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Research Article

Organic amendments effect on the soil chemical properties of marginal land and soybean yield

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Abstract: Land use change is increasing, causing a lack of optimal land for agriculture. Marginal land improvement can be made with the application of organic amendments that can improve soil fertility to be optimal for crop cultivation. Land-use change is increasing, causing a lack of optimal land for agriculture. Marginal land improvement can be made with the application of organic amendments that can improve soil fertility to be optimal for crop cultivation. This study was carried out on acid soil of Karanganyar Regency. The treatments tested were P0 (control), P1 (2.5 t rock phosphate/ha + 5 t cow manure/ha), P2 (5 t rock phosphate/ha + 5 t cow manure /ha), P3 (2.5 t dolomite/ha + 5 t cow manure /ha), P4 (5 t dolomite/ha + 5 t cow manure/ha), P5 (5 t rock phosphate/ha + 5 t dolomite/ha + 5 t cow manure/ha) . The result showed that the application of P5 gave the highest yield of soybean of 1.41 t/ha. The application of manure significantly affected soil chemical properties of available P, available Ca, organic matter, and cation exchange capacity, but it did not significantly affect total N.

Keywords: *marginal land, soil chemical characteristic, soybean yield*

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Introduction

Marginal land is a nutrient-poor terrestrial ecosystem so that the use of this land is not optimal because the soil organic matter content is minimal. Optimization of marginal land use is relatively unknown to many people because of unfavourable soil conditions, namely dry and poor nutrients so that the land is less fertile and unfavourable for agriculture. Naturally, marginal soil fertility is relatively low. This is indicated by the reaction of acidic soil, low nutrient reserves, alkaline exchange capacity and low base saturation, while high to very high aluminium saturation (Suharta, 2010).

Increasing the productivity can be done by fulfilling nutrient requirements that are in the status of the deficiency by adding fertilizer inputs, reducing the negative effects of physical and chemical soil properties by adding ameliorant or biological agents (Wijanarko and Taufiq, 2004). The application of organic matter can improve soil structure, increase water holding capacity (Dinesh et al., 2010), C-organic content on soil (Sevindrajuta, 2012), and increase the cation exchange capacity. Manure also improves the physical properties of cation and acts as a counterweight to pH (buffer). The saturation of soil cation exchange capacity (CEC) with exchangeable base cations, simplified to as base saturation (BS), has been considered a complex physicochemical parameter that approximates the relationships between exchangeable basic and acidic cations with other soil properties (Kabala and Beata, 2018). Marginal soil conditions vary from acid to very acid, and generally acid. Such soil reaction conditions making marginal lands are often classified as acid soils. The low reaction of this soil will have an impact on the increasing content of Al that is toxic for plants (Suharta, 2010).

Amelioration materials such as lime and manure are needed to increase soil pH, organic matter, and nutrient of Ca and Mg. The increase of soil pH is, in turn, followed by the decrease in the solubility of Al, Fe, and Mn so that they are less toxic. The increase of soil pH increases the soil CEC so that the soil can bind nutrients against leaching. The increase in soil pH also increases the availability of N, P, and Mo nutrients. In an acid dry land, the problem of availability of phosphorus becomes a major obstacle in increasing yield (Hilman, 2005). The low level of available phosphorus in acid soils is due to fixation of dissolved phosphorus by aluminium and iron so that it is no longer available for plants. This condition can be minimized by organic amendments (Chng et al., 2015), such as rock phosphate. Soybeans can grow optimally at a pH between 6-7 (neutral pH) (Saragih et al., 2016). Organic fertilizer, in combination with lime on acidic soils, has a very beneficial effect in increasing the availability of nutrients for plant growth and in maintaining soil fertility (Jokubauskaite et al., 2015). This study aimed to assess the effects of the use of organic amendments (cow manure, dolomite, and rock phosphate) on the soil chemical properties and soybean production in marginal land.

Materials and Methods

This study was conducted in a field located in the village of Sukosari, Jumantono District, Karanganyar Regency, Central Java. Soil of the research area is an Alfisol with the following characteristics: pH H_2O = 4.9, C-organic = 1.75 g/kg, soil organic matter = 1.83 g/kg, CEC = 24.13 cmol/kg, base saturation = 26.57 g/kg, C/N ratio = 4.42, total-N = 0.26 g/kg, available P = 4.45 mg/kg, available K = 0.24 cmol/kg, Ca = 1.74 cmol/kg, Mg = 0.44 cmol/kg, clay fraction = 71.67%, sand fraction = 15.05%, and silt fraction = 13.28%. Materials used for this study were rock phosphate, dolomite, and cow manure. The rock phosphate has a pH value of 8.1 and total P content of 1.197%. The dolomite has a pH value of 7.1, Ca content of 21 cmol/kg, and Mg content of 10.8 cmol/kg. The cow manure has the following characteristics: organic-C = 14.34 g/kg, total N = 1.7 g/kg, available P = 0.31 mg/kg, available K = 0.49 cmol/kg, Ca = 0.56 cmol/kg, Mg = 0.87 cmol/kg, total P total = 0.48%. Treatments tested were P0 (control), P1 (2.5 t rock phosphate/ha + 5 t cow manure/ha), P2 (5 t/ha + cow manure 5 t rock phosphate/ha), P3 (2.5 t dolomite/ha + 5 t cow manure/ha), P4 (5 t dolomite/ha + 5 t cow manure/ha), P5 (5 t/ha + dolomite 5 t rock phosphate/ha + 5 t cow manure/ha). The six treatments were arranged in a completely randomized block design with four replications. The land was made of 4 blocks, with a distance between blocks of 50 cm. Each block was made into six plots with a plot size of 2 m x 1 m. At one week of planting, a soybean seed was planted with a planting space of 20 cm x 25 cm. Soil samples were collected from each plot at soybean harvest at 90 days. The soil samples were dried at room temperature and were subjected to laboratory analyses for determination of pH, total N content, available P and Ca contents, soil organic matter contents, and cation exchange capacity. The methods used for determining the soil chemical properties were those developed by soil laboratory of the Faculty of Agriculture, Sebelas Maret University, Surakarta. Yield components of soybean measured at harvest included weight of seed yield and weight of 100-seeds weight. The data obtained were subjected to analysis of variance followed by Duncan Multi Range Test at 5% level.

Results and Discussion

Soil pH

The application of ameliorant did not significantly increase soil pH (Table 1). The highest pH reached 6.7 in the treatment of P5 while the control gave the lowest pH of 5.7. Dolomite containing Ca and Mg can increase soil pH (Noza et al., 2014). Manure and dolomite have the same role in neutralizing Al toxins and increasing pH in the soil and increasing physical and biological properties of the soil (Moreira et al., 2015). Soil pH is a key factor controlling soil nutrient availability, soil microbial activities, and crop growth and development (Zhang et al., 2019). The use of the amendment was able to increase the pH even though it does not show significant results. The increase in dosage and combination of amendments is directly proportional to the increase in pH. The P5 treatment showed a pH of 6.7, while the control treatment was only 6.29. Manure increases soil pH and decreases exchangeable acidity. Fertilizer applied releases cations which can be exchanged with soil solution, which replaces Al^{3+} and H^{+} ions at the soil absorption site, thereby increasing soil pH (Bolan et al., 2003). Dolomite application can increase soil pH (Oo et al., 2018). An increase in pH will encourage the process of soil activity to be optimal. Soil pH is also controlled by biological processes in the soil (Neina, 2019).

Soil total N

The experimental results showed that the addition of organic amendments gave no significant effect on total N ($p>0.05$) (Table 1). This condition that was caused by the use of manure itself had a slow effect but was able to release nutrients because of the microbial activity. The use of soil amendments can improve soil conditions to be optimal for the process of microbial mineralization and increase the availability of N in the soil, high N uptake by plants will have a positive effect on improving yields. The highest nitrogen content in P5 application was 0.70% (Table 1). The increase in total N due to the increase in organic amendment dose was caused by the addition of N derived from the decomposition of the organic matter. The higher the organic amendment dose added, the higher the N released. Syukur and Harsono (2008) reported that the provision of cow manure dose significantly increased the total N-level from 376.67 ppm to 474.00 ppm, and soil available N from 10.65 ppm to 11.14 ppm. Phosphate rocks also play a role in increasing soil microbial activity and increasing N (Cong, 2017).

Soil available P and Ca

The addition of organic amendments gave significant effect on available P and available Ca ($p<0.05$). The use of rock phosphate increased the availability of P nutrients in the soil (Table 1). The application of the amendments increased total P and available P in the soil. Sanchez (1976) pointed out that the role of lime to reduce P fixation in the soil is very slow and requires a long time so that the available P released from fixation is still low. The highest level of total P of 2.63 ppm was obtained with the application of P5. Phosphorus deficiency can limit the formation of nodules, N_2 fixation and yield from legume grains (Brahim et al., 2017). Calcification of acid soils increases the pH of the soil, which in turn releases phosphate ions which are precipitated with Al and Fe ions to make P available for plant absorption (Chimdi et al., 2012).

Table 1. Effect of cow manure, dolomite, and rock phosphate on soil chemical properties.

Treatments	Total N (%)	Available P (ppm)	Available Ca (mg/100 g of soil)	Organic Matter (%)	CEC (cmol/kg)	pH
P0	0.34 ns	2.08 a	2.35 a	1.30 a	17.71 a	6.29 ns
P1	0.39 ns	2.20 ab	4.20 a	1.47 a	27.00 ab	6.44 ns
P2	0.42 ns	2.31 abc	6.15 c	1.76 a	30.96 b	6.67 ns
P3	0.55 ns	2.42 abc	6.24 c	2.89 b	39.09 bc	6.47 ns
P4	0.64 ns	2.50 bc	9.11 d	4.29 c	39.75 bc	6.68 ns
P5	0.70 ns	2.63 c	9.63 d	6.28 d	44.97 c	6.70 ns

Remarks: the numbers followed by the same letters in the same row and column are not significantly different according to the Duncan test at 5% level. P0 = control, P1 = 2.5 t rock phosphate/ha + 5 t cow manure/ha, P2 = 5 t rock phosphate/ha + 5 t cow manure/ha, P3 = 2.5 t dolomite/ha + 5 t cow manure/ha, P4 = 5 t dolomite/ha + 5 t cow manure/ha, and P5 = 5 t rock phosphate/ha + 5 t dolomite/ha + 5 t cow manure/ha.

The total content of phosphate and calcium in phosphate rock varies between 8.79 - 31.88% P_2O_5, and 0.60 - 57.50% Ca (Kasno and Sutriadi, 2012). The effects of lime and manure require time to release P soil and for the mineralization process to take place. According to Maerere et al. (2001), P mineralization increases over time after the initial application of organic amendments. The application of 5 t rock phosphate/ha + 5 t dolomite/ha + 5 t cow manure/ha (P5 amendment) resulted in the highest available Ca content of 9.63 mg/100 g of soil which was significantly higher than the control treatment. The increase in Ca value was due to the addition of dolomite in the P5 combination. Suntoro et al. (2018) reported that application of dolomite increased available Ca in the soil compared to controls. When lime is introduced into the soil, Ca^{2+} and Mg^{2+} ions will shift H^+, Fe^{2+}, Al^{3+}, Mn^{4+} and Cu^{2+} ions from the soil adsorption site so that soil pH can increase (McCauley et al., 2017). In addition to increasing soil pH, lime also supplies significant amounts of Ca and Mg. Another amendment for soils that can be used is cow dung. (Moreira et al., 2015). The addition of organic matter into the soil will increase the organic matter in the soil, soil pH, N-total in the soil, and macronutrients such as P, K, Ca, and Mg (Angelova et al., 2013).

Soil CEC and organic matter

The experimental results showed that the addition of amendments significantly increased CEC and organic matter ($p<0.05$) compared to controls (Table 1). Adeniyan et al. (2011) revealed that the application of 5 t manure fertilizer/ha increased available P, pH, CEC, and organic C significantly. Kheyrodin and Antoun (2012) also reported that the application of manure increased Ca and Mg at a depth of 15-30 cm of soil. The application of soil amendments improves the chemical characteristics of the soil, thereby creating a favourable environment for plant nutrition, plant growth and crop yields (Dida and Etisa, 2019). The application of a combination of P5 (5 t rock phosphate/ha + 5 t dolomite/ha + 5 t cow manure/ha) increased CEC values of 44.97 cmol/kg, while the CEC value of the control only reached 17.71 cmol/kg. The increase in soil CEC was probably due to the displacement of cations due to the addition of dolomite. Israel et al. (2018) reported that manure fertilizer could increase soil CEC by 23.96 cmol/kg. Tolanur (2002) reported the application of fertilizer with available minerals significantly increased CEC. The use of organic amendments is effective for improving soil, structure and soil fertility through microbial activity, thereby increasing soil CEC.

Fertilizer applications change soil biological, chemical, and physical properties. Application of 20 t of cow dung per year maintains organic matter and CEC and reaches the requested pH (Sustainable Agriculture Research and Education, 2012). Application of high levels of fertilizer increase phosphorus and potassium. Analysis of variance showed that the combination had a significant influence on soil organic matter. Application of P5 resulted in organic matter content of 6.28%, while that in control was only 1.3%. Ewulo (2005) found that in Nigeria, the use of 6 t manure/ha increased P, K, Ca, Mg, and CEC. When added to the soil, manure will increase the content of soil organic matter and improve the physical properties of the soil (Trisno et al., 2016). Improved soil conditions are integrated from amendments that increase soil pH and release of nutrients from decomposition of organic matter and improvement of soil structure.

Seed yield and 100-seeds weight

Soybean seed yield gave significantly interaction between cow manure, lime, and rock phosphate application (Table 2). However, in P5 the highest production was 1.41 t/ha compared to the control treatment. This means that the amount ameliorant required to produce optimum seed yield depends on the method of ameliorant application. Larger sizes of legumes and peanuts can contribute to higher yields (Simanjuntak et al., 2015). These conditions indicate that the use of ameliorant for marginal land can increase soybean production. The average soybean production of Wilis varieties on fertile land reaches 1.6 t/ha. The use of ameliorant for the first planting period affected the yield. Organic ameliorant is slow-release, so it takes time to release nutrients. The dolomite-rock phosphate fertilizers have been used as P slow-release fertilizers in Alfisol (Yang et al., 2013).

Table 2. Soybean growth and yield.

Treatments	Seed Yield (t/ha)	100-seeds Weight (g)
P0	0.59 a	4.22 a
P1	0.73 b	7.25 b
P2	0.78 bc	8.29 c
P3	0.82 c	8.56 c
P4	1.11 d	8.77 c
P5	1.41 e	9.55 d

The numbers followed by the same letters in the same row and column are not significantly different according to the Duncan test at 5% level. P0 = control, P1 = 2.5 t rock phosphate/ha + 5 t cow manure/ha, P2 = 5 t rock phosphate/ha + 5 t cow manure/ha, P3 = 2.5 t dolomite/ha + 5 t cow manure/ha, P4 = 5 t dolomite/ha + 5 t cow manure/ha, and P5 = 5 t rock phosphate/ha + 5 t dolomite/ha + 5 t cow manure/ha.

The results showed that available P and available Ca had a significant effect on soybean production. Phosphorus is actively absorbed by the roots of the soil solution and stored in plant bodies in high concentrations. According to Sumarni et al. (2012), the availability of P element that is quickly absorbed by soybean plants will be able to optimize the role of P in the formation and filling of pods to increase productivity. Increased supply of phosphorus in the body of the plant will increase metabolism, so the process of optimal seed filling and seed weight increased (Hidayat, 2008).

The high production of dry seed weight per plant occurs due to the fulfilment of Ca elements needed by plants, especially in the formation of pods. Ca is one of the most important elements in determining the pod survival. Nurjayanti et al. (2012) pointed out that Ca is the nutrient that most determines the level of pod beauty. Toyip (2012) reported that fertilizing 1 t Ca/ha gave the highest yield of tiles. Yield reduction due to Ca deficiency can occur by up to 60% (Saragih et al., 2016). The greater dosage of dolomite given will encourage the availability of Ca and Mg in the soil. Ca and Mg will be used by plants in the generative phase (seed formation). Muthaura et al. (2017) reported that dolomite plays a role in triggering enzyme activity and plays a role in seed formation. The higher dose of manure given indicates the higher the dry weight of 100 seeds. Kriswantoro et al. (2016) revealed that the difference in the dose of organic fertilizer given resulted in differences in the level of fertility produced, both physically, chemically and biologically. Thus it will have a different effect on plant growth and production.

Conclusion

The application of organic amendments could improve marginal land through the characteristics of soil chemical characteristics. The application of organic amendments increased soil pH, available P, available Ca, organic matter, CEC, and total N. Optimal soil conditions also increase soybean production to reach 1.41 t/ha.

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References

Adeniyan, O.N., Ojo, A.O., Akinbode, O.A. and Adediran, J.A. 2011. Comparative study of different organic manures and NPK fertilizer for improvement of soil chemical properties and dry matter yield of maize in two different soils. *Journal of Soil Science and Environmental Management* 2 (1): 9-13.

Angelova, V.R., Akova, V.I., Artinova, N.S. and Ivanov, K.I. 2013. The effect of organic amendments on soil chemical characteristics. *Bulgarian Journal of Agricultural Science* 19(5): 958-971.

Barus, J. 2015. The Effectiveness of Dolomite and Biochar Husk on the Productivity of Two Swamp Vub. *Proceedings of the National Seminar on Suboptimal Land. Palembang,* 8-9 October 2015. Agricultural Technology Assessment Center, Lampung. p2-5 (*in Indonesian*).

Bolan, N.S., Adriano, D.C. and Curtin, D. 2003. Soil acidification and liming interactions with nutrient and heavy metal transformation and bioavailability. *Advances in Agronomy* 78: 215–272, doi:10.1016/s0065-2113(02)78006-1.

Brady, N.C. 1984. *The Nature and Properties of Soils*. 9th Edition. New York: Macmillan Publishing Company.

Brahim, S., Niess, A., Pflipsen, M., Neuhoff, D. and Scherer, H. 2017. Effect of combined fertilization with rock phosphate and elemental sulphur on yield and nutrient uptake of soybean. *Plant, Soil and Environment* 63: 89-95, doi: 10.17221/22/2017-PSE.

Chimdi, A., Gebrekidan, V., Kibret, K. and Tadesse, A. 2012. Effects of liming on acidity-related chemical properties of soils of different land use systems in Western Oromia, Ethiopia. *World Journal of Agricultural Science* 8(6): 560-567.

Chng, H.Y, Osumanu, H.A. and Majid, N.M. 2015. Improving phosphorus availability, nutrient uptake and dry matter production of *Zea mays* L. on a tropical acid soil using poultry manure biochar and pineapple leaves compost. *Experimental Agriculture* 52(3): 447-465.

Cong, T.T. 2017. Effect of rock phosphate to corn and groundnut on basaltic soil in Vietnam. *Journal of Fertilizers & Pesticides* 2017: 8:3

Dida, G. and Etisa, D. 2019. Effect of Lime and compost application on the growth and yield of common bean (*Phaseolus vulgaris* L.): a review. *Advances in Oceanography & Marine Biology* 1(3): 1-9, doi: 10.33552/AOMB.2019.01.000512.

Dinesh, R., Srinivasan, V., Hamza, S. and Manjusha, A. 2010. Short-term incorporation of organic manures and biofertilizers influences biochemical and microbial characteristics of soils under an annual crop turmeric *(Curcuma longa* L.*). Journal of Bioresource Technology* 101: 4697-4702.

Evanita, E., Widaryanto, E. and Heddy, Y.B.S. 2014. The influence of cattle dropping fertilizer on growth and yield of the eggplant (*Solanum melongena* L.) in intercropping pattern with Napier grass (*Penisetum purpureum*) of the first crop. *Jurnal Produksi Tanaman* 2(7): 533-541 (*in Indonesian*).

Ewulo, B.S. 2005. Effects of poultry dung and cattle manure on chemical properties of clay and sandy clay loam soil. *Journal of Animal and Veterinary Advances* 4(10): 839 - 841.

Hidayat, N. 2008. Growth and production of peanut (*Arachis hypogaea* L.) local varieties of Madura at various spacing and dosages of phosphorus fertilizer. *Jurnal Agrovigor* 1(1): 55-64 (*in Indonesian*).

Hilman, Y. 2005 Soybean production technology in acid dry land. *Proceedings of Workshop on Soybean Development in Suboptimal Land*. Research and Development Center Bogor, Indonesia, pp 78-86 (*in Indonesian*).

Indonesian Soil Research Institute. 2005. *Analysis of Chemical, Plants, Water, and Fertilizer*. ISBN 978-602-8039-21-5 (*in Indonesian*).

Isreal, Z., Tamado, T., Lemma, W. and Mohammed, A. 2018. Effect of combined application of cattle manure, mineral nitrogen and phosphorus fertilizer on soil physico-chemical characteristics and tuber yield of potato (*Solanum tuberosum* L.) in Masha District, South-Western Ethiopia. *International Journal of Environmental Sciences and Natural Resources* 14(5): 555900, doi: 10.19080/IJESNR.2018.14.555900.

Jokubauskaite, I., Slepetiene, A. and Karcauskiene, D. 2015. Influence of different fertilization on the dissolved organic carbon, nitrogen and phosphorus accumulation in acid and limed soils. *Eurasian Journal of Soil Science* 4(2): 137-143.

Kabala, C and Beata, L. 2018. Relationships between soil pH and base saturation – conclusions for Polish and international soil classifications. *Soil Science Annual* 69(4): 206–214.

Kasno, A. and Sutriadi, M.T 2012. Indonesian rock-phosphate effectivity for maize crop on ultisols soils. *Agrivita* 34(1) : 14-21, doi: 10.17503/Agrivita-2012-34-1-p014-021.

Kheyrodin, H. and Antoun, H. 2012. Tillage and manure effect on soil physical and chemical properties and on carbon and nitrogen mineralization potentials. *African Journal of Biotechnology* 10(48): 9824 - 9830.

Kriswantoro, H., Safriyani, E. and Bahri, S. 2016. Provision of organic fertilizer and NPK fertilizer on sweet corn plants (*Zea mays saccharata* Sturt). *Klorofil: Jurnal Ilmu-Ilmu Agroteknologi* 11(1): 1-6, doi: 10.32502/jk.v11i1.209 (*in Indonesian*).

Maerere, A., Kimbi, G. and Nonga, D. 2001. Comparative effectiveness of animal manures on soil chemical properties, yield and root growth of amaranthus *(Amaranthus cruentus* L.*). African Journal of Science and Technology* 1(4): 14-21.

McCauley, A., Clain, J. and Kathrin, O.R. 2017. *Soil pH and Organic Matter*. Nutrient Management Module No. 8. Montana State University.

Moreira, l.G., Sfredo, J., Moraes, L.A.C. and Fageria, N.K. 2015. Lime and cattle manure in soil fertility and soybean grain yield cultivated in tropical soil. *Communications in Soil Science and PIant Analysis* 46(9): 1157-1169. 2015.

Muthaura, C., Mucheru-Muna, M., Zingore, S., Kihara, J. and Muthamia, J. 2017. Effect of application of different nutrients on growth and yield parameters of maize (*Zea mays*), case of Kandara Murang's County. *ARPN Journal of Agricultural and Biological Science* 12(1): 19-33.

Neina, D. 2019. The role of soil pH in plant nutrition and soil remediation. *Applied and Environmental Soil Science* 2019, Article ID 5794869, doi:10.1155/2019/5794869.

Noza, H., Yetti, H. and Khoiri, M.A. 2014. Dolomite and N, P, K fertilizers effect on growth and yield of sweet corn (*Zea mays saccharata* Sturt) in peat land. *Jurnal Online Mahasiswa Fakultas Pertanian Universitas Riau* 1(2): 1-10 (*in Indonesian*).

Nurjayanti, N., Zulfita, D. and Raharjo, D. 2012. The use of eggshell powder as substitution of lime and compost taro for growth and yield of red chili on Alluvial soil. *Jurnal Sains Mahasiswa Pertanian* 1(1): 16-21 (*in Indonesian*).

Oo, A.Z., Sudo, S., Akiyama, H., Win, K.T., Shibata, A., Yamamoto, A., Sano, T. and Hirono, Y. 2018. Effect of dolomite and biochar addition on N_2O and CO_2 emissions from acidic tea field soil. *PLoS ONE* 13 (2): e0192235, doi: 10.1371/journal. pone.0192235.

Trisno, Widjajanto, D. and Hasanah, U. 2016. The effect of cow manure bokashi on physical characteristics of some Entisols of Lembah Palu. *Jurnal Agrotekbis* 4(3) : 288 – 294 (*in Indonesian*).

Sanchez, P.A. 1976. *Properties and Management of Soils in the Tropics*. John Wiley & Sons, New York.

Saragih, S.D., Yaya, H. and Bayu, E.S. 2016. The growth response and production of soybean (*Glycine max* L. Merril.) on biological fertilizer and eggshell powder. *Jurnal Agroteknologi* 3: 2167 – 2172 (*in Indonesian*).

Sevindrajuta. 2012. Effects of giving several measures of cow cattle fertilizer on the chemical properties of Inceptisol and spinach plant growth. Universitas Muhammadiyah Sumatera Barat Press. Sumatera Barat (*in Indonesian*).

Simanjuntak, W, Hapsoh, H. and Tabrani, G. 2015. Influence of application of dolomite and phosphate on growth and yield of peanut (*Arachis hypogea* L.) *Jurnal Online Mahasiswa Fakultas Pertanian Universitas Riau* 2(2): 1-15 (*in Indonesian*).

Suharta. 2010. Characteristics and problems of marginal soils from acid sedimentary rocks in Kalimantan. *Jurnal Litbang Pertanian* 29(4): 139-146 (*in Indonesian*).

Sumarni, T., Fajriani, S. and Effendi, O.W. 2012. The response of Soybean Plants to the Provision of Phosphorus Fertilizers and Paitan Green Fertilizers. *Proceedings of the Seminar on the Research of Various Beans and Tubers*, Faculty of Agriculture. Brawijaya University, Indonesia, p 183-189 (*in Indonesian*).

Suntoro, S., Widijanto, H., Suryono, Syamsiyah, J., Afinda, D.W., Dimasyuri, N.R. and Triyas, V. 2018. Effect of cow manure and dolomite on nutrient uptake and growth of corn (*Zea mays* L.). *Bulgarian Journal of Agricultural Science* 24(6): 1020–1026.

Sustainable Agriculture Research and Education 2012. *Effects of Manuring on Soils*. The University of Maryland.

Syukur, A. and Harsono, E.S. 2008. The effect of giving manure and NPK on the chemical and physical properties of the sandy soils of Samas Beach, Bantul. *Jurnal Ilmu Tanah dan Lingkungan* 8(2):138-145 (*in Indonesian*).

Than, A.A. and K. Egashira. 2008. Evaluation of phosphorous status of some upland soils in Myanmar. *Journal of the Faculty of Agriculture Kyushu University* 53(1): 193-200.

Tolanur, S.I. 2002. Integrated nutrient management on physical conditions, soil fertility and productivity of crops in dry land vertisol. *Karnataka Journal of Agricultural Sciences* 14(3): 186-187.

Toyip, H. 2012. Effect of phosphorus and calcium fertilization on nutrient uptake and productivity of two soy genotypes in water-saturated cultivation. *Jurnal Agroland*. 20(1): 28-36 (*in Indonesian*).

Wijanarko, A. and Taufiq, A. 2004. Management of acid dry soil fertility for soybean plants. *Buletin Palawija* 7 & 8: 39–50 (*in Indonesian*).

Yang, Y., Zhenli, He., Yang, X. and Stoffella, P.J. 2013. Dolomite phosphate rock (DPR) application in acidic sandy soil in reducing leaching of phosphorus and heavy metals—a column leaching study. *Environmental Science and Pollution Research* 20: 3843–3851.

Zhang, Y-Y., Wu, W. and Liu, H. 2019. Factors affecting variations of soil pH in different horizons in hilly regions. *PLoS ONE* 14(6): e0218563, doi: 10.1371/journal.pone.0218563.