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SHORT COMMUNICATION

The Use of Bokashi to Enhance Agricultural Productivity of Marginal Soils in Southeast Sulawesi, Indonesia.

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Abstract

The yield of agriculture crops tends to be decreasing in many parts of world including in Indonesian farmers' land. One of the causes of the decreased yields is the reduction of organic matter in the soil. Peanut is one of the important crops in southeast Sulawesi and is usually intercropped with maize. However, the yield of peanut and maize crops were low as they were grown in marginal lands that have low nutrient contents, low CEC, high acidity, and low organic matter. The objectives of this paper were to summarize the results of our studies on the use of bio fertilizer bokashi plus fertilizer to improve peanut yields grown in marginal soil in southeast Sulawesi, Indonesia. The study also examined the agronomical performance of several local peanut varieties which had high adaptability to the local conditions and marginal lands. The results of this study demonstrated that application of mulch and bokashi increased maize and peanut production, seed dry weight and 100-seed weight. This practice has potentials to be applied in other agricultural lands of southeast Sulawesi region with similar soil and climatic condition to increase peanut yield, and promote the sustainable agriculture production of the region.

Key words: biofertilizer, land use change, marginal lands, peanut, Celebes island

Introduction

The increase in human population worldwide, particularly in the developing countries, has put tremendous pressures on land. The expansion of agricultural land for food production has been directly responsible for the reduction of forests and grass lands. When an area is converted from a natural system to an agricultural system the soil organic matter can decline of up to 60% within a few years of clearing and cultivation.

In Sulawesi regions farmers have grown peanuts either in mono cropping or multiple cropping to optimize the quantity and quality of the products. However, the peanut production has not yet met the demand of the region, particularly due to marginal lands used for peanut production.

The potential of biomass accumulation from secondary vegetation as a source of organic materials for marginal lands in southeast Sulawei has not been explored. Secondary vegetation contained nutrients required to improve the fertility of the marginal lands. Among dominated plants found in the abandoned fallow in southeast Sulawesi region were *Chromolaena odorata* L. which has been recognized as a plant species that have association with mycorrhiza (Halim, 2008).

Southeast Sulawesi is one of the six provinces in Sulawesi Island, geographically located in the eastern part of Indonesia covering the total area of 38,140 km^2 with various soil types and farming systems. Ultisol is the predominant soil type (60.3%) of marginal land in south east Sulawesi, and the smallholder farmers grow crops on these lands. Ultisols limiting factors include low fertility, low organic matter content, low cation exchange capacity, shallow top soil, and high acidity (Pasolon, 1998; Karimuna, 2000); these limitations have led to low agriculture production in this region (Karimuna, 2003).Therefore, it is important to explore the use of sustainable technology to improve soil fertility in order to increase crop production on marginal land.

Bio fertilizer contains living microorganisms which, when applied to soil, colonizes the rhizosphere and can promote plant growth by increasing the supply or availability of primary nutrients to the host plant

(Ahrens et al., 1983). Bio-fertilizers add nutrients through the natural processes of nitrogen fixation, solubilizing phosphorus, and stimulating plant growth through the synthesis of growth-promoting substances. Bio-fertilizers have potentials to reduce the use of chemical fertilizers and pesticides. The microorganisms in bio-fertilizers can restore the soil's natural nutrient cycle and build up the organic matter in marginal soils.

In Java peanut and other agricultural crops are commonly cultivated in arable land and have high yields. However, most of favored lands used for staple foods in Java located in flat areas have been converted into industrial areas, ecotourism, and housing, which has led to the big gap between the demand and supply of agricultural produces in Indonesia, particularly in the last ten years.

The general objective of this research is to promote sustainable agricultural production in Sulawesi area. The research was funded by Higher Education Directorate, Indonesian Ministry of Agriculture under the scheme of Master plan for the accelerated development of the Indonesian economy through agriculture. Improvement in agricultural production in the Sulawesi Corridor is expected to boost the local economy and increase the welfare of the smallholder farmers in the region.

The specific objectives were to evaluate the performance of the local peanut cultivars that based on our past studies have high adaptability to survive in marginal lands; and to determine the benefits of using bokashi-plus fertilizer in enhancing soil fertility and crop production in marginal soils.

Materials and Methods

Study Location

The study of biomass accumulation of fallow vegetation was carried out in Buke and Amasara villages, Tinanggea district. The site is characterized by three predominant shrubs growing in the area, *Chromolaena odorata* L, *Imperata cylindrica* L. Beauv, and *Colopogonium mucunoides* L. Studies on various technology of secondary vegetation were conducted from 2010 to 2013. Field tests on the effects of biological fertilizer treated by EM4 and mulch treatment derived from secondary vegetation on the growth and yield of intercropped maize and peanut were carried out at the farmer's land at Abeli village, Kendari, and at the experimental fields of Faculty of Animal Science, University of Halu Oleo, Kendari (3.9985° S, 122.5130° E), Sulawesi, Indonesia. The application of biofertilizer bokashi on the growth and yield of peanut in marginal lands was conducted at Wali village, Watuputih district, Muna Regency from July to December 2014.

Materials and Methods

Biomass accumulation and nutrient stocks following 2, 3, 4, 6, 8 and 10 years of fallow were quantified. Plant materials used were maize "Bisi 2", six local ecotypes of peanut "Wadaga", "Lasehau", "Parigi", "Kolaka", "South Konawe", and "East Kolaka" (Table 1), and a commercial peanut cultivar "Gajah". Mulches were sourced from secondary vegetation.

Data Collection and Analyses

The local peanut ecotypes were collected from 17 districts of Southeast Sulawesi provinces and scored for the agronomical and physical characters. All data were tabulated using excel and analyzed using ANOVA using SAS version 2012.

Results

Biomass and Nutrient Stocks from Secondary Vegetation

The use of biomass from secondary vegetation as a source of bokashi fertilizer combined with mycorrhiza had shown the promising results to improve crop production in Ultisols. Biomass accumulation after 2, 3, 4, 6, 8 and 10 years of fallow were 11, 22.7, 34.2, 68.5, 108 and 235 t.ha-1, whereas range of N, P, K, Ca and Mg were 123 to 758, 9.4 to 68.1, 113 to 939, 94.8 to 1054, and 38.8 to 209.7 kg.ha-1, respectively.

Identification of Peanut Local Ecotypes

From this study 30 ecotypes have been collected from various districts of Southeast Sulawesi provinces. These ecotypes vary in their morphological characteristics and yields. Six out of 30 ecotypes grown in the farmers' land had high yields of 1.1 to 1.3 $t.ha^{-1}$ as shown in Table 1.

Effects of various doses of mulch and bokashi on the yields of intercropped maize and peanut are shown in Table 2.

Even though the effects mulch and bokashi were not always significant, increases in mulch and bokashi doses generally increased maize and peanut production, seed dry weight and 100-seed weight (Table 2). This finding confirmed the hypothesis that organic substance application can increase crop productivity in ultisols. Sahs and Lesoing (1985)

Table 1. Six peanut ecotypes collected from different districts of southeast Sulawesi provinces, Indonesia

No.	Local variety name /ecotype	Seed morphology	Pod morphology	Yield (t.ha^{-1})
1.	"Wadaga"			1.1-1.2
2.	"Lasehao'"			1.1-1.3
3.	"Parigi"			1.1-1.2
4.	"Kolaka"			1.1
5.	"South Konawe'"			1.0
6.	"East Kolaka"			1.0

Table 2. The yields of intercropped peanut and maize treated with mulch and bokashi

Doses ($t\ ha^{-1}$)	Tissue compaction	100-seed weight of peanut (g)	Peanut seed dry weight ($t.ha^{-1}$)	Tissue compaction	100-seed weight of maize (g)	Maize seed dry weight ($t.ha^{-1}$)
Mulch						
0	Less	26.95	1.84 b	Medium	17.36 b	6.27
4	Less	27.26	2.12 ab	Medium	19.15 ab	7.08
8	Medium	30.87	2.31 a	High	21.95 a	8.49
Bokashi						
0	Less	27.68	1.854 b	Less	18.45	6.74 b
5	Medium	28.94	2.153 ab	Medium	20.49	7.98 ab
10	Medium	31.74	2.377 a	High	21.56	8.32 a

Note: Values followed by different letters at the same column (a-c) were significantly different at DMRT 5%.

also reported similar results in maize using synthetic fertilizer versus manure. Manure-treated plots had significantly higher yields in during drought year (Sahs and Lesoing, 1985). Similar results and observations were also reported by the USDA organic farming team (USDA, 1980). Mulch treatment protects plants from high temperatures and creates good microclimate to support plant growth (Soepardi, 1983, Hakim, 1986). Decomposed mulch might increase soil fertility (Histiani, 2005; Parr, 1982).

One of the important indicators of a successful agribusiness is its impacts on community welfare. Table 4 described the results of the study conducted by Maros Cereal Research Center in 2004. This study reported that integrated crop system of "Lamuru" maize using combined organic and in organic fertilizers not only increased maize production but also increased farmers' revenue (Table 4).

Table 4. Productivity and revenue of maize in an integrated cropping system in dry season in Maros, South Sulawesi.

No	Description	Average Revenue of South Sulawesi Farmer	Integrated Agricultural System
1.	Productivity ($t.ha^{-1}$)	4.81	7.87
2.	Production Value (Rupiah per ha^{-1})	3,281,625 (US$ 260)	5,366,250 (US$ 426)
3.	Production Budget (Rupiah per ha^{-1})	2,054,725 (US$163)	2,320,750 (US$134)
4.	Benefit	1,226,950 (US$ 98)	3,045,500 (US$ 242)

Source: www.balitsereal.com, Cereal Research Center, Maros, South Sulawesi (1US$ = Rp. 12,600,-).

Discussion

Biofertilizers derived from secondary vegetation could improve soil fertility through soil nutrient recovery. Therefore, the use of bokashi could be one of the good alternatives to improve soil fertility and ensure the sustainability of crop yield cultivated in marginal lands. The use of bokashi could reduce land clearing through the use of the converted lands. Other studies by Karimuna (2006a, 2006b, 2007, 2009) demonstrated that the use of agrobost and mulch significantly increased yield of intercropped maize and peanut in ultisols up to 9 $t.ha^{-1}$ for maize, and 1.78 $t.ha^{-1}$ for peanut in dry season (Karimuna, 2009).

The role of biomass in improving soil fertility have been discussed in Seubert et al. (1977), Aweto (1981), Denich (1989), Burger (1991) and Silva et al (1998). In these studies the biomass accumulation in four and six years fallow was 34 and 69 $t.ha^{-1}$, respectively. Silva et al. (1998) reported that six year secondary vegetation produced biomass up to 53 $t.ha^{-1}$. Similarly Denich (1989) reported that four to five years of fallow increased the total biomass up to 28 $t.ha^{-1}$. More recently the terms alternative, regenerative low-input have been used to describe farming systems that recycle on-farm organic resources and off-farm materials such as municipal wastes, to maintain or improve soil productivity (USDA, 1980). Biomass from fallow vegetation may protect and maintain soil fertility by changing preparation from slash and burn to slash and mulch. Similar studies to replace slash and burn practices in Amazon were reported by Kato (1998).

The results of this study has provided an alternative effort to restoring the productivity of marginal, degraded, and infertile soils in the southeast Sulawesi as it has demonstrated that changes in cultural practices could promote crop quality and yields. The addition of bokashi could potentially reduce the cost of chemical fertilizers, and improve the growth of beneficial soil microorganism which would maintain the natural habitat of the soil.

Selection of local ecotypes that have high yield and adaptability to the local environment will ensure agricultural sustainability in the south east Sulawesi region. Intercropping of maize with peanut may contribute nutrient through nitrogen enrichment in the soil (Turmudi, 2002). The results of this study has supported the main objective of Master plan for Acceleration of Indonesian Economic Development in Sulawesi Corridor, Indonesia.

Conclusions

Application of bokashi and organic matters derived from secondary vegetation improved agricultural crops productivity. This practice has potentials to be applied in other sites of southeast Sulawesi region with similar soil and climatic condition to promote the stability and sustainability of agriculture production of the region. The use of local variety for peanut and maize is recommended due to their high adaptability to the local condition. Further research should be conducted to determine the interaction of organic amendments, soil types, climates, and crop productivity to create sustainable crop production systems in Sulawesi.

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References

Ahrens, E., Elsaidy, S., Samaras, Samaras F., and Wistinghausen, E. (1983). Significance of fertilization for the post-harvest condition of vegetables, especially spinach. In “Environmentally Sound Agriculture” (W. Lockeretz, ed.), pp. 239-246. Praeger, New York.

Aweto, A.O. (1981). Secondary succession and soil fertility restoration in South-Western Nigeria III; soil and vegetation inter relations. *Journal of Biology Nigeria* **69**, 957-963.

Burger, D.M. (1991). “Land use in the Eastern Amazon region in Studies on the utilization and Conservation of soil in the Eastern Amazon region”. Final report EMBRAPA-CPATU-GTZ, p. 69-93.

Denich, M. (1989). Untersuchungen zur Bedeutung der Sekundaervegetation fuer die Nutzung der Produktivitaetssysteme in mostlichen Amazonasgebieten, Brazilien. Göttinger Beiträgezur Land- und Forstwirtschaft in den Tropen und Subtropen 46. 265 pp.

Hakim, N. (1986). “Introduction to Soil Science”. University of Lampung, Lampung Province.

Halim. (2008). “Exploration of Weed Indigenous Mycorrhiza”. Faculty of Agriculture, University of Halu Oleo, Kendari.

Histiani. (2005). “Efficiency test of various bokashi fertilizers and SP-36 doses on the growth and yield of peanut (*Arachis hypogaea* L.) local variety from Muna”. B.Sc. Thesis. Faculty of Agriculture, University of Halu Oleo, Kendari, Indonesia

Karimuna, L. (2000). “Floristic Composition and Biomass of Fallow Vegetation In Abandoned Agricultural Field Of Southeast Sulawesi”. Georg - August- University Goettingen, Goettingen. Cuvillier Verlag Goettingen. 207 pp.

Karimuna, L. (2003). “The role of organic farming on the improvement of agriculture production in southeast Sulawesi, Indonesia”. Published in Book of Abstracts Tropentag 2003, University of Goettingen, Germany, 2003.

Karimuna, L. (2004). “Succession and vegetation analyses of fallow vegetation in abandoned agricultural fields of Southeast Sulawesi”. Fakultas Pertanian Universitas Halu Oleo, Kendari.

Karimuna, L. (2006a). “Increasing high and sustainable agricultural production through appropriate technology implementation in supporting development of agribusiness/agro-industry at Southeast Sulawesi". August 19, 2006.

Karimuna, L. (2006b). "Study of secondary vegetation treated as bokashi on the intercropped maize and soybean of smallholding farmers land in Southeast Sulawesi, Indonesia". Tropentag 2006, October 11-13, 2006, Bonn, Germany.

Karimuna, L. (2007). "Optimization use of organic fertilizer derived from secondary vegetation as bokashi in supporting National Food Security", National Seminar on Natural Resource Management of Southeast Sulawesi Region, April 2, 2005, Kendari,

Karimuna, L., Leomo, S., and Indriyani, L. (2009). "Applications of mulch technology and bokashi fertilizers derived from secondary vegetation on the growth and yield of intercropped maize and peanut in Abeli Village", Department of Agrotechnology, Faculty of Agriculture, Science and Art Technology Application Program, Institution of Extension Services, Universitas Halu Oleo, Kendari, 34 pp.

Kato, O.R. (1998). "Fire-free land preparation as an alternative to slash and burn agriculture in the Brantagina region, Eastern Amazon: Crop performance and nitrogen dynamics". PhD thesis. George-August-University. Cuvillier Verlag Goettingen. 132pp.

Parr, J. F. (1982). Composted sewage sludge, a potential resource for small farms. *In* "Research for Small Farms" (H.W. Kerr and L. Knutson, eds.), pp 90-99. USDA, ARS, Misc. Pub. No 1422, Washington DC, USA.

Pasolon, Y.B. (1998). "Concepts and Strategies for Agriculture Development in Supporting Regional Food Stability". Upland Study Center, Institution of Research, Universitas Halu Oleo, Kendari, Indonesia.

Sahs, W.W. and Lesoing. G. (1985). Crop rotation and manure versus agricultural chemicals in dryland grain production. *Soil and Water Conservation Journal* **40**, 511-516.

Seubert, C.E., Sanchez, P.A., and Valverde, C. (1977). Effects of land clearings methods on soil properties of an ultisol and crop performance in the Amazon jungle of Peru. *Tropical Agriculture Trinidad* **54**, 307-321.

Silva, M.L.Jr, Vielhauer, K., Denich M., and Vlek, P.L.G. (1998). Can tree enrichment of secondary vegetation and fire-free land preparation by cutting, chopping and mulching improve the following crops? *In* "Studying on Human Impact on Forest and Flood Plains in the Tropics" (R. Lieberei, K. Vob, and H. Bianchi, eds.), pp 110-113. German-Brazilian Research Program.

Soepardi, G. (1983). "Sifat dan Ciri Tanah". Bogor Agriculture University, Bogor.

Turmudi, E. (2002). Studies on the growth and crop development of intercropped maize and four bean cultivars in various crop spacings. *Journal of Indonesian Agriculture Sciences* **4**, 89-90.

U.S. Department of Agriculture. (1980). "Report and Recommendations on Organic Farming". U.S. GPC Washington DC. 94 pp.