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Effect of humic acid on the growth and yield of two maize (*Zea mays* L.) cultivars on andisol

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ABSTRACT

One way to improve maize (*Zea mays* L.) production is through land extension using Andisol land. However, Andisol soil has phosphate (P) fixation problem due to the high amorphous material. Hence, the use of organic material in the form of humic acid that has greater affinity to amorphous minerals is recommended to solve the problem. This research was conducted in February-May 2017 at Tri Dharma field of Faculty of Agriculture, Universitas Gadjah Mada. The Andisol land used has a low available P category from Datar, West Java and Wonosobo, Central Java. This research was arranged in a Randomized Complete Block Design (RCBD), consisting of two factors. The first factor was maize cultivar (Bisi-2 and Pioneer-35). The second factor was the doses of humic acid, consisting of control treatment (without fertilizer and humic acid), NPK without humic acid, and NPK + humic acid at 5%, 10%, and 15%. The percentage of humic acid given, based on the amount of NPK 16:16:16 fertilizer, was 350 $kg.ha^{-1}$. Fertilization was applied three times 100 $kg.ha^{-1}$ on 1 WAP, 150 $kg.ha^{-1}$ at 3 WAP and 100 kg ha^{-1} at 7 WAP. The results is, humic acid treatment had the same effect with NPK fertilization treatment only and control on P available Andisol soil. Humic acid, also has the same effect with NPK fertilizer treatment in increasing the yield component of 100 seeds weight, dry weight of seeds, harvest index, length of cobs and productivity.

INTRODUCTION

Andisol is soil made up of material originating from volcanic eruptions, which then become weathered over time and turned into soil with high tendency for nutrients. This can be one way to increase the productivity of a food crop commodity such as maize through the expansion of planting land (extensification). Maize is one of the crop commodities with high economic opportunities in the future if the management is carried out properly. Maize imports increased in 2010-2014 by 15.72% due to the intensifying demand for maize which continues to climb by 5.72% and the rate of consumption which rose by 3.33 % in 2011-2015 (Kementerian Pertanian, 2016).

So this makes maize a commodity that requires special attention, especially to solve its productivity problems. The superior maize cultivars used are Bisi-2 and Pioneer-35. Those cultivars have resistance to maize curry which is one of the problems in maize cultivation and those are also frequently cultivated by farmers in Andisol soil.

The expansion of the andisol soil (750-3000 m asl) (Dariah and Sukarman, 2014) is possible because the land area of Andisol in Indonesia is 5.4 million ha or about 2.9% of Indonesia (Subagjo et al. 2004). The problems found in Andisol soil are, the high amorphous minerals such as allophane, imogolite, and ferihidrit, which can retain the P element up to 97.8% (Dariah and Sukarman, 2014) and cause the unavailability of the P element for plants as it is absorbed by the amorphous mineral of Andisol. Therefore, the fertilization cannot be absorbed by maize plants optimally. The non-fulfillment of nutrient requirement of P in maize plant is indicated by the appearance of purple-reddish-brown leaf, whereas on yield, the resulting ear size becomes small with a curved tip (Kementerian Pertanian, 2010).

One way of increasing the availability of P element in Andisol soil is by providing organic matter in balanced fertilization (Nyangjang, 2003). Organic matter can serve as one the materials to improve physical and biological properties of soil (Baskoro, 2010), since such matter is a loose granular adhesive, and is an energy source for most soil organisms (Dewanto et al., 2013). One of these organic materials is humic acid. Humic acid consists of complex compound including humin fraction, humic acid fraction, and sulfuric acid fraction (Stevenson, 1982). Humic acid owns chelation function, which strongly binds metal ions with covalent (strong bond), so that the metal chelates can percolate down or settle (Tan, 2011). The ability to absorb humic acid is also influenced by components found in the soil, such as clay minerals (Qi et al., 2017). Humic acids as chelates of amorphous minerals have more sustainability and are difficult to decompose. As the affinity of amorphous minerals to organic materials is greater than that of P, the organic material can strongly chelate out amorphous minerals and release element P making it available to plants.

Therefore, this research aimed to determine the growth response, the results of cultivar of Bisi-2 and Pioneer-35, and the availability of soil phosphate using the administration of humic acid in Andisol soil.

MATERIALS AND METHODS

The research was conducted in February-May 2017 at Tri Dharma Experimental Garden of Faculty of Agriculture, Universitas Gadjah Mada, located in Banguntapan, Bantul, Yogyakarta, which is included in the wet dry month with the average rainfall of 173.16 mm (BMKG, 2019). The average temperature and humidity of the study area were 28.98°C and 71.76%, respectively. The land used was land with Andisol soil with low availability of P category from Datar, West Java and Wonosobo, Central Java.

This study was arranged in a Randomized Complete Block Design (RCBD), consisting of 2 factors. The first factor was maize cultivar (Bisi-2 and Pioneer-35). The second factor was the doses of humic acid, consisting of control (without fertilization and without humic acid), NPK without humic acid, and NPK+humic acid at 5%, 10%, and 15%. Percentage of humic acid based on the amount of NPK 16:16:16 fertilizer given was 350 $kg.ha^{-1}$. The fertilization was applied 3 times, i.e. 100 $kg.ha^{-1}$ on 1 WAP, 150 $kg.ha^{-1}$ at 3 WAP and 100 $kg.ha^{-1}$ at 7 WAP. Maize is grown on Andisol soil at 35×40 cm polybag size and placed with polybag distance of 70×30 cm. The humic acid used for treatment are made from the base of pure cow dung. The application of humic acid is given in conjunction with fertilization by mixing NPK directly with humic acid powder by making a planting media hole around the roots and then closing it again.

Soil sampling is carried out prior to planting. The treatment aimed to know the initial state of the Andisol soil. The second soil sampling was carried out simultaneously when the 7 WAP crop samples were taken, and the third one was carried out simultaneously with the 15 WAP maize crop harvest age.

The research variables observed were soil chemical properties including (1) pH (H_2O 1:5 and NaF) (7 WAP and 15 WAP); (2) Phosphate (P) available (modete Bray) (7 WAP and 15 WAP); and (3) C-Humat (7 WAP and 15 WAP).

Plant growth and yield observed included (1) Plant leaf area (cm^2), from which the green leaves were measured using leaf area meter (7 WAP and 10 WAP); (2) Percentage of purple leaf area (%), which was calculated using formula : leaf area of deficiency P / leaf area×100 (7 WAP and 10 WAP); (3) Root surface area (cm^2), which was calculated using a surface area without a lid with formula : $(\pi r^2) + (\pi d p)$ (7 WAP and 10 WAP); (4) Plant height (cm) observation, which was done routinely once a week starting from the V3 (4 WAP) phase to the VT phase (male flower formation) (7 WAP); (5) The dry weight of leaves, flowers, stems, roots, cobs, seeds, total dry weight (g), which were stirred at 80°C for 48 h until constant weight, then weighed using analytic scales (15 WAP); (6) Harvest index, which was calculated by dividing economic results by biological results. The intended economic yield was the weight of the oven dry seeds, while the biological yield was the results of all parts of the plant (stover, cob and seeds) in the oven dry (15 WAP);

Table 1. Initial analysis of Andisol soil properties

Test Parameter	Andisol	Unit	Method	Value
Humic Acid	0.33	%	Titration	Very low
Fulvic Acid	0.15	%	Titration	Very low
pH (H_2O)	5.85	-	pH meter 1 : 5	Medium acid
pH (NaF)	11.25	(24 h)	pH meter	High
Organic-C	7.55	%	Walky & black	Very high
Total N	0.67	%	Kjeldahl	High
Available P	7.43	ppm P	Olsen	Low
Cation Exchange Capacity	27.62	cmol (+) kg^{-1}	Distillation	High

Remark: Value based on Balai Penelitian Tanah (2009).

(7) The length of cobs (cm), which were measured after stripping the cob from the skin of the cob. The counting was done with a ruler from the tip of the cob to the base of the cob (15 WAP); and (8) Efficiency of P uptake (%) in seed and leaf tissue, which was calculated using the formula of (P-uptake of nutrient P-fertilized plants in unpowered plants) / P nutrient content in fertilizer given×100% (15 WAP). The data were analyzed using SAS 9.3 with variance analysis (ANOVA) and tested further with DMRT with 95% of confidence level.

RESULTS AND DISCUSSION

Soil chemical properties after humic acid application on andisol soil

Initial soil analysis was carried out to determine the soil condition before the treatment application. The soil sampling was carried out at several points on the land, from which the soil was made composite. The results of preliminary analysis of Andisol soil are shown in Table 1. Humic Acid content was higher than Fulvic Acid, which was 0.33% and 0.15% respectively; the soil contained a pH of 5.85 H_2O, which was slightly acidic, with a pH of NaF was 11.25 and it was included as a high NaF pH (> 9.5). That indicates that the amorphous mineral content (allophane) in the soil is high so that it can cause low availability of P in the soil due to sorption by allophane (Soepardi, 1983). The organic C level was 7.55% (very high); N-total obtained 0.67% (high), with available P of 7.43 ppm P (Low); and cation exchange capacity (CEC) contained 27.62 cmol (+) kg^{-1} which has a high KPK value (Rosmarkam and Yuwono, 2015).

Application of humic acid as well as the use of cultivars had the same effect on pH, soil H_2O, pH NaF and available P soil. Table 2 showed that H_2O pH in the 15 WAP was higher than 7 WAP, it is related to Rosmarkam and Yuwono (2015) which categorized slightly acid. P availability during the age of the crop of 15 WAP was still relatively low ≥ 2 and it became very low ≤ 1 (Balai Penelitian Tanah, 2009). It is possible that the existing amorphous mineral binding of Andisol soil is characterized by the high pH value of NaF> 9.00 (Rosmarkam and Yuwono, 2015), indicating that the amount of amorphous mineral was contained in Andisol soils. Low P is available on 15 WAP as the available P element can be utilized by plants. This is also supported by the opinion of Ai et al. (2019). Humic acid has the potential of binding aggregate in the form of colloids to various contaminants but it can help in the trace process of nutrients.

Application of humic acid as well as cultivar use had the same effect on C-Humic content when the plant was in 7 weeks of age after planting (WAP) (Table 3). Cultivar Bisi-2 and Pioneer-35 with NPK or NPK + Humic Acid treatment had the same effect on C-Humic content compared to control. The decrease of C-Humic content value was present when the plant was 15 weeks of age after planting (WAP) and it was possible due to the presence of humic compounds that chelated out amorphous minerals in Andisol soils. Humic acid has a functional group of carboxyl, hydroxyl, phenolic, and amine (Tan, 1983), which serves to chelate various metal elements thereby reducing the presence of plant poisoning to the metal, and increasing soil pH (Setijono, 1996). Therefore, the metal fixation of phosphate (P) is decreased

Table 2. The value of soil pH, pH of NaF and Phosphate (P) availability (mg.kg^{-1}) in Andisol soil by administering several doses of humic acid

Treatment	pH H_2O		pH NaF (24 h)		P available	
	7 WAP	15 WAP	7 WAP	15 WAP	7 WAP	15 WAP
Cultivars						
Bisi 2	5.68 a	5.87 a	11.32 a	11.11 a	2.62 a	1.71 a
Pioneer 35	5.68 a	5.84 a	11.34 a	11.22 a	2.89 a	2.23 a
Application of Humic Acid						
Control	5.77 a	5.82 a	11.17 a	11.14 a	2.84 a	2.57 a
NPK without Humic Acid	5.72 a	5.80 a	11.43 a	11.23 a	2.40 a	2.79 a
NPK+ Humic Acid 5%	5.50 a	6.13 a	11.40 a	11.22 a	3.24 a	1.41 a
NPK+ Humic Acid 10%	5.77 a	5.88 a	11.33 a	11.23 a	2.70 a	1.50 a
NPK+ Humic Acid 15%	5.64 a	5.66 a	11.31 a	11.00 a	2.62 a	1.58 a
Interaction	(-)	(-)	(-)	(-)	(-)	(-)
CV	3.67	4.75	1.42	1.66	10.50	18.02

Remark: The number followed by the same letter in the same column shows no significant difference according to DMRT α= 5%. The (-) indicates no interaction between factors.

Table 3. Content of C-Humat (%) Andisol soil with some doses of humic acid

	Cultivars	Application of humic acid					
		Control	NPK with no humic acid	NPK+ humic acid 5%	NPK+ humic acid 10%	NPK+ humic acid 15%	Average
7 WAP	BISI 2	0.04	0.05	0.05	0.09	0.05	0.06 p
	Pioneer 35	0.03	0.06	0.04	0.03	0.06	0.05 p
	Average	0.04 a	0.06 a	0.05 a	0.06 a	0.06 a	
	CV	1.39(*)					
15 WAP	BISI 2	0.03 ab	0.05 ab	0.03 b	0.05 ab	0.04 ab	0.04
	Pioneer 35	0.07 a	0.03 ab	0.04 ab	0.03 b	0.02 b	0.04
	Average	0.05	0.04	0.03	0.04	0.03	(+)
	CV	0.67(*)					

Remark: The number followed by the same letter in the same column shows no significant difference according to DMRT α= 5%. The (+) indicates an interaction between factors. (*) indicates data is transformed using $\sqrt{(x+1)}$

and phosphate (P) is again available to the plant. Although the use of humic acid to the highest dose of 15% had not been able to increase the available P content in the soil, it is also seen that NPK fertilization and NPK+humic acid had the same effect as controls in P uptake efficiency in leaf and seed tissue (Table 11).

Canopy growth, roots and yield components of two maize cultivars in Andisol soil with the application of several doses of humic acid

Cultivar Bisi-2 and Pioneer-35 showed the leaf area, and the percentage of leaves with P deficiency was in equal value (Table 4). The fertilization provided with humic acid can significantly increase the leaf area. Fertilization affected the decrease in percentage of purple leaves that were symptomatic of P deficiency at plant age of 15 WAP. Leaf analysis is one of the ways to diagnose nutrient problems and as a basis for fertilization recommendations in plants (Shear and Faust, 1962). One of the symptoms of P-deficient plants is the formation of anthocyanin pigment due to the accumulation of sugar in the leaves as the protein synthesis is inhibited. That occurs because it cannot form protein and glucose is accumulated. As the result, visually old leaves will be purplish (Elfiati,

Table 4. Leaf area (cm^2), percentage of leaf area with P deficiency (%), and leaf area duration (DLD) (cm^2 weeks) of two maize cultivars on andisol with application of several doses of humic acid

Treatment	Leaf area (cm^2)		Percentage of purple leaf area (%)	
	7 WAP	10 WAP	7 WAP	10WAP*
Cultivars				
Bisi 2	4256.8 p	4022.9 p	12.78 p	1.01 p
Pioneer 35	4334.3 p	3755.5 p	11.74 p	0.10 p
Application of Humic Acid				
Control	939.7 b	838.5 b	29.88 a	2.72 a
NPK without Humic Acid	4724.5 a	5068.5 a	9.01 b	0.00 b
NPK+ Humic Acid 5%	4988.7 a	4030.6 a	8.08 b	0.02 b
NPK+ Humic Acid 10%	4985.7 a	5403.8 a	7.44 b	0.01 b
NPK+Humic Acid 15%	5839.1 a	4104.5 a	6.91 b	0.02 b
Interaction	(-)	(-)	(-)	(-)
CV	8.75*	16.69*	24.95	20.23

Remark: The number followed by the same letter in the same column shows no significant difference according to DMRT α= 5%. The (-) indicates no interaction between factors, and (*) indicates data transformed using √(x+1)

Table 5. Root surface area (cm^2) of two maize cultivars on andisol as affected by several doses of humic acid

Treatment	7 WAP	10 WAP
Cultivars		
Bisi 2	151.60 p	340.05 p
Pioneer 35	134.32 p	340.74 p
Application of Humic Acid		
Control	56.46 b	170.76 a
NPK without Humic Acid	174.54 a	407.68 b
NPK+ Humic Acid 5%	141.50 a	404.92 b
NPK+ Humic Acid 10%	201.42 a	427.65 b
NPK+ Humic Acid 15%	140.88 ab	290.95 b
Interaction	(-)	(-)
CV	22.68	16.18

Remark: Values followed by the same letters in the same column or row are significantly different according to DMRT at α= 5%. The (-) indicates no interaction between factors.

2005) and the activity of plants in photosynthesis can be decreased. Chemical and biological application of phosphorus fertilizers can increase photosynthetic pigments (Sahadi et al., 2019) and this is indicated by a decrease in the percentage of purple leaves.

According to research by Wen et al. (2017), root responses, both morphologically and physiologically, have a stronger association with P status in the canopy portion of the plant, compared with soil P status, therefore observation of root development is necessary. Bisi-2 and Pioneer-35 showed the same root surface area at plant age of 7 WAP and 10 WAP (Table 5). Application of humic acid up to 15% had the same effect on root surface area compared to control. While at age of 10 WAP, humic acid application up to 15% had significantly higher effect on root surface area compared to control. This was also explained in Embleton et al. (1973), who stated that plants with deficiency of element P showed some symptoms, such as stunted growth of plants, weak stems and small,

Table 6. Plant height (cm) of two maize cultivars two maize cultivars on andisol as affected by several doses of humic acid at 4 WAP and 7 WAP

	Cultivars	Application of humic acid					
		Control	NPK with without humic acid	NPK+ humic acid 5%	NPK+ humic acid 10%	NPK+ humic acid 15%	Average
7 WAP	BISI 2	51.42 d	95.17 ab	94.50 ab	95.15 ab	95.75 ab	86.40
	Pioneer 35	61.02 c	92.50 b	100.25 a	92.45 b	95.72 ab	88.39
	Average	56.22	93.83	97.38	93.80	95.73	(+)
	CV	3.13					
15 WAP	BISI 2	77.50	168.67	174.67	169.34	165.50	151.13 p
	Pioneer 35	86.09	164.83	171.67	164.50	165.83	150.58 p
	Average	81.79 b	166.75 a	173.17 a	166.92 a	165.67 a	(-)
	CV	3.40					

Remark: Values followed by the same letters in the same column or row are not significantly differenc according to DMRT α= 5%. The (-) sign indicates no interaction, and (*) sign indicates data is transformed using √(x+1)

and the development of small roots. Treatment of control resulted in the largest root area. This is one form of plant defense in obtaining nutrients, on which it increases the surface area of the roots. This is also supported by the opinion of Pinton et al. (1999) that humic acid has a function in the development and growth of plant roots.

Fertilization without and/or with humic acid in Bisi-2 significantly increased plant height compared to control (Table 6). Meanwhile, in Pioneer-35 cultivars of 5% humic acid significantly increased plant height compared to NPK treatment and control treatment. However, at the time of plant was 7 WAP, there was no interaction between the use of humic acid dose and the cultivars used. Two cultivars had the same plant height. NPK fertilization with or without humic acid had a significant effect on the increase of plant height compared to plants that were not fertilized or having no humic acid. This is because the fulfillment of plant nutrients was done through fertilization to increase the growth and production of plants (Winarso, 2005). Furthermore, the provision of humic acid participates in increasing the availability and uptake of nutrients for plants through its ability to bind, absorb, and exchange nutrients and water so that the needs of plant nutrients are met (Hermanto et al., 2013). The need for P elements is also met then so it will increase cell division which may affect the increase of plant height (Mosse, 1981).

Application of humic acid up to 15% (Table 7), in Bisi-2 and Pioneer-35 had a significant effect on the increasing of total dry weight compared to the control one. This proves that the addition of nutrients plays an important role in increasing the dry weight obtained, because nutrients especially N, P, and K and the use of organic matter are the main factors

Table 7. Total plant dry weight (g) two maize cultivars on andisol soil as affected by several doses of humic acid at 15 WAP

Cultivars	Application of humic acid					
	Control	NPK with no humic acid	NPK+ humic acid 5%	NPK+ humic acid 10%	NPK+humic acid 15%	Average
Bisi 2	14.93 c	188.31 b	220.33 ab	246.97 a	219.94 ab	178.09
Pioneer 35	22.46 c	225.75 ab	206.37 b	193.85 b	218.47 ab	173.38
Average	18.69	207.03	213.35	220.41	219.20	(+)
CV	16.10					

Remark: Values followed by the same letters in the same column or row are not significantly different according to DMRT at α= 5%. The (+) indicates an interaction between factors.

Table 8. Harvest index of two maize cultivars on Andisol soil as affected by humic acid application

Cultivars	Application of humic acid					
	Control	NPK with without humic acid	NPK+ humic acid 5%	NPK+ humic acid 10%	NPK+ humic acid 15%	Average
Bisi 2	0.00 d	13.31 c	14.92 ab	14.65 abc	14.39 bc	11.45
Pioneer 35	0.00 d	15.93 ab	14.82 abc	15.9 ab	16.04 a	12.55
Average	0.00	14.62	14.87	15.31	15.21	(+)
CV	10.21					

Remark: Values followed by the same letters in the column or row are not significantly different according to DMRT α= 5%. The (+) indicates an interaction between factors.

Table 9. The cob length (cm) of two maize cultivars on Andisol soil as affected by several doses of humic acid (15 WAP)

Cultivars	Application of humic acid					
	Control	NPK with without humic acid	NPK+ humic acid 5%	NPK+ humic acid 10%	NPK+ humic acid 15%	Average
Bisi 2	0.00 d	13.31 c	14.92 ab	14.65 abc	14.39 bc	11.45
Pioneer 35	0.00 d	15.93 ab	14.82 abc	15.90 ab	16.04 a	12.55
Average	0.00	14.62	14.87	15.31	15.21	(+)
CV	10.21					

Remark: Values followed by the same letters in the column or row are not significantly different according to DMRT α= 5%. The (+) indicates an interaction between factors.

Table 10. Seed dry weight (g) of two maize cultivars on andisol soil as affected by the application of several doses of humic acid

Cultivars	Application of humic acid					
	Control	NPK with without humic acid	NPK+ humic acid 5%	NPK+ humic acid 10%	NPK+ humic acid 15%	Average
Bisi 2	0.00 c	75.71 ab	85.74 ab	95.05 a	82.56 ab	67.81
Pioneer 35	0.00 c	93.05 a	86.97 ab	62.00 b	94.19 a	67.24
Average	0.00	84.38	86.35	78.53	88.38	(+)
CV	30.63					

Remark: Values followed by the same letters in the same column and row are not significantly different according to DMRT at α= 5%. The (+) indicates an interaction between factors.

in plant growth, such as in the formation of roots, stems, flower, and cob, and they increased the dry weight of plants (Elfiati, 2005). It is also supported by a statement from Sarno (2012) that providing humic acid can increase plant height, fresh weight, dry weight of plant, and growth of shoots. Moreover, according to Eyheraguibel et al. (2008), humic acid has many functions, one of which is to help improve roots, leaves and bud growth. Phosphorus is also an essential nutrient needed for plant growth and formation of approximately 0.2% as the form of plant dry weight (Toth et al., 2014).

Cultivar Bisi-2 and Pioneer-giving of humic acid had the same effect on harvest index compared to the treatment which only provided NPK fertilization. However, in both Bisi-2 and Pioneer-35 cultivars, fertilization can significantly increase the harvest index (Table 8). The use of 5% humic acid in Bisi-2 cultivars had a significant effect on increasing the length of maize cobs (Table 9), while in Pioneer-35

Table 11. The efficiency of P uptake in the leaves and seeds of two maize cultivars on Andisol soil as affected by several doses of humic acid at harvest time (15 WAP)

Treatment	P Uptake Efficiency (%)	
Cultivars	Seeds	Leaves
Bisi 2	20.51 p	5.38 p
Pioneer 35	16.93 p	4.02 p
Application of Humic Acid		
NPK without Humic Acid	18.38 a	4.20 a
NPK+ Humic Acid 5%	15.98 a	3.77 a
NPK+ Humic Acid 10%	17.15 a	4.86 a
NPK+ Humic Acid 15%	23.37 a	5.99 a
Interaction	(-)	(-)
CV	23.35*	21.78*

Remark: Values followed by the same letters in the same column are not significantly different according to DMRT at α= 5%. The (-) indicates no interaction between factors, and (*) indicates data transformed using √(x+1)

cultivar the application of humic acid gave the same effect as the treatment which only gave NPK. Application of additional elements of NPK fertilization with or without humic acid plays an important role in the formation of cobs. This is evidenced by the non-formation of cobs on the treatment with no fertilization and humic acid during the growth process.

Cultivar Bisi-2 and Pioneer-35 treatment of NPK or NPK+humic acid had the same effect on dry weight of seeds (Table 10). NPK fertilization alone and NPK+humic acid in Bisi-2 and Pioneer-35 significantly increased the plant dry weight compared to control treatment. The results of the study from Dahnke and Olson (1990) indicated that that adding nutrients to the soil can help plants to grow and produce optimally, in case the soil is not able to provide it. Therefore, the nutrient especially P is one of the essential elements in the formation of seeds in maize. The P element is one of the inhibiting factors of growth and the cause of the decreasing of production rate in the world up to 30-40% (Wissuwa et al, 2005). From the explanation above, it proves that the provision of fertilization and humic acid showed response in the increasing of dry weight of maize plant pipe on Andisol soil both in Bisi-2 and Pioneer-35 cultivars. In addition according to Ishizawa et al. (2017), applying phosphorus fertilizer through chemical or biological fertilizers can increase the dry weight of plants.

The efficiency of P uptake in leaf and seed tissues of two maize cultivars on acid soils as affected by several doses of humic acid

The use of cultivars and doses of humic acid gave the same effect in P uptake efficiency in both seed and leaf compared to NPK fertilization only. From the results obtained, more P elements are needed in seed tissue. This is evidenced by the high efficiency of P uptake in seeds compared to leaves. So the availability of P nutrient is needed for crops, especially maize, during the formation of seeds. At pH 5 the binding of metals by humic acid had a lower bond when at pH 7. This was due to the greater dissociation of humic acid in the functional group and the stronger cation attraction which was negatively stronger. On the other hand, the soil at pH 5 where humic-metal acid complexes, especially Fe, it is positively correlated with the COOH+OH content found in humic acid (Boguta et al., 2019), so that this also affects the availability of nutrients especially P which can be utilized by plants.

CONCLUSIONS

Based on the results of the study, the application of humic acid had the same effect as the treatment which provided NPK fertilization only that was on increasing the yield components of 100 seeds, dry weight of seeds, harvest index, length of cobs, and productivity.

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