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Development of soil characteristics in the UPN "Veteran" Jawa Timur experimental field in Wonosalam District, Jombang Regency, East Java

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Abstract

Soil characteristic and properties are essential determinants for effective land management. Soil genesis results from the interaction of various pedogenic factors, which are influenced by environmental conditions, thereby producing diverse soil types in different locations. This study was conducted in the Wonosalam sub-district, an area characterized by diverse regional conditions due to its varied physiographic features. The physiographic and climatic conditions in this region significantly influence soil formation processes. This research focused on monitoring soil development at several locations within Wonosalam, specifically at the UPN "Veteran" Jawa Timur experimental field. The study included five observation points, categorized by land map units: PW1, PW2, PW3, PW4, and PW5. Morphological analyses indicate the presence of two distinct soil types among the five observation points. The soils in PW1, PW2, PW3, and PW4 are classified under the Alfisols order, specifically within the Typic Hapludalf subgroup. In contrast, the soil at PW5 belongs to the Inceptisols order, specifically the Typic Humudepts subgroup. This diversity suggests that the area encompasses soils of different orders. The soil characteristic data obtained from the UPN "Veteran" Jawa Timur experimental field can be utilized as a basis for planning the management of the area.

INTRODUCTION

Soil is formed through the complex interactions of various pedogenic factors. Soil develops after geomorphology processes occur. Geomorphology processes that work on bedrock are carried out by geomorphological forces that produce weathered rock material. Each geomorphology stage will affect the distribution of weathered bedrock material, which is the parent material. Soil properties can change and are always evolving because they are caused by the ongoing process of weathering and soil development. However, the process of soil development can be slow, moderate or fast as soil formation is determined by soil formation factors (Tugel et al., 2005; Mapelli et al., 2018; Khusrizal et al., 2022). According to Soil survey staff (2014), soil has horizons or layers that can be distinguished from the parent material as a result of the process of addition, loss, transfer and transformation of material.

Soil formation factors can be divided into two groups, namely passive (parent material, topography and time) and active (climate and vegetation) soil formation. The first factor in soil formation is the source of mass along with the conditions influencing the mass, including the parent material, topography, time and age. Meanwhile, active soil-forming factors are factors that produce energy in the soil mass,

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namely climate (hydrosphere and atmosphere) and living things (biosphere). Even so, soil-forming factors such as parent material, climate, organisms, relief and time play an important role in soil formation that takes place integrally and simultaneously. However, the climate factor plays a major role, which is classified as active in the formation of soil characteristics (Hardjowigeno., 1993; Mappelli et al., 2018; Aditya et al., 2021). The development of soil at the climatic level through the process of rainfall and temperature can stimulate the process of weathering and leaching; if the two elements of climate are at high intensity, soil formation will proceed quickly (Pareek et al., 2017; Aditya et al, 2020; Khusrizal et al., 2022). While organisms and topography can distinguish soil properties from organic matter, topography can provide differences in soil properties and characteristics through the depth of the solum (Aditya et al., 2022). In topography, there are three main components, namely the shape of the slope, the degree of steepness, and the position of the slope. Soil development caused mainly by the influence of one soil-forming factor (topography) is called toposequence.

Soil taxonomy is a scientific discipline focused on the systematic classification of soils based on their various characteristics, providing a structured framework for understanding the diversity of soils worldwide. Understanding soil taxonomy holds immense benefits for agriculture. Firstly, it enables precise soil management by allowing farmers to identify and comprehend different soil types. Knowledge of soil taxonomy is instrumental in predicting soil behavior, guiding decisions on irrigation, fertilizer application, and erosion control. It empowers farmers to optimize crop rotations, minimize nutrient runoff, and implement effective erosion control measures. Additionally, soil taxonomy assists in water management by evaluating water retention and drainage characteristics, contributing to the development of efficient irrigation strategies. In essence, the significance of soil taxonomy lies in its role as a foundational tool for sustainable agriculture, fostering informed decision-making, environmental conservation, and the overall health of soils.

Considering the importance of the role of land in human life for all agricultural needs, the information on the characteristics of the soil that has been classified in the UPN experimental field, Wonosalam District, Jombang, East Java is very important land processing that is prioritized for agriculture. Therefore, research is needed to determine differences in morphological characteristics and levels of soil development in the UPN experimental field, Jombang, East Java.

MATERIALS AND METHODS

This research was conducted in the experimental field area of UPN "Veteran" Jawa Timur, Wonosalam District, Jombang Regency, East Java. Wonosalam District is located at 112°21'05"–112°23'22" E and 07°44'59"–07°40'01" SL. Wonosalam District covers an area of 121.63 km². Sample analysis was carried out at the Laboratory of Soil Science, Faculty of Agriculture, UPN "Veteran" Jawa Timur. This research was conducted for three months starting from October to December 2023. The tools used were soil auger, shovel, hoe, camera, field knife, tape measure, Soil

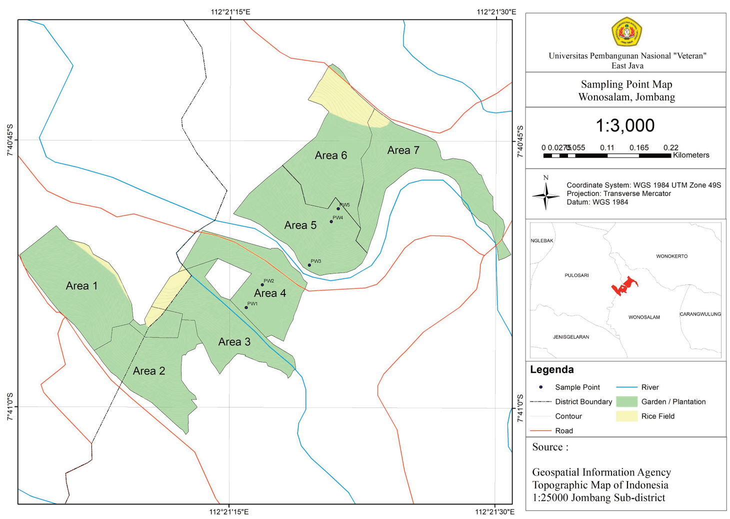

Figure 1. Observation map and point of soil profile

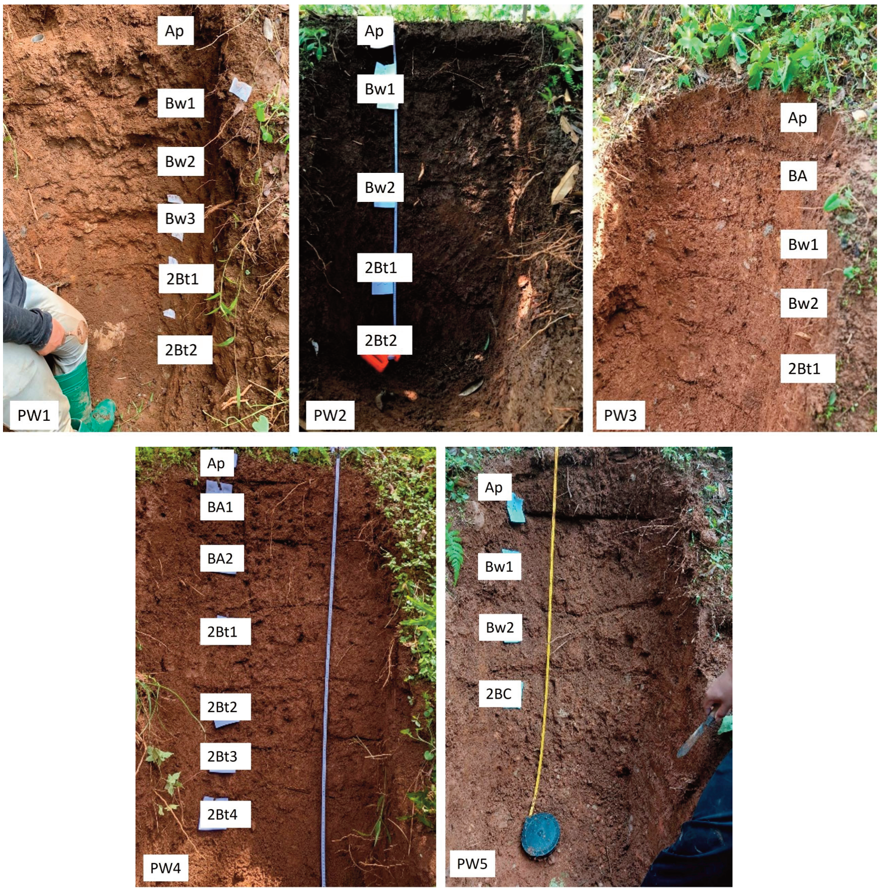

Figure 2. Soil profile in UPN experimental field (PW1, PW2, PW3, PW4, and PW5)

Munsell Color Chart book, clinometer, compass, and GPS, as well as laboratory equipment for pH testing, test tubes, analytical balances, ovens, shakers, volumetric rings. Data were managed using Microsoft Excel 365 and ArcGIS 10.3.

The research method used was land survey method. The data collected included primary and secondary data. Primary data were obtained through field observations and morphological observations of soil samples. Secondary data were taken from previous research, literature review, physiochemical data and key soil taxonomy book. Sampling locations were determined using land map units resulting from the overlay (elevation, topography, land use, geology, contour, and administrative map). Observation point and location were determined based on toposequence in each slope position (ridge to foot slope). Soil morphology was observed by observing the soil profile method by digging the soil to a depth of 1 meter and a width of 2 meters. The soil characteristics observed included layer boundaries, color, texture, structure, and consistency in each soil layer. Observation of environmental aspects (physiography) in the form of observations of slopes, land use and others. Disturbed and undisturbed soil samples were analyzed to determine soil properties (physical and chemical) to support soil classification data. The type of soil classification was determined based on the guideline book of Key of Soil Taxonomy (2014), and the soil was classified from order to sub-group level.

RESULTS AND DISCUSSION

Morphological characteristics of the soil in the UPN "Veteran" Jawa Timur experimental field

The description of the soil profile on the five pedons was obtained through direct observations in the field by making a soil profile. The soil profile is a cross section (vertical) consisting of layers of soil and layers of parent material. The developed soil profile will show a number of different horizons arranged from top to bottom. Soil morphology properties can be measured visually or by feeling. Some variables of soil morphology that can be directly observed in the field are color, texture, structure, and consistency. The differences in these five properties can be attributed to land use, processing, the type of parent material, and the chemical properties of each pedon. The soil profile in the Wonosalam experimental field varies, ranging from 100–200 cm. The provision of soil horizons in the field is generally based on the characteristics of the soil used as a differentiating factor, including soil color, texture, structure, consistency, and horizon boundaries. The most important variables observed on soil characteristics are the boundaries of each soil horizon, the thickness of the horizon and the topography of the soil surface. The observed soil profiles with codes PW1 to PW5 (Pedon Wonosalam) are representative of each area in the UPN experimental field, Wonosalam District.

Soil color is the easiest morphological characteristic to observe. Each topsoil in each soil profile (Ap) has a dark brown to brown soil color (10 YR 5/6–10 YR 3/6). Soil color (Ap horizon) is heavily influenced by the density of vegetation in the UPN Experimental Field and the presence of tillage activities. The color of the soil on the surface (topsoil) is influenced by mineral particles that have been mixed with organic matter. In the surface horizon, color development occurs due to organic matter content; this is influenced by soil cover, such as weeds and plant residues. The content of organic matter in alfisol and the thickness of the surface horizon (epipedon) increase with decreasing internal drainage and soil aeration (Rahmayanti et al., 2018). However, the color of the soil tends to get lighter or lighter brown (7.5 YR 4/6 and 5 YR 3/4) due to the decreasing organic matter content followed by increasing soil depth (Bt and Bw horizons). According to Erisa et al. (2018), the change in soil color to a light color is due to the primary mineral content of light fractions, such as quartz and plagioclase, giving a grayish-white color, while iron oxides, such as goethite and hematite, give a brownish to red color. Soil that is browner in color generally indicates a high geotite content, and the redder the color of the soil, the higher the hematite content (Sembiring et al., 2013; Efriandi, 2020).

Table 1 shows the morphological characteristics of the soil (color, texture, soil structure and consistency) of the five soil profiles that have almost the same characteristic properties. According to the land survey activities that have been carried out, soil texture, structure, and color have developed, one of which was identified by the presence of clay illuviation in the B horizon (Bt) in all horizons at PW1 to PW5. The soil texture in the UPN experimental field was sandy loam in the surface horizon (Ap) to silt clay in the lower horizon (B). The presence of clay content in the entire soil indicates that the soil in the UPN experimental field has developed at the Juvenile/adult level. Soil structure also shows that the level of soil development in Wonosalam experimental field is highly developed. This can be proven by the condition of the angular and subangular blocky structures, each of which has a strong level of development and the decreasing organic matter in the soil. The extremely friable structure on the surface is due to soil being affected by organic matter.

The level of soil consistency in moist conditions on the five soil profiles (PW1–PW5) was loose to extremely firm. The wet condition is determined by the nature of the adhesiveness and plasticity with the degree of non-sticky to non-plastic in the A horizon and sticky to plastic in the B horizon. The level of soil consistency in the A horizon indicates that the soil has been mixed with organic matter and coarse mineral fractions, such as quartz sand, so that the soil becomes non-sticky and non-plastic. According to Efriandi (2020), soil with high organic matter conditions can cause the consistency to become loose and a little sticky. It was discovered that the soil texture dominated by clay fraction in the UPN experimental field affected the firm to extremely firm properties of moist consistency (Rajamuddin and Sanusi, 2014). The sticky and plastic conditions in the B horizon indicate that the soil in Wonosalam experimental field is dominated by clay content. Soils that have a high clay content will stick more easily between two fingers and are easier to shape than soils that have a low clay content. According to Sanggu (2019), attachment to soil affects tillage in wet conditions, in which soil that is easily sticky will make it difficult to cultivate so that it is categorized as heavy soil, while soil with a high sand content is categorized as light soil.

Pedogenesis and soil classification in UPN “Veteran” Jawa Timur experimental field

The soil in the research location is classified based on the results of soil descriptions, including morphological, physical and chemical charateristics of the soil. Soil classification was determined based on the morphological observation results and supported by some data of chemical and physical characteristics. Soil is classified according to the book

Table 1. Result of soil morphology in UPN experimental field

Profile	Position	Symbol horizon	Depth	Color	Texture	Structure	Consistency		Distinctness horizon	Topography
				Moist			Moist	Wet		
PW1	Ridge	Ap	0–29	10 YR 5/6	Sandy loam	ab/fn/wk	vfr	nst/npl	Gradual	Wavy
		Bw1	29–52	10 YR 5/8	Loam	ab/fn/mr	fr	nst/npl	Gradual	Wavy
		Bw2	52–76	7.5 YR 5/8	Silty clay loam	sb/md/mr	fr	sst/spl	Diffuse	Wavy
		Bw3	76–88	7.5 YR 5/8	Silty clay loam	sb/md/k	fr	sst/spl	Diffuse	Smooth
		2Bt1	88–104	7.5 YR 4/6	Clay loam	ab/md/k	fi	st/pl	Diffuse	Smooth
		2Bt2	104–150	7.5 YR 4/6	Clay loam	ab/md/k	fi	st/pl	Diffuse	Smooth
PW2	Upper slope	Ap	0–23	10 YR 3/3	Silty loam	ab/fn/wk	vfr	nst/npl	Abrupt	Smooth
		Bw1	23–34	10 YR 4/3	Silty loam	sb/md/wk	fr	nst/npl	Gradual	Smooth
		Bw2	34–76	7.5 YR 3/4	Silty clay loam	sb/md/st	fi	sst/spl	Diffuse	Smooth
		2Bt1	76–115	7.5 YR 5/4	Clay loam	ab/md/st	vfi	sst/pl	Diffuse	Smooth
		2Bt2	115–144	7,5 YR 5/6	Silty clay	ab/cr/st	vfi	st/pl	Diffuse	Smooth
PW3	Middle slope	Ap	0–29	7.5 YR 4/4	Sandy loam	sb/fn/wk	vfr	nst/npl	Abrupt	Smooth
		BA	29–52	7.5 YR 4/6	Sandy clay loam	sb/md/wk	fr	nst/spl	Gradual	Smooth
		Bw1	52–70	7.5 YR 5/8	Silty clay loam	ab/md/mr	fi	sst/spl	Diffuse	Smooth
		Bw2	70–102	7.5 YR 5/8	Silty clay loam	ab/md/st	vfi	sst/spl	Diffuse	Smooth
		2Bt1	102–150	7,5 YR 5/8	Clay loam	ab/md/st	vfi	st/pl	Diffuse	Smooth
PW4	Lower slope	Ap	0–20	7.5 YR 3/2	Sandy loam	sb/fn/wk	vfr	nst/npl	Gradual	Smooth
		BA1	20–45	7.5 YR 3/4	Sandy clay loam	sb/fn/wk	vfr	nst/ spl	Gradual	Smooth
		BA2	45–70	7.5 YR 4/4	Sandy clay loam	ab/fn/mr	fr	nst/ spl	Diffuse	Smooth
		2Bt1	70–100	7.5 YR 4/6	Clay loam	ab/md/mr	fi	sst/pl	Diffuse	Smooth
		2Bt2	100–126	7.5 YR 5/6	Clay loam	ab/md/mr	fi	sst/pl	Diffuse	Smooth
		2Bt3	126–140	5 YR 4/4	Silty clay	ab/cr/st	vfi	st/pl	Diffuse	Smooth
		2Bt4	140–180	5 YR 3/4	Silty clay	ab/cr/st	vfi	st/pl	Diffuse	Smooth
PW5	Foot slope	Ap	0–18	10 YR 2/2	Silty loam	sb/fn/wk	vfr	sst/spl	Gradual	Smooth
		Bw1	18–51	10 YR 3/2	Silty loam	sb/cr/wk	vfr	sst/spl	Diffuse	Smooth
		Bw2	51–78	10 YR 4/4	Silty clay loam	ab/cr/mr	fr	sst/pl	Diffuse	Smooth
		2BC	78–137	10 YR 5/6	Sandy loam	ab/cr/mr	fi	nst/npl	Diffuse	Smooth

Remarks: ab=angular blocky; sb=subangular blocky; f=fines; md =medium; cr=coarse; wk=weak; mr=moderate; st=strong; vfr=very friable; fr=friable; fi=firm; vfi=very firm; nst= non sticky; sst=slightly sticky; st=sticky; npl=non plastic; spl=slightly plastic; pl=plastic

Table 2. The results of soil classification in the UPN experimental field, Wonosalam District

Pedon	Horizon		Order	Suborder	Group	Subgroup
	Epipedon	Endopedon				
PW1	Umbric	Argilic	Alfisol	Udalf	Hapludalf	Typic hapludalf
PW2	Umbric	Argilic	Alfisol	Udalf	Hapludalf	Typic hapludalf
PW3	Umbric	Argilic	Alfisol	Udalf	Hapludalf	Typic hapludalf
PW4	Umbric	Argilic	Alfisol	Udalf	Hapludalf	Typic hapludalf
PW5	Umbric	Cambic	Inceptisol	Udepts	Humudepts	Typic humudepts

of Key of Soil Taxonomy (2014). Soil classification was carried out sequentially, starting from the level of the epipedon, endopedon, order to the soil subgroup. From the results of observations, it was found that the soils of the five study locations belonged to the alfisol order. Observations on pedons 1 to 5 (PW1–PW5) found that the epipedon is umbric and has fulfilled the main requirements of the umbric epipedon, namely an epipedon composed of mineral soil material with a top layer of 18 cm thick, soil structure units with a diameter of 30 cm or less, dominant soil color with a moist value of 3, a moist chroma of 3, and base saturation (NH4OAc) < 50%. on all epipedons (Key Soil Taxonomy, 2014). The umbric epipedon has an organic c content of not more than 2.5% and the soil is moist for more than three months (Panjaitan et al., 2014).

The results of observations in the field showed that PW1 to PW4 in UPN experimental field, Wonosalam District, had argillic endopedons, while PW5 had a cambic endopedon. The PW1 and PW4 areas are argillic because they contain a Bt horizon. The Bt horizon shows a clay illuviation. The PW1 to PW4 areas have met the main requirements of an argillic horizon, namely the presence of signs of illuviation, namely oriented clay bridging the sand grains, a thin film covering the pore walls, a thin film of clay on the surface of the vertical and horizontal peds (Soil Key Taxonomy, 2014). The argillic horizon shows evidence of clay illuviation, an argillic horizon forms below the soil surface, but later due to erosion, an argillic horizon may be exposed on the soil surface (Setiawan et al., 2020). The main process by which clay is transferred from the surface horizon to the lower horizon is known as lessivage. Lessivage is a process of leaching fine clay and a little coarse clay or fine dust in suspension form through cracks or soil pores (Aditya et al., 2020; Nova et al., 2023).

Table 2 shows that the soils in the study area belong to the orders of alfisols and inceptisols. The alfisol orders are found in the PW1 to PW4 areas, while PW5 belongs to the inceptisol orders. The PW1 to PW4 areas are included in the alfisol order because they have fulfilled the main requirements, namely having argillic, kandic or natric and fragipan horizons that have a thin layer of clay 1 mm thick or more in some parts (Soil Key Taxonomy, 2014). Alfisol order specifically contains a Bt horizon, meaning B with a high clay accumulation content and an argillic horizon (Rahmayanti et al., 2018). The four areas are included in the udalf suborder because they have an udic moisture regime. Meanwhile, none of the alfisol soil types defined by the Soil Taxonomy Key Book meet the certain criteria or other more specific criteria of alfisol soils. Thus, the soil in the UPN experimental field has fulfilled the criteria for the typic hapludalf subgroup. Alfisols are fertile soils widely used as agricultural land, livestock grass or forests. This soil has high base saturation, high cation exchange capacity and lots of nutrients (Setiawan et al., 2020).

The PW5 research area has different soil type from the four areas in the UPN experimental field, Wonosalam District. There was no indication of clay accumulation in the B horizon in the soil profile in PW5 so that the soil in this area is included in the Bw horizon; the B horizon with the development of color and structure is included in the cambic horizon. Cambic is a horizon formed through a process of physical alteration, transformation, or chemical displacement. Its characteristics include having evidence of alteration that is at least 15 cm thick, lacking a rock structure with fine stratification, having a color that remains constant when exposed to air, and having a dominant color that is moist color value 3 or less with a chroma value of 4 or higher (Soil Key Taxonomy, 2014). According to Panjaitan et al. (2015), the cambic horizon does not have an extremely fine texture; the thickness of the horizon is more than 15 cm; and it does not have a percent (%) clay content that is greater than the horizon above or below it, but does not meet the criteria of an argillic horizon. The soil in the PW5 area is included in the inceptisol order because it meets the requirements and criteria for the soil, one of which is a cambic horizon (Bw). the suborder belongs to the udepts, which have a Udic moisture regime. The inceptisol soil group in the PW5 area is humudepts because it has an umbric epipedon, and the soil subgroup meets the criteria of a typic humudepts. Inceptisols are young and developing soils, have low to high soil fertility, easily washable surface layers, low organic matter content, low to moderate pH (Munir, 1995; Swanda et al., 2015; Siswanto and Widowati, 2018).

CONCLUSIONS

The morphological characteristic of alfisols and inceptisols soil in the experimental field of UPN "Veteran" Jawa Timur is high clay content in the subsurface horizon caused by an illuviation process with the presence of a clay film on the peds. The clay content in alfisols and inceptisols is caused by leaching due to rainfall and the position of the slopes or topography in the area. The subgroups of soil in the experimental field of UPN "Veteran" Jawa Timur have fulfilled the conditions of alfisols and inceptisols and have met the requirements and characteristics of Typic Hapludalf in the PW1 to PW4 area and Typic Humudepts in PW5. Alfisols and inceptisols soil in UPN experimental field are considerably potential to be used as agricultural land, given that alfisols is considered fertile soil. In addition, inceptisol soil in the UPN experimental field can also be maximized as agricultural land by adding macro and micro nutrients in the form of inorganic and organic fertilizers and dolomite to increase soil pH, thereby increasing soil fertility.

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