

Agroforestry enhance soil moisture and fertility in rain-fed farmlands

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Abstracts. Since draught and fertility of farmland can be considered as main constraint for food productions, mitigation of these constraints has to be continuously performed. The important of this mitigation mainly due to various data reported which show that rainforest has been continuously decreased for other uses. This decrease could then inhibited the potential of local water cycles and enhance draught. In order to minimize the overwhelming draught during dry seasons and flooding during rain seasons, agroforestry system might become an option that has to be improved, as well as inhibiting the reduction of rain forest. This agroforestry system do not only varied income for smallholder farmer, but also increased the capability of rain forest to maintain fresh water supply. This system could therefore also increase soil moisture and fertility of farmland. Mechanism by which this system could mitigate agricultural constraint is relied on the ability of deep root system of trees to absorb mineral and water. Whereas water taken up by this root system then evaporated to enhance local water cycles, mineral taken up from deep soil will enrich top soil of farmland. Thus, agroforestry could become a promising method to sustain food productions.

Key word, agroforestry, crops, trees, litters, soil fertility and moisture.

Introduction

Agroforestry is a land use management system in which trees or shrub are grown around or among crop [1]. Traditionally, trees in plantation are grown to provide shade and a steady supply of food and income [2, 3]. The trees also grown for a cultural need, such as offering and traditional architecture like that found in Bali where temple and offering are made from various kind of tree or shrub. This conservation practice has been change into a more profit oriented plantation by booming yields. Since this practice is usually involving trees clearance, natural mechanism which maintains soil moisture and fertilities are at minimum. Therefore, high yield could not be maintained and impact of extreme climate change becoming more severe [4]. In order to secure food production, optimization of agroforestry is considered very urgent.

The role of agroforestry in maintaining soil moisture and fertilities

Soil moisture is regarded as very important for plant growth and production [5]. Therefore, maintaining local water cycles in

rain forest is crucial for food production. Naturally, fresh water cycles involving trees in plantation and rainforest (Fig. 1). Conservation effect of trees is due to litter of fallen leaves, twig and branches which slow runoff and increased water infiltration [6]. This litter could also enrich food for soil organism such as earthworm which contributed to a faster mineralization of the litter [7]. These trees make a large total leaves area per plant and develop long deeps root. In desert, root may extent down more than 50 m and in orchard may reach a total length 12-18 km per tree [8]. So, large trees enable more water to be taken up from deeper soil before evaporation into the atmosphere via stomata. Trees produce flow of water vapor 10 times greater than herbaceous [9]. Therefore, transpiration of water via the trees increase the capacity of forest to produce rain cloud that eventually transformed into rain fall. This recycled water is therefore could maintain soil water content require by plants to grow.

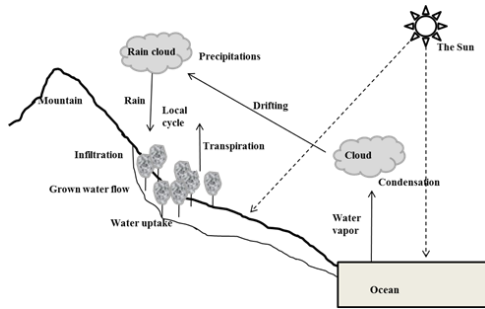


Fig.1 Fresh Water Cycles.

Since the trees has a much deeper root system, nutrient absorbed for growth is most likely also originated from lower soil. From the root system, this nutrient is then distributed into various plant parts and some of the nutrient underwent reduction into organic compounds. Nutrient such as nitrogen, sulphur and possibly also phosphorus, are incorporated into molecules and stay in the leaves [10, 11]. This compound could then become nutrient for shallower rooted crop plants. Thus, the present of trees in agroforestry increase the capacity of rain forest to maintain soil moisture and soil fertilities.

Agricultural practice in rain-fed farmland

It is inevitable that increasing cost of living in modern economic development demanding the implementation of agribusiness management. In this practice, agricultural activity is directed into the production of high yield in respect to profit. This practice is mainly performed to increase income for daily spending and for longer education of children [12]. However, this system then brought some serious impact whether economically or environmentally. Conversion of traditional agroforestry into a high yield crop production has been experienced as not sustainable.

Crop production is significantly high (booming) in the initial period after shade clearance [13]. However, this production then decreased (bust) and unable to be resumed (Fig.2). This crop production was reported in Brazil and Malaysia for cacao plantations, similar to that found in Indonesia for Vanilla and also cacao. The main factor that has been considered as the cause of this problems is diseases outbreak. However, in view of plant growth and reproduction, soil

moisture and fertilities might become significant factors.

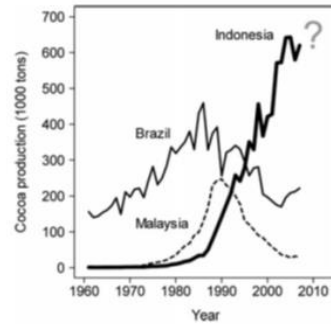
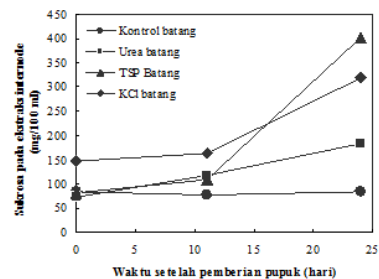
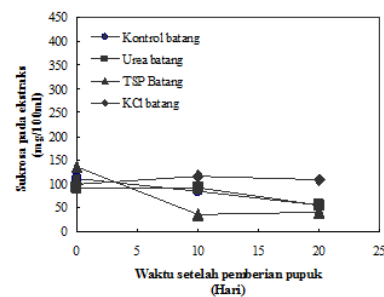


Fig.2. Boom and bust of cacao productions (Clough et al. 2009)

Studies which were aimed to resume crop production were conducted using various approaches, such as the use of disease free vanilla seedlings or improving soil fertilities by addition of synthetic fertilizers. Experiments that conducted to examine the effect of fertilizer on growth of vanilla were conducted for two year [14]. In these experiments, the growth of vanilla plants was monitored after application of various fertilizers. This experiment examined a hypothesis that slow vanilla growth is attributed by low amount of nutrient available for uptake. These experiments found that vanilla required fertilizers only in a particular dosage (Figs. 3a, b).



Figs. 3a,b. Sucrose content in internode of Vanilla plants after addition of various fertilizer (Adiputra et al. 2008)

After a prolonged observation, this vanilla plants then almost totally unable to continue growth. It is speculated that fertilizer does not the main cause of growth inhibition. Accordingly, in order to examine more comprehensive study on the effect of fertilizer to plants growth, further experiment was then conducted using orchid seedlings.

This experiment concluded that synthetic fertilizer absorbed by plant could inhibit physiological mechanisms [15]. Fertilizers taken up via leaves system may squeeze water from physiological machinery in the leaves (Fig.4). These experiments imply that there is more likely that vanilla plant was inhibited by water deficit, rather than soil fertilities. This example of difficulties in resuming crop yields after booming then has a significant effect on environment and income.

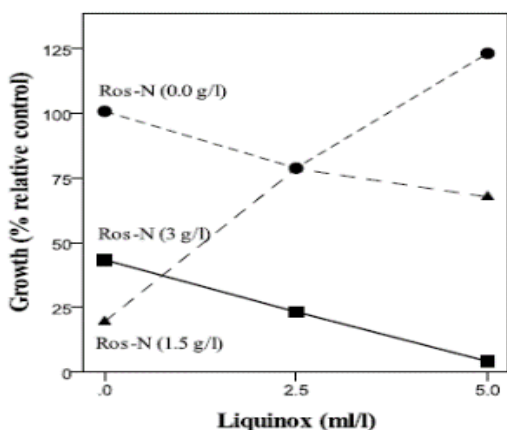


Fig. 4. Growth of orchid seedlings after application of fertilizer (Adiputra 2014)

Decreasing crop productivity, such as Vanilla and cacao, directly decreased income particularly for people whose income depended on the crops. Therefore, in order to resume production, all possible method then applied, such as increasing dosages and rate of pesticides and fertilizers applications. However, without sufficient knowledge on soil and plant characteristic, application of synthetic compounds into plantations may be useless or endanger environment and human health. This practice has widely concern conservationist since these chemical compounds contain heavy metal that endanger not only human health but also soil biota and environment [16, 17]. By contrast, diseases outbreak is hardly

controlled without the involvement of the synthetic fungicide.

Farmlands previously grown cacao then changed into trees plantations. This plantation very likely influenced by green movement, such as one billion trees programs [18]. This program is really a good support for the forest function in maintaining fresh water cycles and coping global warming issues. However, without crop plants, there is a little worry since small holder farmer may undergo a scarifying income for daily spending. Unlike crop plants, where harvests are conducted more than twice a year, trees have to be grown for about 10 years before a single harvest.

A compromise option and has already been practice traditionally is agroforestry. This system may not produce yield as high as that in shading clearance methods, but environmentally much more sustainable. For example, agroforestry system has been known to have a capacity to maintain fresh water cycles and soil moisture [6] which is very important in maintaining plant growth [5]. Therefore, it is speculated that agroforestry which involving trees in production of crop is a suitable practice for sustainable environment and income for small holder farmer. Problems raised by this system should then become a priority for researcher in finding the solutions. For example, climate changes which reduce crop production urgently require varieties-resilient breeding [19].

Summary

It is concluded that enhancing the capacity of rain forest to slow water runoff via optimization of agroforestry would mitigates constraints of food productions and impact of extremes climate changes.

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