International Journal on Advanced Science Engineering Information Technology

Vol.8 (2018) No. 1
ISSN: 2088-5334

Andisols Water Retention Under Peasant Oil Palm Plantation

Bujang Rusman[#], Agustian[#], Aprisal[#], Syafrimen Yasin[#]

[#] *Departement of Soil Science, Faculty of Agriculture, University Andalas, Padang, Indonesia*
E mail: bujang.rusman@yahoo.com

Abstract— **Available water soil is one of the critical factors that influence oil palm growth and production. This research used field survey method. Soil samples were taken in the field and then analyzed in the laboratory using the membrane plate apparatus for assessment of the filed capacity and the permanent wilting. This research aimed to obtain data about water retention variability of Andisols in oil palm plantation of peasants on various age levels of oil palm in Pasaman sub-district, West Sumatera. The advantage of this research was to find out the effect of different age levels of oil palm on soil water retention and other physical soil properties in Andisols. This research identified water retention of the soil was between 21.2-42.7% volume with the bulk density (BD) was between 0.31-0.83 g/cc. The results showed that there is no significant difference between the oil palm ages (5-10 years, 10-15 years, and above 15 years) on either the soil water retention or the soil bulk density for both the topsoil (0-20 cm) and the subsoil (20-40 cm). This research indicated that there is no effect of the oil palm age on the soil bulk density, field capacity, permanent wilting point, and plant available water. This research suggested that the soil should be saturated with high water content since West Sumatera has very high rainfall intensity so that the situation can be an advantage for oil palm growth over the years.**

Keywords— **Andisols; available water; oil palm; soil water retention.**

I. Introduction

The Indonesian archipelago encompasses one of the most active volcanic areas in the world, surrounded by 128 active volcanoes. On the island of Sumatera, there are 31 volcanoes, situated mostly along the Barisan Mountain Range [1].Most of the Indonesian Andisols are among the most productive soils. The soils are being cultivated with both annual and perennial of upland crops, such as tea, coffee, cacao with quite high productivity. The areas in the vicinity of volcanoes are also well known as the horticultural center and support more than 50% of the Indonesian people needs [2]. Various kinds of soils can be formed from volcanic ash based on the individual set of soil formation factors at different sites. Among these soils, Andisols show unique properties mostly due to abundant noncrystalline materials, such as allophane, imogolite, Al-humus complexes, and ferrihydrite. Highly porous structures made of aggregated no-crystalline Andisols material have a light and fluffy nature, accommodating large amounts of both plant-available and hygroscopic water [3]. These soils have unique and distinct properties with low bulk density, high water retention, high permeability, stable structure, high amount of current Al and Fe, variable charge, and high phosphate fixation [4].

The potential of natural resources in the region of North Sumatera is enormous with a vast plantation reaches 15.2% of Indonesia palm oil plantation. Crude Palm Oil (CPO) reach 7.9% of total Indonesia palm oil export [5]. Deforestation for oil palm plantation in West Sumatera conducted since last few decades [6]. Deforestation for tree cash crop plantation, such as oil palm, rubber, and cacao agro-forest in the tropics results in sharp decreases in soil organic carbon (SOC) stocks. Much of this carbon lost through carbon dioxide (CO2) emission and leaching [7]. The land use change from native forest to pasture exposed the soil to higher mechanical stresses leading to soil compaction. Since soil shrinkage during drying, the bimodal character of the water retention curve changed only the macropore range. Meanwhile, the textural range remained constant when native forest (NF) changed to P50 (permanent pasture for over 50 years). The land use change affected the saturated hydraulic conductivity of the soil [8].

Farming in sloping areas is not the only risk for the erosion, but also problematic to the fertility [9]. Soil characteristics influence essential soil functions, such as: (1) Moderating and partitioning water and solute movement and their redistribution and supply to plant, (2) Storing and cycling nutrients, (3) Filtering, buffering, immobilizing and detoxifying organic and inorganic materials, (4) Promoting root growth, and (5) Promoting resistance to erosion [10]. Bulk density (BD) of Andisols in Indonesia was highly varied that was 0.37-0.90 g/cm³. This low BD of Andisols depend on amorphous mineral-dominated by this soil. Since Andisols dominated by amorphous mineral, the soil has many micropores with inter-aggregates of the allophane [11]. Characterisation of Available Water Capacity (AWC) of soil is essential for assessing the soils physical status and quality. The availability of soil moisture would control the rates of evaporation and transpiration and have a significant impact on climate. It also manages hydrologic processes for instance; groundwater recharging, infiltration and surface runoff. Soil water content is one of the soil factors for plant growth, influencing carbon allocation, nutrient cycling, and the rate of photosynthesis [12].

Soil water storage is commonly measuring at different moisture tensions, that is pF (potential force) 1, 2, 2.54, and 4.2. Water storage of soils from Mt. Merapi measured at pF one ranges between 53 to 72% w/w or between 25 to 209 mm while materials of Mt. Pasaman have water storage between 53 to 72% w/w or 53 to 162 mm [2]. Based on the previous research on the arid region in Ivory Coast, West Africa, and India, the oil palm plantation was interfered the groundwater for other crops outside of the farm [13]. Furthermore, it is explained that the groundwater draining by oil palm is big in which one oil palm plant can absorb 20 to 40 liters water per day and can also suck up the water up to the depth of 5.2 meters.

Available water is one of the essential components for the growth and development of oil palm in Andisols. The water absorbed by the plant is the water located in soil pores. Every type of soil has a different distribution and pore size, which will affect the water content in the soil by considering the high water consumption of oil palm. Some research results, for example in the Ivory Coast and India or arid regions, show that due to the high water consumption, it can cause the water deficit in an area, especially in the dry season.

The connection between soil, water, and plants is known as a concept of available water for plant growth, in which water content is the range of water content in the soil that is needed by the plants [14]. This condition is strongly related to the ability of the ground to hold water (water retention). The basic principles of available water for the plant are related to the provision of water in sufficient and balanced quantities for plant growth in which the soil water content is between field capacity (2.54 pF) and permanent wilting point (pF 4.2).

This research focused on analyzing the effect of age of oil palm on the physical properties of the soil and the diversity of soil water retention on Andisols in Pasaman sub-district. West Sumatera, Indonesia.

II. Material and Methods

A. Research Site

This research was conducted in the oil palm plantation of a peasant in Pasaman sub-district, West Pasaman district and the physical analysis of soil identified at Soil Laboratories of Faculty of Agriculture, Andalas University and Soil Centre Research Bogor. This research conducted from January up to May of 2016.

B. Research Methods

The research methods were through a field survey. Soil samples were taken in the field and then analyzed in the laboratory. Soil sampling points were determined by overlaying four types of the map; those were an official map of Pasaman Region, visual earth map of Indonesia, soil and land unit map, and Shuttle Radar Topography Mission (SRTM). Geographical position of sampling location in Bangka sub-district was N.00°23'40, 2''-E.99°33'47, 7''; N.OO°23'49, 0''-E.99°33'48, 9''; and N.00°23'38, 22''-E.00°23'38, 2''-E.99°33'48, 5'' with elevation 292-311 meter above sea level (masl). Meanwhile, soil physical analysis has conducted at soil laboratory Faculty of Agriculture, Andalas University, and soil physics laboratory Soil Centre Research Bogor.

The soil sample was taken based on three groups of oil palm age, at age range from 5-10 to 10-15 and above 15 years on sloping land that is more than 15%. In the point of each soil sample, the undisturbed sample taken by using soil cores in 0-20 cm and 20-40 cm depth, in which on each layer, two samplings were chosen. Therefore, in each observation place, there were four soil core samples with total amount 12 samples and soil analysis for soil profile sample.

Soil core sample was taken to determine the bulk density (BD), particle density (PD), total pore space by using gravimetric method [15] and available water content by using pressure plate apparatus method [16]. For soil texture analysis, the sample took from the composite soil in depth of 0-20 cm and 20-40 cm. The soil texture analyzed by using sieve and pipette method based on Stokes Law, and the texture class determined by using the textural triangle.

III. Result and Discussion

A. Bulk density and total pores space

The effect of soil physical properties analysis especially the bulk density (BD), particles density (PD), and total pore space is presented in Table 1.

TABLE I
BULK DENSITY (BD) AND TOTAL PORE SPACE IN THE OIL PALM PLANTATION OF THE PEASANT IN PASAMAN SUB-DISTRICT, WEST SUMATERA.

Age of palm tree (years old)	Soil layer (cm)	Particle Density (g/cc)	Bulk Density (g/cc)	Total pore space (%.vol)
5-10	0-20	2.23	0.57	74.35
	20-40	2.23	0.52	77.00
10-15	0-20	2.34	0.69	70.4
	20-40	2.46	0.79	67.90
>15	0-20	2.34	0.67	71.4
	20-40	2.42	0.81	66.4

Table 1 shows that the value of soil bulk density on the topsoil (0-20 cm) was ranging from 0.52 to 0.88 g/cc (with 0.36 g/cc difference). The soil particles density was around 2.08 to 2.48 g/cc (the with 0.40 g/cc difference). Whereas, on the subsoil, the bulk density was around 0.51 to 0.83 g/cc (with 0.32 g/cc, difference), and the particles density was around 2.14 to 2.62 g/cc (with 0.48 g/cc difference). On the other hand, the total pore space of topsoil 0-20 cm was 64.5