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Review article

The Strategy of Developing Sweet Potato Cultivation in Tidal Land

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Abstract

The development of sweet potato cultivation in tidal land has begun. These activities require an appropriate invention in agricultural technology. An integrated management in physical, chemical and biological aspect also needs to be done. The content of soil microbes in tidal land is low, but it's fairly high diversity can be used to improve the soil fertility. This paper describes some success of microbiological studies on tidal land. Further attempt is by integrate the potential of soil microbes utilization which supported by LEISA (Low External Input Sustainable Agriculture) technology.The success of this activity supports the national food security program and realizing sustainable agricultural system in the utilization of tidal land.

1. Introduction

Sweet potato is a carbohydrates producer commodity that has potential to be developed. Indonesia's sweet potato production level is still low, around 10-12 tons/ha. The development of sweet potato to marginal land, such as tidal land, was begun to do. Sweet potato has potential to be developed based on several supportive factors: (1) sweet potato cultivation requires a low input, low level of risk, and has quite extensive deployment of grown environments; (2) short lived (3.5 months); (3) high level of productivity; (4) contains good nutrients for the health; (5) tuber has relatively higher price; (6) potential of the utilization is quite wide (Shah *et al*, 2009).

The development of sweet potato to marginal land, such as tidal land, was begun to do.The potential of tidal land in Indonesia for the expansion of sweet potato planting area is very large, about 20.10 ha or 10.8% of the land area (Widjaja *et al.*, 1992). The management and utilization of tidal land required a careful planning by applying the right technology (Haryono, 2013).

2. Tidal Land Development Challenges

The development of tidal land encountered numerous obstacles in its process. It is based on it is formation history, which originated from anaerobic decomposition of organic matters that influenced by the ebb and flow of the water. Tidal land assessed as a marginal and fragile ecosystem. The marginality and fragility level of tidal land is determined by inherent properties of the land; either it is physical, chemical or biological properties (Ratmini, 2014). The obstacles encountered in the development of tidal land include low soil fertility, high soil acidity (pH 3.0-4.5), nutrient deficiency, the presence of toxic ions and compounds (Al, Fe, SO4) and organic materials that not yet decomposed.Moreover, unrepresentative state of the water system will be a limiting factor in its management (Noor, 2004).

Soil microbes are the component of life in the soil, usually less than 1% of the soil volume (Schinner et al, 1996). The populations of soil microbes in marginal land are usually quite low, but it has a high level of diversity (Prihastuti and Sudaryono, 2013). The average population of soil fungi isolated from peat lands is 7.1x103 – 8.5x105cfu/g of dry soil (Suciatmih, 2006). Peat soil bacterial population reaches 105-106 cfu/g soil (Sudiana et al, 1994). The type of soil microbes found in tidal land is nitrogen-fixing bacterial Azotobacter and phosphate solubilizing bacterial Bacillus and Pseudomonas (Wibowo et al, 2012), fungi Acremoniellasp., Chloridiumsp., Gliomastix murorum (Corda) Hughes, Malbranchea pulchella Saccardo & Penzig, Thermomyces stellatus (Bunce) Apinis, and Torula sp. (Suciatmih, 2006), actinomycetes that active to phosphate solubilizing and cellulose biodegradazing are Streptomyces, Nocardia, Microbiospora, Micromonospora (Nurkanto, 2007). The average population of bacteria Thiobacillus sp. ranged from 1.50x1014 to 2.50x1014 cells/g of soil and the average population of Thiobacillus ferooxidans bacteria ranged from 8.33x106 to 2.00x107 cells/g of soil.

3. Technology of Tidal Land Management

In tidal land management for agriculture, the dynamics of physical and chemical properties of the soil needs to be considered, especially the chemical properties which related to the groundwater management, including: (1) the dynamic nature of soil acidity associated with the control of poisonous organic acids, and (2) the dynamics of soil fertility with respect to the availability of macro and micro nutrients needed by the cultivated plants (Sabiham, 1994). The actions to solve the peat soil problem that has been taken are: the attempt to improve soil fertility by leaching of toxic substances (Prasetyo, 1996), liming to increase the soil pH (Mawardi et al., 1997), increasing the plant nutrients' availability (Nelvia, 1997), and applying organic matter decomposing microbial (Poeloengan et al., 1995). Ameliorant materials can neutralize toxic organic acids, increase the pH, and improve the growth and production of plant (Mawardi et al., 1997). Liming can increase the soil pH, neutralized Al, and increase the availability of P for plants. The low pH and large buffering capacity of the peat soil increases the amount of lime needed to increase each pH unit (Sastrosupadi et al., 1992).

4. Challenges of Developing Sweet Potato Cultivation in Tidal Land

A lot of physical and chemical treatment has done to handle tidal land and has not shown an optimal result yet. Huge input of chemical material and high labor costs made the outlay of expanding the sweet potato planting area to tidal land high. Consideration should be given to apply the method of sweet potato planting that supported by specific local technology.

In fact, biological treatment of tidal land has not been done optimally (Mariana et al., 2012). Many studies have shown that the presence of soil microbes plays an important role in the biogeochemical cycles and maintaining ecological stability in the soil (Prihastuti, 2011). The treatment of land used for cultivation (either physically or chemically) leads to the changes in soil microbial community structure, such as the use of pesticides (Heilmann et al., 1995), amendment with chitin (Hallmann, Rodrıguez-Kábana, & Kloepper, 1999), compost or animal manure (Schonfeld et al, 2002) and the introduction of microbial mutants (De Leij et al, 1995; Mahhaffee and Klooper, 1997). The physical and chemical properties of land (Kennedy and Smith, 1995) soil particle sizedistribution (Ranjard et al, 2001), the presence and age of plant species (Garland, 1996; Grayston et al, 1998) and crop rotation (Villich, 1997) are some determinative key factor of soil microbes' compositional structure.

The existence of microbes in the soil shows the need of abiotic conditions and the nutrients available in the biosphere. In a stable system, it can be hypothesized that the land is inhabited by microbes that are able to adapt to the soil environment. Soil microbes functioned as biochemical catalyst of the processes that take place in the soil, which leads to the changes in the soil. There are three main factors that contribute to the dynamics in the soil: the type of crop, soil type, and management techniques (Loreau, 2001).

On the other hand, the presence of pathogenic microbes will harm the plant. The main disease of sweet potato plants is scabies, caused by the fungus Sphaceloma batatas (Elsinoebatatas). The disease that is in the tropics can reduce the yields up to 30% (Jannah, 2015). In the new areal of tidal land found Cylas formicarius pests which can damage the sweet potato crops (Stathers et al, 2003). The percentage of damage caused by Boleng pests reaches 59.99 to 81.88% (Nonci, 2005).

5. Application of The Concept of Sustainable Agriculture

The expansion of sweet potato cultivation areato the tidal land encountered many obstacles in the aspect of land infertility. Increased productivity of the land is a dynamic interaction of three aspects of land's quality; physical, chemical, and biological aspects. Of these three aspects, only the biological aspect that still has minimum information. There are only a few biological researches on tidal land, but it should not be underestimated. The biological quality of tidal area will be a staple key of the success on its land management through its dynamic and alive role.

The inventory of the types and dominance of soil biota is very important. This research step will support the implementation of the concept of sustainable agriculture LEISA (Low External Input Sustainable Agriculture), which is a low input agriculture system, but optimize the use of natural resources (soil, water, plants, animals) and human resources (labor, knowledge, skills) available in the place, economically feasible, ecologically stable, socially equitable and suitable in the local culture (Prihastuti, 2012). The basic principle of LEISA is to ensure the condition of the soil that support plant growth by managing organic matter and increasing the life of soil microbes in order to optimized the availability and balance of the flow of the nutrients, in particular by nitrogen fixation, nutrients recycle, and using outside fertilizer as a complement, minimizing the losses as a result of solar radiation, air and water with microclimate management, water management and erosion control, complementarily and synergic in using the genetic resources which includes the merge in integrated farming system with high levels of functional diversity (Prihastuti, 2012).

The presence of bacterial, fungal and actinomycetes that have the ability to degrade lignin and cellulose can be empowered to enhance the degradation process of organic material, so it will be a qualified source of natural organic matter. The availability of nutrients can be obtained by utilizing the presence of nutrient providers microbial (i.e. the non-symbiotic nitrogen-fixing bacterial, phosphate-solubilizing fungi and bacteria or vesicular arbuskular mycorrhizae).

By noting the diversity of soil microbes, which most of them are beneficial microbes, maintaining the indigenous microbe on tidal land is possible. The maintenance technique of soil microbes in its growth environment can be done by adding the nutrients required, providing organic matter to increase the level of the nutrients and improving the growing environment of the microbes. If the input of microbes from the outside is needed, then it must be able to survive in the condition. Things to note is to maintain the proportional authenticity of indigenous microbial population, therefore the attempt of increasing the amount of microbial population would not affect the stability of the growing environment.

6. Conclusion

The management of tidal land for sweet potato cultivationneeds to begin with the study on the microbes' life in it. This activity will complete the management of the physical and chemical treatment in tidal land that has been done. Microbes' life in the soil plays an important role in controlling the stability of the soil ecosystem. Factors that affect the structure of microbial communities in the soil are soil and plants' type, as well as the management of the land. Besides soil microbes that beneficial for plants by producing nutrients and plant's growth hormone, there are also some microbes in the soil that cause plant diseases. In a stable soil ecosystem condition, suppressive microbial pathogen can be suppressed naturally.

By understanding the properties of the soil; from physical, chemical, and also the biological aspects, the right treatment in order to maintain the soil's fertility can be done. Managing the soil's fertility is ecologically more promising to accomplish the concept of sustainable agriculture, through observing the interaction between the microbes and the soil as well as the microbes and the plants by the influence of time and space in the soil. The comprehension of how far the influence of plants to the space and time will be a big challenge for the future agriculture, this is also supported by the fluctuations in the soil's abiotic conditions (such as the moisture and temperature of the soil) which influence the microbial community structure.

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