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INITIATIVE FOR DEVELOPING *Moringa oleifera* AS *GALENGAN* CROP IN MIXED CROPPING SYSTEM FOR SUPPORTING SUSTAINABLE AGRICULTURE IN POTERAN ISLAND

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ABSTRACT

All of agricultural land in Poteran Island has a dry land with dry climate which is used for food crop cultivation to fulfill food need and farmer income sources. In this area, the farmers have been cultivating several food crops by using mixed cropping farming system. The combining crop is corn or cassava and legumes such as peanuts, green beans, and pigeon pea. Mixed cropping is done traditionally by using inorganic and organic fertilizers. To increase conservation effect on the agricultural land, it needs to modify the traditional mixed cropping system by using Moringa as *Galengan* crop. This paper tries to describe the role of *Moringa oleifera* to support sustainable agriculture ecologically and economically. *Moringa oleifera* which is incorporated in the mixed cropping can reach about 640 trees/ha planted in *galengan* with the row 1.5 meters between plants. These plants can be used as climbing poles for *Piper retrofractum* that has high economic value. In fact, the farmer can harvest *Piper retrofractum* 96 kg/year, assuming a yield of 0.15 kg per tree. *Moringa oleifera* as a component of mixed cropping also provide benefits to increase biodiversity, and its potential as biofertilizer, biopesticide, and natural growth regulators to support sustainable agro-ecosystems. In addition, nutrient-rich *Moringa* can be used for improving the farmer community nutrition.

Key words: *Moringa oleifera, mixed cropping, Galengan crop*

INTRODUCTION

In the Poteran island, land resources available for agriculture is low land with dry climates E5 category. Soil temperature regime is hot and soil moisture regime is rather dry (Disperta Sumenep, 2005). The main obstacle in this land use is limited water so it cannot be planted throughout the year. As another dry land, scarcity of water causes only selected plants can be growth. Generally, farmers cultivate annual crops and perennial like corn, peanuts, cassava, pigeon pea, bean, teak, neem, palm, and tree of coastal area.

Besides ecological factors, the constraint on the dry land in Poteran Island is the narrow land of the farmer's, with an average of only less than 0.5 ha (Bapenas, 2014). With

this narrow land the farmers are required to be able to meet the need for food, fodder, and income for their household needs. The activities in dry land farming is a farmer strategy to fulfill household food needs (Kumar and Shivay, 2008).

In an effort to fulfill food needs, farmers develop a corn-based polyculture system (mixed cropping) or cassava-based, while the combination crop is peanuts, pigeon pea, and bean. Local knowledge of farmers needs to be developed to sustain production. As in India, cropping systems developed based on ecological knowledge of farmers has benefit until the next generation (Saravasan, 2010). Reintjes (2003) suggested a combination of plant species in mixed cropping is potential to support sustainable agriculture. Some ecological and economic advantages were obtained from mixed cropping (Malézieux *et al.*, 2009). Legume contribute to improve soil fertility through biological nitrogen fixation and has the effect of storing N in the soil (Wani *et al.*, 1995; Haizel, 1974). In addition, mixture cereal with legume encouraged to increase biodiversity in below ground (Qiao *et al.*, 2012).

Although mixed cropping has been applied by the farmers in Poteran island, the crop biodiversity in agricultural land still needs to be improved. To select the combined plants, ecology and economy advantages to be considered. Malezieux *et al.* (2008) stated that in multispecies systems ecology and agronomy concepts need to be combined. It is intended to optimize the use of natural resources. To improve the biodiversity of organisms in this area, one of the ways is to utilize the galengan (embankment) by planting crops that potential as a source of organic fertilizer and pesticide, feed and also having high economic value. One of them is Moringa plant. This plant can be used as a climbing pole of Java long pepper that has high economic value (Setiawan *et al.*, 2013). Besides to increase plant biodiversity, biological interaction between these two plants can support pest control. Java long pepper not only can serve as repellent plants to control pests (Su, 1990), but also can increase farmers' income.

Based on observation and several studies literature, the writing of this paper is intended to provide overview advantages of Moringa as a galengan (embankment) crop to support sustainable agriculture.

METHODS

Paper was writen based on observation results of plant cultivation and land resources in Poteran island, and literature study related to Moringa potential, java long pepper, mixed cropping. Furthermore, the potential of Moringa as galengan crops in mixed cropping in order to provide agricultural sustainability in Poteran Island was studied.

FARMING PRACTICES IN POTERAN ISLAND

Agricultural land in Poteran island is low land with dry climate. The predominant soil in this area are Litosol and mediteran, so the main barriers to the development of agriculture in this region is the shallow soil profiles , water availability is limited , and sensitive to erosion (Disperta Kabupaten Sumenep, 2005). Because of the water supply depend on rainfall, so farmers choose to cultivate several crops that relatively tolerant to water stress. Crops cultivated like food crops include cereals and legumes, perennial crops (Coconut, jackfruit, mango, and breadfruit). Agriculture Department of Sumenep Regency (2005) reported that coconut as perennial crops is the highest planting area. Horticulture such as water melon also cultivated at the end of the rainy season after the corn harvested (Isdiantoni, 2014). Other horticulture crops that selected by farmers are onion, chili, banana, sugar apple. The largest horticultural area in the village of Palasa (Isdiantoni, 2014).

Planting the crops that they select becomes a source of their food and income, as is the case in other dry land area ((Ferreira *et al*., 2008). Observation results showed that commonly, farmers grow the food crops such as corn, cassava, peanuts, green beans, and pigeon pea in mixed cropping. Local corn variety Talango and Adira cassava was planted in rows and the bean planted without row arrangement. Otherwise, horticulture crops grown monoculture. But there is also some farmers grow chili as the intercrop. The chili planted before the corn harvested. Farmers manage the crop traditionally. They use inorganic fertilizer in excessive doses and combine with low doses of organic fertilizer. Weeding was done by pulling the weed and using traditional tools. To meet the water need of the crops farmer use groundwater efficiently. Water from the well was flowed to the field by polyethylene pipe.

MIXED CROPPING AND ITS BENEFIT

Planting two or more species of plants on the same land namely mixed cropping. There are many different combination of crops planted in dry land was identified. For instance, corn combined with legumes, cereal with cereal, cereal with horticulture crops (Ndakidemi, 2006; Molla and Sharaiha 2010). Combination of these plants are managed in

various ways, such as traditional or modern. Selecting cultivated plant depends on the purpose of farmers, whether used to fulfill basic food needs, as a source of protein, or fodder. Mixed cropping can improve the plant biodiversity. Conservation of biodiversity above and below ground is important to keep the agro-ecosystem service (Van Noordwijk and Hairiah, 2006). Even though polyculture systems supporting sustainable agriculture (Reijntjes et al., 1999), but the management needs to pay attention to conservation measures so that production can be sustainable (Ramert *et al.*, 2002).

Agronomic and ecological principles need to be considered in combining plants, (Malezieux, 2009). Plants that combined in a mixed cropping should be chosen which can improve soil fertility, efficient use of resources, and complement each other. For the conservation of nutrients, legumes are often combined with the cereal crop, due to its ability to fix N2. (Bohlool *et al*., 1992). In the legume-cereal cropping system occured a transfer of nitrogen from legume to cereal, so production of cropping system increased (Fujita *et al.*, 1992). Nitrogen assimilation is transferred through interaction of the root system of legume and cereal. By utilizing BNF soil fertility can be improved (Haizel, 1974). This biological N fixation can be exploited to develop sustainable agriculture (Wani *et al*., 1995). Forage legumes have real impact on the sustainability of farming systems (Elzaki *et al.*, 2013). It was also reported that mixed cropping can also lead to greater diversity of bacteria in rizofer (Qiao *et al*., 2012) .While, FAO (2009) states that the BNF and biodiversity become a mainstay for increased agro-ecosystems productivity.

In addition to a transfer of nitrogen in the cereal-legume combinations (Fujita *et al.*, 1992), the root interactions may facilitate the provision of growth hormone, amino acids, enzymes extracellular, biofumigation which is a resource and plant growth is important for plants growing in low fertility soil and low-input agroecosystem (Hauggaard-Nielsen and Jensen, 2005). Based on the agronomic concept, the development of mixed cropping in dry land is the right thing in order to utilizing resources and nutrient conservation.

In terms of agronomy, important characters of each plant are combined is also important to note. Combining the character is intended to improve productivity through the use of dry land resources. As well, barley crop combined with wheat under consideration has the character of rapid early growth, while wheat has a slow initial growth so that the peak nutritional needs different that can reduce the level of nutrient competition (Molla and Sharaiha, 2010). Cereal-legume mixture where there are differences in the size and depth of the root system causing plants use water and nutrients from the different soil layers (Staniak

et al., 2014). It was also reported that the use of resources in a mixed cropping better than monocultures, so that be obtained the advantage in resources arrest.

Mixed cropping also potential be used as a tool to control plant pests and dispeases (Ramert *et al.*, 2002). Similarly, Frison (2011) states the diversity of plants can be used to anticipate the attack of pests and diseases. The population of natural enemies of plant pests in mixed cropping is higher compared to monoculture, while the pest population decreases (Altieri, 1999; Ramert *et al.*, 2002). *Brassica napus* is grown with cereal or legumes can suppress insect pests and parasitoids of insect pests in support (Paulsen *et al.*, 2006). The development of new pests can be inhibited by increasing the diversity of plants in the field that drives the abundance of natural enemies (Lin, 2011). This means that mixed cropping aimed at increasing biodiversity can be used to suppress the emergence of new pests. But according Ratnadass *et al.* (2012) the use of plant species diversity to control pests and plant diseases have limitations in terms of the ability of pests and diseases using plants as alternative hosts.

Herbaceous perennial polyculture increased production 73% compared to monoculture, and increase in species abundance followed by increasing productivity (Picasso *et al.*, 2008). Application of mixed cropping will increase the efficiency of land use that can be viewed using the Land equivalent ratio (LER) indicator (Malezieux *et al.*, 2009). Mixture of two or more species in the same land LER obtain more than one means of mixed cropping is advantageous. Cropping systems that encourage ecosystem services will reduce the risk of yield loss and more resistant to environmental changes (Lin, 2011).

Growing different crops through intercropping or mixed cropping has several advantages compare with monoculture such as, improve the food and nutritional security of households, generating cash income from the sale of different product, improve soil fertility and reduce certain pest and diseases, conservation of agro-biodiversity (in situ), and effective use of resource (Katwal, 2013).

INTEGRATE MORINGA AS GALENGAN CROPS IN MIXED CROPPING

As described previously, mixed croping applied for ecological and economic benefit. Application of mixed cropping is expected to increase biodiversity. Improvement is necessary to preserve the biodiversity of agro-ecosystem that can provide ecological services to increase food production. According Gliessman (2000) such farmer formation diversity will improve the conditions of abiotic and improve biotic diversity, so resulting in improved quality of agricultural systems. Altieri (1999) showed that the planned biodiversity (ei mixed cropping)

promote ecosystem functions such as pest regulation, nutrient cycling, water and soil conservation. In addition, it also creates conditions that promote is associated biodiversity. Therefore, it can be used as a strategy for achieving sustainable agriculture. Plants combined should be selected which crops complementary to each other in using the resources and support the sustainability of production.

Moringa plant has the potential to be introduced to the dry land by in mixed cropping management. These plants can be planted in galengan (embankment) to maximize land use and increase agro-ecosystems biodiversity. The advantages of this plant is growing rapidly and is a perennial, it is low demand for soil nutrients and water (Foidl *et al.*, 2001). In addition *Moringa* leaves have economic value that demand is increasing (Amaglo, 2006).

Combines *Moringa* in the mixed cropping as galengan crops is a strategy to develop sustainable agriculture. With this strategy will be obtained various advantages, namely:

1. Increase Biodiversity

   Moringa is a tree that can be used as climbing pole of Java long pepper, so that besides *Moringa* also can be developed Java long pepper that has high economic value. Therefore, the incorporation of these plants in mixed cropping will increase the diversity of plants in dry land. Existing condition on dry land shows that the area planted corn, cassava, beans in mixed cropping systems. While galengan (embankment) only planted tree of coastal area and cacti as a fence. Integrating perennial crops to improve biodiversity is a viable strategy to improve health of agro-ecosystem (Liebman *et al.*, 2013). There is a significant relationship between biodiversity with sustainability ecosystem in mixed cropping (Elzalki *et al.*, 2013).

2. Increase the effective use of resources

   Moringa has deep roots (Krisnadi, 2015), so combined it in mixed cropping as embankment plants avoid competition between plant species in the use of nutrients and water. Moreover, supported the growth of these plants need low in soil nutrients and water (Foidl *et al.*, 2001). Likewise, when Moringa is used as pole climbing of java long pepper, because its roots are deep, and the roots of java long pepper resembling roots that grow from cuttings, roots structure shallow and short radius (Zuchri, 2008; Djauhariya and Rasman, 2009). Java long pepper adaptive to shade, and can grow to 50-75% of solar radiation (Djauhariya and Rasman, 2009). So, associate this crop with Moringa obtain a number of potential agronomic benefit such as more capturing of soil nutrition and increasing solar radiation use efficiency. In Ethiopia moringa tree is planted in dry land

intercropping system, resulted the arrest of soil nutrients and solar radiation is more optimal than mono cropping (Jiru *et al.*, 2006).

3. Material of organic fertilizers, natural growth regulators, and botanical pesticides

   Growing the *Moringa* tree in bunds (embankment) will harvest the leaves and seeds. *Moringa* seeds can be used as fertilizer and its application in corn fields can increase the nutrients available to plants within a short period of time (Emmanuel *et al.*, 2011). Similarly, compost of moringa seed can increase the abundance of invertebrates indiginius (FAO, 2010). Other studies have shown that *Moringa* leaf extract can inhibit the growth of E. coli bacteria significantly (Nugroho, 2013). *Moringa* leaves are extracted with 80% ethanol containing growth hormone type cytokinine and when sprayed through the leaves cause the plants to grow faster and are more resistant to pest and disease (Foidl *et al.*, 2001). It shows that the planting of Moringa in embankment will support the realization of sustainable agriculture.

4. Sources of food and fodder

   Poteran island community has been accustomed to consumption of *Moringa* leaf which is used as a vegetable. Generally, young leaves and young pods are consumed. *Moringa* leaf is a source of protein, provitamin A, vitamin B and C, and minerals (Foidl, *et al.,* 2001). Vitamin C content of the leaves ranged from 7.09 to 9.67 g kg-1 dry matter depending on the planting site (Foidl *et al.*, 2001). Above-ground parts of the plant consists of 30-31% leafs and the rest is a stems and petioles that can be used as animal feed (Amaglo, 2006). Crude protein content of the leaf can reach 23.64% (Jiru *et al.*, 2006), while the stems containing 8.6% crude protein (Nouman et al., 2014). The digestibility of *Moringa* that measured by in vitro organic matter digestibility showed the material easily digested by human and livestock (Jiru *et al.*, 2006). So, *Moringa* can be used to improve community nutrition.

5. Increase farmers' income

   Moringa incorporation in mixed cropping as galengan (embankment) plant will obtain various benefits as described earlier. Among them *Moringa* can be used as a climbing pole of java long pepper. By planting *Moringa oleifera* in embankment with 1.5 m spacing, it will obtain 640 *Moringa* trees per hectare that can be used as a climbing pole of java long pepper. The productive plant age 2 years or older, the average production reached 2 kg/tree/year (Djauhariya and Rosman, 2009). However, based on the resulted of interviews with farmers in Talango showed that the production of java long pepper in this

area is only 150 grams/tree/year. This low production due to cultivation technology that applied has not been in accordance with the standards of crop management of java long pepper. Moreover, it can also be caused by low soil fertility. Based on the results of interviews with farmers, each hectare will be gained additional income of Rp 7.968 million, per year. This additional revenue could be used farm capital and meeting the needs of farmers' cash. With the improvement of cultivation techniques are concerned with standards of Good Agricultural Practices (GAP) allow increased production of java long pepper. In turn, it will increase the income of farmers.

Based on *Moringa* potential to support sustainable agriculture in dry land require various researchs related to cultivation technology that can enhance the ecological and economic advantages incorporation of *Moringa* in mixed cropping.

CONCLUSIONS

Development of *Moringa* as a galengan crop on mixed cropping can be used as a strategy to bring into reality of sustainable agriculture, because of its potential as a source of biofertilizer, biopesticide, natural growth regulator, and increase of biodiversity. Besides that, it can be use as strategy to increase the farmers incomes in dry land. To develop it as galengan crop required various research that related to technology cultivation to maximize the ecological and economic advantages.

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