Effect of Ultisol with Different Texture for Pakchoy (Brassica rapa L)

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Abstract. Soil water avaibility is one of the important factors for plant growth. Field capacity can be de determined by different methods.The objective of this research is to study the levels of field capacity by among methods at Ultisol texture with different soil texture and a response of pakcoy growth. This research was initiated with field capacity measurement with free drainage method 24 hours, free drainage 48 hours, and pressure plate at different soil textures, i.e. sandy loam and sandy clay loam. Furthermore, pakcoy planting with different watering treatment based on field capacity of each mentioned methods was carried out in greenhouse. Parameters that measured such as soil texture, field capacity, and weight of pakcoy. The results showed that field capacity on sandy loam (32,94%) was lower than sandy clay loam (35,78%). Measurement with free drainage method 24 hours produced the highest field capacity (37,63%) among the pressure plate method (33,39%) and free drainage method 48 hours (32,06%). Watering treatment based on field capacity of each method at different soil texture have significantly affect on fresh weight and dry weight of steams and leaves, and significantly affect on fresh weight of roots, and not significantly affect on dry weight of roots.

1 INTRODUCTION

Ultisol soil is marginal soil (Anikwe. 2015) and usually used by rubber and palm oil plantation. Ultisol soil has been used for horticultural cultivation in green house laboratory but productivity is low. Watering with different concentration affect bulk density and particle density value (Sumono. 2018).

Availability of water is an important factor to increasing yield production. Moisture and nutrition of soil is affected by bulk density (Xu. 2016), particle density (Martin. 2016; Schjonning. 2016) and soil porosity (McGrath and Henry, 2016). Determination of the field capacity water content (FC) needs to be known. Several method that often can be used are free drainage method and pressure plate method.

Field capacity water content also according to texture of soil. ultisol soil as we know that consist of various textures. Soil texture decided by soil fraction such as sand, silt (loam) and clay. Soil particle and pore structure affect the hydraulic properties of unsaturated media, in example is soil water retention (Ding. 2015). Therefore, the study about utilization ultisol soil with different texture are needed to explain characterize and the effect to horticulture crop, such as pakcoy (Brassica rappa L).

The aims of this studies are to determine the field capacity water content with different soil textures using free drainage method and pressure plate method; and effect of field capacity water content on fresh weight and dry weight of Pakcoy (Brassica rappa L).

2 MATERIALS AND METHODS

The material used in this study is the ultisol soil, it is used as the object under study, chemical reagent, pakcoy plant seeds as material to be planted in the soil, water as an ingredient for watering, polybags as a container for soil. The tools used in this study were ring samples, ovens, digital scale, erlenmeyers, pressure plates apparatus, 10 mesh sieves and glass.

This research method uses the experimental method in the greenhouse and soil analysis is carried out in the research and technology laboratory of the North Sumatera University agricultural faculty and the soil physics and environmental faculty of agriculture. The study used a completely randomized design with 6 treatment and 4 replications, they are Sandy clay texture with free drainage method (24 hours), sandy clay texture with free drainage method

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(48 hours), sandy clay soils with pressure plate method, sandy clay loam texture with free drainage method (24 hours), sandy clay loam texture with free drainage method (48 hours), sandy clay loam texturewith pressure plate method.

Several parameters that can be measured are:

1. Soil texture which analyzed in laboratory
2. C-organic, total nitrogen (N-total), phosphorus availability (P-av), and pH
3. Soil mass density

   Soil mass density determined by :

$$(D_b) = \frac{Mp}{v_t} \text{.....(1)}$$

Where : D_b : soil mass density ($g.cm^{-3}$); Mp : soil compact mass (g); and V_t : total volume (cm^3)

4. Soil particle density

   Soil particle density determined by equation :

$$(P_b) = \frac{Mp}{v_p} \text{.....(2)}$$

Where : $P_{d:}$ soil particle density($g.cm^{-3}$); M_p : soil compact mass (g); and V_p : soil compact volume (cm^3)

5. Porosity

   Porosity determined by equation :

$$f = \left(1-\frac{\rho b}{\rho s}\right) \text{ x } 10 \text{.....(3)}$$

where: f : porosity (%); ρb : soil mass density ($g.cm^{-3}$); and ρs : soil particle density ($g.cm^{-3}$)

6. Evapotranspiration

   Evapotranspiration determined by equation :

$$ET = (\theta x ht)/T \text{.....(4)}$$

Where : ET : Evapotranspiration ($cm.day^{-1}$); θ : volumetric water content (%);

Ht : soil depth (cm); and T : time (day)

7. Field capacity water content (FC) with free drainage and pressure plate method
8. Fresh weight and dry weight of pakcoy according water treatment based on field capacity water content (FC)

3 RESULT AND DISCUSSIOIN

3.1 Texture

Texture analysis from ultisol soil can be seen in figure 1.

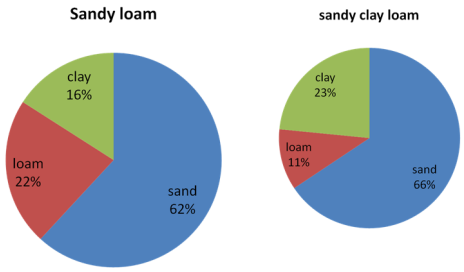

Figure 1. soil textures of ultisol soil

Figure 1 shows that based on USDA, ultisol soil texture consist of two types i.e. sandy loam and sandy clay loam. Sandy loam texture have loam fraction more than sandy clay loam texture, and content of clay fraction as low as sandy clay loam texture. Sandy loam texture is harder to water and nutrition holding than sandy clay loam texture, therefore, plants will more easily utilize water and nutrients in sandy loam texture. It will affect physiology of plant, where leaf chlorophyll can be used as an indicator of stress (McGrath and Henry, 2016)

3.2 C-organic, Phosphorus Availability (P-av), Total Nitrogen (N-total), pH

Measurement result of C-organic, phosphorus, total N , pH of soil can be seen in table 1.

Table 1 shows that Ultisol soil have P-av, N-total, and C-organic are very low. Ultisol soil formed by degradation land that has low leached, reduce K-exchange, soil going to acid and Al, Fe, Mn toxic, whereas macro essential soil increase. Generally, N-total and C-organic on sandy clay loam higher than sandy loam, whereas phosphorus low. it has been caused by sandy clay loam texture pH higher than sandy loam texture. pH have big impact to P retention i.e. pH increasing will decrease P retention. Land use, process, fertilization, compaction can changes chemical, physical and soil biological (Gao Lu. 2014).

3.3 Bulk Density, Particle Density and Porosity

Bulk density, particle density and porosity performance can be seen on below (table 2).

Based on table 2, bulk density of sandy loam texture is bigger than sandy clay loam. Soil with high total pore have low trend bulk density, whereas soil with macro pore size causing as big as bulk density. Bulk density is one of important parameter use to calculate organic carbon soil, as a basic of physics

soil (Xu. 2016). Organic matter content also affect bulk density. C-organic on soil with sandy loam is lower than sandy clay loam. Organic matter will decrease bulk density. Particle density values vary across soil types and regions. Particle density decrease while organic matter content as increase as sand particle (Schjonning. 2016).

Table 1. C-organic, P-av, N-total, pH of soil

Parameters	Unit	Value	Grade
Sandy loam			
Phosphorus (P-av)	Ppm	2.27	Very low
Nitrogen (N-total)	%	0.02	Very low
C-organic	%	0.26	Very low
Organic matter	%	0.45	Very low
pH	-	5.82	Acid
Sandy clay loam			
Phosphorus (P-av)	Ppm	2.10	Very low
Nitrogen (N-total)	%	0.02	Very low
C-organic	%	0.28	Very low
Organic matter	%	0.48	Very low
Ph	-	5.85	Acid

Table 2. Bulk density, particle density and porosity

Texture	Bulk density ($g.cm^{-3}$)	Particle density ($g.cm^{-3}$)	Porosity (%)
Sandy Loam	1.19	2.60	53.23
Sandy Clay Loam	1.10	2.36	53.39

3.4 Evapotranspiration

Evpotranspiration measurements result can be seen in table 3.

Table 3 shows that evapotranspiration value in middle phase and final phase are same in sandy loam texture and decrease for final phase in sandy clay loam texture. For the all, there are no gap evapotranspiration value both of textures. the justify of evapoptranspiration sandy loam texture as same as sandy clay loam texture.

3.5 Field Capacity Water Content Both Free Drainage and Pressure Plate Method

Measurements result from field capacity water content (FC) both sandy loam and sandy clay loam texture on below (table 4).

Based on the table 4. FC average value in sandy clay loam (35,78%) bigger than sandy clay soil. It is caused by water holding capacity is bigger than sandy clay soil. Measurement by 24 hours drainage method generates the highest average (35,33%) field capacity water content. Between pressure plate method (33,39%) and 48 hours drainage method (32,06%). Soil in free drainage method thicker than pressure plate method, so the water in free drainage method is not easily lost compared with soil water in pressure plate method.

Field capacity water content in pressure plate method sandy clay soil generates bigger value than 48 hours free drainage method. It is because sandy clay soil has rough texture with short time drainage, which decreasing water capacity very sharp in first day (24 hours) till second day (48 hours). Rough texture soil has dominant macro pore (drainage pore) causes drainage process in high water level condition is faster. Relationship between soil particle and pore structure in its role to detect groundwater is important. Soil structure is one of soil quality indicator, affects the hydraulic properties of unsaturated media, in example is soil water retention. soil pores structure affected by compact phase soil (Ding. 2015).

Table 3. Evapotranspiration value from soil

Growth phase	Temperature (°C)	Evapotranspiration (ETc) (mm.day^{-1})	
		Sandy loam	Sandy clay loam
middle (25-33 d.a.p)	30.58	2.4	5.8
final (34-42 d.a.p)	30.72	2.4	5.6

Table 4. Field capacity water content (FC)

Measurement Method	Soil texture		Average
	Sandy loam (%)	Sandy clay loam (%)	
Free drainage 24 hours	35.33	39.93	37.63
Free drainage 48 hours	29.20	34.91	32.06
Pressure plate	34.28	32.49	33.39
Average	32.94	35.78	

3.6 Fresh Weight and Dry Weight of the Pakcoy (*Brassica rapa* L.)

Water content of field capacity on various soil textures measured by different method gives a very significant influence on the fresh weight of the pakcoy and its dry weight. The result showed that the effect of various soil textures with different moisture content method on the wet weight of the stem and leaves for each treatment can be seen in the table 5.

Table 5 shows that FC water content on various textures measured by different methods have significantly effect on stems and leaves fresh weight of pakcoy and significant different on root. FC water content on various textures measured by different methods have significantly effect on stems and leaves dry weight of pakcoy and not significant different on root. Overall, weight of Pakcoy still under the standard from ministry of agriculture, Republic of Indonesia. Fertilizer application is needed for cultivation process and also about management practical impact and environmental in soil quality change (Gao Lu. 2014).

4 CONCLUSION

From the research we can concluded:

1. Textures of ultisol soils are Sandy loam and sandy clay loam
2. P-av, N-total, C-organic, Organic matter in Sandy loam are very low as same as sandy clay loam. pH are acid both of them.
3. Bulk density and particle density in sandy loam texture are bigger than sandy clay loam texture, whereas reverse for porosity
4. FC water content sandy clay loam is bigger than sandy clay texture
5. Evapotranspiration in sandy loam 2.4 mm.day^{-1} and in sandy clay loam is 5.6-5.8 mm.day^{-1}
6. FC water content on variuous textures measured by different methods have significantly effect on stems and leaves fresh weight of pakcoy and significant different on root
7. FC water content on variuous textures measured by different methods have significantly effect on stems and leaves dry weight of pakcoy and not significant different on root

Table 5. Fresh weight and dry weight of Pakcoy

Textures	Field capacity measure methods	Fresh Weight (gr)		Dry Weight (gr)	
		Steams and leaves	Root	Steams and leaves	Root
Sandy loam	Free drainage 24 hours	12.75^{aA}	0.84^{aA}	0.83^{aA}	0.08^{aA}
	Free drainage 48 hours	9.00^{abAB}	0.55^{abAB}	0.55^{bAB}	0.06^{abA}
	Pressure plate	6.25^{bcB}	0.40^{bAB}	0.41^{bB}	0.05^{abA}
Sandy clay loam	Free drainage 24 hours	5.25^{bcB}	0.39^{bAB}	0.39^{bB}	0.04^{abA}
	Free drainage 48 hours	3.50^{cB}	0.33^{bB}	0.32^{bB}	0.02^{bB}
	Pressure plate	3.00^{cB}	0.24^{bB}	0.26^{bB}	0.02^{bB}

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