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The impact of horticulture farming practices in Andisols forest on organic-P content, Tawangmangu, Central Java

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Abstract. This research aimed at studying the change of organic-P status as an impact of horticultural farming in Andisols forest. Horticulture is an alternative agricultural practice which mainly develops in upland nowadays. However, the presence of this agricultural practice significantly influences on soil chemical properties, at most organic P-content. This research was conducted at five observation sites in the southern slope of Lawu Mountain, Tawangmangu, Central Java. Horticulture farming in this area has been developed for more than 25 years with organic manure application mainly derived from cow dung. This organic manure is applied for 15–25 Mg $Ha^{-1}yr^{-1}$. The Andisols in Lawu forest is mostly covered by Pine (*Pinus merkusii*) and the predominant horticulture vegetation developed in this area is Carrots (*Daucus carota*). The soil sampling was conducted through five replications for each site. The results showed a significant decreasing of organic P-content in the horticulture farming with more than 15 years of cultivation. The decreasing of organic-P content was correlated with the decreasing of organic-C content. There was a positive correlation between organic-P content and organic-C content as well as Fe-humus contents. However, the correlation between organic-P content and pH (H_2O) remained negative.

1. Introduction

Organic-P is the main source of P for plants. It reaches 20–50% of total P content in top soil [1]. The same thing is expressed by [2] that soil organic-P content can reach more than 50% and often 80% of total P in legumes land. However, in Andisols the soil organic-P is found 37% of total P, Aridisols 36%, Alfisol 55%, Spodosol 65% and Vertisol 86% of total P [3]. The largest organic-P compound in the soil is phytin (inositol phosphate) which is strongly depended on type of plants as the main source of soil organic matter. In other cases, grains contain higher P than shrubs and straw trees. This had been proven that cotton seeds contain more P (0.7%) than straw (<0.2%) [2, 3, 4]. Therefore, in developed soils, i.e. Oxisols and Alfisols the role of organic-P becomes crucial to maintain the availability of P in the soil.

Several researches have shown the effect of P in the soils towards different land use. The dynamics of soil organic matter (OM)and P in the soil is various under different land use [5, 6]. The tillage and crop rotation in cultivated land may significantly influence the availability of P in the soils [7].The study of [8]also stated that the levels of organic matter, microbial activity and P are higher in the surface layers of non-tillage soils compared with conventional tillage soils.

In general, the organic-P content in top soil is higher than that in sub soil. This is as a result of organic matter deposited from vegetations on it. P translocation by root from sub soil to top soil passes through transitioning of inorganic-P into organic-P of plant tissue. The soil organic-P content increases with the increasing of soil organic-C content. There is a positive correlation between soil organic-P and soil organic-C contents [9]. The ratio of organic-P content to organic-C content in soils ranges about 1: 100–1: 250 [10]. During decomposition, if the ratio of organic-C content to organic-P content is more than 300, an immobilization will occur between of inorganic-P towards organic-P of microbial tissue [11].

2. Materials and Methods

There are 75 soil samples derived from Andisols forest and horticulture land. They were taken at five observation sites: KLS (Kalisoro), BLB (Blumbang), BNR (Banaran), Bulak Rejo,Tlogodlingo (TDL) in Tawangmangu Subdistrict. Observation included Forest (F) and within horticulture land is divided into two parts, i.e. less than 15yr (Ht<15) of cultivation and more than 15yr (Ht>15) of cultivation. The parameters observed include P-organic, soil organic matter, soil Fe-Humus, soil pH, environmental temperature, and conventional system of land management, i.e. application organic fertilizers with continuous manure. The soil organic-P content was determined with Ignition method while organic-C through the Walkley & Black method [3].

3. Results and Discussion

The impact of Cultivation on the soil organic-P indicates that the inflammation reduces soil organic-P significantly (table 1).

Table 1. The Impact of horticulture practice on soil organic-P content(mg kg-1)

Location	Kalisoro	Blumbang	Banaran	BulakRejo	TlogoDlingo	Avarege
F	933	1075	881	927	878	739 a
Ht<15	918	785	603	713	938	591 ab
Ht>15	698	445	592	730	675	489 b
Average	850 a	768 a	692 b	790a	830a	(-)

Note: F = Forest; Ht<15 = field with less than 15yr of cultivation; Ht>15 = field with more than 15yr of cultivation. The number with the same letter means 5% of significant level

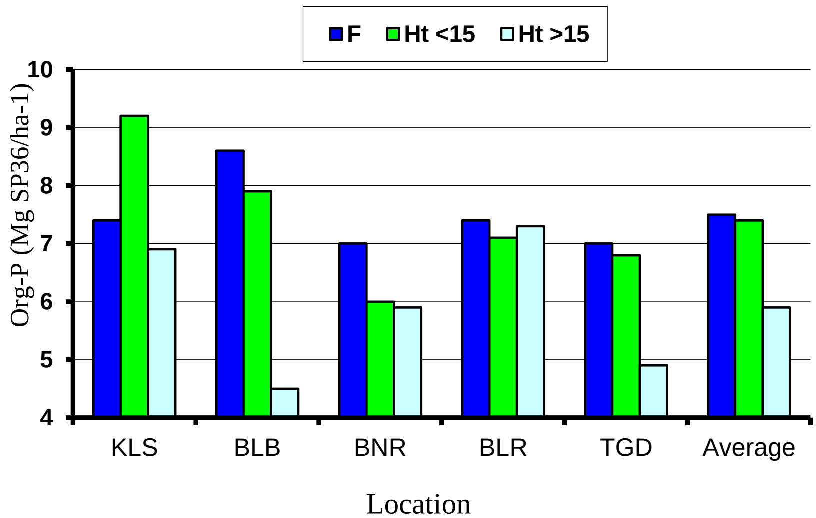

Figure 1. Trends of the average of Organic-P (equal with Mg SP-36 ha^{-1} cultivated layer) in horticulture land at five observation sites.

Table 2. Observed parameters related to soil organic-P

	Vegetation	C-Org (%)	Manure ($MgHa^{-1}yr^{-1}$)	Soil pH	Fe-Humus (%)	Cultivate layers	BV ($g\ cm^{-3}$)	Temperature (°C)
F	Pine with grasses	8.9	none	4.9	0.14	no	0.6	18–20
Ht<15	Annual horticulture	6.7	20-30	5.5	0.11	cultivated	0.75	22–24
Ht>15	Annual horticulure	5.3	20-30	5.8	0.06	cultivated	0.75	22–24

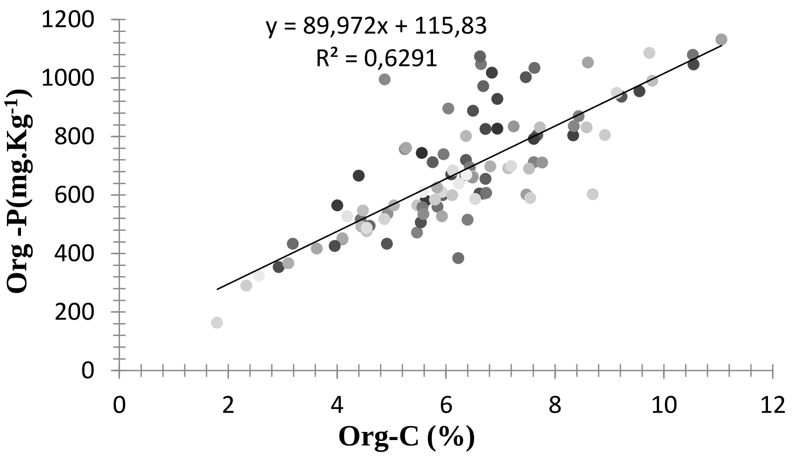

Figure 2. Correlation of soil organic-P and soil organic-C content (Org-P = 89.97 org-C +115.8; r = 0.79**; n = 74)

It shows that there is a significant decrease in soil organic-P content due to land use changing from forest into horticulture land (table 1) and figure 1 describes that organic-P equivalent SP36(super phosphate fertilizer)is about 7.5 Mg/ha/cultivated layers and getting decreased into 6.0 Mg/ha/cultivated layer as an impact of cultivated for more than 15yr.

There is a positive correlation between the organic-C content and organic-P content (figure 2). The organic-P content increases with the increasing of organic-C content. Most of researches show that total-P content of Andisols is more than 2000 mg Kg^{-1}. This high content of total P is especially high in humus horizon rather than in non-humus horizon. However, organic-P content is usually high in A horizon compared to C horizon [12].

Differences of organic-P content in forests at five observation sites are caused by differences in organic matter content accumulated by vegetation within pine forests. The density of vegetation covers such as grass under the pine tree, and the long-term of organic matter accumulation becomes a determinant factor for organic-C content. Thus, this organic-C content will determine the rate of organic-P in the soil. According to the results, organic-P content in pine leaves in the study area is about 0.1% of dry weight.

In soils, organic-P is bounded as organic compounds in the form of mostly phytin (inositol phosphate), phospho-lipid, nucleic acids (DNA and RNA) and high-energy compounds such as ATP, ADP and AMP. The content of inositol organic-P varies between 10–50% with the average value is 12% [11]. However, the organic-P content in Andisol is about 37% of total P [3].

The main causing factor for decreasing of organic-P content in the cultivation land is the decreasing of soil organic matter content due to mineralization. Mineralization of organic-P is associated with an increased soil microbial activity in decomposing the organic matter. The

relationship between organic P and organic C can be seen in figure 2. In table 2 there is a positive correlation between organic-P and organic-C contents. as well as Fe-humus contents. However, the correlation between organic-P content and pH (H_2O) remains negative. The relationship between soil organic-P, pH (H_2O) and Fe-humus can be described by the following regression equation:
Organic-P = -361.4 pH (H2O) + 2822; r = 0.71*; n = 55
Organic-P = 1909 Fe-humus + 505.8; r = 0.73*; n =50

Decreasing of organic-P content is in line with a decreasing of organic matter content. This is as an effect of cultivation which influences an increasing of microorganism activity during organic matter decomposition. This increased microbial activity is caused by changing in land and management such as:

a. Increased of atmospheric and soil temperature due to more opened land;
b. Continuous manure and superphosphate have an effect on increasing pH, decomposer microorganism, native soil organic matter decomposition, as well as bases cations such as Ca, Mg, K and Na;
c. Changes in pH and bases cations (Ca, Mg) which cause a converting of Al/Fe-humus into a more easily decomposed Ca/Mg-humus which finally transform organic-P to inorganic-P. Research conducted by [13] found that the increase in pH will decrease Inositol hexaphosphate in geotite from 4.5 to 0.18 μmol P m-2, and inorganic phosphate from 2.5 to 0.67 μmol P m-2. This release of organic phosphate may accelerate the transformation of organic-P into inorganic-P due to phosphatase enzyme activity;
d. The remnants of vegetations in the pine forest are difficult to be decomposed, in reverse, the horticulture crops are easy to be decomposed, and thus the accumulation of soil organic matter in the forest is higher than that in the horticulture land;
e. Soil cultivation increases microorganism activities so that organic matter decomposition is faster. This is in line by [14] which found that organic matter content is usually high especially in uncultivated soils.

4. Conclusion

Horticulture land practice in Forest-Andisols at Tawangmangu with more than 15 year of cultivation decreases soil organic-P content significantly. The decrease of soil organic-P content is in line with the decrease of soil organic-C content due to horticulture cultivation. There is a positive correlation between organic-P and organic-C contents as well as Fe-humus contents. However, the correlation between organic-P content and pH (H_2O) remains negative.Environmental factors such as soil cultivation, increased of temperature, increased of pH, and input of fresh organic matter may increase the rate of soil organic matter decomposition and decrease organic-P.

References

[1] Sanchez PA 1976 *Propertis and Management of Soil in the Tropics* (New York: John Willey and Sons)
[2] Van-StraatenP 2007 *Agrogeology: The Use of Rock for Crop*(Canada: Enviroquest Ltd)
[3] Tan HK1996*Soil Sampling,Preparation and Analysis* (New York: INC. 270 MadisonAvenue)
[4] Benton JR, Wotf B andMill H A 1991 *Plant Analysis Hand Book*(USA: Micro-Macro Publishing.Inc.)
[5] Turrión MB, Gallardo JF, Haumaier L, González MI, Zech W 2001 *Ann For Sci***58**: 89–98
[6] Turrion MB, Lopez O, Lafuente F, Mulas R, Ruiperez C and Puyo A 2007 *Science of the Total Environment***378**: 195–198
[7] Redel YD, Rubio R, Rouanet JL and Borie F 2007 *Geoderma***139**: 388–396
[8] Rheinheimer DD and Anghinoni I2003 *Commun. Soil Sci. Plant Anal.***34**: 2339–2354
[9] Stevenson FJ 1986 *Humus Chemistry, Genesis Composition Reactions* (New York: John Willey and Sons)
[10] Shoji S, Nanzyo M and Dahlgren R 1993 *Productivity and Utilization of Volcanic Ash Soils In*

Volkanic Ash Soils Genesis, Properties and Utilization(Amesterdam: Elsevier)
[11] Hesse PR 1972 *A Texbook of Soil Chemical Analysis* (New York: Chemical Publishing Co. Inc.) New York
[12] AmanoY 1981 *Phosphorus Status of Some Andosols in Japan*ed K H Tan (New York: Van Nostrand Reinhold Company Inc.) pp 241–248
[13] Celi.L, Presta M, Ajmore-Marsan F and Barberis E 2001*Soil Science Society of America Journal***65**:753–760
[14] Rachman H.M,Okuba A,Sugiyama S and Mayland H F 2008 *Physical,chemical and microbiological properties of Andisol as related to land use and tillage practice.*(Amsterdam: Soil & tillage research)