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Research Article

Diversity of drought-resistant plants and the benefits of their biomass for improving fertility of a degraded soil of Brantas River Basin

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Abstract: In support of healthy agriculture development to improve farmer's prosperity status, soil remediation and land conservation efforts maybe relied on the use of biomass of local vegetation. Results of field exploration conducted at Brantas Watershed of East Java indicated that there were at least 154 species of undergrowth scrubs, 47 species of agriculture-plantation crops, and 59 species of road shelter trees. The native undergrowth vegetations had undergone enormous seasonal variations. Biomass of predominance vegetations, e.g. *Psophocarpus tetragonolobus, Phaseolus lunatus, Flemingia, Mimosa somian, Acacia villosa, Cassia mimosoides, Mucuna* could potentially be used as organic matter sources to improve availability of nitrogen and phosphorus in soils. The amount of nitrogen and phosphorus contributed of the plant biomass significantly correlated with quality of the biomass.

Keywords: *biomass, plant diversity, soil remediation*

Introduction

Brantas river basin has an area of 11,800 hectares and a total length of 320 km. River flow comes from the south side of Mt. Arjuno and ends in the Madura Strait. Calcareous critical land of the Brantas river basin covering the area of Malang, Blitar, Tulungagung and Trenggalek Regencies reach 92,000 ha. The topography of the land is flat, undulating, hilly, slope of 5-60%, moderate to high levels of erosion during the rainy season and dry during the dry season (Utomo, 1989).

The Brantas River Basin land survey team (1988) observed that most of the basin has a shallow soil solum, low soil fertility, low N, P, Mg and Fe. This situation is caused by low soil organic matter content (less than 1%). To maintain soil organic matter content of 2%, organic matter inputs in the form of crop residues around 8-9 t / ha / year is required (Hairiah et al., 1998). However, to obtain plant residues in large numbers in the area is very difficult. Therefore, it is necessary to find an alternative to utilizing the potential of local plant biomass as source of organic matters. Some plants in the dry season deciduous even deadly certain organs, but in the rainy season will grow back. Given the unique role of each plant species, the genetic potential of each species should be utilized according to its niche. Plants that pass the selection pressures of life can be developed to produce biomass throughout the year to improve the biological properties of the soil. However, there is only limited information about the diversity of plants that are adapted to environmental conditions in the Brantas River Basin. Utilization of biomass of plants that are adapted as sources of organic matters has not been done by farmers.

This paper reports the results of an inventory of diversity of some dominant plant and their biomass potential as sources of organic matter for improving soil fertility.

Materials and Methods

Qualitatively vegetation inventory was conducted using roaming in the Brantas River Basin partially degraded land in the rainy dry seasons. Quantitative observation of plant diversity was performed with the line intercept method on selected areas at Ngembul and Banyurip villages of Pagak District, Malang. Forty sampling plots each of 2 m long were randomly made during the dry and raining season.

The parameters measured were the density and shade of each taxon. The relative values of the density, canopy and frequencies calculated were to determine the important value index that describes the mastery of a taxon in its habitat. Plant species diversity index was calculated using the Shannon Wiener (Pielou, 1975), while the influence of the season and or location was determined by calculating the index Bray-Curtis similarity community (Krebs, 1989). Two communities are considered to have the great similarity if the similarity index is close to 100%. Potential biomass test of some dominant plants was made through decomposition and mineralization studies of plant biomass and its influence on soil fertility improvement. Fresh chopped biomass of 1-2 mm was mixed with soil and incubated for 8 weeks. Mineralization of N and P were observed for 8 weeks incubation in the laboratory. Mineralization rate constants were predicted by a single exponential model that $y1 = yo^{-kt}$ (Handayanto et al., 1994).

Results and Discussion

Plant diversity

Results of plant diversity inventory showed that in critical area of Brantas river basin during the rainy season, there were 251 taxa consisting of 144 taxa of undergrowth, 47 taxa of arable crops and 60 taxa of roadsides, shades, reforestation and other plants (Table 1). Several vegetations were found to grow in two seasons and some others were found in the rainy season only. The greatest reduction in plant species diversity from rainy season to dry season was observed for undergrowth plants.

Table 1. Seasonal variations in the number of taxa of plant communities on degraded land of Brantas River Basin

Vegetation Group	**Number of Taxa**		
	Rainy Season	**Dry Season**	**Re-duction**
Undergrowths	144	128	16
Arable Crops	47	46	1
Roadside plants	60	60	0
Total	251	234	17

Changes from the rainy season to dry season resulted in a decrease in the number of taxa. In Ngembul areas from 45 taxa in the rainy season decreased to 41 taxa in the dry season, while in Banyuurip areas hill has been a decline from 72 taxa in the rainy season to 66 taxa in the dry season (Table 2). Due to the change of seasons, there has been a shift of co-dominant vegetation in both locations. The position of *Themeda arguens* at Ngembul village with the highest IVI value in the rainy season was replaced by *Imperata cylindrica* in the dry season, while the position of *Imperata cylindrica* at Banyuurip with the highest IVI value in the rainy season was replaced by *Lantana camara* in the dry season (Table 2). The growth of *Imperata cylindrica* including helophytes was reduced by shade. This weakness was exploited by farmers to control the growth of weeds (Purnomosidi and Rahayu, 2002).

Table 2. Comparison of wild plant communities at Ngembul and Banyuurip villages during rainy season.

Location	**Rainy Season**			
	Total Species	**H**	**Co-dominant Species**	**Important Value Index (IVI) %**
Ngembul	45	4.0	*Themeda arguens*	34.6
			Imperata cylindrica	30.5
			Ageratum houstonianum	27.5
			Eulalia amaura	21.9
			Acacia villosa	19.1
			Centrosema pubescens	17.7
Banyuurip	72	4.7	*Imperata cylindrica*	26.6
			Lantana camara	24.2
			Acacia villosa	23.5
			Eragrostis sp.	22.2
			Ageratum houstonianum	21.5
			Salvia riparia	18.2

Remarks: H = diversity index; IVI = Important Value Index

Table 3. Comparison of wild plant communities at Ngembul and Banyuurip villages during dry season.

Location	Dry Season			
	Total Species	H	Co-dominant Species	Important Value Index (IVI) %
Ngembul	41	3.7	*Imperata cylindrica*	48.8
			Eulalia amaura	43.8
			Ageratum houstonianum	32.8
			Centrosema pubescens	21.2
			Thridax procumbens	20.2
			Acacia villosa	18.8
Banyuurip	66	4.5	*Lantana camara*	41.0
			Salvia riparia	34.1
			Acacia villosa	31.3
			Imperata cylindrica	26.3
			A. houstonianum	18.9
			Eragrostis sp.	17.1

Remarks: H = diversity index; IVI = Important Value Index

The addition of mineral N and P to the soil by plant biomass

Some of the dominant plant biomass was then studied their potential as sources of organic matter that can contribute nutrients for plant growth. Since the release of nutrients from organic matter, through the process of decomposition and mineralization, is associated with the quality of the organic material itself (Handayanto et al., 1995a), the quality of some biomass was analyzed (Table 3).

Table 3. Quality of pruning of various wild plants and agricultural crop residues

No	Species	C3/ C4	Energy kcal/g	C %	N %	P %	Lignin %	Poly-phenol %
1	*Acacia villosa*	C3	3,04	33.9	3.99	0.18	7.52	4.62
2	*Aeschynomene americana*	C3	2,70	35.8	2.60	0.15		
3	*Ageratum conyzoides*	C3	2,90	34.6	2.31	0.58	11.44	0.82
4	*Ageratum houstonianum*	C3	2,60	50.0	3.04	0.29	9.00	2.24
5	*Cajanus cajan*	C3	2,44	34.8	3.85	0.19		
6	*Cassia hirsuta*	C3	2,23	37.5	3.34	0.17		
7	*Cassia mimosoides*	C3	2,50	36.2	2.51	0.10	12.14	10.76
8	*Centrosema pubescens*	C3	2,56	36.6	3.11	0.07	12.82	4.80
9	*Dalbergia latifolia*	C3	3,01	37.0	2.62	0.09		
10	*Desmodium* sp	C3	2,62		2.32	0.09		
11	*Eulalia amaura*	C4	2,32	37.4	1.17	0.23		
12	*Flemingia congesta*	C3	2,76	40.6	3.08	0.18	23.6	6.32
13	*Gliricidia sepium*	C3	2,38	44.5	4.05	0.27	13.64	1.78
14	*Imperata cylindrica*	C4	2,36	38.8	0.83	0.04		
15	*Lantana camara*	C3	2,51	46.9	3.19	0.31	19.96	0.78
16	*Mimosa somian*	C3	2,48	32.8	2.99	0.14	12.20	11.24
17	*Mucuna pruriens*	C3	2,59	38.0	2.96	0.23	9.20	5.11
18	*Oplismenus burmann*	C4	1,71		1.79	0.17		
19	*Pennisetum purpureum*	C4	1,80	41.7	1.80	0.32	2.66	0.87
20	*Phaseolus lunatus*	C3	2,67	36.3	2.86	0.23	6.92	6.46
21	*Phaseolus vulgaris*	C3	2,51	36.5	3.76	0.28		
22	*Psophocarpus tetragonalobus*	C3	2,66	37.3	3.00	0.17	13.06	4.61
23	*Salvia riparia*	C3	2,52	39.7	1.76	0.12		
24	*Tectona grandis*	C3	2,05	43.5	1.31	0.13	19.68	0.53
25	*Themeda arguens*	C4	2,44	32.9	0.99	0.05		
26	*Tithonia diversifolia*	C3	2,35	43.5	5.31	0.47	5.32	2.08
27	*Zea mays*	C4	2,27	46.4	2.28	0.31	2.90	0.97

N mineralization

N mineralization was measured by the value of mineral N at 1, 2, 4, 6 and 8 weeks after incubation. From week 1 to week 8 after incubation showed the different increase in the value of mineral N depending of the organic material studied. From the first week until the last week of observation the cumulative mineral N was in the order of *Acacia villosa* (27.98 mg / kg) > *Phaseolus lunatus* (21.43 mg / kg) > *Mucuna pruriens* (19.50 mg / kg) > *Centrosema pubescens* (19.02 mg / kg) > *Flemingia sp* (16.23 mg / kg) > *Cassia mimosoides* (13.90 mg / kg) > *Psophocarpus tetragonolobus* (12.70 mg / kg) > *Mimosa somian* (11.29 mg / kg) (Figure 1).

Acacia villosa had the higher rate of N mineralization compared with other organic materials (k = 0.1114), because it contained the higher value of N total (3.994%) compared with other organic materials. *Acacia villosa* mineralization was indicated by the percentage of cumulative N mineralization percent for 8 weeks of 70.06% and the lowest value of N mineralization of 28.26% (*Mimosa somian*).

The results showed that N mineralization rate constant was strongly influenced by the quality of organic matter (Handayanto et al., 1995b). The correlation between N mineralization rate constant with the chemical composition of organic matter showed that the value kN was closely related to the initial value of N (r = 0.797). This indicates that the initial N content of organic matter greatly affected the rate of N mineralization. N content in organic materials is generally expressed as an important quality factor that controls the rate of mineralization of N from crop residues (Frankenberger and Abdelmagid, 1985, Handayanto et al., 1995a).

P mineralization

The highest value of soil available P was indicated by application of *Psophocarpus tetragonolobus*. At 4 weeks, P content increased by 63% (*Psophocarpus tetragonolobus*), but from 6 week to 8 week, the content of available P tended to decline (Figure 2).

Application of organic matter can increase the availability of P. The increase of available P depends on the quality of organic matter applied. Application of high-quality organic material will increase the availability of P. Organic materials can be considered to be of high quality if the concentration of P in the high organic matter is high. Hairiah et al. (2000) suggested that the quality of organic material that is related to the supply of P is determined by the concentration of P in the organic matter.

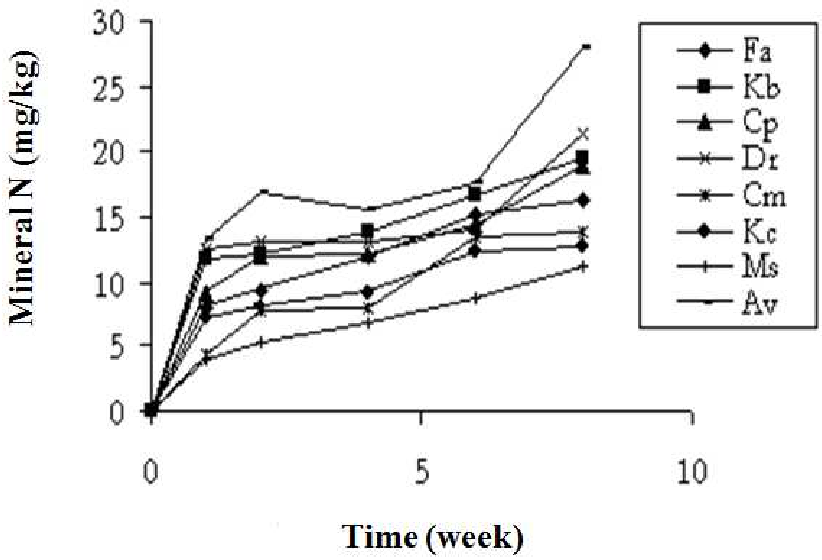

Figure 1. Cumulative N mineralized from prunings of *Flemingia congesta* (Fa), *Mucuna pruriens* (Kb), *Centrosema pubescens* (Cp), *Phaseolus lunatus* (Dr), *Cassia mimosoides* (Cm), *Psophocarpus tetragonalobus* (Kc), *Mimosa somian* (Ms), *Acacia villosa* (Av).

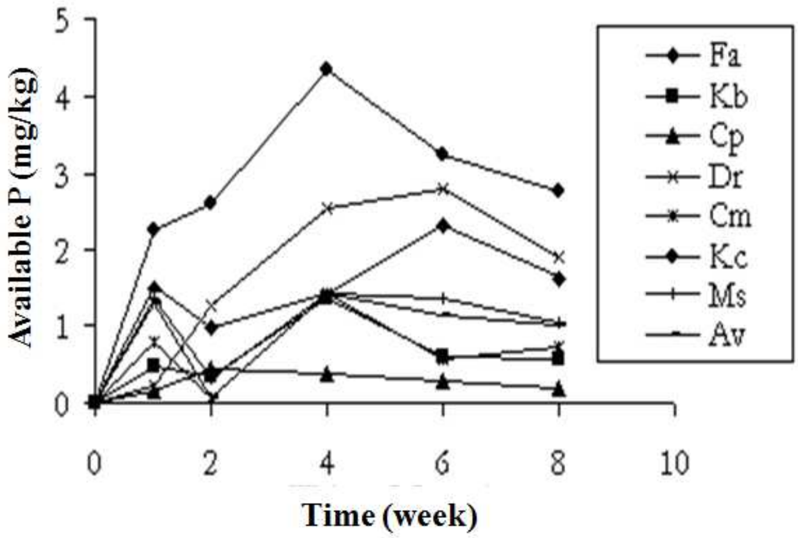

Figure 2. Cumulative P mineralized from prunings of *Flemingia congesta* (Fa), *Mucuna pruriens* (Kb), *Centrosema pubescens* (Cp), *Phaseolus lunatus* (Dr), *Cassia mimosoides* (Cm), *Psophocarpus tetragonalobus* (Kc), *Mimosa somian* (Ms), *Acacia villosa* (Av).

The critical value of P content in organic materials is 0.25%. However, in this study showed that the ratio of C / P also affected the rate of P mineralization. This was evidenced by the results of the analysis of available P performed at 1, 2, 4, 6, 8 weeks after incubation. Results the analysis showed that the highest value of available P was observed for *Psophocarpus tetragonolobus*. This is because the organic material had a higher P concentration value compared with other organic materials. However, the rate of mineralization of organic materials was relatively low. The highest mineralization rate was observed for *Flemingia congesta*. *Psophocarpus tetragonolobus* had a higher C / P ratio than *Flemingia congesta*. The C / P ratio affected the process of P mineralization. The greater the value of the C / P ratio, the lower is the rate of P mineralization. According to Stevenson (1982), the value of the low value of C / P ratio low indicates that the organic matter can decompose rapidly and thus the organic material is considered high quality.

Conclusion

There were 251 plant taxa during the rainy season and 234 taxa during the dry season at the Brantas River Basin. The highest reduction of taxa occurred for undergrowth plants. Biomass of some of the dominant plant, including *Psophocarpus tetragonolobus, Phaseolus lunatus, Flemingia congesta, Mimosa somian, Acacia villosa, Cassia mimosoides, Mucuna pruriens* were potential to be used as sources of organic matter to improve the availability of N and P in the soil. The contribution of N and P was associated with the quality (composition) biomass.

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