Retention And Availability of Andisol Soil Phosphorus in Monocultural and Policultural Crop Patterns in Ngablak and Getasan Subdistrict, Magelang and Semarang, Indonesia

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ABSTRACT
Element P in Andisol soil is absorbed by amorphous minerals such as allophane, imogolite , and amorphous Al/Fe. This study aims to determine the retention and availability of P as well as differences in soil chemical properties on land with monoculture and polyculture cropping patterns. Parameters measured were available-P, P-retention, texture, CEC, C- organic , pH (H_2O, KCl , NaF), Potential-P, Al/Fe/Si with three selective solvents. The sample used 3 replicates at 2 depths (0-20cm and 20-40cm) and 2 different locations, namely Ngablak Subdistrict and Getasan Subdistrict. The data obtained were processed using ANOVA for the RCBD design and LSD Fisher's follow-up test. P retention data in Ngablak Subdistrict showed significantly different results, while those in Getasan Subdistrict were not significantly different. Available P did not show any significant difference, but the availability of P was higher in polyculture land. On agricultural land in Ngablak Subdistrict, cropping patterns have a significantly different effect on soil properties in the form of P retention and C-Organic. Meanwhile, on agricultural land in Getasan Subdistrict, cropping patterns had significantly different effects on soil properties of pH H_2O, pH KCl , Potential-P, amorphous Al + Fe , and Allophane + Imogolite.

Keywords : *phosphorus, allophane, imogolite, C-organic, monoculture, polyculture*

1. Introduction

The land area with Andisol Soils in Indonesia reaching 5.4 million ha or around 2.9% of Indonesia's land area [7]. However, besides have potential to be used as agricultural land, Andisol soil also has necessary problem that need more special attention related to the availability of phosphorus nutrients. While, phosphorus is one of the essential nutrients for plants [12]. In Andisol soils, phosphate elements usually bind to non-crystalline clay minerals such as allophane, imogolite, and ferrihydrite, where allophane is able to hold P up to 97.8% and the presence of Al and Fe in amorphous form also binds P [18].The availability of P in the soil also depends on land management strategies that create different conditions from the initial land [2]. On a different cropping pattern, different land management will be carried out. The common cropping pattern used by farmers in the Ngablak and Getasan sub-subdistricts is the monoculture and polyculture. The monoculture is a cropping pattern using one type of plant in one cropping period, while the polyculture is a cropping pattern that use more than one type of plant in one cropping period.In the polyculture cropping pattern interaction and competition of plant is different than monoculture cropping patern [1]. Variations in surface plant species will provide the potential for a diversity of available biomass to be returned to the soil, which will later become a nutrient contributor after the decomposition process [10]. In addition, the pattern of monoculture and polyculture plant species also affects the number of communities and types of microbes in the land that are useful in nutrient cycling [1]. The implications cropping pattern for soil properties must be considered by farmers. This is important so that farmers can choose cropping patterns that are appropriate to the conditions of the land, including in this case P nutrient fertilization. Therefore, further measurements regarding P adsorption and availability of P in Andisol soil are needed. The aims of this study were : to determine the retention and availability of P as well as differences in soil chemical properties on land with monoculture and polyculture cropping patterns.

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2. Methodology

2.1 Location Description

Most of the land at the research location is used as agricultural land. The agricultural land at the research location has been cultivated for a long time, in fact for more than 30 years, and in 2010 they started using an organic farming system. Agricultural land is dominated by horticultural commodities. Generally, farmers market their products to markets, restaurants, shopping centers, and even export abroad. So it can be said that horticultural agriculture has the potential to be developed. Choosing the right planting pattern needs to be evaluated in order to increase the effectiveness of soil management and the efficiency of fertilization, especially phosphorus nutrients.

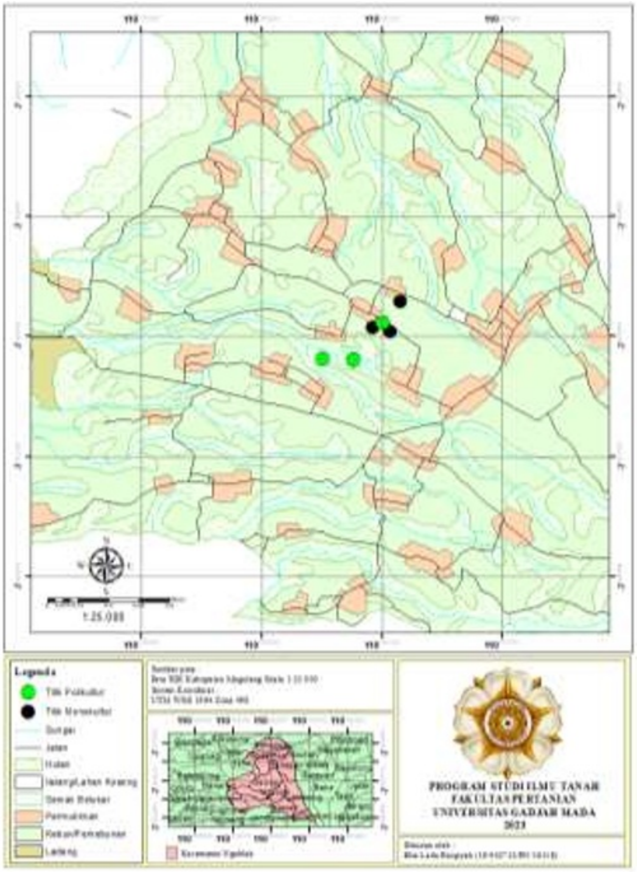

Figure 1. Map of research sample points in Ngablak Subdistrict

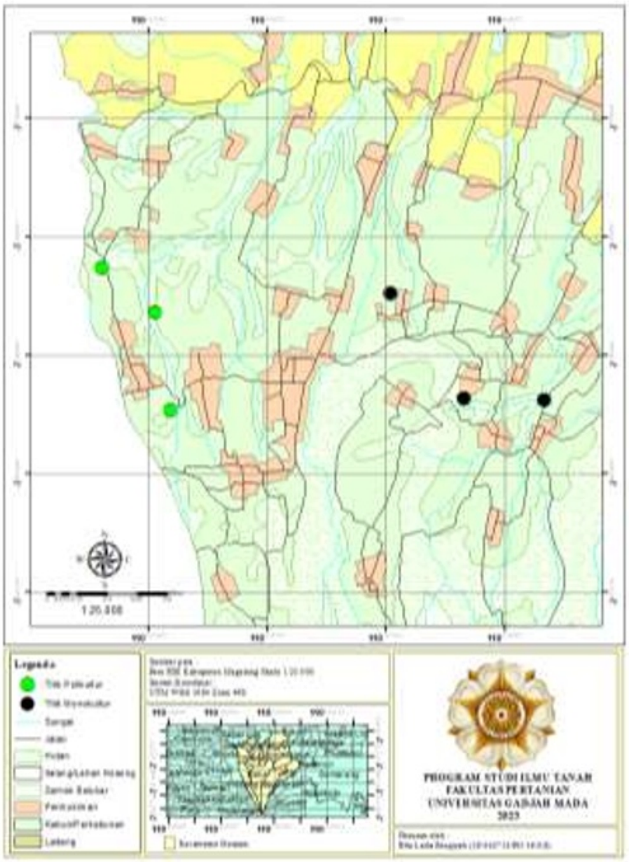

Figure 2. Map of research sample points in Getasan Subdistrict

2.2 Research Design and Data Collection

This study was carried out at the end of 2022 – mid-2023 in the Ngablak Subdistrict, Magelang and Getasan Subdistrict, Semarang, Central Java and the Laboratory of the Department of Soil Science, Faculty of Agriculture, University of Gadjah Mada. The design was prepared using Randomized Complete Block Design (RCBD) with 2 factors: cropping pattern and soil depth in 2 different subdistricts. The first factor is the cropping pattern with 2 variations, Monoculture and Polyculture. The second factor is soil depth with 2 variations, 0-20 cm and 20-40 cm. The research location consists of 2 subdistricts, namely Ngablak Subdistrict and Getasan Subdistrict. The method used is random sampling. Repetition of sample points was carried out 5 times.

2.3 Analysis of Soil

Parameters that measured in this research are P potential soil with solvent HCl 25%, available-P with the Bray method, P retention with the Blackmore method, pH NaF and H_2O, humic acid extracted with a mixture of alkaline and strong acids, soil texture, Cation Exchangeable Capacity (CEC), C-Organic, Al/Fe/Si uses three selective solvents, namely selective solvent consisting of 0.2M Ammonium Oxalate, Dithionite Citrate Bicarbonate (DCB) pH 3, and 0.1M Sodium Pyrophosphate. Then the results are used to calculate Al/Fe Humus, Amorphous Al/Fe, Allophane and Imogolite [15].

- Fe/Al-humus = Fe/Al Na-Pyrophosphate
- Fe/Al-amorphous = Fe/Al NH4-Oxalate – Fe/Al Na-Pyrophosphate
- Allophane + Imogolite = %Si NH4-Oxalate x 7.1
- Terms Andisol = Al NH4-Oxalate + ½ Fe NH4-Oxalate > 2

2.4 Statistics analysis

The data were analyzed using ANOVA (Analysis of Variance) Completely Randomized Block Design (RCBD), which is useful for testing the significance of cropping pattern variations for each parameter using the 5% level. Then proceed with the LSD (Least Significant Difference) test with a level of 5% to find significant variation.

3. Results and Discussion

3.1 Soil Type at the Research Location

The pH value of NaF ≥ 9.4 indicates that amorphous minerals dominate the soil exchangeable complex [13]. Based on the results of the NaF pH test on land overall value was > 9.4. The reaction that occurs when adding NaF solution is the exchange of F^- with OH^- which is on the edge of the allophane so that OH^- is released into the soil solution which has implications for increasing the pH of the solution [14].

Table 1. NaF pH at the research location

Cropping Pattern	pH NaF Ngablak		Average	pH NaF Getasan		Average
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	10.10	10.20	10.2a	10.17	10.22	10.2a
Polyculture	10.19	10.33	10.3a	10.10	10.17	10.1a
Average	10.1a	10.3a		10.1a	10.2a	

Note : Numbers followed by letters that are not the same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test.

Other properties or parameters that can be used as indicators that the soil contains a lot of amorphous minerals are Al/Fe/Si with three selective solvents. One of the selective solvents that can detect the presence of non-crystalline minerals is ammonium oxalate. A soil can be classified as an andisol soil if it has andic properties, while these characteristics have conditions NaF pH above 9.4 and Al Oxalate + ½ Fe Oxalate > 2 [16].

Table 2. Al Oxalate + ½ Fe Oxalate at the reasearch location

Cropping Pattern	Al Oxalate + ½ Fe Oxalate Ngablak		Average	Al Oxalate + ½ Fe Oxalate Getasan		Average
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	2.01	3.92	2.96a	5.04	3.15	4.10a
Polyculture	2.17	3.79	2.98a	2.35	1.72	2.03b
Average	2.09a	3.85a		3.69a	2.43a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test.

Monoculture and polyculture cropping patterns gave significant differences, while variations in depth did not give significantly different results. High results of Fe oxalate and Al oxalate indicate that mineral crystallization at these locations is slow [15]. Based on the two properties above, it can be said that the soil in this research location is indeed Andisol soil.

3.2 Soil Physical and Chemical Properties

Texture

The texture class at the study site was sandy loam. This means that the composition of the soil fractions : sand, clay and silt, is not much different, but is dominated by the sand fraction. These results are in accordance with Juarti's research, 2016 where in this study also obtained Andisol soils with a sandy loam texture [8].

Table 3. Soil texture at the research location

Cropping Pattern	Texture		Texture	
	Ngablak		Getasan	
	0-20cm	20-40 cm	0-20cm	20-40 cm
Monoculture	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
Polyculture	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam

The texture is owned by the result of the parent material development in the form of volcanic material. Volcanic material released by volcano during eruptions, it's can be sand and volcanic ash, so the content of silt and sand in Andisol is relatively high [8]. In addition, the texture of Andisol soils is characterized by the presence of micro-aggregates or pseudo-sand which has a granular structure, is reddish in color, and thixotropic [3]. Pseudo sand can be formed due to the process of aggregation or attachment of amorphous minerals with other particles such as organic matter.

Soil Reaction (pH)

Reaction soil (soil pH) is an indicator that show the level of soil acidity. The results measurement of pH H_2O at the research location are shown in Table 4.

Table 4. Soil pH H_2O at the research location

Cropping Pattern	pH H_2O		Average	pH H_2O		Average
	Ngablak			Getasan		
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	7,2	7,23	7,2a	7,22	7,33	7,3b
Polyculture	6,93	6,97	6,9a	7,38	7,4	7,4a
Average	7,1a	7,1a		7,3a	7,4a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Based on the data in Table 4, the pH value of H_2O at the research location in Ngablak Subdistrict show that monoculture and polyculture cropping patterns were not significantly different, nor did the depth of variation give significantly different results. While in the research location of Getasan Subdistrict monoculture and polyculture cropping patterns gave significant differences, variations in depth did not give significantly different results. The more diverse the vegetation, the more exudate that can be secreted by plant roots and this can increase the pH [10]. This is also in line with the research of [10]. where in this study monoculture land had a lower pH. However, other factors may also affect the pH at the research location in Ngablak Subdistrict, where polyculture land has a lower pH. This can be caused by the presence of organic matter or biomass which is more than monoculture land but has not or is undergoing decomposition which produces of organic acids [8].

Cation Exchangeable Capacity (CEC)

Soils that predominantly have amorphous minerals will have a variable charge. Soil with a variable charge will have a charge depending on environmental conditions, which is pH. This can happen because the constituents of the soil fraction are amphoteric so at low pH the colloid surface will be positively charged (OH^- protonation occurs), while at high soil pH it will be negatively charged (H^+ dissociation occurs) [9].

Table 5. CEC at the research location

Cropping Pattern	CEC (cmol (+)/kg)		Average	CEC (cmol (+)/kg)		Average
	Ngablak			Getasan		
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	20.52	18.04	19.28a	24.11	25.06	24.59a
Polyculture	20.41	18.67	19.54a	26.69	28.13	27.41a
Average	20.46a	18.35a		25.40a	26.60a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Based on the data in Table 5 the CEC value at the research location in Ngablak Subdistrict show that monoculture and polyculture cropping patterns were not significantly different, nor did the depth of variation give significantly different results. That also shown in the research location of Getasan Subdistrict. However, based on the average, it can be seen in the two subdistricts that polyculture land has a higher CEC than monoculture land. This can happen because of the input of organic matter from the remaining biomass on polyculture land which is more varied. CEC can increase due to organic matter that enters the soil so that soil with high organic matter will have a higher CEC [10].

C-Organic

There is another form of soil colloid that affects all soil properties, namely soil organic matter. Soil organic matter is composed of carbon chains that can be obtained by multiplying soil organic matter result by the average amount of carbon in organic matter, which is 58%.

Table 6. C-Organic content at the research location

Cropping Pattern	C- Organic (%)		Average	C- Organic (%)		Average
	Ngablak			Getasan		
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	6.17	5.72	5.94a	7.91	7.32	7.61a
Polyculture	7.34	6.91	7.13b	8.06	7.91	7.98a
Average	6.75a	6.31a		7.98a	7.62a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

The results measurement of organic matter on monoculture and polyculture land in Ngablak Subdistrict showed significantly different. This is due to the more varied vegetation on polyculture land compared to monoculture land. So that the input of organic matter into the soil is more numerous and varied. While the results of the Getasan Subdistrict, although not giving significantly different the organic matter content in polyculture soils also showed higher result compared to monoculture soils. In addition, the results also show that the organic matter content at a depth of 0-20 cm is higher than that of organic matter at a depth of 20-40 cm. The organic matter content will decrease with increasing layers, if there is an increase in organic matter in a lower layer of material indicates the presence of new volcanic deposits on top of previously developed material [4].

Humic Acid

Humic acid is heavy molecule organic acid from the decomposition of organic materials. Humic acid is colored dark , have > 50% carbon chain, and soluble in base.

Table 7. Humic Acid at the research location

Cropping Pattern	Humic acid (%)		Average	Humic acid (%)		Average
	Ngablak			Getasan		
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	0.27	0.27	0.27a	0.27	0.29	0.28a
Polyculture	0.28	0.29	0.28a	0.28	0.27	0.27a
Average	0.27a	0.28a		0.28a	0.28a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Based on the data in Table 7 the Humic acid value at the research location in Ngablak Subdistrict show that monoculture and polyculture cropping patterns were not significantly different, nor did the depth of variation give significantly different results. That also shown in Getasan Subdistrict. The presence of humic acid indicates the degree of humification of organic matter, the more humic acid, the higher the humification process [20]. In Andisols, the humification process was quite hampered by the presence of amorphous Al and cold temperatures, so that the humic acid content was very low (<1%). Almost the same results were shown in both monoculture and polyculture land, this indicated that the humification process was almost the same.

3.3 P-Retention and Availability

Andisol is the one of the soils that has problems related to the availability of P nutrient. Because, Andisol has the ability to absorb phosphorus. Table 8 show the P-retention at the research location

Table 8. P Retention at the research location

Cropping Pattern	P-Retention (%) Ngablak		Average	P-Retention (%) Getasan		Average
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	79.35	80.61	79.98b	91.34	90.72	91.20a
Polyculture	85.72	88.80	87.26a	89.83	92.58	91.03a
Average	82.53a	84.70a		90.58a	91.65a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Based on the data in Table 8 P-Retention at the location study Subdistrict Ngablak show that cropping pattern monoculture and polyculture give significant different, meanwhile variation depth neither give significant different. While at Getasan Subdistrict cropping patterns were not significantly different, nor did the depth. The characteristics of Andisols are having high P retention, mostly > 85% and generally reaching 97.8% [18]. but the presence of soil organic matter can affect the P-retention. The decomposition of organic matter carried out by microorganisms produces organic acids, these organic acids can bind allophane and release P nutrients, therefore later P can be absorbed by plants [19]. Humus material can also bind Al and Fe first then form Al/Fe Humus.

Table 9. Al/Fe humus complex at the Ngablak Subdistrict

Cropping Pattern	Al/Fe Humus (%) Ngablak				Average	
	0-20 cm		20-40 cm			
	Al	Fe	Al	Fe	Al	Fe
Monoculture	0.243	0.0058	0.264	0.0051	0,2665a	0,00543a
Polyculture	0.263	0.0081	0.270	0.0068	0,2535a	0,00745a
Average	0,2530a	0,00695a	0,2670a	0,00593a		

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Table 10. Al/Fe humus complex at the Getasan Subdistrict

Cropping Pattern	Al/Fe Humus (%) Getasan				Average	
	0-20 cm		20-40 cm			
	Al	Fe	Al	Fe	Al	Fe
Monoculture	0.239	0.0068	0.237	0.0068	0,2378a	0,00915a
Polyculture	0.234	0.0091	0.267	0.0092	0,2506a	0,00675a
Average	0,2366a	0,0079a	0,2518a	0,0080a		

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

In Table 9 and 10 can be seen complex formation between Al and Fe with humus. Al and Fe humus can be formed as a result of the synthesis of humus compounds which can form chelates with Al and Fe oxides. Al and Fe humus will become cationic complexes that are not hydrolyzed so that the influence of dissolved oxide ions in the soil is decrease [15]. This humus also has potential to interfere the allophane formation process which is characterized by low allophane levels and acid soils, besides that the Fe-crystalline/Fe-Amorphous ratio will also be low [15].

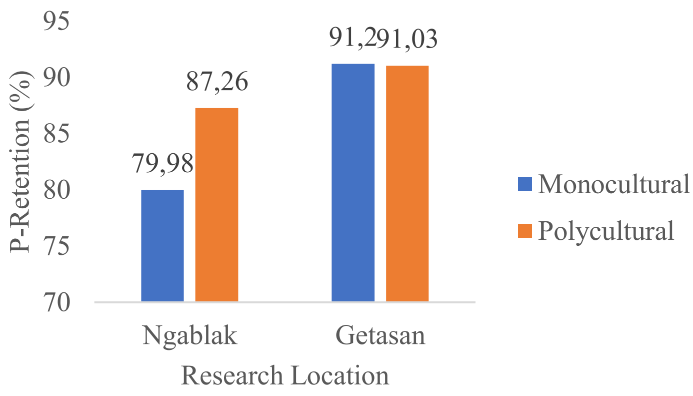

Figure 3. Comparison land P retention monoculture and polyculture

In Figure 3. it can also be seen that P retention on polyculture land tends to be higher than monoculture land, even though in Getasan Subdistrict P retention is almost the same. This can be caused by the amorphous mineral content found on each land. The higher the amorphous mineral, the higher the P-retention. Table 11 shows the amorphous mineral content at the research location.

Table 11 Allophane + Imogolite content at location study.

Cropping Pattern	Allophane + Imogolite (%)		Average	Allophane + Imogolite (%)		Average
	Ngablak			Getasan		
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	14.23	13.49	13.86a	21.67	17.40	19.53a
Polyculture	13.89	14.91	14.40a	7.41	6.67	7.04b
Average	14.06a	14.20a		14.54a	12.04a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Allophane in soils derived from volcanic materials in Indonesia ranges from 1-34% with an average of 11% [18]. Based on Table 11 it can be seen that the allophane + imogolite content in polyculture land in Getasan Subdistrict is higher than monoculture land so that P retention is higher. However, in Getasan Subdistrict, the allophane + imogolite of monoculture land was much higher than that of monoculture land. This is not in line with the results of P retention in Getasan Subdistrict, which is almost the same. This might be influenced by the presence of other factors that inhibit the adsorption process so that P retention does not occur. These factors are for example the presence of phosphate solubilizing microorganisms. The mechanism of dissolving phosphate by microorganisms is by secreting low molecular weight organic acids such as oxalic, succinic, tartaric, citric acids, and others which will chelate with Al, Fe, Ca, or Mg which absorbs phosphate to form a stable organic chelate so that phosphate is released [6].

Table 12 Available-P at the research location

Cropping Pattern	Available-P (ppm)		Average	Available-P (ppm)		Average
	Ngablak			Getasan		
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	4.48	6.02	5.3a	8.20	7.38	7.8a
Polyculture	10.25	10.43	10.3a	5.81	12.37	9.1a
Average	7.4a	8.2a		7.0a	9.9a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Based on the data in Table 12 Available-P at the Subdistrict Ngablak show that monoculture and polyculture cropping patterns were not significantly different, nor did the depth of variation give significantly different results. That also shown in Getasan Subdistrict. Available-P measurement results show low to moderate values. As previously mentioned, the availability of P in Andisols is generally low or very low. Minardi *et al.,* (2011) [11] have also carried out research on the availability of P in Andisol soil and obtained a result of 3.49 mg/kg which is very low. This is due to the large number of P chelating agents, apart from being adsorbed by allophane P in the Andisol soil, it is also adsorbed by Al/Fe in amorphous form. The following is the result of measuring the amorphous Al/Fe content at the research location.

Table 13. Amorphous Al/Fe at the Ngablak subdistrict

Cropping Pattern	Al/Fe Amorphous (%)				Average	
	Ngablak					
	0-20 cm		20-40 cm			
	Al	Fe	Al	Fe	Al	Fe
Monoculture	1,2813	0,9647	3,0487	1,2002	2,1650a	1,0825a
Polyculture	1,5836	0,6299	3,0655	0,9038	2,3246a	0,7669a
Average	1,4324a	0,7973a	3,0571a	1,0520a		

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Table 14. Amorphous Al/Fe at the Getasan subdistrict

Cropping Pattern	Al/Fe Amorphous (%)				Average	
	Ngablak					
	0-20 cm		20-40 cm			
	Al	Fe	Al	Fe	Al	Fe
Monoculture	4,0380	1,5246	2,7359	1,4436	3,3869a	1,4841a
Polyculture	1,7967	0,3632	0,5090	0,2415	1,1529b	0,3024a
Average	2,9173a	0,9439a	1,6224b	0,8426a		

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Based on Table 13 and Table 14 it can be seen that the soil at the study site also contains amorphous Al/Fe which can also absorb P. The mechanism of P adsorption by these amorphous minerals, forms strong covalent bonds or inner-sphere complexes with irreversible properties. So that P can be strongly absorbed into the mineral lattice in the soil and it becomes difficult to be available. The following is an illustration of the adsorption reaction [21] :

$$]\text{Al-OH} + H_2PO_4^- \rightarrow]\text{Al-OH}_2PO_3^- + OH^-$$

Amorphous minerals P- available Complex Retention-P

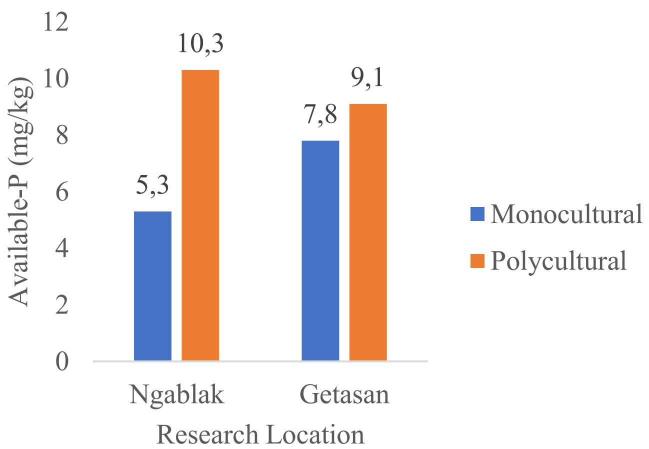

Figure 4. Comparison of Available-P on land monoculture and polyculture

In Figure 4 it can be seen that the availability of P in polyculture land is higher than in monoculture land. Apart from the fact that the research location is an organic agricultural land with great potential to increase the availability of P, this is also due to the fact that polyculture land has a more diverse crop residue. Due to the high input of organic matter, the availability of P can increase. The mechanism for releasing phosphorus in Andisol soil is through mineralization processes, releasing P from adsorption complexes through Al and Fe chelation mechanisms through functional groups and organic acids, and through priming effects [11].

Although the adsorption of P in Andisol soil was quite high and the availability of P showed low-moderate results, P at the study site could be increased. Potential-P is a P substrate that has the potential to be broken down into available-P in the mineralization process. So that the higher Potential-P, the higher chance of increasing the availability of phosphorus in the soil. The results of these measurements show values from high to very high.

Table 15 P- Potential at location study

Cropping Pattern	P- Potential (mg/100g) Ngablak		Average	P- Potential (mg/100g) Getasan		Average
	0-20cm	20-40 cm		0-20cm	20-40 cm	
Monoculture	73.80	64.91	69a	74.08	62.03	68b
Polyculture	82.43	61.91	72a	92.66	85.70	89a
Average	78a	63a		83a	74a	

Note : Numbers followed by letters that are not same indicate that there are real differences between factors (planting pattern and depth) in the 5% LSD test

Based on the data in Table 15 P- Potential at the location study Ngablak Subdistrict show that monoculture and polyculture cropping patterns were not significantly different, nor did the depth of variation give significantly different results. While at the Subsubdistrict Getasan monoculture and polyculture cropping patterns show significantly different result, but the depth didn't give significantly different results.

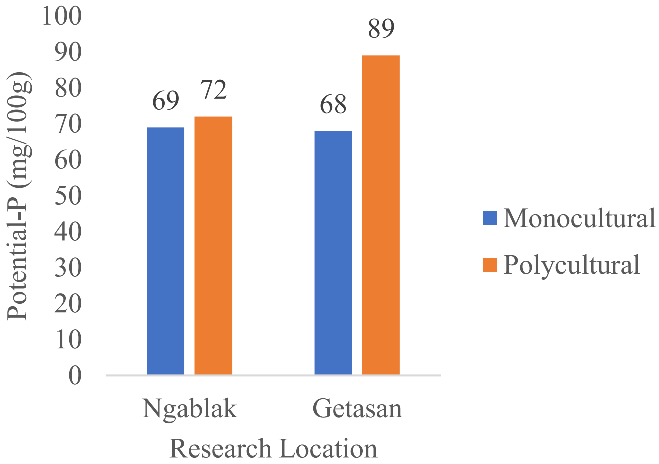

Figure 5 Comparison of Potential-P on land monoculture and polyculture

Based on Figure 5, it can be seen that the Potential-P in polyculture land is higher than in monoculture land. Due to the more diverse potential of biomass litter, there are also more P sources for mineralized substrates. So that the potential availability of P in polyculture land will be higher. The best effort to do on land with high Potential-P is the priming effect. Organic matter can stimulate the availability of P through the Potential-P in the soil, this mechanism is called the priming effect. This process can also be enhanced by the addition of phosphate solubilizing microorganisms. In addition to using organic matter, increasing available P in the soil can be done by applying silica fertilizer. Si dissolves easily in the form of silicic acid and is able to increase the availability of P with anion substitution processes [17].

4. CONCLUSIONS

Based on research that has held can concluded a number of matter following :

1. Retention of P in the field monoculture and polyculture in the Subdistrict Ngablak give significant different result, meanwhile P retention in the Subdistrict Getasan didn't give significant different result. P-Retention in monoculture is higher than polyculture
2. Availability of P on monoculture and polyculture land in Ngablak Subdistrict did not give significantly different results, but in the two sub-subdistricts the availability of P on polyculture land was higher.
3. On agricultural land in Ngablak Subdistrict, the cropping pattern gave significantly different results on soil properties in the form of P and C-Organic retention. Meanwhile, on agricultural land in Getasan Subdistrict, cropping patterns gave significantly different results on soil properties in the form of pH H_2O, pH KCl, Potential-P, amorphous Al + Fe, and Allophane + Imogolite.

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