THE USE OF NATURAL VEGETATION BIOMASS AS AN ALTERNATIVE OF SUSTAINABLE AGRICULTURAL PRODUCTION IN SOUTHEAST SULAWESI

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Abstract

Extensive areas of the secondary vegetation can still be found in Southeast Sulawesi forests where within these forests the slash-and-burn system is being practiced by the local farmers. When the last crop was harvested, the land was initialized to be abandoned and allowed the secondary vegetation comprising of various species composition to grow naturally. It was noted that the capacity of the natural vegetation to accumulate biomass and nutrients mainly depends on the species composition, the intensity of land degradation and soil types. The huge amount of biomass accumulated by the natural vegetation has a high potential use as an alternative sustainable crop production in the study region. A study on the quantity of the secondary vegetation biomass in different fallow ages in abandoned agricultural fields of Southeast Sulawesi was carried out. The results of recent study showed that total biomass of secondary vegetation within 2 – 15 years of fallow ages ranged from 11 – 235 ton/ha, corresponding to nutrient accumulation of 123 – 1180 kg N/ha, 9 – 110 kg P/ha and 113 – 1610 kg K/ha. This capacity of biomass as a source of organic mulch and nutrients is considerable, indicating that nutrients deriving from the biomass can to a large extent supply the demand of main crops such as upland rice and maize in the study region. The results of tested crop conducted in the farmers agricultural areas are described. A detrended correspondence analysis (DCA) using an average biomass production along the fallow ages was also analyzed. The need to seek the most suitable and sustainable agricultural system is obvious and it is assumed that the most appropriate alternative to manage the nutrient content stored in the secondary vegetation. The use of organic matter of fallow vegetation as mulch may be the most efficient use of the fallow vegetation of the region. This method could only be adopted if the land was managed by fire-free land preparation that is reasonable and turns into a promising approach in agricultural development of the region in the future.

Key words: ***Indonesia, nutrient stocks, organic mulch, shifting cultivation, spontaneous vegetation.***

Introduction

For the last two decades, Indonesian huge forest areas have been one of the core of world attentions due to the ecological implications related to the utilization of its natural resources. Agricultural activities have so far been the most important factor in environmental disturbances. In this regard, shifting cultivation practiced for centuries by the farmers has been considered one of the main activities responsible to deforestation. The level of sustainability of shifting cultivation systems could be improved by employing technology which would permit an increase in the amount of time used in cultivating an area to three or more years instead of just one or two as practiced today. Slash-and-burn system of Southeast Sulawesi regions was characterized by short cropping period (1-2 years) and long fallow period (7-10 years) as noted by KARIMUNA (2000).

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The small farmers of the region prefer to use areas with secondary vegetation due to greater ease in land clearing and, therefore, less need for labor in this operation as opposed to primary forest. Slash burning is prefered because the field are more easiliy cleaned for planting and because of the phyto-sanitary effect of fire as well as the immediate fertilizing effects afforded by the ashes of burned fallow vegetation biomass. During burning, however, large amount of nutrients lost occuring through volatilization, constituting one of the main problems for sustaining the system. The loss of nutrients during burning has been described by HÖLSCHER (1995). He found that when a 7-year-old fallow vegetation was slashed and burned and crops were planted, the highest losses of nutrients observed were caused by burning (51.3 %), removal of crop harvest (35.5 %) and leaching (13.2 %). Losses of 308 kg N/ha, 175 kg Ca /ha, 94 kg K/ha and 41 kg Mg/ha were observed.

In order to replenish these losses, initially avoiding loss by burning through better management of organic matter would be a solution. Use of fallow vegetation as mulch could be an alternative to slash burning. According to SANCHEZ et al. (1989), management of organic matter is of great importance in maintaining soil productivity. This practice also tends to maintain the area's biodiversity (DENICH, 1989; BAAR, 1997; HONDERMANN, 1995). Consequently, optimizing the management of of secondary vegetation constitutes one of the main challenges in improving agricultural production of the region in the future.

Site Description and Methods

A study of the species composition and biomass quantities was undertaken in the fallow vegetation of 2-, 3-, 4-, 5-, 6-, 8-, 10- and 15-years of Palangga and Tinanggea districts, Southeast Sulawesi, at altitude range from 180 to 220 masl, held from April 1997 to March 1998, while the tested crop using maize in the small farmers land of 3- and 7-years old fallow.were carried out in Tinanggea district from October to December 2000. The soil under cultivation are podzolic with generally low concentration of major elements and soil erosion may occur on slight but long slopes. The physico-chemical properties of the soil in the study region which was collected in the representative sites were shown in Table 1.

To analyze the floristic composition and quantify the biomass accumulation of natural vegetation based on the successional stages of development was set up using ten 1 x 5 m^2 plots which were stratified randomly placed in the selected sites of Palangga and Tinanggea districts. All plants growing within plot were recorded their Latin name, abundance and its biomass productivity. Analyzing species composition was applied using the formula from LUDWIG and REYNOLDS (1988), and MUELLER-DOMBOIS and ELLENBERG (1974). The simulation of detrended correspondence analysis (DCA) was applied (TER BRAAK and SMILAUER, 1998) using an average biomass of different fallow vegetation.

Table 1. Physical and chemical soil properties (mean value ± SE) in soil depth 0 - 15 cm in the two representative regions (Palangga and Tinanggea districts).

Soil properties	**Palangga district**	**Tinanggea district**
Sand (%)	4,0±0,6	22.0±8.5
Silt (%)	63.0±4,1	70.1±9
Clay (%)	32.4±4.7	7.9±1.1
pH (KCl)	4.6±0.1	4.3±0.1
N (mg/100 g soil)	167±8	119±11
P (mg/100 g soil)	1.12	3.32
***Exchangeable cations*:**		
K ($\mu mol_c/g$)	1.61±0.3	1.73±0.6
Ca ($\mu mol_c/g$)	57.4±3.1	23.3±3.7
Mg ($\mu mol_c/g$)	17.6±7.5	10.5±0.1
Na ($\mu mol_c/g$)	0.44±0.01	0.48±0.1
Al ($\mu mol_c/g$)	2.45±0.3	7.3±6.9
Fe ($\mu mol_c/g$)	0	0.61±0.5
Mn ($\mu mol_c/g$)	4.43±3	0.89±0.3
CEC($\mu mol_c/g$)	83.9±14	90.9±4.5

Source: Karimuna, 2000.

Results and Discussion

A. Species composition of the spontaneous vegetation

The species composition and structure of fallow vegetation varied in different stages of development, but do not change on the regional level with around 12-15 km apart. There is a significant difference found in the floristic composition among young and old fallow ages. In general, however, species composition and structure of the young fallow vegetation following shifting cultivation dominated by shrub and grasses, while in older fallow vegetation trees were dominant. This phenomenon depends on the pre-use of the sites and successional stages of development, similar to the findings by KARIMUNA (1999) and KARIMUNA (2000).

It was shown that plant species of growth form of trees and vines are dominant and comparable in the two districts (Palangga and Tinanggea), represented by 45.2 % and 46.0 %, respectively of the total species (Table 2).

Table 2. The species composition and structure of fallow vegetation based on growth form recorded in Palangga and Tinanggea districts.

Growth form	Palangga district		Tinanggea district	
	No. of species	Percentage (%)	No. of species	Percentage (%)
Trees	91	45.2	82	46.0
Vines	51	25.4	45	25.3
Herbs	37	18.4	30	16.9
Grasses	10	5.0	10	5.6
Shrubs	12	6.0	11	6.2

Species from ten families of Euphorbiaceae, Fabaceae, Rubiaceae Asteraceae, Moraceae, Apocynaceae, Clusiaceae, Convolvulaceae, Poaceae and Zingiberaceae were the most abundant and of importance families, represented by approximately 50 percent of the total. The most frequent and high abundance species recorded in almost all plots of the fallow vegetation are *Chromolaena odorata, Lygodium flexuosum*, *Homalanthus populneus*, *Imperata cylindrica*, *Lantana camara*, *Axonopus compressus* and *Cyrtococcum patens*. Families and species recorded in fallow vegetation of the study region was similar to that of secondary vegetation found in other places as reported by NAGY and PROCTOR (1997) and RISWAN and ABDULHADI (1992). The most interesting shrub species from family Asteraceae is *Chromolaena odorata* due to its capability to grow faster and is able to invade fallow land quickly which spreads rapidly not only in fallow lands but also in lands used for forestry, pasture, and plantation (SIPAYUNG et al., 1991 and MUNIAPPAN, 1996). The high variability of species composition and structure of fallow vegetation allow the capacity to adapt and occupy various climatic and environmental condition.

B. Above-ground Biomass and nutrient stocks

DCA analysis using an average biomass of fallow vegetation shows a weak separation of the two locations. Most of the younger fallows are grouped together, indicating the presence of relative homogenous dominant species contributed to biomass, while in older fallow they are scattered, indicating a dissimilar dominant species contributed to biomass. Another reason is that the rare species in this ordination do not play an important role in the grouping since they contribute a small quantity of biomass.

In this study, biomass can be defined as the amount of plant materials present in a given quadrat at a give time. The biomass of species reflects the productivity of a species in a community. In this study, the biomass of fallow vegetation of various growth forms are considered similarly. The nutrient stocks play an important role in the agricultural productivity. In tropical regions where the slash-and-burn is practiced, most of the nutrients required for the crops are derived from the ashes of the burned vegetation (KALPAGE, 1974; PIMENTAL and HEICHEL, 1991; RAMAKRISHNAN et al., 1992).

The results of study showed that the total amount of biomass accumulation in 2-, 3-, 4-, 5-, 6-, 8-, 10- and 15-yr fallow vegetation ranged from 11 to 235 t/ha. There was an increasing of biomass along the ages of fallow age, while nutrient stocks studied only in 2-, 3-, 4-, 6-, 8- and 10-yr-old fallow show an increasing trend over time (Table 3). It shows that a rapid increase of nutrient stocks for N and P, while a slow increase of K in the above-ground biomass is shown over time.

Table 3. Total nutrient stocks of nitrogen, phosphorus and potassium of above-ground biomass (kg/ha) in different ages.

Fallow age	Biomass (t/ha)	Nutrient stocks (kg/ha)		
		N	P	K
2	11	123	9.4	113
3	22.7	209	21.9	217
4	34.2	216	26.1	319
6	68.5	422	33.5	435
8	108	640	53.6	763
10	151	758	68.1	939

Source: Karimuna (2000).

The biomass of the fallow vegetation correlates with the successional stages of development. Biomass of fallow vegetation determines the amount of nutrient stock in a vegetation, whereas the nutrient concentration of each species depends upon the physiological and environmental factors where a species grows. The role of biomass in nutrient storage have been discussed by SEUBERT et al. (1977), AWETO (1981), DENICH (1989) and BURGER (1991). In this study, the biomass accumulation in 4- and 6-yr-old fallows was 34 and 69 t/ha; respectively. This is similar to the study by SILVA et al. (1998). He found that in 6-yr-old secondary vegetation produced biomass amounting to 53 t/ha. Similarly, DENICH (1989) reported that in 4-5-yr-old fallow vegetation the total biomass produced 28 t/ha.

If we consider the potential of plant biomass providing nutrients to the soil, it shows that maize, upland rice and other common crops can be sufficiently supplied with nutrients. Theoretically, when calculating the nitrogen content derived from the above-ground biomass of fallow vegetation, it is enough to supply the demand of upland rice and maize growth for 4 years of fallow. In addition, the demand of maize and upland rice for nirogen can be covered from the above-ground biomass of fallow vegetation after 6 years fallow. That means that the farmers would not need to maintain a fallow up to 7 to 10 years to have a sufficient nutrient storage for the following crops if these nutrient stocks could be conserved. The test plant using maize was carried out in the region to show the effect of organic mulch from the spontaneous vegetation on the growth and production of maize.

C. Test Plant

Maize was planted in the two different mulch conditions. The vegetal matter in 3- and 7-yr old fallow was manually cut into smaller pieces and used as organic mulch spread out in the six (3 x 5 m^2) plots of agricultural land. N, P and K fertilizer was applied to supply the demand of initial growth of maize plant. The results of test plant showed that the early growth of maize in 3-yr old fallow was better compared to that of 7-yr old fallow, but the further stages of maize development in 7-yr old fallow was surpassed. This indicates that organic mulch of natural vegetation which is decomposed to release nutrients can support a good growth of maize in tested field. This finding is comparable to the study by Kato (1998) for maize and cassava yield. Therefore, there is a possibility to utilize organic material of the spontaneous vegetation as source of mulch of the region. However, this application could only be adopted if the land was managed by free-land preparation.

Conclusions

The results of study concludes that the species composition and biomass accumulation of the spontaneous vegetation in different fallows of this study do not differ from one location to others. The present land-use practices of the smallholder appear not to threaten the species composition and biomass accumulation increases along the ages of development, corresponding to the increase of nutrient stocks. The test plant using maize shows a significant role of the use of organic mulch that guarantee the improvement of agricultural development in the study region.

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