JOURNAL OF DEGRADED AND MINING LANDS MANAGEMENT
ISSN: 2339-076X (p); 2502-2458 (e), Volume 5, Number 1 (October 2017): 987-994
DOI:10.15243/jdmlm.2017.051.987

Research Article

Effect of organic fertilizer and its residual on cowpea and soybean in acid soils

Henny Kuntyastuty, Siti Muzaiyanah*

Indonesian Legumes and Tuber Crops Research Institute (ILETRI), Jl. Raya Kendalpayak KM 8, PO BOX 66, Malang 65101, East Java, Indonesia

*corresponding author: muzayanahid@yahoo.com

Received 03 August 2017, Accepted 10 September 2017

Abstract: The expansion of planting areas on acid soils is one of the strategies to achieve Indonesian self-sufficiency program on food. Acidic soil has low pH that causes contents of Al, Fe, and Mn are high. In addition, acidic soil also only has low microbial population. These conditions make soybean growth is not optimal. This research consisted of two phases i.e., the first and second planting. The first planting was aimed to study the effectiveness of fertilizer treatment, with three replications, using cowpea commodity. The second planting was done without additional fertilizer that consisted of three replicates (continued from the first planting) using soybean. This research that was carried out at Iletri's greenhouse Malang in 2014 was arranged in a randomized block design consisting of eight treatments, namely: (a) control/without fertilizer; (B) 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S); (C) 1500 kg/ha cow manure; (D) 3000 kg/ha cow manure; (E) 5000 kg/ha cow manure; (F) 1500 kg/ha fermented chicken + cow manures; (G) 3000 kg/ha fermented chicken + cow manures; and (H) 5000 kg/ha fermented chicken + cow manures. The results showed that organic fertilizer (cow manure) 5000 kg/ha had higher yields both in the first planting and second planting compared to inorganic fertilizer 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S).

Keywords: *acid soil, cowpea, organic fertilizer, residual fertilizer, soybean*

To cite this article: Kuntyastuty, H. and Muzaiyanah, S. 2017. Effect of organic fertilizer and its residual on cowpea and soybean in acid soils. J. Degrade. Min. Land Manage. 5(1): 987-994, DOI: 10.15243/jdmlm.2017.051.987

Introduction

The expansion area for planting is one effort to achieve Indonesian self-sufficiency program on food. Expansion area can be done by utilizing marginal lands, such as acid soil and saline soil. The potential acid soil in Indonesia that is suitable for crops is estimated about 18.5 million hectares, that are mostly found in Sumatra, Kalimantan, and Papua (Mulyani, 2006). Soybean and Cowpea are two kinds of bean containing high protein. Soybean harvested area in Indonesia is still very limited, it is only about 493-723 thousand hectares with low productivity (1.2 to 1.3 t/ha). Soybean self sufficiency will be achieved if national productivity is around 1.4 – 1.5 t/ha and it needs about 2 million hectares of harvested area (BPS, 2011). In addition, cowpea has not been developed in widely planting area. Acid soil has low pH that causes Al, Fe, and $Mn_{dissolved}$ contents are high, thereby they are poisoning the crops. In addition, acid soil is poor of essential macro and micro nutrients, as well as organic materials (Sudaryono et al., 2011).

Although some examples of Ultisols (Red-Yellow Podzolic) contain low Al_{dd} (<20%), but generally, ultisol contains high Al_{dd} (20-70%). This condition will interfere soybean growth which has critical threshold of $Al_{saturated}$ tolerance only 20% (Arya, 1990). Acidic soil is generally dominated by kaolinite and hydroxides of Fe and Al. Therefore acid soil has low clay activity that causes the cation exchange capacity (CEC) is low.

The ability of acid soil to store water and nutrients withstand low so that the soil dries quickly and the soil nutrients are easily lost through leaching (Uehara and Gillman, 1981). Microbial population on acid soil is also in low level, it is about 57 x 10^3 - 29 x 10^4 cfu/g soil (Prihastuti et al., 2006). Soedarjo et al. (2007) reported that *Rhizobium* population in Ultisol of Central Lampung was 5.8×10^4 cfu/g and in East Lampung was 6.5×10^1 cfu/g To improve the fertility of acid soil, microbial population should be improved. To solve that problem, it is important to improve soil fertility of acid soil by utilizing organic matters.

Organic matter can increase organic acids in acid soil (Iyamuremye et al., 1996; Takata et al., 2011) that can reduce $Al_{dissolved}$ through a binding mechanism of Al-monomer (Al^{3+}) in the form of a stable chelate complexes (stable chelate complex). The organic material also is needed as a source of energy by microfauna to produce organic compounds which are necessary for processing aggregation to form soil structure. Jian-bing et al. (2013) reported that manure more encouraged to form aggregate than micro aggregate. So, it will increase the aeration and drainage that are suitable for root growth. The important role of organic matter to the soil physico-chemical properties is increasing soil cation exchange capacity (CEC). Rahardjo (2000) reported that application of straw 10 t/ha; Azolla 10 t/ha improved the soil CEC from 16.94 me/100 g to 17.77 me/100 g and 17.67 me/100 g. Organic material consists of microbes that encourage plant absorption of nutrients (Onwonga et al. 2010). The organic matter can be derived from agricultural or non-agricultural wastes, which are given directly or have to be decomposed by microbes, such as (fermented chicken + cow manures) organic fertilizer and cow manure.

Santap is an organic fertilizer assembled by Iletri for acid soils. Wijanarko and Subandi (2010) reported that application of 1.5 t/ha Santap (fermented chicken+cow manure) on acid soils in East Lampung, increased soybean yield from 0.85 t/ha (without fertilizer) to 1.43 t/ha. A disadvantage but also become an advantage point of using organic fertilizer is supplying plant nutrient occurs slowly, but it has residual fertilizer effect for the next planting. This study aimed to elucidate the effectiveness of fertilizer treatment and its residue on crop growth and yield.

Materials and Methods

This research that was carried out at Iletri's greenhouse Malang in 2014 was arranged in a randomized block design consisting of eight treatments, namely: (a) control/without fertilizer; (B) 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S); (C) 1500 kg/ha cow manure; (D) 3000 kg/ha cow manure; (E) 5000 kg/ha cow manure; (F) 1500 kg/ha fermented chicken + cow manures; (G) 3000 kg/ha fermented chicken + cow manures; (H) 5000 kg/ha fermented chicken + cow manures.

The soil used for the study was collected from Lebak, Banten, The 20 cm top soil layer was ground and air dried. Each polybag was filled with 10 kg of soil and watered until field capacity was reached. The soil used for this experiment was collected from a dry land area Banten. The chemical characteristic of the soil were as follows: pH 5.3 (acid soil), low N_{abs} (0.16%), medium P_2O_5 (9.67 ppm), low K (0.15 $cmol^+/kg$), low Na (0.19 $cmol^+/kg$), very low Ca (1.95 $cmol^+/kg$), medium Mg (1.10 $cmol^+/kg$), low CEC (9.83 $cmol^+/kg$), low Al-dd (0.43 $cmol^+/kg$), H-dd 0,32 $cmol^+/kg$, very high Fe (448 ppm), very high Zn (53.4 ppm), very high Cu (2.68 ppm), and very high Mn (74.1 ppm). $Al_{saturated}$ is only 10.39% (below the tolerance limit soybean) indicating that the soil does not require addition of lime.

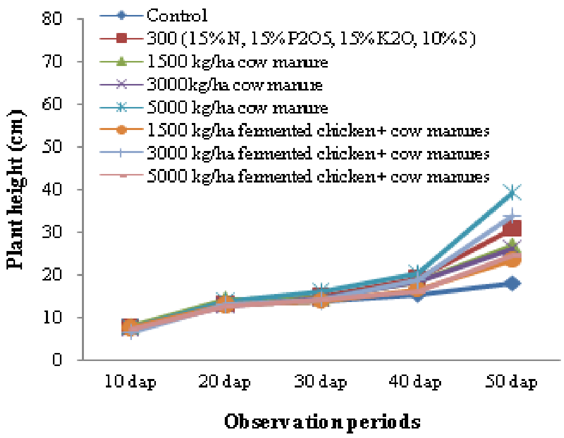
This research consisted of two phases i.e., the first and second plantings. The first planting was to study the effectiveness of fertilizer treatment, with three replications, using commodity cowpea. The second planting was done without additional fertilizer that consisted of three replicates (continued from the first planting) using soybean. Inorganic fertilizer (15% N, 15% P_2O_5, 15% K_2O, 10% S) was applied when the cowpea at 10 days after planting (dap). Cow manure and fermented chicken+cow manure were given at planting. Four seeds were planted in each polybag and thinned to two plants per polybag at 10 dap. Watering, weedings, pests and diseases control were carried out intensively according to condition of cultivation.

The variables observed in this study included (1) soil analysis (before experiment) that consisted of pH, N, P, K, Ca, Mg, Na, H, and Al_{dd}, and (2) plant growth that included (a) cowpea: plant height, chlorophyll value, dry stover weight/pot, root length/plant, number of pods/pot, number of seeds per pot, weight of seeds per pot, weight of 100 seeds, and (b) soybean: plant height, chlorophyll value, flowering age, pod filling age, harvested age, long lateral roots, number of branches/plant, number of nodes fertile/plant, number of pods/plant, number of seeds/pot, seed weight /pot, weight of 100 seeds.

Results and Discussion

Growth and yield of cowpea

The varied chlorophyll value of cowpea leaf occurred since 20 dap, whereas the highest chlorophyll was indexed by cowpea leaf fertilized with 3000 kg/ha fermented chicken + cow manures. Then, the highest value of chlorophyll was indexed by cowpea leaf applied with 5000 kg/ha of cow manure, 5000 kg/ha fermented chicken + cow manures and 3000 kg/ha fermented chicken + cow manures, namely 50-55 at 30 dap. All of cowpea supplied with fertilizer had chlorophyll values that were higher than the control at 40, 50 and 60 dap. All of that treatments had the same chlorophyll value at of 60 dap. Figure 1 shows the chlorophyll value of cowpea leaf at several observation times. There was no difference of height of cowpeas up to 30 dap. But, when cowpeas was at 40 dap, some fertilizer treatments such as 3000 kg/ha cow manure, 5000 kg/ha cow manure, and 3000 kg/ha fermented chicken + cow manures increased the cowpea's height up to 25% of the control as high as the cowpea's height that fertilized by (15% N, 15% P_2O_5, 15% K_2O, 10% S)300 kg/ha. For other treatments , the cowpea's height was the same with control. But, the height of all fertilized cowpeas were higher then the control treatment at 50 dap (Figure 1). Application of both organic and inorganic fertilizers improved the harvest time and dry stover weight of the plants. All fertilizers except 1500 kg/ha fermented chicken + cow manures, made cowpea got harvested more early than control, it was about 78-84 dap of 92 dap (control). All fertilized cowpeas had higher dry stover weight than control. The highest dry stover of cowpea was found on cowpea fertilized with 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S) and 5000 kg/ha cow manure. In this experiment, fertilizer did not initiate root growth. There was no difference on length of roots between using fertilizer or not. Long roots in all treatments ranged from 13 to 20 cm.



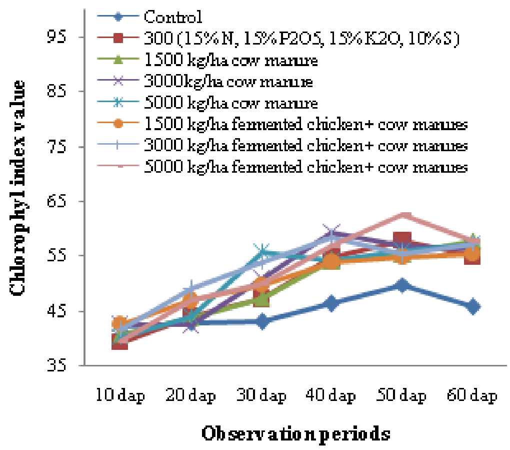


Figure 1. Plant height (left) and chlorophyll index (right) of cowpea at several observation periods

The highest number of pods was provided by cowpea that applied (15% N, 15% P_2O_5, 15% K_2O, 10% S) 300 kg/ha, that equivalent with the number of pods of cowpea fertilized with cow manure 5000 kg/ha, fermented chicken + cow manures 3000 kg/ha and 5,000 kg/ha, which is between 7-10 pods per pot (Table 1). The same case happened on seed weight per pot. Seed weight per pot applied with 5000 kg/ha cow manure was higher 31.4% than cowpea seed weight fertilized with (15% N, 15% P_2O_5, 15% K_2O, 10% S) 300 kg/ha.

Growth and yield of soybean

There was no impact of residual fertilizer on soybean height up to 20 dap (Figure 2). At the age of 30 dap, 40 dap and 50 dap, residual fertilizer made all soybean plants were higher than that without fertilization. In general, all soybean plants had similar trend of growth, with or without residual fertilizer. Residual fertilizer of 5000 kg/ha cow manure provided the most soybean height in all time of observations. Residual fertilizer affected chlorophyll value on soybean leaves after 20 dap (Figure 2).

Table 1. Harvested age, dry stover weight, root length per plant, number of pods per pot, number of seeds per pot, weight of seeds per pot and weight of 100 seeds of cowpea. Iletri Glasshouse, 2014.

No	Treatment	Harvested age (dap)	Dry stover weight/pot (g)	Root length/ plant (cm)	Number of pods/pot	Number of seeds/pot	Weight of Seeds/pot (g)	Weight of 100 seeds (g)
1	Control	92.0 a	3.0 e	14.3 a	2.8 d	10.8 e	1.2 e	11.3 a
2	300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S)	80.3 c	12.3 ab	21.0 a	9.5 a	47.8 bc	6.9 bc	15.2 a
3	1500 kg/ha cow manure	78.0 c	8.4 cd	17.9 a	5.8 bc	33.8 cd	4.2 d	12.3 a
4	3000kg/ha cow manure	83.5 bc	8.5 cd	18.6 a	6.3 bc	38.8 bcd	5.1 cd	13.6 a
5	5000 kg/ha cow manure	78.5 c	14.0 a	15.5 a	9.3 a	71.8 a	9.2 a	13.1 a
6	1500 kg/ha fermented chicken + cow manures	86.5 ab	6.9 d	21.0 a	4.0 cd	28.8 de	3.6 d	12.1 a
7	3000 kg/ha fermented chicken + cow manures	79.5 c	10.7 bc	16.3 a	7.0 ab	49.0 bc	6.6 bc	13.4 a
8	5000 kg/ha fermented chicken + cow manures	80.5 bc	9.4 bcd	16.1 a	7.8 ab	56.5 ab	8.3 ab	14.7 a
	CV (%)	5.07	23.84	20.6	27.43	29.89	24.60	20.47

The same letters in one column show no significant different at LSD 5%.

Chlorophyll value of soybean leaves fluctuated at each time of observation. All treatmens had similar value of chlorophyll at 50 dap and decreased at 60 dap (except for 1500 kg/ha fermented chicken + cow manures). Soybean plants with residual fertilizer or without (control) entered flowering stage and pod filling stage almost together, i.e. at about 32-34 dap and 42-44 dap, respectively. Only soybean that used fertilizer residues of 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S), 5000 kg/ha cow manure and of 5000 kg/ha fermented chicken + cow manures had lateral root longer than that without fertilizer residues (control), which was between 9 and11 cm (Table 2). While other fertilizer residues provided soybean lateral roots did not differ with no fertilizer residue, it was between 6 and 9 cm. Dry Stover weight of all plants having fertilizer residues was higher than that without fertilizer. The highest dry stover was on fertilizer residue treatments of 5000 kg/ha cow manure and 5000 kg/ha fermented chicken + cow manures.

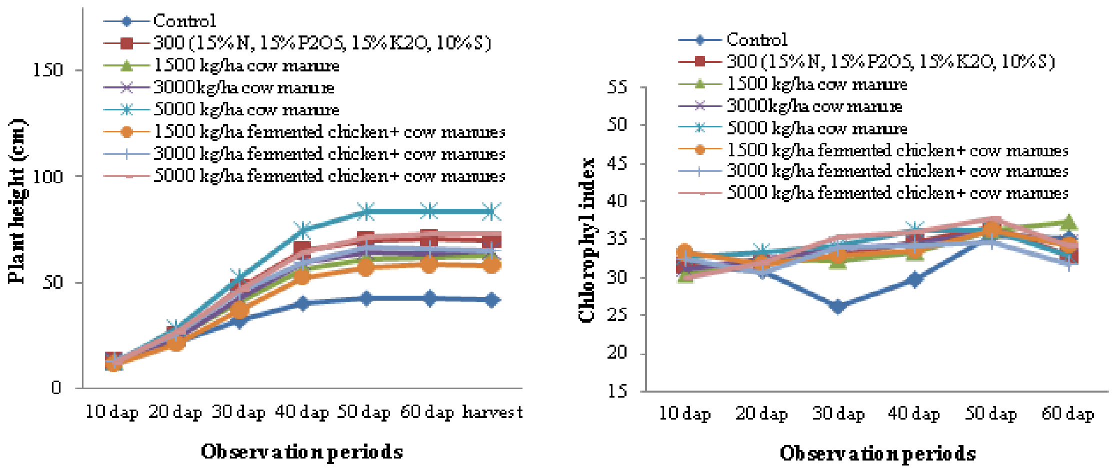


Figure 2. Plant height (left) and chlorophyll index (right) of soybean at several observations periods

Only residues fertilization of 5000 kg/ha which increased the number of branches of plants, but all fertilizer residues increased the number of fertile nodes (Table 7). Residue of fertilization of 5000 kg/ha cow manure produced the highest fertile nodes. There were 7 fertile nodes while the other fertilizer residues had only 5 fertile nodes per plant. The residual fertilizer of 5000 kg/ha of cow manure provided the highest number of pods, number of seeds and seed weight, but had the smallest weight of 100 seeds. The fertilizer residue of 3000 kg/ha cow manure, 3000 kg/ha fermented chicken + cow manures and 5000 kg/ha fermented chicken + cow manures had similar with residue of 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S) on number of pods, number of seeds, seed weight per pot and weight of 100 seeds. The growth of cowpea and soybean was not affected by the fertilizer until 20 dap. It showed by there is no difference both height and chlorophyll index value on either first or second crops. Chlorophyll index values increased after 20 days after planting, both at the first and second crops. Fertilizer application increased chlorophyll content of leaves that caused chlorophyll index was high (Pujiasmoro et al., 2009; Suharja and Sutarno, 2009). At first planting (direct fertilization), fertilization did not affect the root growth of cowpea. This also happened on Jabon (*Anthocephalus cadamba* Roxb. Miq.) (Wulandari and Julian, 2013) and daun dewa (*Gynura pseudochina* (L.) DC) (Anata et al., 2014) seedlings. In the second planting, fertilizer residues of 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S), 5000 kg/ha cow manure, and 5000 kg/ha fermented chicken + cow manures produced lateral roots that were longer than control and other fertilizer residues. Applying 5000 t/ha of cow manure caused cowpea had dry stover and number of pods as weight as cowpea fertilized with 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S). Application of 5000 t/ha produced higher seed number and weight of seeds per pot than that fertilized with 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S).

Table 2. Flowering age, pod filling age, long roots, dry stover weight, number of branches and number of nodes fertile. Iletri Glasshouse, 2014.

No	Residual fertilizer	Flowering age (dap)	Pod filling age (dap)	Long roots / plant	Dry stover weight /pot	Branches /plant	Fertile Nodes/ plant
1	Control	34.0 a	44.0 a	5.9 d	1.5 e	0.0 b	2.8 d
2	300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S)	31.3 a	42.0 b	10.4 ab	3.9 bc	0.4 b	4.6 bc
3	1500 kg/ha cow manure	32.3 a	42.3 b	7.1 bcd	3.0 cd	0.3 b	4.5 bc
4	3000kg/ha cow manure	31.8 a	42.0 b	5.5 d	2.6 d	0.3 b	4.3 c
5	5000 kg/ha cow manure	32.0 a	41.5 b	9.4 abc	5.3 a	1.9 a	6.8 a
6	1500 kg/ha fermented chicken + cow manures	32.5 a	42.8 ab	6.4 cd	2.3 d	0.6 b	4.5 bc
7	3000 kg/ha fermented chicken + cow manures	32.3 a	42.5 b	8.6 abcd	3.8 bc	0.8 b	5.0 bc
8	5000 kg/ha fermented chicken + cow manures	32.3 a	42.8 ab	11.0 a	4.4 ab	0.5 b	5.5 b
	CV (%)	1.54	2.2	29.5	9.0	19.73	16.1

The same letters in one column show no significant different at LSD 5%.

Table 3. Number of pods, number of seeds, seed weight per pot and 100 seeds weight of soybean. Iletri Glasshouse, 2014.

No	Residual fertilizer	Number of pods/plant	Number of seeds /pot	Seed weight /pot (g)	weight of 100 seeds (g)
1	Control	2.6 e	10.3 d	1.6 d	16.3 a
2	300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S)	5.8 bcd	26.8 bc	3.7 b	14.1 abc
3	1500 kg/ha cow manure	4.0 de	21.8 bc	3.2 bc	14.8 ab
4	3000kg/ha cow manure	5.3 bcd	24.0 bc	3.1 bc	12.9 bcd
5	5000 kg/ha cow manure	9.5 a	45.3 a	5.3 a	11.7 d
6	1500 kg/ha fermented chicken + cow manures	4.4 cde	19.3 cd	2.7 c	13.9 bcd
7	3000 kg/ha fermented chicken + cow manures	6.1 bc	29.3 b	3.6 b	12.4 cd
8	5000 kg/ha fermented chicken + cow manures	6.6 b	30.0 b	3.9 b	13.5 bcd
	CV (%)	24.3	0.2	17.6	11.5

The same letters in one column show no significant different at LSD 5%.

This condition occurred because organic material could increase nitrogenase bacteria activity in root crops, so the organic acids that chelate Al were produced in high amounts (reducing Al toxic) and nitrogen needed of crop was fulfilled (Triadiati et al., 2013). In second planting, residue of 5000 t/ha cow manure also made dry weight of stover, the number of seeds and seed weight per pot higher than residue of 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S). These phenomena might be caused by decompotition of organic fertilizer that occurred slowly (Anif et al., 2007). However, for the first planting, cowpea fertilized with 5000 kg/ha cow manure had pods longer than the pods of cowpea fertilized with 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S). This was shown by the number of seeds on cowpea fertilized with 5000 kg/ha cow manure that was 71.8 seeds/pot and cowpea pods fertilized by 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S) that was 47.8 seeds/pot, or 50% increase.

For the second planting, residual of 5000 kg/ha cow manure was able to increase the number of pods per plant, number of seeds per pot, seed weight per pot up to 63.7%, 69%, 43.2% respectively compared to residue 300 kg/ha (15% N, 15% P_2O_5, 15% K_2O, 10% S). Based on these phenomena, it can be said that for acid soil, application of organic cow manures can replace inorganic fertilizer, but the amount of organic cow manure applied should be around 5000 kg/ha.

References

Anata, R., Sahiri, N. and Ete, A. 2014. Effect of various composition of planting media and manure on growth and yield of dewa leaves (*Gynura pseudochina* (L.) DC). *Jurna Agrotekbis* 1: 10-20 (*in Indonesian*).

Anif, S., Rahayu, T, and Faatih, M. 2007. Utilization of tomato waste as a substitute of EM-4 in the process of composting organic waste. *Jurnal Penelitian Sains & Teknologi* 2: 119-143 (*in Indonesian*).

Arya, L.M. 1990. Properties and Processes in Upland Acid Soils in Sumatra and their management for crop production. Winrock Intl. Inst. of Agri. Dev., Raleigh.

Iyamuremye, F., Dick, R.P. and Baham, J. 1996. Organic amendments and phosphorus dynamics: 1. phosphorus chemistry and sorption. *Soil Science* 161: 426–435.

Jian-bing, Z., Jing-song, Y., Rong-jiang, Y., Shi-peng, Y., Fu-rong, L., and Xiao-jing, H. 2013. The effects of farmyard manure and mulch on soil physical properties in a reclaimed coastal tidal flat salt-affected soil. *Journal of Integrative Agriculture*. Advanced Online Publication. 14p.

Mulyani, A. 2006. The potensial of acid dry land for agricultural development. *Warta Penelitian dan Pengembangan Pertanian* 28: 16-17 (*in Indonesian*).

Onwonga, R.N., Lelei, J.J., and Mochoge, B.B. 2010. Mineral nitrogen and microbial biomass dynamics under different acid soil management practices for maize production. *Journal of Agricultural Science* 2: 16-30.

Prihastuti, Sudaryono, and Wardani, T. 2006. Microbiological study on acid dry land, Lampung. *Jurnal Agritek* 5: 10-25 (*in Indonesian*).

Pujiasmanto, B., Sunu, P., Toeranto, and Imron, A. 2009. Effects of organic fertilizer type and dosage on growth and yield of sambiloto plant (*Andrographis paniculata Ness*.). *Jurnal Ilmu Tanah dan Agroklimatologi* 2: 81-90 (*in Indonesian*).

Rahardjo. 2000. The influence of various sources of organic matter and urea tablet fertilizer on soil chemical characteristics. *Jurnal Mapeta* 5: 28-33 (*in Indonesian*).

Sarawa and Baco, A.R. 2014. Photosynthate partition of some soybean cultivar (*Glicine max.* (L) Merr.) on ultisol. *Jurnal Agroteksos* 3: 152-159 (*in Indonesian*).

Soedarjo, M., Prihastuti, Suryantini, Sucahyono, D. and Harsono A. 2007. Technology of biofertilizer assembly for legumes on acid dry land. Final Report 2007. Indonesian Legumes and Tuber Crops Research Institute (*in Indonesian*).

Sudaryono, Prihastuti, and Wijanarko A. 2011. Exploration of potential fertility and land suitability in the subdistrict of Bumi Nabung and Rumbia, Central Lampung for the development of soybean crop. Proceeding of Agricultural Technology Facilitation Seminar in Lampung Province. March 21, 2011, BPTP Lampung. p 160-170 (*in Indonesian*).

Suharja and Sutarno. 2009. Biomass, chlorophyll and leaf nitrogen contents of two varieties of chili (Capsicum annum) on various fertilization treatments. *Nusantara Bioscience* 1: 9-16 (*in Indonesian*).

Takata, Y., Tani, M., Kato, T. and Koike, M. 2011. Effects of land use and long-termorganic matter application on low-molecular-weight organic acids in an Andisol. *Journal of Soil Science and Environmental Management* 10: 292-298.

Triadiati, N.R., Mubarik and Ramasita, Y. 2013. Growth response of soybean plant to *Bradyrhizobium japonicum* acid tolerant and fertilizer application in acid soil. *Jurnal Agronomi Indonesia* 1: 24 – 31 (*in Indonesian*).

Uehara, G. and Gillman, G. 1981. The mineralogy, chemistry, and physics of tropical soils with variable charge clays. Westview Press, Inc., Colorado. 170 p.

Wijanarko, A. and Subandi. 2010. The effects of organic fertilizer type and dosage on soybean yield on acid dry land. *in* Subandi et al. Effects of amelioration to subsoil layer and fertilization on acid dry land on productivity and income of soybean farming. Final Report 2010, p. 12-20.

Indonesian Legumes and Tuber Crops Research Institute, Malang (*in Indonesian*).
Wulandari, A.S. dan Julian, A. 2013. Effect of organic leaf fertilizer on the increase of seedling growth of Jabon (*Anthocephalus cadamba* Roxb. Miq.). *Jurnal Silvikultur Tropika* 01: 47-50 (*in Indonesian*).