giving a negative response (Toyip, 2013).

There is no significant difference in leaf Ca levels due to Calcite and Kiserit treatments, probably due to the antagonism between Ca and Mg. This result is consistent with the results of research by Putra and Hanum (2018), which states that there is an antagonism between Calcium, Potassium and Magnesium nutrients in sweet corn plants (Zea mays saccharata L.) in Inceptisol soil applied with manure, dolomite and KCl fertilizers.

According to Arman (2016), Calcium has a role as a binder between molecules or between phospholipids and membrane constituent proteins that can spur the activity of several enzymes. Calcium and Magnesium are two elements that have essential properties for plants. If these two elements are deficient, it will cause inhibition of plant growth, which will negatively impact crop yields (Firmansyah *et al.*, 2015).

Magnesium Content of Moringa Leaf

The analysis of variance showed that the treatment of Calcite and Kiserite and the interaction of Calcite and Kiserite treatments did not significantly affect the Magnesium content of Moringa leaves. Mg levels of Moringa leaves treated with Calcite and Kiserite are presented in Table 6.

Table 6. Magnesium Content of Moringa Leaves (%) in Calcite and Kiserite Treatment

Calcite (ton/ha)	Kiserite (ton/ha)				
	0.0	0.35	0.45	0.55	Average
0.0	0.530a	0.677a	0.513a	0.420a	0.535A
2.11	0.327a	0.300a	0.530a	0.503a	0.415A
4.22	0.457a	0.360a	0.423a	0.323a	0.391A
Average	0.438A	0.446A	0.489A	0.416A	

Note: Numbers in rows and columns followed by the same capital letter and numbers in each combination followed by the same lowercase letter are not significantly different according to Duncan's multiple range test at the 5% real level.

Based on Table 6. it can be stated that all treatment combinations showed no interaction on leaf Mg content. The provision of several doses of Calcite and Kiserit resulted in no different leaf Mg levels.

The values of leaf Mg content due to Kiserite treatment in Table 6 align with the results of research by Nurmahdy (2015) which states that the application of Kiserite fertilizer does not significantly affect leaf Mg content. This condition can be suspected that the dose of Kiserite used in this study is still insufficient. Research by Kasno and Nurjaya (2011) showed different results. Kiserite fertilization on Ultisols and Oxixols can increase Mg nutrients in the soil and Mg levels in plants.

Leaf Mg levels were not altered in the Calcite treatment. This condition differs from the findings of Putra and Hanum (2018), who found that supplying dolomite increases leaf Mg levels because dolomite increases the levels of Mg and Ca nutrients in the soil. Increasing the amount of Mg in the soil increases Mg nutrient uptake, which raises the level of Mg nutrients in the leaves.

Because Magnesium is the only metal element that makes up the chlorophyll molecule, it plays a crucial role in plants (Tisdale and Nelson, 1985). Mg is contained in chloroplasts in a ±10% concentration and functions as a particular activator of various enzymes (Wirawan et al., 2016). The kind of clay, soil pH, the amount of $Mg^{+2.}$ base saturation, and CEC all influence plant Mg uptake (Nurmahdy, 2015).

4. CONCLUSION

A. Chemical Properties of Soil Media :

- There was an interaction between Calcite and Kiserite on the pH and Ca content of Inceptisol media.
- Calcite application at all doses increased the pH and Ca content of the media compared to those without treatment.

- Applying 0.35 tons ha^{-1} of Kiserite increased the Mg content of the media compared to the untreated one.
- Applying 0.45 tons ha^{-1} and 0.55 tons ha^{-1} of Kiserite increased media Mg and decreased media Ca compared to the untreated media.

B. Leaf and Stover Yield :

Calcite and Kiserite did not interact with leaf yield weight and stems. Still, the main effect of Calcite and Kiserite application significantly increased the weight of leaf and stalk yield of moringa plants.

C. Mineral Content of Moringa Leaf:

- There is an interaction between Calcite and Kiserite on leaf Ca content.
- Calcite and Kiserite at all dose levels gave no different results on leaf Ca and Mg levels.

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