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Potency of Sinabung Volcanic Ash and Chicken Manure on Growth and Production of Peanut (*Arachis hypogaea* L) in Inceptisol Soil

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CHAIRANI*, EDY SUMANTRI[1], MINDALISMA[1]

[1]Agrotechnology Department, Faculty of Agriculture, Islamic University of North Sumatera

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ABSTRACT

The research has been carried out from March 2015 to June 2015 in the experimental farm of the Faculty of Agriculture, North Sumatra Islamic University, a village of Gedung Johor, District of Medan Johor, with an altitude of ± 25 meters above sea level and on flat topography. This study aims to determine the effect of Sinabung volcanic ash and chicken manure on the growth and production of peanut (*Arachis hypogaea* L.). The research design is Randomized Factorial Random Design (RAKF) which consists of two factors. The first factor is Sinabung volcanic ash (D) that consisting of three levels, namely D_0 = 0 g (not given), D_1 = 15 kg/plot, and D_2 = 30 kg/plot, and the second is Chicken manure consisting of four levels, ie A_0 = 0 kg/plot (not given), A_1 = 10 kg/plot, A_2 = 20 kg/plot, and A_3 = 30 kg/plot. The results showed that volcanic ash has significant effect on the number of pods per sample, the number of pods per plot and the weight of pods per plot. The application of chicken manure have the significant effect on the number of pods per sample, the number of pods per plot and the weight of pods per plot. The interaction of the two treatments did not significantly affect the growth and production of peanut.

INTRODUCTION

As a natural resource for crop cultivation, the soil has two functions, namely: (1) as the source of nutrient and water, and (2) where the roots are anchored. One or both of these functions may decrease, even disappear. This loss of function causes soil productivity decline into marginal soils. Thus, marginal soils for crops cultivation are soils that have physical, chemical and biological properties that are not optimal for plant growth. If this soil is for cultivation, its requires technology input thus increasing production costs. In addition, the soil also has no good ecological function to the environment, and Inceptisols belongs to marginal soils and less productive. Productive soils must have fertility that favor for plant growth. But the fertile soil is not necessarily productive. The fertile soils will be productive if managed appropriately, using appropriate plant types and management techniques (Madjid, 2009).

Peanut (*Arachis hypogaea* L.) is one of the most important crops in Indonesia and even the crop that comes from Brasilia nowadays is widespread planting almost all over the world with total harvested area of 23 million ha (Fachruddin, 2000). Peanuts have several benefits for human life such as for cooking oil, food and even as animal feed. Peanut is a source of highly nutritious vegetable protein with 40% - 50% of fat content, protein 27%-30%, carbohydrate 13% and vitamins A, B, C, D, E and K and even contains minerals ie Ca, Cl, Fe, Mg, P, K and S (Suprapto, 2005).

In Indonesia, peanut production and productivity continue to increase from year to year, but still, cannot keep up with domestic consumption. In 2000, the demand for peanuts in the country was estimated to reach 1.9 million tons with production availability is 912,000 tons and the gap was an opportunity for agribusiness development of peanuts which could be designated as export commodities to international markets in the era of free trade (Rukmana, 2001).

Based on Statistics Official Gazette (2014) of the Province of North Sumatera, in 2012, Fixed Rate (ATAP) of peanut production in Province of North Sumatera is 12,074 tons, increase 981 tons compared to ATAP production in 2011. The production increase is due to increase in yield per hectare, that is f 1.59 Ku/ha or 15.44% while the harvested area decreased by 619 ha or 5.75%. Meanwhile, based on Temporary Number (ASEM), peanut production in 2013 amounted to 11,351 tons, a decrease of 723 tons compared to the production of ATAP in

2012. The decline in production was caused by the decrease of harvested area of 777 ha or 7.65% while the yield per hectare decreased by 0.22 ku/ha or 1.85%.

From the official statistical figure, it is necessary to make improvements. To increase the peanuts production, nutrients added to the soil through fertilization needs to be done. Presently, chemical fertilizers are widely used by farmers because easy to obtain and practical use. However, it is now recognized that the continued use of chemicals will have a negative impact on human health and environmental pollution. Suprapto (2005) stated that there are many ways to increase the production and productivity of peanuts in Indonesia namely intensification, extensification, diversification and applying the five actions "*Panca Usaha Tani*". One of the *Panca Usaha Tani* which is an important factor in the cultivation is fertilizing because fertilizer can add nutrients needed by plants.

To increase the nutrients needed by plants is to improve soil fertility by application of organic fertilizer. With this organic fertilizer, it is expected that health status and soil fertility will be maintained (soil physical, chemical and biological properties) (Sutanto, 2002). Among the organic fertilizers that are expected able to maintain soil fertility and provide nutrients for plant growth are Sinabung volcanic ash and chicken manure.

On August 28, 2010, Mount Sinabung which is located in Tanah Karo Berastagi has erupted volcanic ash. Besides the negative impact, volcanic ash can be used as excellent organic fertilizer for plants because contains many nutrients. Thus the presence of volcanic ash can rehabilitate or increase soil fertility in affected areas (Rauf, 2010).

Research on the primary mineral content of Mount Sinabung volcanic ash which erupts at the late of 2013 and early 2014, has been done by Sukarman *et al*. (2014). The results showed that volcanic ash has high easily weathered mineral such as 23% volcanic glass, 11% augite, 14% hyper stein, 8% labradorite, 3% bytownite, and 1% tourmaline. In addition, there are also other easily weathered minerals found in small amounts, namely epidotes. The above pyroclastic materials are high enough nutrient reserves which, if decaying, will become essential nutrient sources especially Ca, Mg, K, Na, P, S, Fe, Mn, and B (Sukarman and Dariah, 2014; You and Wahdini, 2010).

In addition, one of the interesting things of the primary mineral composition of Mount Sinabung is the presence of tourmaline although only 1%. The mineral is very important because of the source of Boron (B) micro nutrients, absorbed by plants in the form of B_2O_3.

The function of boron for plants is to transport carbohydrates in the body of plants, which can improve the quality of plantation crops, vegetables, and fruits. Boron also has significant role in cell propagation, especially in shoot spots, as well as for the formation of pollen, flowers, and roots (Sukarman and Dariah, 2014). Letidjawa (2008) stated that B has the important role in carbohydrate metabolism and absorbed relatively small by plants in the form of H_2BO_3-, HBO_3-, and BO_3-. Boron is closely related to the metabolism of Potassium (K) and Calcium (Ca), can multiply the nodular branches to provide many bacteria and prevent parasitic bacteria.

Chicken manure is a good source of macro and micronutrients to increase soil fertility and as the substrate for soil microorganisms and increase microbial activity so that more quickly decomposes and release nutrients. The application of chicken manure is also believed to improve the soil physical properties and nutrient cycles such as exerting enzymatic effects or hormones directly on plant roots thereby promoting plant growth (Susila, 2013).

In another hand, chicken manure is excellent organic fertilizer. Such manure is a mixture of solid and liquid manure mixed with food scraps and cage beds. The nutrient content of manure consists of a mixture of 0.5% N, 0.25% P_2O_5 and 0.5% K_2O, varies greatly depending on environmental conditions and the feed. Such manure has some properties that are better than other natural fertilizers because, in addition as a source of nutrients, manure can also increase soil humus levels, water retention and contain many microorganisms (Setyamidjaja, 2006).

MATERIALS AND METHODS

The research has been carried out from March 2015 to June 2015 in the experimental farm of the Faculty of Agriculture, North Sumatra Islamic University, a village of Gedung Johor, District of Medan Johor, with an altitude of ± 25 meters above sea level and on flat topography.

The research design is Randomized Factorial Random Design (RAKF) which consists of two factors. The first factor is Sinabung volcanic ash (D) that consisting of three levels, namely D_0 = 0 g (not given), D_1 = 15 kg/plot, and D_2 = 30 kg/plot, and the second is Chicken manure consisting of four levels, ie A_0 = 0 kg/Plot (not given), A_1 = 10 kg/plot, A_2 = 20 kg/plot, and A_3 = 30 kg/plot.

Sinabung volcanic ash is given on each plot according to the level of treatment. The application is one week before planting by sowing evenly on the plot and stirring with the rake. Chicken manure application is also performed one week before planting by entering into the soil evenly then reprocessed by using hoe or rake.

Parameters observed included plant height, a number of branches, number of pods per sample, number of pods per plot, weight of 100 seeds, a weight of pods per plot.

Data Analysis

Data were analyzed using ANOVA; further testing used Duncan Multiple Range Test (DMRT) at 5% significant level. Data were analyzed using the Statistical Analysis System (SAS) Software 9.1.

RESULTS AND DISCUSSION

RESULTS

1. Plant Height (cm)

Effect of volcanic ash and chicken manure on peanut plant height at 4 weeks after planting can be seen in Table 1 below.

Table 1. Effect of Volcanic Ash and Chicken Manure on peanut plant height at 4 Weeks after planting (cm).

Treatment	Chicken manure				
	A_0 (0 t/ha)	A_1 (10 t/ha)	A_2 (20 t/ha)	A_3 (30 t/ha)	Mean
Volcanic ash					
D_0 (0 t/ha)	14.00	14.80	15.00	14.53	14.58
D_1 (15 t/ha)	14.93	14.33	14.53	14.53	14.58
D_2 (30 t/ha)	14.27	15.13	14.33	15.13	14.72
Mean	14.40	14.76	14.62	14.73	

Table 1 showed that the application of volcanic ash has no significant effect on the increase of plant height but there is an increasing trend. Treatment of 30 t/ha (D_2) has the highest plant height that is 14.72 cm. Application of chicken manure also has no significant effect on peanut plant height. Similarly, the interaction of volcanic ash and chicken manure showed no significant effect.

2. Number of Branches (Branch)

The effect of volcanic ash and chicken manure on the number of peanut branches at 4 weeks after planting can be seen in Table 2 below.

Table 2. Effect of Volcanic Ash and Chicken Manure on the number of Peanut Branches at 4 Weeks After Planting (branch).

Treatment	Chicken Manure				
	A0 (0 t/ha)	A1 (10 t/ha)	A2 (20 t/ha)	A3 (30 t/ha)	Mean
Volcanic ash					
D0 (0 t/ha)	8.53	8.67	8.73	8.93	8.72
D1 (15 t/ha)	8.80	8.60	8.73	8.73	8.72
D2 (30 t/ha)	8.67	8.53	8.53	8.93	8.67
Mean	8.67	8.60	8.67	8.87	

Table 2 showed that application of volcanic ash has no significant effect on the increasing number of peanut branches. Application of chicken manure also has no significant effect on peanut height. Similarly. the interaction of volcanic ash and chicken manure showed no significant effect.

3. Number of Peanut Pods (Pods)

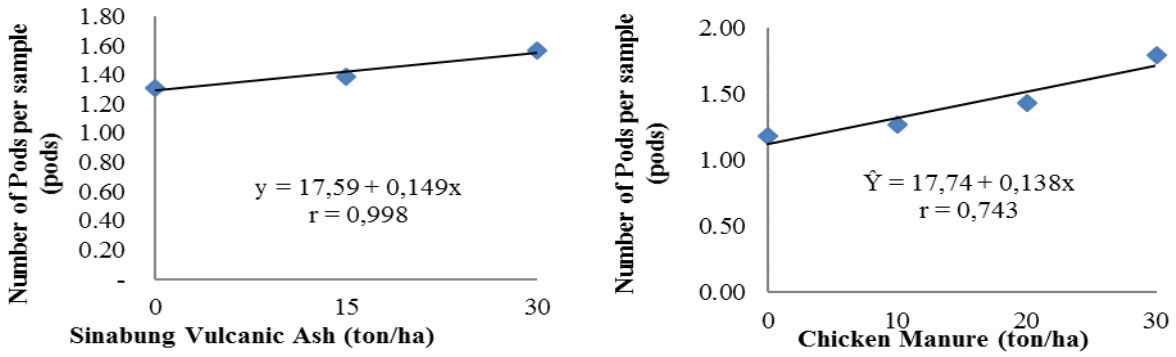
The effect of volcanic ash and chicken manure on the number of peanut pods can be seen in Table 3 below.

Table 3. Effect of Volcanic Ash and Chicken Manure on Number of pods Per Peanut (pod).

Treatment	Chicken manure				
	A0 (0 t/ha)	A1 (10 t/ha)	A2 (20 t/ha)	A3 (30 t/ha)	Mean
Volcanic ash					
D_0 (0 t/ha)	13.89	19.41	18.51	18.73	17.64 a
D_1 (15 t/ha)	15.17	20.55	19.81	23.40	19.73 a
D_2 (30 t/ha)	21.47	22.00	22.24	22.72	22.11 b
Mean	16.84 a	20.65 a	20.19 a	21.62 b	

Note: The numbers followed by not the same letters in the same treatment group differ significantly at the 5% level based on the DMRT

Table 3 shows that the application of volcanic ash at 30 t/ha (D2) has the highest number of pods per plot. namely 22.11 pods. significantly different than 0 t/ha (D0), namely 17.64 pods but not significantly different than Treatment D1 (15 t/ha). This can be seen in figure 1A. Application of chicken manure is also significantly affect the number of peanut pods per plant, where treatment of 30 t/ha (A3) has the largest number of pods per plant, namely 21.62 pods, significantly different than 0 t/ha (A0), namely 16.84 pods but not significantly different with A1 (10 t/ha) and A2 (20 t/ha). This can be seen in figure 1B similarly the interaction of volcanic ash and chicken manure showed no significant effect.



A B

Figure 1. Relationship between volcanic ash and number of peanut (pods) per sample (A); relationship between chicken manure and number of peanut (pods) per sample (B)

4. Number of Pods Per Plot (Pods)

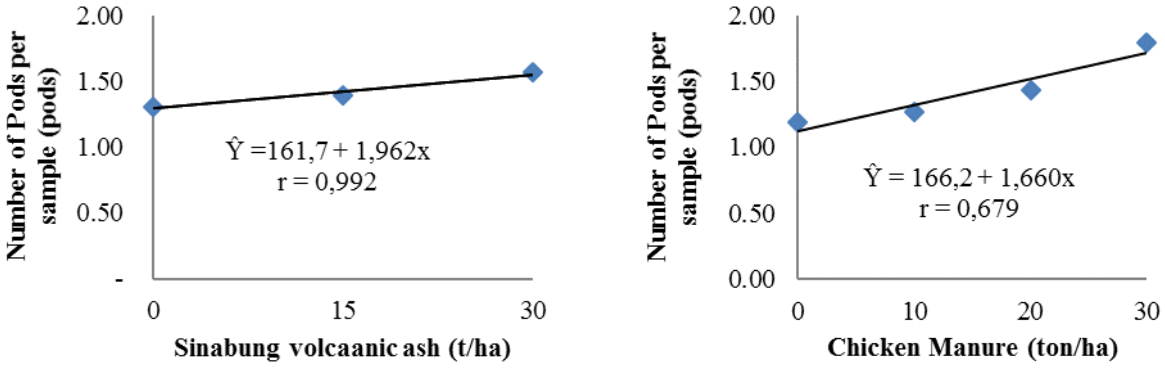
The effect of volcanic ash and chicken manure on the number of peanut pods per plot can be seen in Table 4 below.

Table 4. Effect of Volcanic Ash and Chicken Manure ob Peanut Pods (pods) per plot

Treatment	Chicken manure				
	A0 (0 t/ha)	A1 (10 t/ha)	A2 (20 t/ha)	A3 (30 t/ha)	Mean
Volcanic ash					
D_0 (0 t/ha)	118.93	153.13	171.73	197.33	160.28 a
D_1 (15 t/ha)	145.37	225.47	208.13	197.33	194.08 b
D_2 (30 t/ha)	198.00	203.33	261.40	213.87	219.15 b
Mean	15410 a	193.98 a	213.76 b	202,84 a	

Note: The numbers followed by not the same letters in the same treatment group differ significantly at the 5% level based on the DMRT

Table 4 shows that the application of volcanic ash at 30 t/ha (D2) has the highest number of pods per plot. namely 219.15 pods. significantly different from 0 t/ha (D0), namely 160.28 pods. but not significantly different than D1 (15 t/ha). The relation between volcanic ash applications on the number of peanut pod per plot can be seen in figure 2A. Chicken manure application has significant effect on the number of peanut pod per plot, where treatment at 20 t/ha (A2) has the highest number of pods per plot, namely 213.76 pods, significantly different than 0 t/ha (A0) 154.10, then A1 (15 t/ha) and significantly different with A3 (30 t/ha). The relationship between chicken manure application to the number of peanut pods per plot can be seen in figure 2B. Similarly, the interaction of volcanic ash and chicken manure showed no significant effect



A B

Figure 2. Relationship between volcanic ash and number of peanut (pods) per plot (A); relationship between chicken manure and number of peanut (pods) per plot (B)

5. Pods Weights per Plot (Kg)

The effect of volcanic ash and chicken manure on pods weights per plot can be seen in Table 5 below.

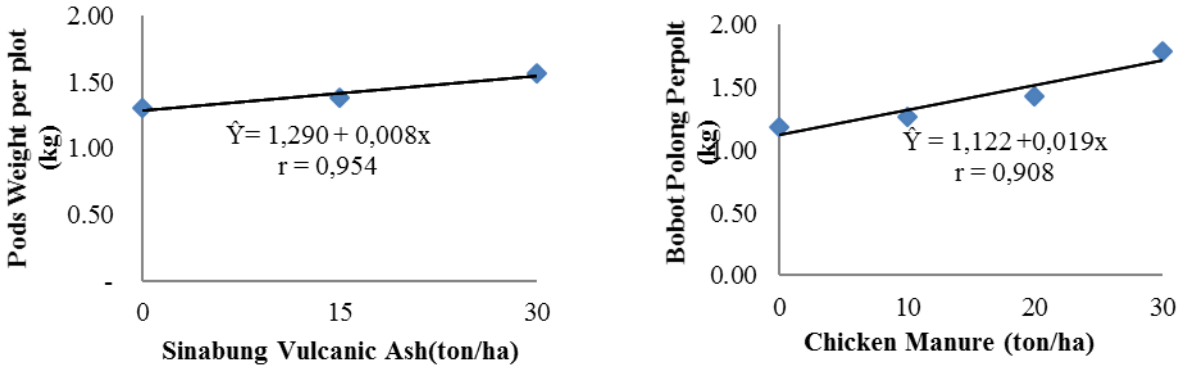
Table 5. Effect of Volcanic Ash and Chicken Manure on Pod Weight (kg).

Treatment	Chicken manure				
	A0 (0 t/ha)	A1 (10 t/ha)	A2 (20 t/ha)	A3 (30 t/ha)	Mean
Volcanic ash					
D_0 (0 t/ha)	0.88	1.21	1.40	1.74	1.31 a
D_1 (15 t/ha)	1.07	1.33	1.24	1.90	1.39 a
D_2 (30 t/ha)	1.61	1.26	1.66	1.73	1.57 b
Mean	1.19 a	1.27 a	1.43 a	1.79 b	

Note: The numbers followed by not the same letters in the same treatment group differ significantly at the 5% level based on the DMRT

Table 5 shows that the application of volcanic ash at 30 t/ha (D2) has the highest pod weight per plot, namely 1.57 kg, significantly different from 0 t/ha (D0), 1.31 kg and D1 (15 t/ha). The relationship between volcanic ash application and pods weights per plot can be seen in figure 3A. Application of chicken manure has the significant effect on peanut pod weight per plot, where treatment A3 (30 t/ha) show the highest value, that is significantly different with

A0, A1, and A2. The relationship between the applications of chicken manure to the pod's weight per plot can be seen in figure 3B. Similarly, the interaction of volcanic ash and chicken manure showed no significant effect.



A B

Figure 3. Relationship between volcanic ash with pods weight per plot (A); relationship between chicken manure with pods weight per plot (B)

6. Weight of 100 grains (g)

The effect of volcanic ash and chicken manure on the weight of peanut grain can be seen in Table 6 below.

Table 6. Effect of volcanic ash and chicken manure on weight of 100 grains (g)

Treatment	Chicken manure				
	A0 (0 t/ha)	A1 (10 t/ha)	A2 (20 t/ha)	A3 (30 t/ha)	Mean
Volcanic ash					
D_0 (0 t/ha)	39.01	38.18	34.64	37.01	37.21
D_1 (15 t/ha)	29.03	38.10	40.29	42.65	37.52
D_2 (30 t/ha)	36.97	40.80	42.69	36.53	39.25
Mean	35.00	39.03	39.21	38.73	

Table 6 shows that the application of volcanic ash has no significant effect on the weight of 100 peanut grains, but there is a tendency of grain increase with the treatment of 30 t/ha (D2) with the highest weight of 100 seeds, namely 39.25 g. Application of chicken manure also has no significant effect on the weight of 100 grains but there is a tendency increasing the

weight of 100 grains and the highest is the application at 20 t/ha (A2), namely 39.21 g. Similarly, the interaction of volcanic ash and chicken manure showed no significant effect.

DISCUSSION

1. Effect of Volcanic Ash Application on Peanut Growth and Production

From the analysis of data as described above. it can be seen that the application of volcanic ash at 30 t/ha showed no significant effect on plant height at 4 weeks after planting. a number of branches. and weight of 100 grains. But an application of volcanic ash at 30 t/ha had the significant effect on the number of pods per sample, the number of pods per plot and the weight of pods per plot.

The significant effect of peanut production on some parameter namely the number of pods per sample. the number of pods per plot and the weight of pods per plot is suspected because the volcanic ash is very responsive to the growth and production of crops and volcanic ash is the soil enhancer that improves soil properties. Volcanic ash contains many good nutrients that support the plant growth. Volcanic ash also serves as a nutrient fixation in the soil so that nutrients are not easily washed by water. The presence of volcanic ash will also facilitate the absorption of nutrients by plant roots (Rauf. 2010).

Sukarman *et al*. (2014) found that volcanic ash of Mount Sinabung has volcanic glass as one of the second highest mineral element of sand fraction (23 %) after rock fragment. This is in line with Shoji *et al*. (1993) *in* Sukarman and Dariah (2014) which stated volcanic glasses are contained in volcanic ash at the time of the volcanic eruption. Volcanic glass is a very important element in the process of soil formation and determines the chemical. physical and biological properties of the soil.

Volcanic glass is an amorphous material that is relatively easy to decay and release elements needed by the plant. The weathered volcanic glass does not form crystalline clay minerals. but forms allophane, imogolite, opaline silica, ferihidrit, and the Al/Fe-humus complex. The weathering results of volcanic glass are generally smooth. vesicular and not solidified. Such properties greatly contribute to the capacity of available water holding and high surface area resulting in rapid release of nutrients by weathering (Shoji *et al*. 1993 *in* Sukarman and Dariah (2014).

Besides. volcanic ash contains minerals needed by soil and plants with the highest total element composition ie Ca, Na, K, and Mg, other macro elements in the form of P and S, while microelements consist of Fe, Mn, Zn, Cu. These minerals have the potential to increase the mineral reserves of the soil enrich the chemical composition and improve the soil physical properties, therefore, it can be used as a material to improve poor soil or weathered soils (Anda and Wahdini, 2010). Setyamidjaja (2006) stated that by the plant growth, especially with spreading density and coverage of root morphology, the nutrients contained in volcanic ash will be more absorbed by plant roots, either from soil solution or from the absorption complexes on the surface Colloids.

This is confirmed by Hakim *et al*. (2006) that a number of absorbed nutrients by the roots is influenced by the root morphological form, such as root length, root distribution area, root growth rate, and root ability to make contact with soil particles and the diversity of root structure. In this case, the nutrients contained in volcanic ash effect the root development. Analysis of volcanic ash shown that there are 0.31% of P_2O_5 and 2.29% K_2O.

Volcanic ash also acts as a soil ameliorant. According to Hardjowigeno (2003), the application of soil enhancers can improve soil aeration increase soil nutrient capacity. increase water holding capacity. increase soil buffer capacity, an energy source for soil microorganisms and as nutrient sources. N element encourages the growth of organs associated with photosynthesis, ie leaves. Potassium acts as an activator of various essential enzymes in photosynthetic and respiratory reactions as well as enzymes which involved in protein and starch synthesis. In plants, P is an important constituent of adenosine triphosphate (ATP), which directly plays in the process of storing and transferring associated energy in the metabolic processes and contributes to the improvement of yield component (Subhan *et al*.. 2005).

The effect of volcanic ash on the observed parameters is because volcanic ash contains several benefits for plants such as improve soil physical properties in order to remain loose. increase soil ability in storing water so that root penetration in the soil develops well adds essential nutrients both macro and micro that are needed by plants, increase the activity of beneficial soil microorganisms and have a positive residual effect so that any plants grown in the following season remain have good growth and productivity.

2. Effect of Chicken Manure Application on Peanut Growth and Production.

Treatment of chicken manure application up to 30 tons/ha has no significant effect on plant height, a number of branches. and weight of 100 grains. But at such level, chicken manure can increase the number of pods per sample, a number of pods per plot, and weight of pods per plot. The heaviest weight of peanut pods was found at 30 t/ha (A3). This is because the more chicken manure applied in the soil, soil nutrients will increase therefore peanut show better growth and development. In this case, the N element is required in vegetative growth. P needed to stimulate the formation of fruit and K elements will activated carbohydrate metabolism.

The result of chicken manure analysis shows that the manure contains elements as follow: N (%) 1.10, P_20_5 (%) 1.65, K_2O (%) 0.32 and C-Org (%) 7.23. Such elements have been able to increase the number of pods and pod weights of peanuts. This increase in production is as a result of the formation of new structural elements, which is strongly influenced by nutrients availability. Nutrients availability is related to the process of manure decomposition which is strongly influenced by microorganism's activity in the soil. Besides the diversity and population, microorganism activity in decomposing the manure is also influenced by other factors in soils such as C/N ratio. High C/N ratio means relatively more C than N on the soil. there will be nitrogen competition between plants and microorganisms, wherein microorganisms will use it as the energy source so that nitrogen is fixed in microorganism's body and will be less available. If the nitrification process goes well, the C/N ratio will be low and this indicates that the manure has been decomposed well. thus the manure will quickly run out, meaning that the nutrient content in manure is already available for plant growth and development (Arifah, 2013).

The addition of chicken manure into the soil will increase the number and activity of soil microorganisms as well as provide nutrients for plants, increase humus, improve soil structure and have a greater cations absorption than clay colloids or higher CEC (Duxbury *et al*., 1989)

According to Tisdale *et al*., (1995), N, P and K nutrients are very important elements in the growth and production of plants. These elements have different roles in organizing organic compounds for growth and production. Nitrogen is a component of many amino acids and proteins in the leaves. Phosphate plays in the enzymatic reaction in vegetative growth. P

element is very important in plant growth because as energy sources. K is crucial for translocation of organic compounds from the leaves to meristem parts. Hakim *et al*., (2006) explains that fertilizers containing various nutrients both macro and micro, when given to plants in optimal amounts will be able to increase plant growth.

CONCLUSION

Application of volcanic ash has the significant effect on the number of pods per sample, the number of pods per plot and the weight of pods per plot, in which the treatment of 30 t/ha (D2) had the highest pod weight per plot, namely 1.57 kg. Application of chicken manure has the significant effect on the number of pods per sample, the number of pods per plot and the weight of pods per plot, in which treatment of 30 t/ha (A3) has the highest pod weight per plot, namely 1.79 Kg. Interaction of the two treatments did not show any significant effect on the growth and production of peanut.

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Appendix 1. Soil Analysis of Chicken Manure

Soil

No	Type of Analysis	Result	Criteria
1	Soil pH (H2O)	5.71	Slightly Acid
2	N – Total (%)	0.11	Low
3	K – exchangeable (me/100g)	0.13	Very Low
4	C – Organic (%)	1.18	Low
5	P – Bray II (ppm)	19.48	Moderate

Chicken Manure

No	Type of Analysis	Result
1	N (%)	1.10
2	P205 (%)	1.65
3	K2O (%)	0.32
4	C- Org (%)	7.23

Note: Analysis was conducted at Laboratory of Agriculture Faculty, UISU, Medan at January 2015

Sinabung Volcanic ash

No	Type of Analysis	Result
1	pH (H_2O)	4.31
2	KTK (%)	9.57
3	Nitrogen (%)	0.13
4	P_2O_5 (%)	0.31
5	K_2O (%)	2.29

Note: - Analysis was conducted at Laboratory of Agriculture Faculty, UISU, Medan at January 2015

- Volcanic ash of Mount Sinabung is taken from Sibintun Sub-Village, District of Simpang Empat, Karo Regency at altitude of 1262 m above sea level and located at 03^0 09' 39.8" North latitude dan 98^0 26' 52.4" East longitude. Thickness of Volcanic Ash is 60 cm and the distance of Mount Sinabung to Sibintun is 3 Km