AGRIVITA VOLUME 36 No. 1 FEBRUARY - 2014 ISSN : 0126-0537

GROWTH AND YIELD OF ORGANIC RICE WITH COW MANURE APPLICATION IN THE FIRST CROPPING SEASON

Wahyu Arif Sudarsono[1*)], Maya Melati[2)] and Sandra Arifin Aziz[2)]

[1)] Department of Agrotechnology, Faculty of Agriculture, Halu Oleo University
Jl. H.E.A. Mokodompit, Kampus Hijau Bumi Tridharma Anduonohu 93232, Kendari
[2)]Department of Agronomy and Horticulture, Faculty of Agriculture, Bogor Agriculture Institute
Jl. Meranti, Kampus IPB Darmaga 16680, Bogor
[*)]Corresponding author Email: wahyoe_as@yahoo.com Phone:+62-81297111570

Received: November 21, 2013/ Accepted: April 30, 2014

ABSTRACT

The study was addressed to investigating the effect of cow manure application rate on organic rice growth and yield in the first cropping season. The study was conducted from January to April 2012 in Blora, Central Java, Indonesia. The experiment was arranged in Randomized Complete Block Design, consisting of four treatments and four replications. There were two types of control treatments i.e. organic fertilizer treatments (statistically analyzed) and conventional fertilizer (not statistically analyzed). The treatments were corn biomass, corn biomass+cow manure (7.5 tons ha^{-1}), corn biomass+cow manure (10 tons ha^{-1}) and cow manure (10 tons ha^{-1}) with square spacing of 20 cm x 20 cm. The organic control treatments were corn biomass+sheep manure (7.5 tons ha^{-1}) with spacing of 20 cm x 20 cm and corn biomass+cow manure (7.5 tons ha^{-1}) with double-row spacing of 40 cm x 25 cm x 15 cm. For every treatment, the rate of corn biomass was 3 tons ha^{-1}. All organic treatments were also added with 3 tons rice hull ash ha^{-1}. The application of cow manure (10 tons ha^{-1}) with square spacing or corn biomass+cow manure (7.5 tons ha^{-1}) with double-row spacing resulted in better performance than those of other treatments.

Keywords: corn biomass, grumosol, organic farming, rice hull ash, sheep manure

INTRODUCTION

The use of chemical fertilizers in rice cultivation potentially reduce soil fertility. The use of P and K fertilizers on rice in a long run may lead to nutrient imbalance in the soil resulting in lower rice productivity (*leveling off*) (Sofyan *et al*., 2004). To improve physical, chemical and biological properties of soil, organic fertilizer can be applied. Several studies have shown that the regular application of organic fertilizer, especially manure, could increase the soil org-P fraction (Reddy *et al.*, 2000), the availability of C and soil microbial activity (Manna *et al.*, 2007), and soil organic matter, N use efficiency and rice yield (Xu *et al.*, 2008). In addition, the use of crops biomass such as rice straw for organic fertilizer (incorporated with chemical fertilizer) has also been carried out in several studies (Eagle *et al.* (2000), Zhu (2007) and Kaewpradit *et al.* (2009)).

As a crops nutrient supplier, organic fertilizer can be used in organic rice cultivation. Currently, demand of organic rice in Indonesia is increasing. This was shown by the establishment of organic rice farmer associations in Klaten and Magelang, Central Java; Bogor and Bandung, West Java; and Magetan, East Java (Andoko, 2010). For consumers, organic rice is believed to be healthier because it does not contain chemical residues. For farmers, organic rice cultivation is profitable because it can improve soil fertility and its selling price is higher than conventional rice.

Most people in Blora work as farmers who grow rice during rainy season. Currently, farmers in Blora are using more chemical fertilizer rather than organic fertilizer because organic fertilizer is needed in large amounts so it is considered inefficient. Rice straw is generally not buried or incorporated in the soil, but used as animal feed. Nevertheless, some farmers add

Accredited SK No.: 81/DIKTI/Kep/2011

http://dx.doi.org/10.17503/Agrivita-2014-36-1-p019-025

corn biomass as a green manure into the soil of experimental field. The corn biomass is produced by planting corn at the beginning of rainy season. Corn biomass are buried in the soil during high rainfall (along with land preparation for rice cultivation). This habit needs to be studied thoroughly in an experiment, so its effects on rice can be determined.

The characteristic of corn biomass may not be able to support the rice growth due to its low biomass, which led to low nutrient supply. To fulfill nutrient demand of the crop, additional input is necessary and it can be supplemented with cow manure, which is widely available in the experimental field. Therefore, this experiment was aimed to study the effect of cow manure rates on organic rice growth and yield components in the first cropping season.

MATERIALS AND METHODS

The experiment was conducted in rainfed paddy field at 31 m above sea level with rainfall average of 1,697 mm per year (year 2003-2011). The experiment was conducted in the first cropping season of organic trials, i.e. January to April 2012 in Nglebur, Jiken, Blora, Central Java. The experiment used Ciherang rice variety, cow manure, sheep manure, rice hull ash and organic pesticides, i.e. leaf extract of *Andrographis paniculata, Azadirachta indica* and *Glyricidia sepium* and biological pesticide *Beauveria* (organic fertilizer nutrient contents are listed in Table 1). Conventional control treatment used commercial orgnic fertilizer, urea, NPK 15:15:15 and chemical pesticide with Dimehipo active ingredient.

Randomized complete block design (RCBD) with a single factor (cow manure rates) with four treatments (Table 2), four replications, and two control treatments (organic and conventional) used in the experiment. Data of cow manure treatments were statistically analyzed using analysis of variance (ANOVA). When significantly different, the data was further tested with Duncan Multiple Range Test (DMRT) at α=5%. Then, the best cow manure treatment was compared to the two organic control treatments using t-test at α=5%, but not statistically compared to the conventional control treatment because the conventional treatment consists of one replication only.

Each plot size was 8 m x 8 m. Manure application was applied twice: 1). 2/3 of manure rate was incorporated together with corn biomass during land preparation (2 weeks before planting), and 2). the rest of manure was broadcast at 2 weeks after planting (WAP). This second manure application was applied because the plants showed nutrient deficiency symptoms.

Three 21 day-old seedlings were planted in a hole. Rice in cow manure treatments were planted in square spacing of 20 cm x 20 cm (population 250,000 clumps ha^{-1}), while the control treatments were planted in double-row spacing of 40 cm x 25 cm x 15 cm (population 215,278 clumps ha^{-1}) and square spacing of 20 cm x 20 cm (Table 2).

Table 1. Organic fertilizer nutrient content

Organic fertilizer	Nutrient content (%)						C/N Ratio
	C	N	P	K	Ca	Mg	
Cow manure	28.42	1.06	0.74	1.25	1.44	0.44	26.81
Sheep manure	19.83	0.87	0.75	1.72	6.93	5.37	22.79
Corn biomass	43.94	0.89	0.15	0.67	na	na	49.37
Rice hull ash	4.00	0.16	0.36	0.41	0.83	0.14	25.00

Remarks: na = not analyzed

Table 2. Treatments used in the experiment

Treatment	Rate (ton ha^{-1})			Spacing
	Corn biomass	Cow manure	Sheep manure	
Treatment				
1	3	-	-	20 cm x 20 cm
2	3	7.5	-	20 cm x 20 cm
3	3	10	-	20 cm x 20 cm
4	-	10	-	20 cm x 20 cm
Organic control				
1	3	7.5	-	40 cm x 25 cm x 15 cm
2	3	-	7.5	20 cm x 20 cm
Conventional control				
1	Petroganik (160 kg ha^{-1}) + NPK 15:15:15 (400 kg ha^{-1}) + urea (400 kg ha^{-1})			20 cm x 20 cm

Plant pest was controlled by spraying organic pesticide and planting *Cymbopogon nardus* as repellant plant onto every plot corner. Grains were harvested when approximately 90-95% of panicles turned yellow or at 30-35 days after flowering.

Vegetative growth variables observed in the experiment included plant height, number of tillers, plant dry weight, root length, leaf area, pest attack percentage, leaf nutrient content, total plant nutrient uptake, net assimilation rate (NAR) and relative growth rate (RGR). Yield component variables observed included number of rice productive tillers, number of grains per panicle, weight of 1000 grains, dry straw weight per plant, and rice yield per ha.

Soil analysis was done twice, i.e. 1). before experiment (composite) and 2). after experiment (soil sample of each treatment). Analysis of leaf NPK nutrient content was performed at 7 WAP.

RESULTS AND DISCUSSION

The experiment was conducted during rainy season with rainfall of 148-246 mm per month. Soil type of the experimental field was grumosol with sand, silt and clay composition 33.99, 24.45 and 33.99%, respectively. Soil analysis after the experiment showed that the soil microbial population, value of org-C, total N, K and Mg decreased in all organic treatments (Table 3). The decline of soil microbial population may be caused by field flooding (reductive condition). According to Kogel-Knabner *et al*. (2010) field flooding cuts off the oxygen supply from the atmosphere which switches soil microbial activities in organic matter fermentation from aerobic to facultative or anaerobic condition. The value of soil pH and available P also decreased after the experiment, except in organic control treatment with double-row spacing. The decreases were due to nutrient immobilization especially from corn biomass (C/N ratio= 49.37) composition and nutrient absorption by plants. However, the composition of corn biomass increased the value of Ca, Mg and CEC when compared to treatment without corn biomass.

The dominant pests attacking rice were caterpillar, grasshopper, rice stem borer (*Tryporiza* sp.) and *Leptocorisa acuta*. Diseases mostly found were bacterial leaf blight (*Xanthomonas orizae*) and brown spotting (*Helminthosporium oryzae*). Harvesting was done at 14 WAP.

Vegetative Growth

The statistical analysis showed that in general the application of 10 ton ha^{-1} cow manure (without corn biomass) resulted in better plant growth and yield than other main treatments, although not statistically different in all variables. The variables' value due to the application of 10 tons ha^{-1} cow manure were then compared with the variables' value of the two organic control treatments using t-test. Based on the t-test results, the application of 10 tons ha^{-1} cow manure was not significantly different from the two organic control treatments, either in vegetative or yield component variables.

The application of 10 tons ha^{-1} cow manure increased plant height and number of rice tillers at 7 WAP up to 5.6 and 22.9 %, respectively, compared with no manure application (P<0.05), and were higher than those of other cow manure rates applications (P>0.05) (Table 4). This cow manure application rate was also generating plant dry weight and leaf area up to 19.3 and 6.5 %, respectively, than without manure (P>0.05). Nonetheless, the variables' value due to the application of 10 tons ha^{-1} cow manure was lower than those of control treatment with application of 3 tons ha^{-1} corn biomass + 7.5 tons ha^{-1} cow manure with double-row spacing (P>0.05).

Manure application resulted in greater plant dry weight and root length than those without manure application (P>0.05), but still lower than those of conventional (chemical) fertilizer treatment. The chemical fertilization resulted in higher plant growth variables, except root length. This might occur due to the higher nutrient availability from chemical fertilizer, so plants do not require intensive root to absorb nutrients from the soil (Melati *et al.*, 2008).

The treatment of 3 ton ha^{-1} corn biomass + 7.5 tons ha^{-1} cow manure with double-row spacing produced higher leaf P and K content, and plant uptake of N, P and K than those of other cow manure treatments (P>0.05) (Table 5). The higher leaf nutrient content and plant uptake of K in this treatment could lower pest attack compared with other organic fertilizer treatments (P>0.05). In addition, the wider distance among row of plants at double-row spacing allowed more optimal application of organic pesticides (more parts of plant are exposed to spray). According to Munawar (2011) K nutrient in the plant tissue plays a role in plant defense system against pest attack by forming a cuticle layer and increasing the plant enzyme activity. Compared with the all organic treatments, the conventional treatment had lower pest attact due to higher plant K uptake and chemical pesticide application was more effective in controlling pest (Table 4 and 5).

Table 3. Soil analysis before and after the experiment

Variable	**Unit**	**Before**	**After**					
			Treatment				**Organic Control**	
			CB 3 +			**CM 10**	**CB 3 +**	
			CM 0	**CM 7.5**	**CM 10**		**CM 7.5 + D**	**SM 7.5**
Microbes population	SPK g^{-1} x 10^{4}	6,500.00	3,435.00	1,455.00	2,020.00	950.00	1,885.00	3,060.00
pH	-	6.40	6.20	6.10	6.50	6.10	6.80	6.20
Org-C	%	1.52	0.96	1.12	0.40	1.36	1.36	0.96
Total N	%	0.14	0.09	0.10	0.05	0.12	0.13	0.09
P_2O_5 Bray	ppm	14.8	9.00	10.20	11.50	12.30	17.20	11.00
K	me 100 g^{-1} soil	0.64	0.17	0.50	0.41	0.19	0.48	0.48
Ca	me 100 g^{-1} soil	23.66	27.14	33.68	34.65	22.84	35.29	33.46
Mg	me 100 g^{-1} soil	5.89	3.05	4.08	3.81	2.44	3.96	4.15
CEC	me 100 g^{-1} soil	34.49	36.51	42.04	39.72	27.66	41.96	43.50

Remarks: SPK: colony-forming unit, CB: corn biomass, CM: cow manure, SM: sheep manure; number following letter in the treatment cells shows manure rate (ton ha^{-1})

Table 4. Vegetative growth per plant at 7 WAP

Variable	Treatment				Control		
	CB 3 +			CM 10	CB 3 +		Conventional
	CM 0	CM 7.5	CM 10		CM 7.5 + D	SM 7.5	
Plant height (cm)	59.21b	61.08ab	61.84a	62.55a	64.53	61.56	77.35
No. of tillers	11.8b	13.1ab	13.2ab	14.5a	13.5	14.5	22.0
Plant dry weight (g)	8.76	9.07	10.21	10.45	10.43	10.59	20.47
Root length (cm)	19.13	21.75	21.75	21.25	23.06	20.94	16.00
Leaf area (cm^2)	512.75	493.76	524.93	546.11	600.68	585.66	1387.71
Pest attack (%)	71.3	75.6	72.5	71.9	69.4	71.9	30.0

Remarks: 1)Numbers within the same row followed by the different letter are significantly different by DMRT at α=5%.
2) CB: corn biomass, CM: cow manure, SM: sheep manure, D: double-row spacing; number following letter in treatment cells shows manure rate (ton ha^{-1})

Table 5. Nutrient content and total nutrient uptake of rice at 7 WAP

Variable	Treatment				Control		
	CB 3 +			CM 10	CB 3 +		Conventional
	CM 0	CM 7.5	CM 10		CM 7.5 + D	SM 7.5	
Leaf N content (%)	2.05	1.82	1.46	1.69	1.73	1.67	2.81
Leaf P content (%)	0.35	0.34	0.34	0.34	0.36	0.34	0.36
Leaf K content (%)	2.46	2.63	2.86	2.74	2.89	2.74	2.37
Total N uptake (mg tan^{-1})	175.92	168.88	148.71	178.19	180.73	176.23	575.24
Total P uptake (mg tan^{-1})	30.59	30.74	34.50	35.55	37.54	35.74	73.69
Total K uptake (mg tan^{-1})	215.20	238.82	294.26	288.61	301.61	290.33	485.17

Remarks: CB: corn biomass, CM: cow manure, SM: sheep manure, D: double-row spacing; number following letter in treatment cells shows manure rate (ton ha^{-1})

Application of cow manure did not result in a significant effect on LAB and LTR (Figure 1). The values of LAB and LTR at 5-7 WAP were lower than those at 3-5 MST which were only up to 58.2% and 74.9%, respectively. According to Gardner *et al*. (1991) the value of LAB decreases with increasing leaf area index (LAI) as long as the plant growth, as a result of the increasing number of leaves that shaded each other. Similar to LAB, Sugito *et al.* (2006) showed that the value of LTR also decreased with increasing age of plant.

Yield Components

The application of cow manure increased the number of rice productive tillers ($P<0.01$), weight of 1000 grains, grain weight and dry straw weight per plant ($P>0.05$), but these values were still lower than those of conventional treatment due to the higher pest attack in the organic treatments (Table 6). Plant in conventional treatment had better value on those parameters which was supported by the higher leaf N content and plant uptake of N, P and K.

Although the numbers of rice productive tillers were statistically different, the rice yield per ha was not significantly different among cow manure treatments. The application of 10 tons ha^{-1} of cow manure produced higher dry weight of straw per plant, 19.9 % greater than no manure application ($P>0.05$). The higher dry weight of straw per plant increased *source*, and supported with higher total plant nutrient uptake of K, produced higher number of grains per panicle, grain weight per plant and rice yield per ha. Potassium (K) affects quality of grain production, especially during the grain filling process (Liu *et al*., 2011). The rice yield resulting from the application of 10 tons ha^{-1} cow of manure was 3.61 ton ha^{-1}, same with the control treatment of 3 tons ha^{-1} corn biomass + 7.5 tons ha^{-1} of cow manure application with double-row spacing ($P>0.05$) (Figure 2).

In general, the application of 10 tons ha^{-1} cow manure (without corn biomass) produced better vegetative growth and yield components than other main treatments that used corn biomass. The use of corn biomass as a green manure might cause nutrient immobilization because it has high C/N ratio (49.37). Harada *et al*. (1993) reported that the decomposition process was still going on in the organic fertilizer with high C/N ratio, resulting in N immobilization and phytotoxic compounds such as phenolic acids and volatile fatty acids. The use of crops biomass as organic fertilizer was also done in research by Eagle *et al.* (2000) which showed that the use of straw as green manure, where no synthetic N fertilizer was applied, caused insufficient levels of N (N immobilization) and rice yield until the third year of the study. The potential for nutrient immobilization due to composition of crops biomass indicated that the organic fertilizer application needed to be done carefully without having to leave the practice.

Despite the lower population (215,278 clumps per ha) and the corn biomass applied, the application of 3 tons ha^{-1} corn biomass + 7.5 tons ha^{-1} cow manure with double-row spacing produced higher number of grains per panicle, weight of 1000 grains, grain weight and dry weight of straw per plant as well as the rice yield per ha than other organic fertilizer treatments. Maximum rice yield prediction (grain weight per plant x population per ha) produced by this treatment was also higher (4.70 tons ha^{-1}) compared to the application of 10 tons ha^{-1} cow manure (4.66 tons ha^{-1}) (data not shown). The higher yield was supported by double-row spacing advantage. Abdulrachman *et al.* (2013) wrote that double-row spacing had wider distance among row of plants, so that inner plants, as well as outer plants in a plot, could optimally obtain sunlight that allows better photosynthesis (*border effect*). Furthermore, it was suspected that the incoming sunlight reached the soil (indicated by warm soil) which was able to reduce the nutrient immobilization influence due to the corn biomass composition.

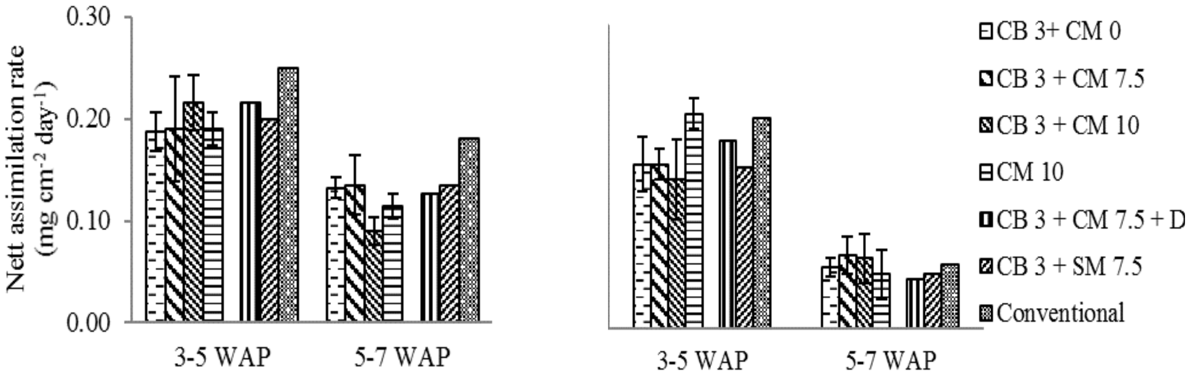

Figure 1. Net assimilation rate (NAR) and Relative growth rate (GRG) of rice

Table 6. Yield components per plant

Variable	Treatment				Control		
	CB 3 +			CM 10	CB 3 +		Conventional
	CM 0	CM 7.5	CM 10		CM 7.5 + D	SM 7.5	
No. of productive tillers	6.9c	8.0a	7.3bc	7.5b	7.9	7.8	10.6
No. of grain per panicle	127.8	129.5	126.8	135.5	152.8	127.9	171.9
Weight of 1000 grains (g)	26.42	26.57	26.63	26.55	26.64	25.95	27.43
Grain weight (g)	16.12	16.29	17.21	18.65	21.82	17.37	23.86
Straw weight (g)	35.08	37.68	38.85	42.08	46.65	39.35	90.80

Remarks: [1)] Numbers within the same row followed by the different letter are significantly different by DMRT at α=5%.[2)] CB: corn biomass, CM: cow manure, SM: sheep manure, D: double-row spacing; number following letter in treatment cells shows manure rate (ton ha^{-1})

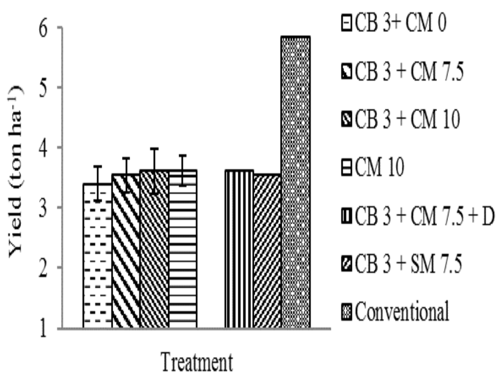

Figure 2. Rice yield per ha

Urea and NPK fertilization on conventional rice cultivation stimulated better vegetative growth, so that rice production reached up to 94.6-158.9% greater than that of the organic rice. This suggested that the conventional rice had a greater *source*, so as to produce the higher number of rice productive tillers, number of grains per panicle, weight of 1000 grains, grain weight per plant and rice yield compared with those of organic rice. The rice yield produced by the conventional fertilization was 5.83 ton ha^{-1}.

CONCLUSION

There was a tendency that the application of 10 tons ha^{-1} cow manure with square spacing of 20 cm x 20 cm or the application of 3 tons ha^{-1} corn biomass + 7.5 tons ha^{-1} cow manure with double-row spacing of 40 cm x 25 cm x 15 cm resulted in higher rice yield per ha when compared with other treatments in the first cropping season.

ACKNOWLEDGEMENTS

This experiment is a part of research program of "Good Agricultural Practices (GAP) of Rice and Soybean Production under Organic Farming System" funded by I-MHERE (Indonesia Managing Higher Education for Relevance and Efficiency) Performance-Based Contract IPB B2.C with SPK No. 17/IT3.24/SPP/I-MHERE/2012 received by the second author.

REFERENCES

Abdulrachman, S., M.J. Mejaya, N. Agustiani, I. Gunawan, P. Sasmita, and A. Guswara. 2013. Cropping systems of Legowo. Suharna, editors. Agency for Agricultural Research and Development. Ministry of Agriculture, Republic of Indonesia. Jakarta (in Indonesian).

Andoko, A. 2010. Inorganic rice cultivation. Penebar Swadaya, Jakarta. (in Indonesian).

Eagle, A.J., J.A. Bird, W.R. Horwath, B.A. Linguist, S.M. Brouder, J.E. Hill and C. van Kessel. 2000. Rice yield and nitrogen utilization efficiency under alternative straw management practices. Agron. J (92): 1096-1103.

Gardner, F.P., R.B. Pearce and R.L. Mitchell. 1991. Physiology of crop plants. Herawati S, Translator. Jakarta: UI Press, Jakarta. (in Indonesian).

Harada, Y., K. Haga, T. Osada and M. Koshino. 1993. Quality of compost produced from animal wastes. JARQ 26 (4): 238-246.

Kaewpradit, W., B. Toomsan, G. Cadisch, P. Vityakon, V. Limpinuntana, P. Saenjan, S. Jogloy, and A. Patanothai. 2009. Mixing groundnut residues and rice straw to improve rice yield and N use efficiency. Field Crops Research 110: 130-138.

Kogel-Knabner, I., W. Amelung, Z. Cao, S. Fiedler, P. Frenzel, R. Jahn, K. Kalbitz, A. Kolbl and M. Schloter. 2010. Biogeochemistry of paddy soils. Geoderma 157: 1-14.

Liu, L.J., E.H. Chang, M.M. Fan, Z.Q. Wang and J.C. Yang. 2011. Effects of potassium and calcium on root excudates and grain quality during grain filling. Acta Agron. Sin. 37 (4): 661-669.

Manna, M.C., A. Swarup, R.H. Wanjari, B. Mishra and D.K. Shahi. 2007. Long-term fertilization, manure and liming effects on soil organic matter and crop yields. Soil and Tillage Research 94: 397-409.

Melati, M., A. Asiah and D. Rianawati. 2008. Application of organic manure and its residue for young soybean production. Bul. Agron. 36 (3): 204–213. (in Indonesian).

Munawar, A. 2011. Soil Fertility and Plant Nutrition. IPB Press, Bogor. (in Indonesia)

Reddy, D.D., A.S. Rao dan T.R. Rupa. 2000. Effects of continuous use of cattle manure and fertilizer phosphorus on crop yields and soil organic phosphorus in a Vertisol. Bioresource Technology 75: 113-118.

Sofyan, A., Nurjaya and A. Kasno. 2004. Soil nutrient status for manure recommendations.http://www.balittanah.litbang.deptan.go.id/dokumentasi/buku/tanahsawah/tanahsawah3.pdf. [20 Oktober 2013].

Sugito, Y., E. Handayanto and E. Murniyanto. 2006. Leaf activity, growth, and efficiency of solar energy arroids edible tubers under the shade. Agrivita (28)1: 1-7. (in Indonesian).

Xu, M.G., D.C. Li, J.M. Li, D.Z. Qin, K. Yagi and Y. Hosen. 2008. Affects of organic manure application with chemical fertilizers on nutrient absorption and yield rice in Hunan of Southern China. Agricultural Sciences in China 7 (10): 1245-1252.

Zhu, N. 2007. Effect of low C/N ratio on aerobic composting of swine manure with rice straw. Bioresource Technology 98: 9-13.