

Research Article

The potential of *Arachis pintoi* biomass to improve quality of soil continuously used for cassava cropping

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Abstract: A field experiment that was aimed to elucidate the effects of application of *Arachis pintoi* biomass and animal dung on quality of soil continuously used for cassava cropping was conducted at Jatikerto Village, Kromengan District of Malang Regency. Eight treatments tested were 100% NPK inorganic fertilizer, 100 kg N *Arachis pintoi*/ha, (3) 100 kg N chicken dung / ha, 100 kg N cow dung /ha, 100 kg N goat dung /ha, 100 kg N *Arachis pintoi* + chicken dung /ha, 100 kg N *Arachis pintoi* + cow dung /ha, and 100 kg N *Arachis pintoi* + goat dung /ha. Monitoring quality of top soil (0-20 cm) was carried out at planting time and 3 months after planting. Soil samples were collected and analyzed for chemical and physical properties. Yield of cassava was measured at 6 months after planting. Results of this study showed that application of organic fertilizer in forms of green manure (*Arachis pintoi* biomass), and animal dung significantly improved physical and chemical properties of soil. Application of 50% NPK combined with organic manures did not significantly gave different tuber yield with that of 100% NPK.

Keywords: *Arachis pintoi*, cassava, farmyard manures, soil quality

Introduction

Yield of cassava in Indonesia that ranges 14.3 to 18.8 t/ha is lower compared to that of normal yield of 30-40 t/ha (Prihandana et al., 2007). This low production of cassava is basically caused by the traditional management system, low inputs, and the characteristics of cassava crop itself than tend to accelerate degradation of soil fertility used for planting cassava. Cassava is a crop that has a low broad leaf canopy so it is considered less able to protect the soil from raindrop and make cassava cultivation area sensitive to erosion. Cassava is also considered as a plant that produces a low organic matter and removes more nutrients other plants. This assumption is strengthened by the fact that cassava land mostly located in marginal lands with low fertility status.

According Wargiono et al. (2000) cassava production areas are generally located in upland soil that is generally dominated by elements with low status and low organic matter and are susceptible to erosion, while crop production is highly dependent on rainfall. In general, cassava

is planted on soils classified as Alfisols, Ultisols, Entisols and Inceptisols. Sustainable land productivity can be achieved through the concept of land conservation. One of implementation concepts of land maintenance is the use of organic material that acts as a soil amendment followed by monitoring of soil quality. Larson and Pierce (1996) revealed that the content of organic matter in the soil is one of the attributes of land that has a great influence on the productivity of the land.

Soil organic matter content can be improved by application of organic manures, either green manures or farmyard manures. Green manure can be obtained from, prunings or litters and soil cover plants (Hairiah et al., 2000). Prunings of soil cover plants from the legume family can give input of organic matter from 1.8 to 2.9 t / ha (age 3 months) and 2.7 to 5.9 t / ha to 6 months old. One type of soil cover plants that has been widely used by farmers in apple plantations in Poncokusuma of Malang is *Arachis pintoi* which is known as ornamental beans. *Arachis pintoi* that was first collected by GCP Pinto in 1954 is one of

a family of herbaceous annual legume that grows spreading over the surface of the soil. Several benefits of *Arachis pintoii* are (a) controlling erosion of farming on sloping areas through the covering of soil surface by its stem arrangements that can protect the soil from raindrops, (b) forage and (c) land rehabilitation (Anonymous, 2008). The addition of organic matter in the form of manure can be either livestock manure includes cows, goat, chicken and other impurities in the form of solid or liquid.

Based on the roles and functions of green manure and manure as a soil amendment (improved physical properties of soil chemistry and biology) and as a source of nutrients, the use of organic fertilizers in land maintenance implementation can provide a solution in order to maintain sustainable land productivity. To determine the effect of soil quality improvement as the implementation of maintenance actions via the addition of organic fertilizers can be done with the activities of monitoring changes in soil quality. Changes in soil quality include changes in quality attributes (quality) of land that includes the physical, chemical and biological soil. This study was aimed to investigate the effects of application of organic fertilizers in the form of green manure *Arachis pintoii* and farmyard manures (chicken dung, cow dung and goat dung) on physical and chemical properties of soil continuously used for cassava cropping.

Materials and Methods

The study was conducted from November 2009 to June 2010 in the village of Jatikerto, Kromengan sub district, Malang. Soil of study site is classified in the order Alfisol with the following

characteristics: 0.8% organic matter content, total-N content of 0.11%, CEC 15.2 cmol / kg, P content of 8.86 mg / kg, content of 0.76 cmol K / k, the weight soil content of 1.18 g/cm³, porosity 50%, permeability of 1.06 cm / h, very stable aggregates (2.38 mm). A local variety of cassava “Tambak Urang” having a potential yield of 20-25 t / ha was planted in an experimental plot of 5 m x 6 m with a planting distance of 1 x 1 m. Eight treatments, i.e. 100% NPK fertilizer, 100 kg N *Arachis pintoii* / ha, 100 kg N chicken dung / ha, 100 kg N cow dung / ha, 100 kg N goat dung / ha, 100 kg N + *Arachis pintoii* + chicken dung / ha, 100 kg N + *Arachis pintoii* + cow dung / ha, and 100 kg N + *Arachis pintoii* + goat dung / ha, were arranged in a completely randomized block design with three replicates. The composition of organic materials used for this study is presented in Table 1.

Each plot received NPK basal fertilizers of 100 kg Urea/ha, 50 kg SP36/ha, and 50 kg KCl/ha. The rates of NPK fertilizers applied to the control treatment (no organic matter application) were 200 kg Urea/ha, 100 kg SP36/ha, and 100 kg KCl/ha. During the experiment, water was regularly supplied to ensure that water did not limit plant growth.

Monitoring of quality of top soil (0-20 cm) was performed at planting time and 3 months after planting. Soil quality parameters measured were bulk density, porosity, and permeability of soil aggregate stability, pH, organic C, contents N, P, K, CEC, and microbial population density. Cassava yield (number of tubers per plant) was observed at 6 months after planting. The data obtained were subjected to analysis of variance and Duncan test at 5% level.

Tabel 1. Chemical composition of *Arachis pintoii* biomass and animal dung.

No	Composition	Organic Materials			
		<i>Arachis pintoii</i>	Chicken dung	Cow dung	Goat dung
1.	pH (H ₂ O)	5.6	7.8	7.9	7.7
2.	C-organik (%)	36.5	13.5	13.8	30
3.	Organic Matter (%)	62.1	23	23.5	51
4.	Total NI (%)	2.2	2.5	1.3	2.2
5.	C/N	15	6	12	14
6.	P (%)	0.29	0.29	0.30	0.34
7.	K (%)	1.20	3.15	0.84	0.68
8.	Lignin (%)	0.08	0.02	0.09	0.29
9.	Polyphenol	3.61	3.35	0.49	3.61

Results and Discussion

Soil physical properties

Application of *Arachis pintoii* green manure and animal dung gave significant different effects ($\alpha = 0,05$) on soil bulk density, soil porosity, aggregate stability and soil permeability (Table 2). Compared to the initial soil quality, the soil bulk density decreased 3,3 %-11 %, soil porosity increased 6% - 17% (Table 2). Dariah and Rahman (1989) reported that the use of green manure and farmyard manure improved soil physical properties, such as reduced soil bulk density, increased total porosity and improved soil aeration. Application of farmyard manures, *F. congeta* green manure dan *Gliricidia sp* green manure each at a rate of 20 t/ha reduced soil bulk density to 0.87; 0.85 and 0.86 g/cm³, respectively, compared to control (0.93 g/cm³). Jamilah (2003) reported that application of 75 t animal dung/ha/year for 6 years increased 4% soil porosity, 14.5% soil air volume under filed

capacity, and increased 33.3% soil organic matter, as well as reduced soil compaction by 3%. Soil aggregate stability for all treatments decreased due to soil tillage and plant growth. The greatest reduction (70% in aggregate stability) was observed for NPK treatment, whereas the smallest reduction was observed for PS treatment that maintained the greatest aggregate stability ((1,19 mm) (Table 2). Stability of soil aggregate against forces that disrupt soil structure is affected by the presence of chelating agents and stabilizing agents, i.e. organic compounds (Soepardi (1983). Soil permeability increased from 1.06 cm/hour at the beginning of the experiment to 8.6-10.2 cm/hour (Table 2). Combinations of green manure and animal dungs resulted in the higher increase of soil permeability compared to application of animal dung or green manure alone. Permeability is ability of soil to deliver air or water that is measured in relation to rate of water flow at a certain time (Foth, 1994).

Table 2. Effects of application of *Arachis pintoii* biomass and animal dung on soil physical properties

Treatment *)	Bulk Density (g/cm ³)	Porosity (%)	Aggregate (mm)	Permeability (cm/hour)
100% NPK fertilizer	1.14	53.33	0.57	8.58
PH (100 kg N <i>Arachis pintoii</i> biomass/ ha)	1.12	53.00	0.67	8.72
PA (100 kg N chicken dung / ha)	1.10	54.00	0.75	9.13
PS (100 kg N cow dung / ha)	1.01	58.67	1.19	8.61
PK (100 kg N goat dung / ha)	1.07	55.00	0.81	8.68
PH + PA	1.08	56.67	0.74	10.20
PH + PS	1.08	54.67	1.04	9.87
PH + PK	1.11	54.67	1.09	10.15

The initial soil characteristics: bulk density 1.18 g/cm³, porosity 50%, aggregate 2.38 mm, permeability 1.06 cm/hour

Soil chemical and biological properties

Application of *Arachis pintoii* green manure and animal dungs also gave significant different effects ($\alpha = 0,05$) on soil chemical properties (Table 3). In comparison with the initial soil chemical properties, soil pH decreased from 10% (PS treatment) to 20% (NPK treatment) (Table 3). According to Atmojo (2003), the effect of organic matter application on soil pH depends on the decomposition stage of the organic materials added and soil types. Fresh organic materials (for example green manure), or decomposing organic matters applied to the soil will produce organic acids that in turn decrease soil pH. According to Winarso (2005), frequent application N fertilizer or high rate will decrease soil pH by 1 unit during

3-4 weeks due to nitrification reaction that releases NO₃ and H⁺.

Soil C organic content increased from 11% (PH treatment) to 38 % (PH+PAS treatment), but for the NPK treatment soil C organic content decreased by 9%. Difference in chemical compositions of organic materials used in this study also contributed to the significant influence on differences in soil organic matter content. Winarso (2005) pointed out that soil organic matter will be continuously decomposed to organic acids, CO₂, water, and carbonate forming agents, This carbonate forming agents will react with carbonate Ca and Mg in soil to form soluble bicarbonate that can easily be leached out from the soil leading to soil acidity

Application of combination of green manure and animal dungs also significantly affected total N and available P contents in the soil, but did not affect exchangeable K (Table 3). In comparison with the initial soil characteristics at the planting time, PA, PK and (PH+PK) treatments did not significantly reduce the total N content. The

highest contents of total N, available P, and exchangeable K for the tree treatment were 0.11% N, 20.4 mg P/kg and 1.33 cmol K/kg. The lowest total N content (0.09%) was observed for PH treatment, while the lowest available P content was observed for 100% NPK treatment (no addition of organic materials).

Table 3. Effects of application of *Arachis pintoi* biomass and animal dung on soil chemical and biological properties

Treatment (*)	pH	Organic C (%)	Total N (%)	Available P (mg/kg)	Exchangeable K cmol/kg	CEC (cmol/kg)	Microbial population density (propagule/g)
NPK	5.03	0.41	0.10	1.67	1.07	14.30	179333
PH	5.23	0.50	0.09	2.77	1.20	15.20	220666
PA	5.60	0.58	0.11	20.37	1.33	16.20	239333
PS	5.67	0.51	0.10	2.47	1.00	18.30	244000
PK	5.47	0.52	0.11	3.90	1.27	15.60	256333
PH + PA	5.33	0.62	0.10	3.30	1.13	15.20	308333
PH + PS	5.43	0.56	0.10	2.20	0.93	14.80	336000
PH + PK	5.30	0.62	0.11	3.33	1.23	19.40	380000

The initial soil characteristics: pH 6.30, organic C 0.45%, available 8.86 mg/kg, exchangeable K 0.76 cmol/kg, CEC 15.20 cmol/kg, microbial population density 63000 propagules/g

*) see Table 1

Application of green manure and animal dung increased CEC by 27%. In general, soil that received addition of green manure and animal dung had higher CEC than that with no addition of organic materials (i.e. 100% NPK inorganic fertilizer). Application of green manure and animal dung significantly ($\alpha = 0, 05$) affected soil CEC. The supply of N, P and K nutrients as the effects of addition of organic materials into the soil system occur through various decomposition processes involving soil microorganisms. Time needed to complete decomposition and mineralization processes ranges from day to year, depending on soil conditions and quality of organic materials added

Environmental conditions that enhance decomposition and mineralization rates were neutral pH, sufficient soil humidity, good aeration (60% of soil pores was filled with water) that related to soil microbial activities (Brady and Weil, 2002). According to Handayanto dan Hairiah (2007), quality or chemical compositions of organic matter that affect rate of organic matter decomposition was determined by the contents of N, lignin, polyphenols. Organic materials containing high N content, low lignin and

polyphenols contents are considered as high quality organic materials (Hairiah et al., 2000).

Application of green manure and animal dung increased soil microbial density (Table 3). The highest density was observed for PH+PK treatment, while the lowest density was for NPK treatment. Application of organic matters to the soil contributes to major changes on the amount and activities of soil microorganisms, decomposition and mineralization of organic matters. The increase of soil microorganism activities due to addition of organic matter as their energy sources is indicated by the release of CO₂ and energy (Soepardi, 1983).

Cassava yield

Application of chicken dung (PA treatment) resulted in the highest yield of cassava (14 tubers), followed by PA treatment (13.67 tubers), PH+PA treatment (13.60 tubers), PS treatment (13.33 tubers), PH+PK treatment (13 tubers), NPK treatment (12 tubers), and PH treatment (11.67 tubers). This results were inline with results reported by Mayadewi (1997) that chicken dung was better than cow dung or goat dung for

improving yield of sweet maize. Ammanulloh et al. (2006) also showed that application of 10 t decomposed chicken dung/ha resulted in the highest production of cassava. This is because of the higher nutrient contents in the chicken dung than that in other animal dungs, including cow and goat dungs (Hartatik and Widowati, 2008). Although there were different effects of application of green manure and animal dung on cassava yield, the differences were not significant. This is merely due to a very short experimental time.

Table 4. Number of cassava tuber per plant as affected by application of green manure and animal dung.

Treatment *)	Number of tuber per plant
NPK	12.00
PH	11.67
PA	14.33
PS	13.33
PK	13.67
PH + PA	13.60
PH + PS	11.33
PH + PK	13.00

*) see Table 1

Conclusion

Application of organic fertilizers in the form of green manure (*Arachis pintoi* biomass), and animal manure (cow dung, chicken dung, and goat dung) increased organic C content 11%-26% reduced soil bulk density 3,3%-11%; increased soil porosity 6%-17%; improved aggregate stability 0,67 mm-1,19 mm, compared to initial soil aggregate of 2,38 mm; increased soil permeability 8,6 cm/hour -10,2 cm/hour compared to the initial permeability of 1,06 cm/hour; reduced pH 9%- 17%; increased CEC 27%.

Application of cow dung gave better effects on bulk density reduction, porosity increase, and aggregate stability, than other organic matters applied. Application of chicken dung gave better effects on the increase of N, P and K contents as well as cassava yield than other organic matters applied.

Application of 100% NPK treatment resulted in quality physical, chemical and biological soil lower than the organic fertilizer treatment. Reduction of 50% NPK fertilizers accompanied with organic fertilizer production results (number of tubers per plant) were not significantly different from 100% NPK.

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