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Effect of Cow Manure Dosages as Organic Fertilizer on the Productivity of Organic Rice in West Sumatra, Indonesia

Atman[1], B. Bakrie[2], R. Indrasti[2]

[1]Assessment Institute for Agricultural Technology (AIAT), West Sumatra. Jl. Raya Padang-Solok Km 40, Sukarami. Gunung Talang Solok, West Sumatra Province. Indonesia- 27365.
[2]Indonesian Center for Agricultural Technology Assessment and Development (ICATAD), Bogor. Jl. Tentara Pelajar No.10, Kampus Penelitian Pertanian, Cimanggu. City of Bogor, West Java Province. Indonesia -16114.
Corresponding Email: bachtarbakrie@yahoo.com

***Abstract*— *This research was conducted on rice paddy area at the Simarasok Village, West Sumatra Province, Indonesia, aimed at investigating the effect of dosage of cow dung as organic fertilizer on growth, yield component and production of organic rice. The experiment was arranged using a Complete Randomized Block Design with four treatments and six replications. The treatment was organic fertilizer of cow dung composted using local microbial organisms with four dosage levels, namely: a) 2 tons/ha; b) 4 tons/ha; c) 6 tons/ha; and d) 8 tons/ha. The rice variety used was the Kuriak Kusuik and the observed variables included: leaf color score, plant height, maximum number of tillers, number of productive tillers, panicle length, number of grains per panicle, percentage of empty grain, weight of 1000 grains, and grain yield. The result showed that the dosage of organic fertilizer of cow dung had significant effect on leaf color score at 56 days after planting (DAP), number of productive tillers, number of grains per panicle, and grain yield. In contrast, plant height, maximum number of tillers, panicle length, weight of 1,000 grains, and empty grain were not significantly affected. It was found that there was a positive relationship between the dosages of organic fertilizer of cow dung with the grain yield. The addition of cow dung as the organic fertilizer as much as 1 ton/ha to the soil could cause an increase in the yield of grain by 0.097 ton/ha.*

Keywords*—*Cow dung, Kuriak Kusuik rice, Organic fertilizer, Rice paddy, West Sumatra

I. INTRODUCTION

The organic farming system is agricultural development through a sustainable agricultural development approach, where inputs are natural and the use of chemical fertilizers, synthetic chemical pesticides, and genetic engineering for seeds, are prohibited (Jamil, *et al*., 2014). In the Province of West Sumatra, this organic farming system has been developed in the last few decades. It was recorded that, in 2007, the total area of organic rice farming was only 77.81 ha and has increased to 138.48 ha in the year period of 2013-2016. The rate of increase is relatively slow due to: a) lack of relevant institutional support, b) wide range of cross-consultation between agricultural experts and policy makers, c) low productivity of organic paddy rice, d) the un-competitiveness of the organic product price, and e) lack of farmers' interest to manage organic paddy rice (Daniel, *et al*., 2014)

The world market demand for organic agricultural products is growing rapidly about 20% per year (ISRI, 2004). In 1998, total sales of organic food products worldwide reached US$ 13 billion, increasing to US$ 26 billion in 2001 (CHO West Sumatra, 2010). Based on the growth rate of about 20% per year, it is estimated that total sales of organic food products would reach US$ 400 billion in 2020. Increasing demand for organic products may be due to the followings: a) the strengthening of environmental awareness and healthy lifestyle of the society, b) government policy support, c) support of food processing industry, d) support of modern market (supermarket absorb approximately 50% of the organic products); e) high price at consumer level; f) generic label; and g) incessant national campaign of organic farming. However, the problem is, the only realizable market share of the organic products is only 0.5-2.0%. Although the area of organic farming in Europe continues to increase, from an average of less than 1.0 percent in 1987 to 2.0-7.0% in 1997 (highest in Austria reaching 10.12%), the increase has not been able to meet the rapid demand (IAARD, 2005).

One of the factors that must be considered in producing organic rice is the management of soil fertility. To meet the nutrient needs of the plant, the effort to increase the fertility of the soil naturally, which may be done through recycling of plant nutrients or the use of compost from animal manure. All of these efforts are targeted to the improvement of biological activity, as well as physical, and soil chemistry. The use of organic fertilizer derived from rice straw or animal manure is an alternative way to organic rice farming system in accordance with the National Standard of Indonesia (NSI) No: 01-6729-2002 (ANSI, 2002).

The organic rice field in Simarasok Village of Baso District, Agam Regency, has been developed since the planting season of January 2009. The problem was the low productivity of the rice, which was only 4.2 ton/ha (Atman and Nurnayetti, 2014). Non-organic rice productivity in West Sumatra in 2015 was 5.02 ton/ha, lower than the national productivity of 5.15 ton/ha (ISB, 2015). This low productivity may be due to the majority of the farmers (63.3%) still using local varieties, including the local organic rice variety, the Kuriak Kusuik (Nurnayetti and Atman, 2013). However, other studies have shown that the use of Integrated Crop Management technology of paddy rice with the Kuriak Kusuik variety was able to produce 7.74 ton/ha or 28.1% higher than farmer technology (6.04 ton/ha) (Winardi, 2014). On the study reported by Zen (2013), it was found that the use of improved varieties (Cisokan and IR42) were able to give rice production of 6.23 ton/ha and 6.31 ton/ha, respectively.

Another reason of the low productivity of organic paddy rice is the diversity in the use of organic fertilizers. The use of organic fertilizer on paddy rice has begun to be encouraged by local government since 2007 due to the growing issue of the damage of the quality of the rice fields (Sumarno and Kartasasmita, 2012). Organic fertilizer is a biological buffer that has the function in improving the physical, chemical, and biological properties of the soil in order to provide balanced amounts of nutrients. There is a positive correlation between organic matter content and soil productivity (Adiningsih, *et al.*, 1995). According to Kartaatmadja *et al.* (2000), the amounts of nutrients transported from the soil on the rice farming system with yield rate of 8.0 ton/ha, are 269 kg N, 44 kg P2O5, 207 kg K2O, 28 kg Mg, and 24 kg S respectively. Therefore to ensure the stability of yield and sustainability of the production system, it is absolutely necessary to return nutrients in the form of organic materials or fertilizers to the soil.

The addition of organic fertilizers can increase the content of organic carbon, increase water holding capacity, and crop yields including biomass and seeds Materechera and Mehuys, 1991). According to Pratiwi and Sumarno (2014), the provision of manure of 5 ton/ha can only replace 20% of the recommended inorganic NPK fertilizer dosage on rice crops. While Kasno and Hidayat (2006), stated that the addition of manure of 2 ton/ha in paddy rice can reduce SP36 fertilizer requirement by 60%, and the use of straw as much as 5 ton/ha can reduce the requirement of KCl fertilizer by 78%.

Kasno and Rostaman (2017) found that the soil organic matter content can affect the efficiency in the use of N fertilizer, thus becoming a limiting factor for paddy rice growth. Furthermore, Sujitno *et al*. (2014), states that organic fertilizers can increase the productivity of paddy rice, ranging from 21.07 to 23.33%. In upland rice, the provision of manure can increase yield, between 19.4-27.3% (Barus, 2012).

Based on the above problems, this research was aimed to find out the effect of cow dung as organic fertilizer on growth, yield components, and yield of organic paddy rice. It is expected that the results of this study can be used as a recommendation for the optimal dosage of cow manure as organic fertilizer.

II. MATERIALS AND METHODS

This research was carried out in the area of organic farming of rice paddy in West Sumatra, in collaboration with Lurah Sepakat Farmer Group in Simarasok Village of Baso District, Agam Regency, West Sumatra Province, Indonesia. The organic rice cultivation was started in this area in early 2009 and the Organic Food Certificate (OFC) for this area was obtained in 2010 issued by the OFC Agency of West Sumatra. The nutrient contents of soil in the research location were: pH (H2O) 8.13; pH (KCl) 7.79; C-organic 1.91%; N-total 0.22%; C/N 8.68; P-Bray I 10.45 ppm; and K-can be exchanged 0.60 me/100g.

The study was arranged using a Complete Randomized Block Design, with four treatments and six replications. The treatment was organic fertilizer derived from cow dung composted using local microbial organisms (Microbial II) with four dosage levels, namely: a) 2 tons/ha; b) 4 tons/ha; c) 6 tons/ha; and d) 8 tons/ha. The nutrient contents of organic fertilizer tested were: 1.90% N; 0.80% P; 3.6% K; 10.04% C; and 5.28% C/N. Therefore, for the treatment of 2, 4, 6, and 8 ton/ha, the nutrient contents successively were 38, 76, 114, and 152 kg N/ha; 16, 32, 48, and 64 kg P2O5/ha; and 72, 144, 216, and 288 kg K2O/ha. Meanwhile, fertilizer recommendations for the study area were 69, 27, and 45 kg/ha respectively for N, P2O5, and K2O (Hasan *et al.*, 2015). According to Dobermann and Fairhurst (2000) to produce an average grain of 6 ton/ha, rice plants need 165 kg N, 19 kg P, and 112 kg K/ha or equivalent to 350 kg Urea, 120 kg SP36 and 225 kg KCl/ha.

Another nutrient source was the local liquid organic fertilizer made from local raw materials (snails, bones, and coconut husk) by spraying it into the plants. Dosage of liquid organic fertilizer was three tablespoons per liter of water, which was applied four times with the interval time of 15 days, starting at the plants age of 15-60 days after planting (DAP). The nutrient content of the organic liquid fertilizer materials were: snails (0.06% N; 0.07% P; 0.43% K), bone (0.01% N; 0.10% P; 0.08% K); and coconut husk (0.01% N; 0.02% P; 0.08% K).

Soil processing was conducted completely with two plows and one rake. The organic rice varieties used are the local superior variety which was propagated by farmers and continuously planted organically, namely: the Kuriak Kusuik. The seeds, with the age of less than 21 days old, were planted on a 4x5 meter plot. The spacing used was 25x25 cm with the number of seeds was 1-3 stems/clump. Weeding was done twice, i.e. at 30 and 60 DAP. Pests and diseases control carried out depending on the development of the pests and diseases, using vegetable pesticides (formulated from local plant materials). The technology of organic rice cultivation used was based on the NSI No: 01-6729-2002 (ANSI, 2002).

The observed variables included: leaf color score using leaf color chart (AIAT West Sumatra, 2012), plant height, maximum number of tillers, number of productive tillers, panicle length, number of grains per panicle, percentage of empty grain, 1,000 grains weight, and grain yield. The data obtained were analyzed statistically using analysis of variance (ANOVA) and correlation/regression analysis. If there were differences between treatments, it will be then continued by the Duncan Multiple Range Test (DMRT) at 5% level (Steel and Torri, 1960; Gomez and Gomez, 1984).

III. RESULTS AND DISCUSSION

Leaf Color Score

Observation on the leaf color score showed that there was a significant effect of organic fertilizer dosage at the plant age of 56 DAP (Table 1). From the correlation analysis it was found that the dose of organic fertilizer had a positive correlation with the leaf color score at 56 DAP, with r = 0.952*. This means that, the more organic fertilizer was applied, the leaf color score tended to be higher at 56 DAP. However, the provision of organic fertilizer up to the dose of 8 ton/ha had not been able to meet the nutrient deficiency of N in the rice crops. According to AIAT West Sumatra (2012), if the leaf color score <3.0 indicates that the plant is deficient of N, therefore additional Urea fertilizer is needed as much as of 75 kg/ha, 100 kg/ha, 125 kg/ha and 150 kg/ha respectively to obtain grain yield of 5 ton/ha, 6 ton/ha, 7 ton/ha, and 8 ton/ha.

Growth Components

The observation on the growth components showed that the treatment of organic fertilizer dosages did not have significant effect on plant height and maximum number of tillers (Table 2). However, from the correlation analysis it was found that the organic fertilizer dosages had a significant positive correlation with plant height (r = 0.974*), and the positive correlation but did not have significant with the maximum number of tillers (r = 0.546^{ns}). This means, the more the organic fertilizer was applied, will cause significant increase in plant height and the maximum number of tillers will also tended to be increased.

Yield Components and Grain Yield

It was found that the organic fertilizer dosages had significant effect on the number of productive tillers, number of grains per panicle, and grain yield (Table 3). However, it did not have significant effect on the panicle length, weight of 1,000 grains, and percentage of empty grain. From the correlation analysis it was found that the dosage of organic fertilizer had a significant positive correlation with the number of productive tillers (r = 0.965*) and the percentage of empty grain (r = 0.988*). There was no significant correlation between the dosages with the panicle length (r = 0.476^{ns}) and number of grains per panicle (r = 0.629^{ns}). In contrast, there was a negative and no significant correlation with the weight of 1,000 grains (r = -0.535^{ns}).

Good plant growth is characterized by the high yield and large number of tillers. A higher plants will produce a longer panicles (r = 0.632^{ns}), the long panicle will cause more number of grains per panicle (r = 0.670^{ns}), and more number of grains per panicle will cause more grain yield (r = 0.643^{ns}). Furthermore, more number of tillers will result in more productive tillers (r = 0.326^{ns}), so the grain yield will increase significantly (r = 0.986*). Well-grown plants will be able to utilize sunlight for the process of photosynthesis and are able to absorb nutrients optimally. According to Yoshida (1981), the availability of nutrients in the soil and the ability of plants to well utilize the sunlight could increase the plant growth and yield.

Result of the regression analysis showed that there was a real positive relationship between the organic fertilizer dosages and the organic rice yields (Fig. 1), with the equation: Y = 0.097x + 4.17 (r = 0.969). It means that, the addition of organic fertilizer as much as 1 ton/ha would increase the yield of organic paddy rice by 0.097 ton/ha. The results of research by Tufaila *et al.* (2014) on Ultisol soil in Southeast Sulawesi Province showed that dung manure compost with doses ranging from 5.0-7.5 ton/ha gave better influence to growth and production of Konawe rice variety. In the System of Rice Intensification

(SRI), the application of organic fertilizer of 4-8 ton/ha could produce rice between 6-8 ton/ha without the addition of inorganic fertilizers (Gani *et al*., 2002; Uphoff and Satyanarayana, 2006). Furthermore, research by Suhardi *et al.* (2014) found that the use of 5 ton/ha of organic fertilizer plus 20 liter/ha liquid organic fertilizer, called the biourine, on a newly open paddy field gave no significant difference in rice production with the use of inorganic fertilizers of 200 kg Urea + 300 kg NPK per ha.

In this study, although the addition of organic fertilizer dosages could significantly increase the grain yields (maximum 4.96 ton/ha), the yield of these grains was much lower than its potential production which could reach up to 5.50 ton/ha (Zen et al., 2011). This is supported by Syam (2006) who stated that the superiority of SRI technique based on the supply of plant nutrients derived from organic matter is still in doubt because the rice productivity using SRI technology is lower than the conventional technology.

IV. CONCLUSION

There was a real positive relationship between the dosages of organic fertilizer with the yield of organic rice paddy. The addition of cow dung as organic fertilizer as much as 1 ton/ha would be able to increase the grain yield by 0.097 ton/ha. In order to reach the potential production of the Kuriak Kusuik rice variety of 5.50 ton/ha it is recommended to apply approximately 13.7 ton/ha of the cow dung as the organic fertilizer.

REFERENCES

[1] Adiningsih, J. S., Setyorini, D. and Prihatini, T. (1995). Integrated nutrient management to achieve stabile food production and environmentally friendly. *Proceedings of Technical Meeting on Soil and Agro-climate Research*. Bogor (In Indonesian). Pp: 55-59.

[2] AIAT West Sumatra. (2012). The use of Rice Soil Test Kit (RSTK) and Leaf Color Chart (LCC) for specific location rice fertilization. *Assessment Institute for Agricultural Technology of West Sumatra Province* (In Indonesian).

[3] ANSI. (2002)**.** Indonesian National Standard for Organic Food Systems. *Agency for National Standard of Indonesia.* Jakarta (In Indonesian).

[4] Atman and Nurnayetti. (2014). Existence of organic farming in rice agribusiness development in West Sumatra. *In* Daniel *et al.* (Eds). Agribusiness Development: Technology Innovations and System Reparation for Agribusiness Development. *Kristal Multimedia Publication* (In Indonesian). Pp: 162-175.

[5] Barus, J. (2012). The effect of manure application and planting system on the production of upland rice varieties on the dried acid land in Lampung. *Journal of Suboptimal Land*. 1(1): 102-106. (in Indonesian).

[6] CHO West Sumatra. (2010). Organic Agriculture. *Crops and Horticulture Office of West Sumatra.* Padang (in Indonesian).

[7] Daniel, M., Nieldalina and Hardiyanto. (2014). Assessment on existence of organic rice farming in West Sumatra. *Proceedings of the National Organic Agriculture*. Held in Bogor, on 18-19 June 2014. Pp.: 35-41.

[8] Dobermann, A. and Fairhurst, T. (2000). Rice: Nutrient Disorders & Nutrient Management. *Potash & Phosphate Institute (PPI), Potash & Phosphate Intitute of Canada (PPIC), and International Rice Research Institute (IRRI).*

[9] Gani, A., Kadir, T.S., Jatiharti, A., Wardana, I.P. and Las, I. (2002). The System of Rice Intensification in Indonesia. *In* N. Uphoff *et al.* (Eds.). Assessment of the System of Rice Intensification. *Procedings of International Conference of Cornell Instuitute.* Institute For Food, Ithaca, New York. Pp.58-63.

[10] Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. *John Wiley and Sons.* New York.

[11] Hasan, N., Ismon, L., Hardiyanto, Abdullah, S. and Roswita, R. (2015). Fertilizer Recommendation for Specific Location in West Sumatra to Support the Acceleration of Rice Self-Sufficiency. ISBN: 978-602-8843-25-6. *Assessment Institute for Agricultural Technology of West Sumatra Province.* Solok (in Indonesian).

[12] IAARD. (2005). Agricultural Research News. Vol. 27, No. 3. *Indonesian Agency for Agricultural Research and Development.* Jakarta (In Indonesian).

[13] ISB. (2015). Provincial rice production. *Indonesian Statistical Board*. Accessed from http://bps.go.id. on 13 November 2015.

[14] ISRI. (2004). Land management for organic vegetable cultivation in supporting the go-organic program of the year 2010. *Indonesian Soil Research Institute.* Bogor (In Indonesian).

[15] Jamil, A., Widowati, L.R. and Hartatik, W. (2014). Soil fertility management and fertilizer innovation to support the organic farming agriculture. *Proceedings of the National Organic Agriculture*. Held in Bogor, on 18-19 June 2014. Pp.: 1-14.

[16] Kartaatmadja, S., Makarim, A.K. and Fagi, A.M. (2000). Integrated Crop Management and Approach for Sustainable Rice Production. *Indonesian Agency*

for Agricultural Research and Development. Jakarta (in Indonesian) (unpublished).

[17] Kasno, A. and Hidayat, E. (2006). Phosphate and potassium fertilization of paddy rice: West Java and Banten Provinces. 1st Edition. *Indonesian Center for Agricultural Land Resources Research and Development.* Bogor (In Indonesian).

[18] Kasno and Rostaman, T. (2017). Response of Rice Crop to Nitrogen Fertilization on the Rainfed Lowland Area. *Journal of Agricultural Food Crops Research*. 1(3):201-210 (in Indonesian).

[19] Materechera, S. A. and Mehuys, G.R. (1991). Organic manure addition and the leaf water potential and yield of Barley. *Plant and Soil Journal*. 138: 239-246.

[20] Nurnayetti dan Atman. (2013). The competitive outstanding of local variety paddy rice in West Sumatra. *Journal of Agricultural Technology Assessment and Development.* 16(2): 100-108 (in Indonesian).

[21] Pratiwi, G. R. and Sumarno. (2014). Effect of manure and compliance varieties - planting season on the yield of paddy rice). *Journal of Agricultural Food Crops Research*. 33(3):177-187. (in Indonesian).

[22] Steel, R.G.D. and Torri, J.H. (1960). Principles and Procedures of Statistics with Special Reference to the Biological Sciences. *McGraw-Hill Book Company, Inc.*

[23] Suhardi, Herniwati, and Djufry, F. (2014). Crops productivity and financial feasibility of rice on the newly opened paddy field with various type of fertilizers in South Celebes. *Journal of Agricultural Technology Assessment and Development.* 17(3):187-196. (in Indonesian).

[24] Sujitno, E., Kurnia and Fahmi, T. (2014). The use of various type of organic fertilizers on rice plants in an irrigated paddy field. *Proceedings of the National Seminar on Organic Agriculture.* Held in Bogor on 18-19 June 2014: 211-216. (in Indonesian).

[25] Sumarno and Kartasasmita, U.G. (2012). The readiness of farmers using organic fertilizer for rice paddy. *Journal of Agricultural Food Crops Research*. 31(3):137-144. (in Indonesian).

[26] Syam, M. (2006). Controversion on System of Rice Intensification (SRI) in Indonesia. *Journal of Crops Science and Technology.* 1(1):31-40. (in Indonesian).

[27] Tufaila, M., Yusrina and Alam, S. (2014). The effect of cow dung Bokashi on the growth and production of paddy rice in Ultisol soil of Puosu Jaya, Konda District, South Konawe. *Journal of Agrotechnos.* 4(1):18-25. (in Indonesian).

[28] Uphoff, N. and Satyanarayana, A. (2006). Prospect for rice sector improvement using System of Rice Intensification with evidence from India. *In:* Sumarno, *et al.* (Eds.). Rice Industry, Culture, and Environment. Book 1. Indonesian Center for Rice Research, ICFORD, IAARD, Bogor dan Jakarta. Pp.:131-142.

[29] Winardi. (2014). Innovations on paddy rice cultivation technology including the past and ongoing development in West Sumatra in order to improved rice production. *Agritech.* 16(1):25-37. (in Indonesian).

[30] Yoshida, S. (1981). Fundamental of rice crop science. IRRI Manila, Philippines; 111-176.

[31] Zen, S. (2013). The performance of promising lines of low land rice variety at Solok District, West Sumatra. *Journal of Applied Crops Research.* 13(1):38-44 (in Indonesian).

[32] Zen, S., Syarif, A.A. and Yufdy, P. (2011). Outstanding rice varieties with high amylose content of West Sumatra. ISBN: 978-602-8843-07-2. *Assessment Institute for Agricultural Technology of West Sumatra Province.* Solok (in Indonesian).

Table.1: Leave color score of organic rice plant at different ages with various doses of organic fertilizer

Organic fertilizer dosage (ton/ha)	**Plant ages**		
	28 DAP	**42 DAP**	**56 DAP***
2	3	3	2,4 c
4	3	3	2,6 b
6	3	3	2,8 a
8	3	3	2,9 a
CV (%)			**2,72**

*) Means within a column with no common superscript differ significantly (P<0.05).

Table.2: Growth components of organic paddy rice with various dosage of organic fertilizer

Organic fertilizer dosage (ton/ha)	Growth components*	
	Plant height (cm)	Number of tiller (per Hill)
2	105,1 [a]	19,9 [a]
4	105,8 [a]	19,1 [a]
6	106,1 [a]	20,4 [a]
8	106,4 [a]	20,3 [a]
CV (%)	**1,68**	**4,50**

*) Means within a column with no common superscript differ significantly (P<0.05).

Table.3: Yield components and grain yield of organic paddy rice with various dosage of organic fertilizer

Organic fertilizer dosage (ton/ha)	Yield components and grain yield					
	Number of productive tillers (per Hill)	Panicle length (cm)	Number of grains per panicle	Weight of 1000 grains (g)	Empty grain (%)	Grain yield (ton/ha)
2	10,5 [c]	22,8 [a]	131,9 [b]	25,14 [a]	12,91 [a]	4,33 [c]
4	11,3 [b]	23,5 [a]	142,8 [ab]	24,77 [a]	14,56 [a]	4,63 [b]
6	11,5 [b]	23,1 [a]	145,8 [a]	24,43 [a]	15,34 [a]	4,69 [b]
8	11,9 [a]	23,3 [a]	140,6 [ab]	24,85 [a]	17,34 [a]	4,96 [a]
CV (%)	**1,67**	**2,14**	**5,52**	**2,28**	**23,68**	**2,72**

*) Means within a column with no common superscript differ significantly (P<0.05).

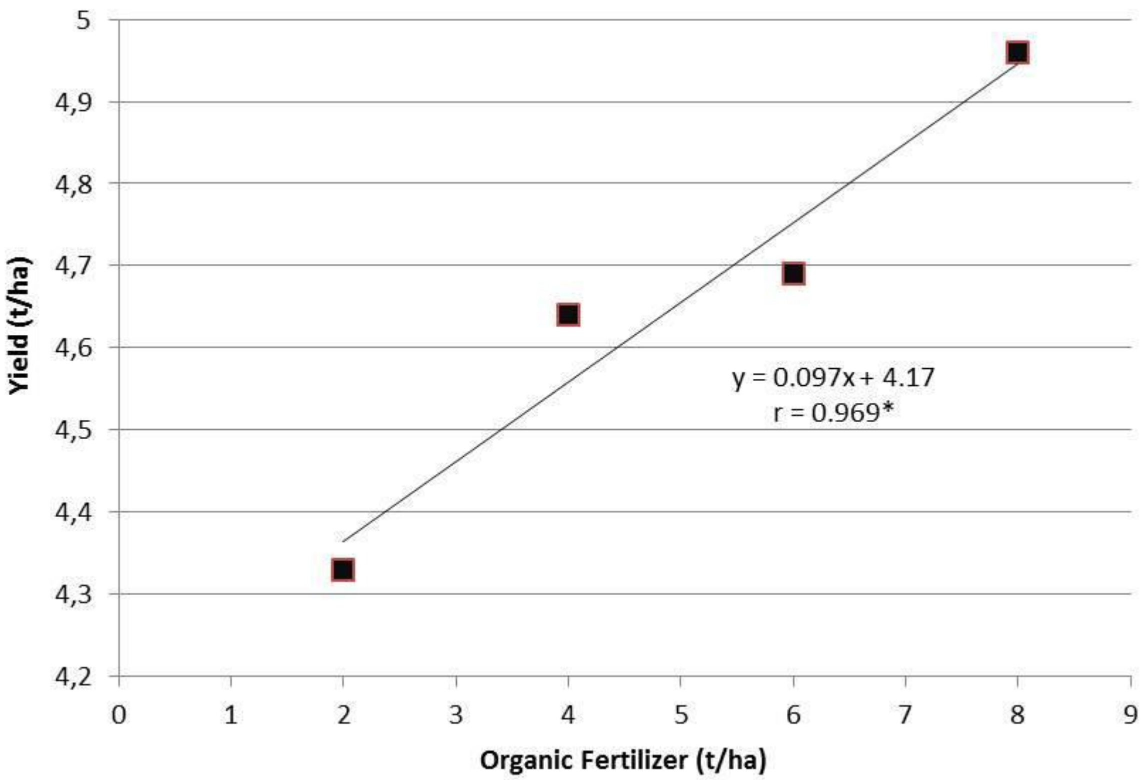

Fig.1: Relationship between the dosages of organic fertilizer of cow dung with the yield of organic rice paddy