International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 6; Issue 11; November 2017; Page No. 7523-7526
DOI: http://dx.doi.org/10.24327/ijcar.2017.7526.1170

Research Article

THE EFFECT OF ZEOLITE/TSP FERTILIZERS TO AMOUNT OF PHOSPHATES AVAILABLE IN SOIL

Ayus Diningsih[1,2]*., Rikson Siburian[1]* and Jamahir Gultom[1]

[1]Chemistry Department, Post Graduate of Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara
[2]Senior High School, Laksamana Martadinata, Medan

A R T I C L E I N F O

Article History:
Received 15th August, 2017
Received in revised form 25th September, 2017
Accepted 23rd October, 2017
Published online 28th November, 2017

Key words:
Phosphate, slow-release, Triple Super phosphate (TSP) fertilizers, zeolite

A B S T R A C T

A study on the effect of zeolite dosage mixed TSP fertilizers to the amount of phosphates available in soil was carried out. The purposes of this research were to obtain the optimum dose of zeolite mixed with TSP fertilizer in an effort to increase the phosphate available in the soil. This research method is laboratory experimental and field observation. Analysis of phosphate concentration uses stanchloride method using UV-Visible Spectrophotometer. This suggests that adding zeolites may increase the availability of phosphate in the soil. Meanwhile, when uses TSP (1 week) fertilizer the phosphate (0, 10, 20 and 30 cm) levels were 1.385; 0.866; 0.422 and 0.748 mg/L, respectively. Meanwhile, when uses TSP (1 week) fertilizer the phosphate (0, 10, 20 and 30 cm) levels were 1.385; 0.866; 0.422 and 0.748 mg/L, respectively. The results showed that the phosphate content of the zeolite ratio to TSP (1 : 2) was 1.575; 1.153 mg/L; 0.768; 0.583 mg/L. The ratio of zeolite to TSP (1 : 4) is 1.32; 1.26; 0.825; 0.753 mg/L. The ratio of zeolite to TSP (1: 6) is 1.608; 1,143; 0.869 and 0.764 mg/L. The ratio of zeolite to TSP (1: 8) is 0.932; 0.869; 0.881 and 0.589 mg/L. The ratio of zeolite to TSP (1 : 10) is 1.017; 0.791; 0.58 and 0.634 mg/L. Based on the data, the optimum ratio between zeolite and TSP fertilizer is 1: 2 ratio.

INTRODUCTION

Fertilizers very important role in plant growth, Especially to meet the nutrient needs of plants that are required to produce well. Phosphorus (P) includes macro nutrients that are essential for plant growth, but its content in plants is lower than Nitrogen (N), Potassium (K), and Calcium (Ca). Plants absorb P from the soil in the form of phosphate ions, especially $H_2PO_4^-$ and HPO_4^{2-} contained in the soil solution. Much effort was made to improve the availability of phosphate by adding phosphate fertilizer. Therefore, an increased availability of P in the soil and more effective and efficient use of P fertilizer is necessary.

Phosphate fertilizers such as superfosphate fertilizers when added to the soil not all phosphorus of the fertilizer can be absorbed by plant roots. However, the large amount of P fertilizer continuously reduces its efficiency because it increases the accumulation of deposited phosphates that settle in the soil, effect of Fe^{3+}, Al^{3+} and Mn^{2+} ions. Therefore, an increased availability of P in the soil and more effective and efficient use of P fertilizer is necessary [6].

Corresponding author:* **Rikson Siburian
Chemistry Department, Post Graduate of Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara

Natural zeolite is a hydrated alumina silicate compound that physically and chemically has the ability as an adsorbent, cation exchanger and catalyst. Application of Zeolite as one of the soil enhancers has not been widely used by farmers as the use of manure [7]. According to Pickering [10], zeolites provide a good role as slow release of phosphate fertilizers in plants in pots. From the rock-shaped structure, ion exchangers, high absorption and many other characteristics that make the natural zeolite is needed in agriculture to increase crop production.

In North Sumatra zeolite widespread deposition area with reserves estimated amount large enough but the zeolite mineral has not been used properly and optimally. Precipitation of natural zeolite in the Sarulla region is one of the locations that has a considerable natural zeolite potential in North Sumatra. The result of research laboratory of Research Center of Technology Development of Mineral and Coal of Bandung, declared Sarulla natural zeolite deposit is Clinoptilolite type. In previous studies of the use of natural zeolite has been done by Bansiwal [4] states that zeolite modified with surfactant has great potential as a carrier of fertilizer P and support the release of P. In addition, monmorillonite zeolites are excellent for reducing/ eliminating phosphate in water [14] .

And on research conducted by Nadapdap stated that with the addition of zeolite to the willingness phosphate (RP) in the soil decreased significantly at weeks 1 and 2. In her research, Nadapdap stated that the variation of the zeolite dose ratio to TSP is expected because at the time the zeolite used becomes saturated [8].

Research methods

This research was conducted at the analytical chemistry laboratory of North Sumatera University. Plants used as a medium for the absorption of phosphate fertilizer (TSP) are corn crops (Zea mays L. Saccharata). Natural zeolite samples used were obtained from Simangumban village, Sarulla, North Tapanuli regency of North Sumatra.

Activation of Zeolite Samples

Zeolite rocks washed and cleaned of dirt with distilled water, dried and then pulverized and sieved using a 100 mesh sieve. Then Zeolite in activation by heating in the oven at a temperature of 250 oC for 4 hours. Zeolite in weigh and put into desiccator [5].

Corn is conventionally grown, before the application of TSP and zeolite fertilizers, soil samples are taken as much as 20 grams to test the initial concentration of phosphate in soil samples. Two weeks after planting is given treatment on each bed. The dose of TSP fertilizer given is 20 grams.

Bed 1 of zeolite without TSP fertilizer
Bed 1 of TSP fertilizer without zeolite
Bed 3 ratio of zeolite to TSP 1: 2
Bed 4 ratio of zeolite to TSP 1: 4
Bed 5 ratio of zeolite to TSP 1: 6
Bed 6 ratio of zeolite to TSP 1: 8
Bed 7 ratio of zeolite to TSP 1: 10

Then measured phosphate levels settling in the soil in each bed with variation of soil depth: 0; 10; 20; 30 cm, also variation of number of days after administration of mixture of zeolite and TSP fertilizer are 1, 2, 3 and 4 weeks. Soil samples taken from farming land as much as 20 grams.

Phosphate Extraction In Soil Using Truog's Method
The soil sample is mashed to a size of 100 mesh then dried in an oven at 105 ^{o}C for 2 hours. 1 gram of soil is added 100 mL 0.002 N H_2SO_4 (pH = 3), where each liter of H_2SO_4 contains 3 grams of K_2SO_4 with mixing time 30 minutes, then filtered until clear [13].

Determination of Phosphate Content Using Method of Stanoklorida

100 mL sample of phosphate extraction in the filtered soil was added 0.05 mL (1 drop) phenolphyalin indicator. When red is formed, dilute sulfuric acid solutions are added dropwise until the color is lost. Then add 4 mL of solution solution of molybdate reagent, then homogenized. Then add 0.5 mL (10 drops) of stochloride reagent then stirred until blue, wait 10-12 minutes. Measured absorbance by using UV-Vis spectrophotometer at λ 690 nm [3]

RESULT AND DISCUSSION

Concentration and Absorbance Data of Phosphate Standard Solution

Standard solution calibration curve for determination of phosphate content in soil samples treated with addition of zeolite without TSP fertilizer, TSP fertilizer without zeolite and ratio zeolite to TSP fertilizer are 1: 2; 1: 4; 1: 6; 1: 8; 1: 10, performed with various concentrations are 0,2; 0,4; 0,6; 0,8; 1,0; 1,2; 1,4; 1,6; 1,8 ppm and blank solution was measured for absorbance by UV-Visible spectrophotometer. The absorbance data of standard phosphate solution can be seen in the table below.

Table 1 Data Concentration and Absorbance Solution Phosphate Standard

Concentration (ppm)	Absorbance
0	0,005
0,2	0,173
0,4	0,339
0,6	0,491
0,8	0,651
1,0	0,806
1,2	0,947
1,4	1,139
1,6	1,260
1,8	1,432

The result of measurement of absorbance of standard phosphate solution in table 1 is plotted against the concentration so that the calibration curve is obtained in the form of linear line as in the following figure.

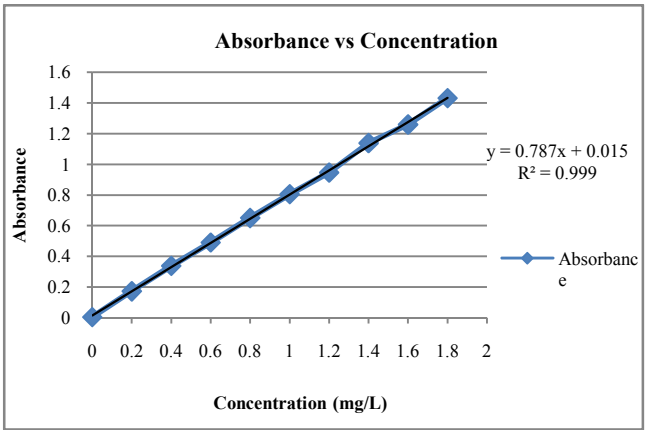


Figure 1 Graph of Standard Phosphate Solution Calibration Curve

The addition of zeolite and TSP fertilizer was done at 14 days old corn plant, where there were four leaves on corn plant with root length 10 cm. At planting age 14 days the plants begin to need nutrients for the growth of the plant. Before the addition of zeolite and TSP fertilizer, soil samples were taken first for analysis of the initial phosphate content of soil samples. Further soil samples taken after 7 days (1 week) treatment with a depth of 0, 10, 20 and 30 cm [1].

Table 4 is the result of phosphate analysis on soil sample before treatment is given. The data show that phosphate concentrations at 0, 10, 20 and 30 cm depths were 0.112 mg/L, 0.137 mg/L, 0.104 mg/L and 0.117 mg/ L, respectively. This was done in order to see the difference of phosphate concentration in soil samples before adding zeolite with phosphate concentration after being added with zeolite.

Table 4 Phosphate Concentration Data In Sample Before Treatment

Soil depth (cm)	Absorbance	Concentration (mg/L)
0	0,103	0,112
10	0,121	0,137
20	0,096	0,104
30	0,108	0,117

Comparison of Phosphate Concentrations In Soil Samples

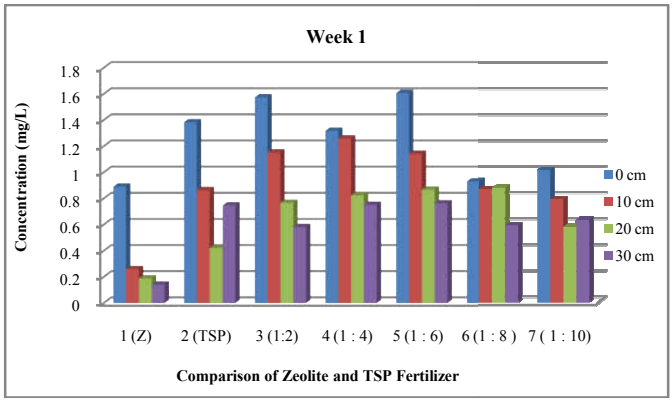


Figure 2 Comparison Chart of Zeolite and TSP Fertilizer Against Soil Depth In First Week.

From the above data it can be explained that the sample at week 1 on the ratio of zeolite and TSP fertilizer (1:6) at a depth of 0 cm has the highest phosphate content of 1.608 mg/L among other samples, this is because the initial phosphate content of the sample before being treated contains high levels of phosphate. Then followed by a sample with the ratio of zeolite to TSP fertilizer (1:2) is 1.575 mg/L. This is due to the more concentration of zeolite mixed with TSP fertilizer, it will result in higher levels of phosphate [15].

Meanwhile, the lowest phosphate concentration in the sample with zeolite addition treatment was 0.892 mg/L, this was due to the absence of TSP fertilizer addition, so that the phosphate content obtained only comes from within the soil.

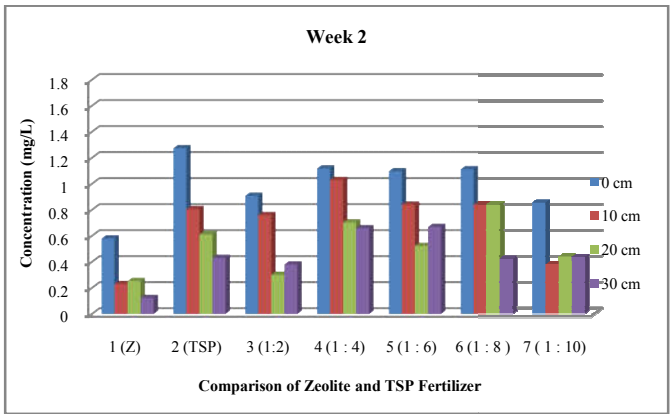


Figure 3 Comparison Chart of Zeolite and TSP Fertilizer Against Soil Depth In Second Week.

From the above data it can be explained that the sample at week 2 on TSP fertilizer without zeolite at a depth of 0 cm has the highest phosphate content of 1.276 mg/L, this is due to the absence of zeolite addition that serves as the cation ground exchanger so that the phosphate that settles in the soil together with Al, Mn and Fe metals can not be absorbed by plant roots [12].

The highly effective phosphate absorption in the second week was on treatment with addition zeolite without TSP fertilizer, the ratio of zeolite and TSP fertilizer (1:2), the ratio of zeolite and TSP fertilizer (1:4), the ratio of zeolite and TSP fertilizer (1:6), the ratio of zeolite and TSP fertilizer (1:10) on corn plant. While the ratio of zeolite to TSP fertilizer (1:8) does not provide effective phosphate absorption.

The highly effective phosphate absorption at week 3 is on the ratio of zeolite to TSP fertilizer (1:2), the ratio of zeolite and TSP fertilizer (1:4), the ratio of zeolite and TSP fertilizer (1:6), the ratio of zeolite and TSP fertilizer (1:8) on corn plant. While in addition to zeolite without TSP fertilizer, the addition of TSP without zeolite and zeolite ratio to TSP (1:10) fertilizer did not provide effective phosphate absorption.

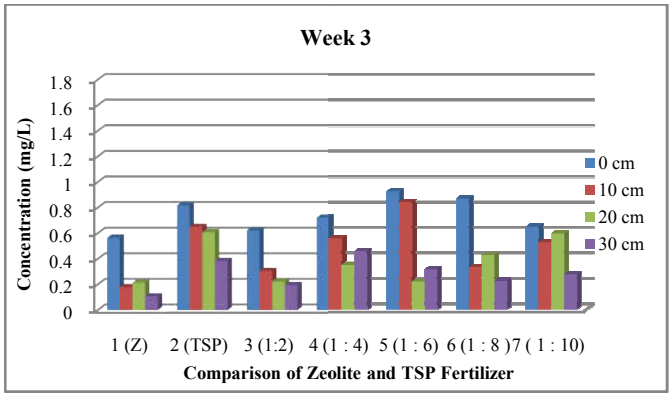


Figure 4 Comparison Graph Fertilizer TSP concentration of Zeolite And Depth Of Land In Three Week

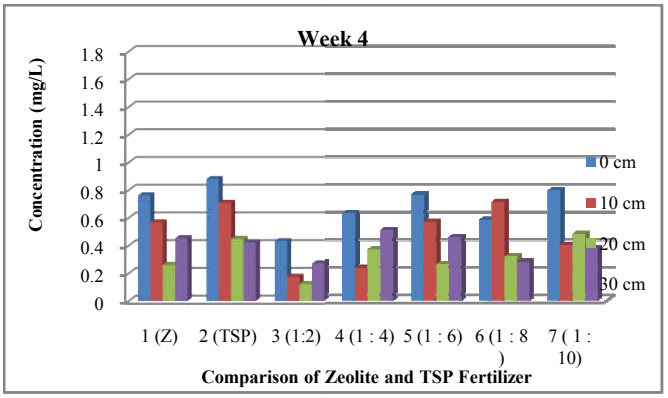


Figure 5 Graph of Comparison of Zeolite and TSP Fertilizers Against Depth of Land on the Fourth Week

The highly effective phosphate absorption at 4 weeks is in the ratio of zeolite to TSP (1:2) fertilizer on corn plant. While the addition of zeolite without TSP fertilizer, the addition of TSP fertilizer without zeolite, the ratio of zeolite to the TSP (1:4), the ratio of zeolite to the TSP (1: 6), the ratio of zeolite to the TSP (1:8) and the ratio of zeolite to TSP (1:10) in maize does not provide an effective phosphate absorption. This can be seen from the graph above where the phosphate concentration increased from the third week. This is due to the presence of metals that accumulate in the soil at every depth of the soil. In this study, the authors measured only the phosphate levels absorbed by plant roots, while for soil pH and metal contained in the soil were not measured.

Of all the variations of zeolite concentration on TSP fertilizer, the highly effective absorption of phosphates is a ratio 1:2 at week 1 to 4, this is because the greater the ratio between zeolite and TSP fertilizer will provide a larger phosphate release so that much of the phosphate will be absorbed by plant roots. The larger zeolite exchange cycle in Ca absorption,

resulting in decreased Ca concentration and increased phosphate concentration [2].

Meanwhile, in samples with zeolite without TSP fertilizer, the ratio of zeolite to TSP fertilizer (1:4), the ratio of zeolite to TSP fertilizer (1:8) and zeolite the ratio of zeolite to TSP fertilizer (1:10), undergoing highly effective phosphate absorption in weeks 1 to 2 weeks. While at week 3 and week 4 there is no significant phosphate absorption, this is because the saturation level of zeolite has reached its maximum limit because the concentration of zeolite given is small, especially in the 1: 10 ratio [11].

If linked to the amount of rainfall during planting corn, the average rainfall during the growth period of maize in the month of December 2016 was 550.9 mm (climate data obtained from PT. Socfin Indonesia). It can be said that at the time of planting corn get enough rainfall, so availability of ground water also sufficient for the absorption of fertilizer at root of plant. If the amount of groundwater is sufficient or large, the soil cation concentration will be low, the tendency of the phosphate ion to be attached to the Al, Fe and Mn metal will be smaller and settle in the soil so that the phosphate will be easily absorbed by the plant roots by the addition of zeolite as an exchanger ion [16]

The reactions formed between the $AlPO_4$, $FePO_4$ and $Mn_3(PO_4)_3$ deposits with zeolites are as follows:

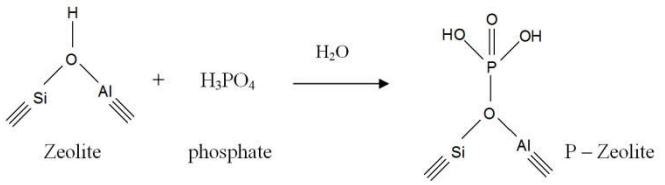
$2AlPO_4 + Z\text{-}(Ca^{2+})_3 \rightarrow Z\text{-}Ca_3(PO_4)_2 + 2\ Al^{3+}$

$2FePO_4 + Z\text{-}(Ca^{2+})_3 \rightarrow Z\text{-}Ca_3(PO_4)_2 + 2\ Fe^{3+}$

$Mn_3(PO_4)_2 + Z\text{-}(Ca^{2+})_3 \rightarrow Z\text{-}Ca_3(PO_4)_2 + 3\ Mn^{2+}$

From the above reaction can be seen the exchange of cations between phosphate deposits in the form of AlPO4, $FePO_4$ and $Mn_3(PO_4)_3$ with zeolite into phosphate that can dissolve in the soil phosphate ion can be absorbed by plant roots to the maximum.

The phosphate in the form of H_3PO_4 reacts with the zeolite to exchange the cation by the following reaction:



CONCLUSION

The addition of zeolite has significant effect on phosphate availability in the soil. The value of phosphate concentration available in soil at the soil depth of 0, 10, 20 and 30 cm in corn plants week 1 - IV decreased are : Added zeolite without TSP fertilizer was 0.892 mg/L to 0.129 mg/L, The addition of TSP without zeolite was 1.385 mg/L to 0.424 mg/L, the ratio of zeolite to TSP fertilizer (1:2) was 1.575 mg/L to 0.273 mg/L, the ratio of zeolite to TSP fertilizer (1:4) was 1.32 mg/L to 0,507 mg/L, the ratio of zeolite to TSP fertilizer (1:6) was 1.608 mg/L to 0.456 mg/L, the ratio of zeolite to TSP fertilizer (1:8) was 0.932 mg/L to 0.28 mg/L, the ratio of zeolite to TSP fertilizer (1:10) was 1.017 mg/L to 0.377 mg/L. The optimum dose ratio between zeolite and TSP fertilizer was in the ratio of 1: 2, with phosphate concentration at week I - IV ranged from 1.575 mg/L to 0.273 mg/L. This is because the greater the ratio between zeolite and TSP fertilizer will provide greater phosphate release and will be absorbed by the roots of corn plants.

Reference

1. AAK, 1993. *Teknik Bercocok Tanam Jagung*. Yokyakarta: Kanisius.
2. Allen E, Hossner L, Ming D, Henninger D, 1993. Solubility and Cation Exchange Relationships In Mixtures Of Phosphate Rock and Saturated Clinoptilolite. *Soil Sci Soc Am. J.* 57, 1368-1374.
3. American Public Health Association (APHA), 1995. Standard Methods For The Examination of Water And Wastewater. 19 Th ed. AWWA.WEF. New York. Pp. P-4500.
4. Bansiwal AK, Sadhana SR, Nitin KL, Asha AJ, Sukumar D, 2006. *Surfactant-Modified Zeolite As A Slow Release Fertilizer For Phosforus*. National Environmental Engineering Reserch Institute Nahur Marg. *Journal India* 54 : 4773-4779.
5. Balitbang SU, 2006. *Kajian Bahan Galian Zeolit Untuk Dimanfaatkan Sebagai Bahan Baku Pupuk*. 9-47.
6. Fauzi, 1999. *Mekanisme Peningkatan P-Tersedia Tanah akibat pemberian kapur, Bahan Organik dan Jasad Renik Pelarut Fosfat Pada Ultisol*. Tesis S-2. Program Pascasarjana USU Medan. 1-78.
7. Handayani EP, 2015. *Optimization Of Production Of Sweet Corn (Zea Mays Saccharata L.) In The Ultisol Soil With The Application Of Zeolite And Manure*. STIPER Dharma Wacana Metro-Lampung. Journal. 46 – 56.
8. Nadapdap M, 2016. *Studi Pengaruh Penambahan Zeolit Terhadap Konsentrasi Fosfat Tersedia di Dalam Tanah*. Tesis S-2. Pascasarjana USU : 1 - 66.
9. Notohadiprawiro T, Soeprapto S, Endang Sukana, 2006. *Pengelolaan Kesuburan Tanah dan Peningkatan Efisiensi Pemupukan*. Yogyakarta. Fakultas Pertanian UGM.
10. Pickering H, W Menzies, NW Hunter, MN, 2002. *Zeolite/ Rock Phosphate – A Novel Slow Release Phosphorus Fertiliser For Potted Plant Production Journal Horticulturae.* 94: 333-343.
11. Puschenreiter M, Morak O, 2003. *Slow-Release Zeolite-Bound Zinc and Copper Fertilizers Affect caadmium Concentration in Wheat And Spinach. Commun Soil Sci Plaant anal* 2003; 341 (1 - 2): 31-40.
12. Sabadash V, Jaroslaw Gumnitsky, Anna H, 2016. *Mechanism of Phosphates Sorption By Zeolites Depending on Degree Of Their Substitution for Potassium Ions.* J Chem. Technology; p. 235-240.
13. Sarkar D, Abhijit H, 2005. Physical and Chemical Methods in soil Analysis. New age Internasional Publisher. India. 101-110.
14. Tian S, 2009. Enchanced adsorption Removal of Phosphate From Water By Mixed Lanthanum/ Aluminium Pillared Monmorillonite. *Chemical Engineering Journal.* 141-148.
15. Yusupov TS, Shumskaya LG, 2002. Control of Cation-Exchange Interaction Between Zeolitesand Phosphate on The Basis of Soft mechanochemical Activation. Mining Science. 2. Vol. 38 (2).
16. Utomo M, Sudarsono, Bujang R, 2016. *Ilmu Tanah (Dasar-Dasar Dan Pengelolaan)*. Jakarta: Prenamedia group.