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RESEARCH ARTICLE

ORGANIC MATTER AND ROOT DEVELOPMENT OF SOYBEAN IN AGROFORESTRY OF BENGAWAN SOLO SUB WATERSHED WONOGIRI INDONESIA

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ABSTRACT

Alfisols is a soil that lack of organic matter (OM), that's make the physical properties of the soil is easily damaged, because OM is used to be an adhesive on soil physical properties. The aim of study was to examine the physical properties of Alfisols in agroforestry based of teak and its effect on the development of soybean. This research used a Randomized Block Complete Design (RBDC) which consists of three factors (soybean varieties, teak litter dose and NPK chemical fertilizers). The results showed that Alfisols in agroforestry based on teak relative good with the stability of the aggregate value as big as 225.10 (Very Steady). Varieties and increasing teak litter doses affect soybean root development while there was no impact on NPK fertilizier. Argo Mulyo varieties have better root development than Grobogan, and litter dose of 2.5 Mg ha^{-1} gave the best root development in each variety.

Keywords : Agroforestry, Organic Matter, Root Development, Soybeans

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INTRODUCTION

Alfisol is a soil that has evolved with the characteristics of the soil profile form a sequence of horizon A / E / Bt / C, which is formed through the combination of podsolisasi and laterisasi on wet climatic regions and is usually formed under hardwood forest stands (Tan 2000). Forest soil conditions showed its own uniqueness. The biological activity of the soil is seen around 80% on the top soil layer.

Therefore, the presence of agroforestry systems is expected able to improve soil fertility, especially soil physical properties due to physical properties of the soil greatly affect the viability of the forest.

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Hoffer explained (2003), that the existence of forest vegetation in an area can improve soil hydrological properties more than to other types of vegetation closure. Forests can produce flood discharge at a low level and increase the stability of the soil which is caused due to high infiltration capacity, protection and tree canopy cover, the high tensile strength of the roots of trees. The increase of soil erosion is almost certainly due to the removal of the canopy and surface litter that protects the soil surface from the energy of raindrop impact and surface detachment (An 2008).

Good soil physical properties can help development of soybean roots. Soybean have a taproot with many of root branches that grow straight into the ground. Nodules can be found on the root branches and contains of

Rhizobium japonicum which can improve soil fertility by absorbing N_2 from atmosphere (Andrianto 2004). Symbiosis between roots with Rhizobium in favorable condition can supply of N up to 74% – 90% from N-total needed of plants (Sutoyo 1992). Availability of nitrogen (N) is one factor that can improve soybean production in sour land. In general, soybean absorb nitrogen (N_2) from the air through N fixtation by Rhizobium activity that symbiosis with soybean root, which can stimulate growth and production of soybean

Basically, soil requirement for soybean is not too wet, but the water remains available. Corn is a good indicator plant for soybean. It means, soil condition will get better if corn and soybean are planted together. Soybean doesn't require special soil structure for growing. Even in marginal and sour land condition, soybean can also grow well, the important thing is don't make unflooded condition for avoiding rotten roots (Supriyadi *et al* 2013). Soybean can grow well on a variety of soil types, with a good drainage and aeration of soil. Suitable soils are: alluvial, regosol, grumosol, latosol and andosols. Soybean doesn't grow very well if cultivated on red yellow podzolic soil dan soil that contains a lot of quartz ,unless given additional organic fertilizer or compost in sufficient quantities . the main constraints of cultivation agroforestry systems is the interaction between trees with crops in the form of competition for light, water, and nutrients (Hairiah et al, 2003).

MATERIAL AND METHODS

This study was conducted in November 2013 at Girimarto district, Wonogiri Indonesia and laboratory analysis at the Laboratory of Physics and Soil Conservation and Chemistry and Soil Fertility Laboratory Faculty of Agriculture, Sebelas Maret University. RBCD is used as research design with three factors, there are soybean varieties (Argo Mulyo and pangrango), dose of litter teak and N,P,K fertilization,each of combinations is repeated three times. At the time of harvest soil should be analyzied at laboratory. Tools and materials consisted of soybean (Grobogan variety), urea, SP-36, KCl, teak litter and chemicals and instruments for laboratory analysis.

Research was started by survey to determine the location of experimental design, making litter, litter applications, preparation of planting material, planting, maintenance and harvesting of sampling that performed twice at the beginning and at the end of the observation. The variable consisted of weight of soil volume (volumetric) , soil density (gravimetric), stability of soil aggregates (double sieving method), and soybean root biomass. Data were analyzed using Kruskal-Wallis test and correlation.

RESULTS AND DISCUSSION

Agroforestry Land Fertility

Alfisol in sub-humid regions and semiarid Tropical have a low sediment fraction, weak structure, and can easily undergo slaking, hardening and compaction. Due to the low activity of the main factors, clay (eg kaolinite and illite) and low organic matter content were the majority of Alfisols, also be easily hardened (hard-setting), such as hardening of the ground into a mass of activities that are not structured as drying (Risnasari 2002).

Tan (2000) suggested that the lands of Alfisol which have experienced erosion, less favorable for plant growth. This is due to argillic horizon will be exposed to the outside into the upper layer, this layer can inhibit the growth of plants, especially root growth.

Fertility is the ability of the soil to support plant growth. It could be said fertile if there have a physical, chemical, and biological support plant growth, with a record of other factors such as climate and management measures aren't limited.

Table 1. Agroforestry land fertility

Parameter	Unit	Value	Dignity
pH H_20		5,8	Sligthly acid*
Organic Carbon	%	0,90	Very low*
Cation Exchange Capacity	me%	23,2	Average*
Base Saturation	%	29,27	High*
Texture			
Sand	%	30.875	
Silt	%	43.875	Clay***
Clay	%	25.25	
Porosity		41,86	
Permeability	cm $hour^{-1}$	15,66	Fast**
aggregate stability		225,10	Very steady**

Source : Analysis in Chemistry and Soil Fertility Laboratory, Physics and Soil Conservation Sebelas Maret University 2015

*)Level by Sulaeman et al. 2005

**) Level by Kurnia et al. 2006

***)Level by USDA triangle texture

At the initial soil analysis (Table 1) shows that the soil is a slightly sour (5.8), Munir (1996) explains that Alfisol soil acidity caused by the presence of several sesquioksida elements such as Al, Fe, and Mn binding bases so it makes the lower of pH. Alfisol pH value is an optimum pH for soybean crops, as be told by Intan Sari that high production of soybean is caused by increasing of the pH to 6.0. From Table 1 it is known that this land has a low content of organic carbon (0.90%). Forests have a low value of organic carbon due to decomposition of organic matter such as imperfect plant litter. Decomposition influenced microbial activity that utilizes carbon compounds for cell division and the release of CO_2 will reduced soil organic carbon (Jacob 1992 cit Dahlan et al. 2008).

Physical fertility rate is in excellent research sites, detected from soil texture dominated by clay. Solum shallow soil aggregate stability is very steady and very slow permeability. Hydrological state of the land is quite good despite the circumstances sloping slope, texture, and low levels of soil organic matter capable of causing erosion, but by creating terracing and land cover by trees can reduce the rate of run-off. As pointed out by Hoffer in 2003, that the existence of forest vegetation in an area can improve soil hydrological properties better than any types of vegetation cover. Forests can produce flood discharge at a low level and increase the stability of the soil which is caused due to high capacity of infiltration, the protection from tree canopy cover, the high tensile strength of the roots of trees.

The Effect of Litter Treatment To Soybean Root Development

The physical properties of the soil is very important role in plant growth. Due to the physical properties of the soil can be an indicator of the ability to conserve soil, drain and provide nutrients for plants. The physical properties of the soil are soil structure, bulk density of soil permeability, aggregate stability and soil porosity. The structure affect the properties of the soil and good soil texture can bind water and provide nutrients that plants need to growth, especially by mulching.

Organic matter as mulch is one of the way to improve the physical properties of soil. Organic materials can improve soil structure, increase the water holding capacity, aeration

and infiltration rate, as well as facilitate the penetration of roots, so that the land productivity and crop yields can be increased (Sumarni et al 2010).

Priambodo et al. (2009) conducted a treatment of mulch thickness significantly in all growth parameters were observed that the thickness of the two pieces of teak leaves real effect on the components of the soybean plant growth, including the number of leaves and leaf area index and the yield components include the weight of seeds per plant, weight seeds per hectare and the weight of 100 seeds.

From the analysis of variance is known that the interaction between varieties and doses litter have very significant effect on the soybean root biomass. This is due to the provision of litter able to improve soil physical properties that can improve soybean root development. Soybean roots can get nutrient easily as long as soil physical properties get better. Roots with a good growth will produce nodules more than roots under stress condition. Root nodules that contains *Rhizobium japonicum* (effective nodules) can absorb N_2 from atmosphere and other nutrients to help root development. Same as Ningsih (2004) opinions, that high population of rhizobium on soybean roots can increase roots ability to absorb nutrients so that can increase root biomass.

In Figure 1 shows that the highest biomass is shown on varieties of teak litter Argo Mulyo and 2.5 Mg ha^{-1} and significantly different from other treatments. Argo Mulyo has characteristic roots better than Grobogan, among both varieties, teak litter (2.5 Mg ha^{-1}) has the highest growth compared with other litter.

Root biomass is stover of root that has been dried. Analysis of variance on the weight of root biomass showed that varieties and doses of litter have very significant effect on root biomass weight. Root biomass indicates the ability of plants to absorb water, because the plants that have high root biomass have greater root and a higher level of tolerance to water stress than plants with low root biomass (Kurniasih and Wulandhany 2009).

In this case, teak litter become source of carbon for rhizobium or other microbia activities to increase nutrients mineralization so that improve nutrients availability for soybean. According to Grossman et al (2011) opinion, that addition of organic matter on soybean cultivation can increase population of rhizobium on soybean roots (rhizosphere). It means that teak litter can increase population of rhizobium and effective root nodules (contains of rhizobium) for each soybean

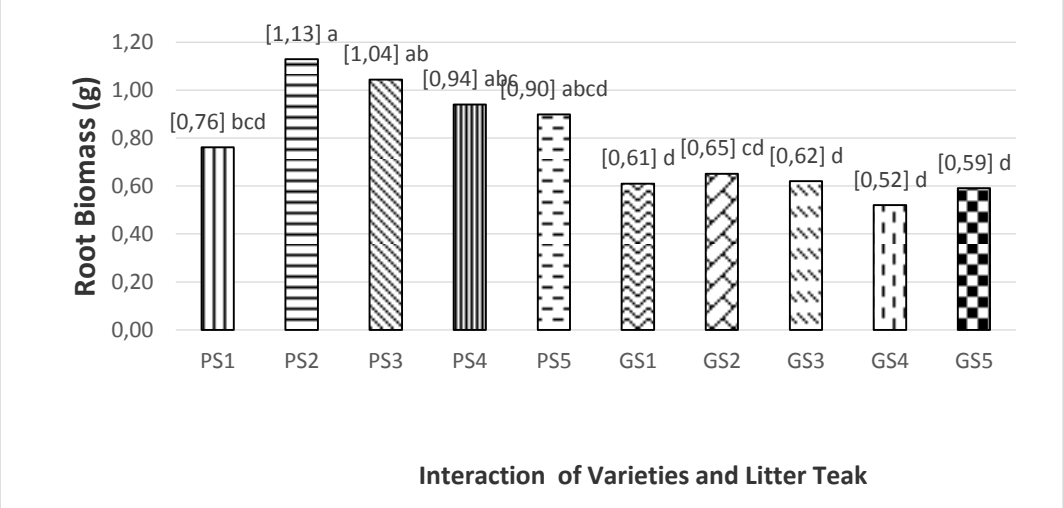

Figure 1. Histogram Interaction between Varieties and Teak's Litter on Root Biomass

varieties. Argo Mulyo variety maybe have effective nodules more than Grobogan variety so that roots of Agro Mulyo variety can absorbs nutrients easily and grow better as well as has high root biomass.

Aggregate Reveals can create a good physical environment for the development of plant roots through its influence on porosity, aeration and water holding capacity. Soil aggregates will less stable when exposed to disturbance and finally destroyed easily. Fine grains will inhibit soil pores and caused increasing of soil bulk density, poor aeration and permeability becomes slow. Aggregate stability also determines the level of sensitivity of the soil against erosion. Aggregate ability to withstand external destroyer force (stability) can be determined quantitatively by Aggregate Stability Index (ASI). This index is a quantitative assessment of the aggregate stability.

From the results of analysis of variance showed that no significant effect of varieties, litter, and fertilizer to the soil physical properties, due to the changes of soil physical properties is very slow because it needs of OM as a material to improve the soil physical properties. This is dictated by Pidwirny (2006), soil organic matter improves soil structure, either directly or indirectly. Direct role is done by the content of hummus that acted as water storage. Indirect effect of the adhesive is produced by soil biota organic matter as a source of carbon. Hummus (adhesives), and soil biota work together to bind soil particles small particles and form space for the movement of water and air. Organic materials and clay for soil aggregate serves as a binder for soil aggregate stability. Activity of plant roots increase the amount of soil pores so that the percolation improved (Supangat 2010).

Research conducted by Hajabbasi and Hemmat (2000) on the effect of tillage on soil aggregate stability showed similar results seen in the first three years of research.

CONCLUSION

The conclusion of this research, as following : (i) the soil physical properties in agroforestry relatively good views of the level of soil aggregate stability 225 101 (Very Steady); (ii) the permeability of the soil is at the value of 15.66 mm h^{-1}(fast) and 41.86% porosity; (iii) provision of teak litter does not affect soil physical properties of Alfisol teak agroforestry; (iv) litter dose of 2.5 Mg h^{-1} increases root growth (biomass) on the variety of Argo Mulyo.

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