Conference Paper

Identification the Availability of P in Land Planted with Corn on Volcanic, Karst and Acid Soils in Indonesia

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Abstract

Indonesia has many low fertile soils so that agricultural productivity is not optimal. Indonesia is currently challenged by corn self-sufficiency, with a target to increase corn production by 1 $t \cdot ha^{-1}$. However, one of the major constraints of land for corn production is a low P availability. To support the increase in production, and provide a database of potential production, the identification of corn land that has P availability problems is extremely required. In this study, the approaches are to observe the distribution of soil parent material from geological maps, soil maps to determine the type of soil, statistical data from the statistics bureau to get the center area of corn, and field observations. From the survey conducted, we found that most of the land evolved from volcanic material, karst material, and acid soils are the soils with a problem of P. However, some areas of the soils showed a high P availability. Further identification of P availability in acid, volcanic, and karst soils needs to be done so that the database of potential corn production can be structured as a basis of corn land management policies in Indonesia.

Keywords: Acid soils, Corn, Karst, P availability, Volcanic

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1. Introduction

Development of corn commodity is done to supply the needs of the industry, also to increase the income and welfare of farmers. Until now, Indonesia is still imported corn to supply the needs as the main raw material production. Indonesian's government through special effort program design and seek self-sufficiency in some important agricultural commodities, and one of them is maize. Many efforts were made to address the challenges of self-sufficiency in corn both with the expansion of cultivation of maize as well as optimization of the factors that support the improvement of agricultural production.

One of the important factors for the success of agriculture is fertilizer. The use of fertilizers as effectively and efficiently will provide optimal production and increase revenue as well as environmentally friendly. Optimal plant growth needs support in sufficient numbers to intake nutrient to include nitrogen (N), phosphorus (P), and potassium (K). Besides other necessary nutrients such as calcium (Ca) and magnesium (Mg) and micronutrients that are very few such as zinc (Zn), copper (Cu), and iron (Fe).

Phosphate (P) is an essential element that plays an important role in photosynthesis and root development. The availability of phosphate in the soil is rarely exceeding 0.01 % of total P and mostly bound by colloidal soil making it unavailable to plants [1]. Fixation of phosphor in the Andisols is a significant obstacle, where most of the minerals are bound by non-crystalline allophane, imogolite, and ferrihydrite. Allophane have the capability to retain up to 97.8 % of P, and the presence of Al and Fe in amorphous form also has the ability to bind of P. Andisols generally has very high total P and available P content, it can be understood because parent material of the Andisols contain very high primary mineral apatite (calcium phosphate) [2].

Some characteristics of acidic soils are low pH < 5.5, low exchangeable cations such as Ca, Mg, K, and Na, low cation exchange capacity (CEC), and base saturation value become low. Acidic soils contain Al, Fe, and Mn in toxic quantities for plants due to increased solubility, which then reacts with phosphate to be unavailable to plants [3, 4]. The high rainfall in most of Indonesia caused high levels of nutrients leaching the bases particularly, so bases in the soil will be leached and will leave Al and H in the adsorption complex of clay and humus. As a result, the soil becomes acidic to react with low base saturation and showing a high aluminum saturation [5].

Karst is rocky, barren land with the typical hydrology as a result of rock soluble and secondary porosity growth. As a special style of a landscape containing caves and extensive underground water systems that is developed on especially soluble rocks such as limestone, marble, and gypsum [6]. Karstification is a process of dissolution of CO_2 by H_2O to produce of H_2CO_3. The formed carbonic acid will react with the calcium carbonate to release Ca and bicarbonate acid ions. The existence of Ca in karst soils could make the availability of P nutrients in the soil becomes low due to the fixation of P by Ca. Karstification is influenced by two factors, are controlling and driving forces factors. Controlling factor is a factor that led to runs and whether the process karstification. These factors include soluble rocks, compact and numerous fractures, rainfall more than $0.25\ m \cdot yr^{-1}$, exposure of rocks at a height that allows the circulation of water. The driving factor is a factor that determines the speed and perfection karstification process. Higher temperatures will increase the activity of soil microorganisms resulting in CO_2 and cause high evaporation that occurs recrystallized carbonate solution on the soil surface. Vegetation produces CO_2 on the roots and organic matter and will increase $CaCO_3$ solubility [6, 7]. The management of the lands that have problems with the availability of P is certainly important to optimize agricultural production. Identification of soils with problematic availability P becomes important, related to the governance system of agricultural land. Primarily related to government policies on fertilizer distribution. Where this policy will lead to the target of increasing production and efforts to achieve self-sufficiency in maize.

2. Methods

This research was conducted by looking for the land site of corn plant centers from output data of Statistics Indonesia, generally known as *Badan Pusat Statistik* (BPS). The three criteria soil (acid, karst and volcanic) in Yogyakarta, Central Java, and West Java obtained from geological and soil maps. Soil with low available P and K status obtained from P and K maps status. Survey location, available P tested quickly with a soil test kit for upland that called as dry soil test kit or *Perangkat Uji Tanah Kering* (PUTK), pH with pH stick. Farmer interviewing agricultural cultivation systems are used as supporting data. Soil analysis to determine the level of available P (Bray-1 and Olsen) and pH was also conducted in the laboratory [8].

3. Results and Discussion

Based on data from BPS about corn production, geological maps, and soil types maps, the site for acid soil taken from Jumantono Karanganyar (Central Java), Ultisol from Jasinga West Java, oxisol from Cigudeg Bogor (West Java), Karang Salam and Tangerang [redacted] Banyumas (Central Java). Karst soils obtained from Ponjong Gunungkidul (Yogyakarta), Pracimantoro Wonogiri (Central Java), Grobogan, Kalisari Kebumen (Central Java), and Padalarang Bandung (West Java). Andisol as volcanic soil obtained from Tawangmangu, Salatiga, Wonosobo, Datar Banyumas (Central Java) and Lembang Bandung (West Java) [9–16].

Based on a quick test with a pH stick and PUTK, the fifth acid soil has pH below 5.5. The P available has low values based on PUTK test. This result goes along with pH of acidic soil, which the pH is acidic, the fixation of Fe or Al to P nutrient have very high values that make P not available for plants. From field study seen all soil sample that has been identified showing low available P [8].

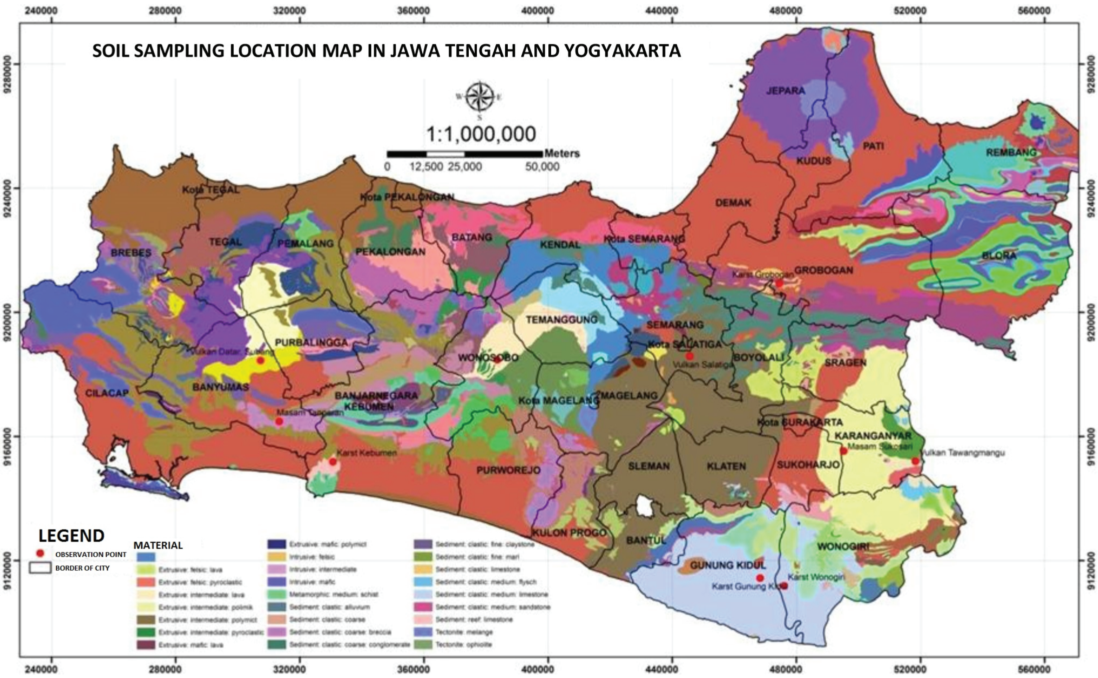

Figure 1: Site location soils sample in Special Region of Yogyakarta (*Daerah Istimewa Yogyakarta/DIY*) and Central Java.

Karst is an area that has special characteristics typical of relief and drainage, mainly due to the level of rock's dissolution intensively [6]. Karst has a special type of hydrological due to soluble rock and the development of secondary porosity. There are closed basin or dry valleys in various sizes and shapes, poor drainage, and hilly up to ramps landform. The soil classification in Karst are Entisol, Mollisol, Alfisol, Vertisol, Inceptisol [17–20]. Karst soils are taken from five locations (Gunungkidul, Wonogiri, Grobogan, Buayan Kebumen, and Padalarang Bandung) around the limestone hills with varies pH from slightly acid to alkaline. Karst of Padalarang, Bandung, West Java has slightly acid pH. In other areas have neutral to alkaline pH, so its suit to environmental conditions of limestone hills that contains Ca. The presence of high Ca due to P banded by Ca P and makes the availability of P in karst areas is relatively low.

The five locations (Gunungkidul, Wonogiri, Grobogan, Buayan Kebumen, and Padalarang Bandung) acquired low levels of available P up to 53.3 %, 13.3 % for medium, and 33.3 % for high P availability. P availability provided that medium and low in soils with problems in P is certainly related to the system of agricultural cultivation is carried out by local farmers, like SP-36 fertilizer application. According to interviews with farmers in Wonogiri karst regions that have a medium level in the status of P availability, it appears that manure as basal fertilizer are given as much as 600 kg $\cdot$ ha^{-1}, Urea 350 kg $\cdot$ ha^{-1}, and NPK Phonska 350 kg $\cdot$ ha^{-1}. Application of phosphorus (P) fertilizers to P-deficient soils can also result in P accumulation [21].

Table 1: Analysis result of P and pH soils for the research.

Location	Soil Type	pH	P (1×10^{-6})
Wonogiri Batuwarno	Karst	6.40	2.88
Kebumen Buayan	Karst	5.05	2.02
Bandung Cipatat	Karst	5.55	1.59
Gunung Kidul Karst	Karst	6.71	371.70
Wonogiri Girimulyo	Karst	6.54	16.01
Grobogan	Karst	8.02	7.97
Grobogan Karst	Karst	7.95	3.38
Grobogan Pak Har	Karst	8.00	40.03
Gunung Kidul Karst 1	Karst	6.85	2.88
Gunung Kidul Karst 2	Karst	7.47	48.08
Wonogiri Karst	Karst	6.38	13.34
Bandung Padalarang	Karst	5.07	4.46
Gunung Kidul Semanu	Karst	6.47	19.23
Kebumen Watukelir	Karst	6.93	15.46
Kebumen Wonodadi	Karst	7.19	2.48
Bogor Cigudeg	Acidic	4.60	4.99
Bogor Jasinga 1	Acidic	5.06	1.58
Bogor Jasinga 2	Acidic	4.35	3.67
Bogor Jasinga 3	Acidic	4.68	0.32
Bogor Koleang Jasinga	Acidic	4.80	0.35
Karanganyar Jumantono	Acidic	5.34	3.91
Banyumas Karangsalam	Acidic	5.14	1.13
Banyumas Masam	Acidic	5.25	3.43
Karanganyar Sukosari	Acidic	4.55	1.85
Kebumen Tanggeran	Acidic	5.26	2.22
Bogor Cisarua	Volcan	5.03	0.32
Kebumen Datar	Volcan	5.75	5.52
Kebumen Datar Sawah	Volcan	5.96	9.82
Bandung Lembang	Volcan	5.55	4.61
Salatiga	Volcan	5.68	1145.67
Tawangmangu	Volcan	5.74	34.79
Tawangmangu Lurah	Volcan	6.25	7.24
Wonosobo	Volcan	6.12	26.28

The volcanic soil has relatively high fertility. The six areas of volcanic soil (Tawangmangu, Salatiga, Wonosobo, Datar Kebumen, Lembang Bandung, and Cisarua Bogor) located in the highlands, the hilly terrain, and Andisol soil type. The condition of the soil pH varies from acidic to slightly alkaline. Amorphous materials in the soil will result in Phosphate fixation, making it unavailable to plants [22]. Phosphate content is obtained from the volcanic soil for research of low to high. From interviews with farmers in the

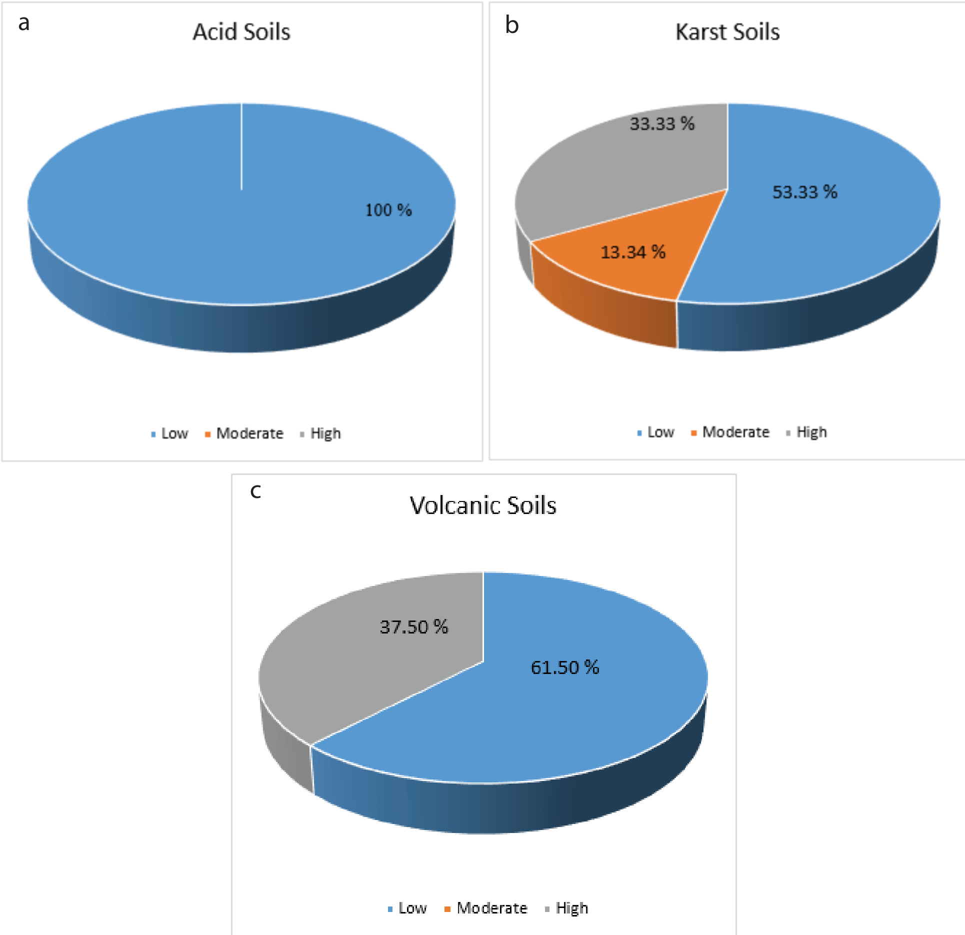

Figure 2: Availability of P; a Available P in acid soils, b Available P in karst soils, c Available P in volcanic soils.

Tawangmangu which has the status of Phosphate available very high, the fertilizer dose given in three times fertilization among urea (300 kg · ha^{-1}), SP-36 (300 kg · ha^{-1}), and KCl (300 kg · ha^{-1}). The dose of SP-36 as much as 300 kg · ha^{-1} dose is too high, which should only about 100 kg · ha^{-1}. The things thus resulting in the discovery of high nutrient status of available Phosphate in Phosphate problematic soils such as in volcanic soil.

Status of Phosphate were higher in soil Karst particularly in the Grobogan, Gunung, Girimulyo, Watukelir, and DIY as well as on the ground volcanic particularly in the Tawangmangu, Salatiga, and Wonosobo. It possible result because their fertilization exceed the dosage, and the use of land-intensive the ones or contributing directly to the build-up of Phosphate available in the soil is getting high than the other. This is evidenced by fertilizer use Phonska kinds of NPK fertilizer with a range of 300 kg · ha^{-1} to 350 kg · ha^{-1}, TSP/SP-36 with a dose range of 300 kg · ha^{-1} to 350 kg · ha^{-1}, even in areas Grobogan use of TSP/SP-36 to a dose of 500 kg · ha^{-1}, this dose exceeds the recommended dosage, recommendation that the calculation of TSP/SP-36 dose of

150 kg · ha^{-1}. Also supported also by the addition of basic fertilizers such as manure at 10 kg · ha^{-1} that this can increase the available Phosphate in the soil. Therefore, it highly supports the high Phosphate is available in the location of Karst soils samples and the Vulkan soils.

4. Conclusion

The identification and survey results from the lands that have availability P problem show in some areas of volcanic and karst soil has moderate or high P availability. Therefore, further identification of available P in acid, volcanic and karst soils needs to be done as the basis for land management policy in Indonesia, especially for fertilizers distribution. So the target of increasing corn production can be achieved. And the data base of potential corn production can be collated, and the challenges of self-sufficiency in corn can be achieved.

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