Improvement of Soil Quality and Rice Yield by Using Baranik (Organic Coal) Fertilizer in Irrigated Paddy Field

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Improvement of Soil Quality and Rice Yield by Using Baranik (Organic Coal) Fertilizer in Irrigated Paddy Field

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Abstract **– The application of sustainable agriculture in order to improve soil quality is needed to achieve food self sufficiency in Indonesia. Low soil quality for most of paddy field land in Indonesia was because of more than 40 years soil in paddy field land had received inorganic fertilizers in huge quantity and in long period of time as well as lack of organic matter usage for rice paddy field production system. The objectives of this research were to study the effect of Baranik (organic coal) fertilizer addition on improving soil quality and rice yield in irrigated paddy field area. This study was conducted from April to August 2014 in irrigated paddy field area of Belitang, OKU Timur District. The method used in this study was Factorial Randomized Completely Design with nine treatments combination and three replications with 10 sample plants. The treatment factors were consisted of fertilizer type with three levels: P_0: recommended chemical fertilizer (250 kg urea ha^{-1} +150 kg SP-36 ha^{-1} + 50 kg KCl ha^{-1}), P_1: organic fertilizer of crop waste at dose of 5 $ton.ha^{-1}$ and P_2: organic coal) fertilizer (Baranik) with dose of 750 kg ha^{-1} as well as rice varieties with three levels: V_1: Mentik Wangi, V_2: Gogo Aromatik and V_3: Ciliwung. Application of Baranik fertilizer at dose of 750 $kg.ha^{-1}$ could increase quality of paddy field soil in term of C-organic content from 1.44% in initial stage into 2.90% after research implementation. Application of Baranik fertilizer at dose of 750 $kg.ha^{-1}$ could increase rice production of Ciliwung variety with magnitude of about 7.62 $ton.ha^{-1}$in which description for average rice production of Ciliwung variety is 6.5 $ton.ha^{-1}$.**

Keywords **– Baranik Fertilizer, Irrigated Paddy Field, Rice Production, Soil Quality.**

I. INTRODUCTION

Rice is a food crop that has important role for agricultural development in Indonesia because it is the main food resource for people of Indonesia so that a technology which can create the achievement of food self sufficiency is needed through sustainable agriculture. [12] described that current condition of most paddy field land in Indonesia had low soil quality as a results of intensification program that used inorganic fertilizers input in huge quantity and in long period of time as well as lack of organic matter usage for rice paddy field production system.

The decrease of paddy field soil quality is indicated by the decrease of C-organic content of soil. [16] had reported that random sampling from 30 locations of paddy field soil in Indonesia showed 68% had C-organic content of soil less than 1.5% and only 9% that had C-organic content of soil higher than 2 %. Similar condition was also found on soils at rice production centers in South Sumatra Province, especially at OKU Timur Districts which had average C-organic content of soil with magnitude less than 1.5% [5].

Addition of organic fertilizer is an effort to improve agricultural soil quality and to increase crop production. Organic fertilizer usually is obtained from crops waste or animals waste. An alternative material that has high C content to be used as organic fertilizer is immature coal. [7] had described that immature coal (*Lignit*) has composition as follows: C of 69%, H of 5.5%, O of 25%,N of 0.5%, P_20 of 0.04% and K_20 of 36 %. The use of immature coal (*Lignit*) as organic fertilizer can add macro nutrients such as N, P, K,Ca, Mg and S as well as micro nutrients such as Fe, Mn,Cu, Zn, Mo and CI within soil.

The disadvantage of organic fertilizer is that it should be applied in huge volume (ton ha^{-1}) and has very low nutrients content so that its application requires huge volume per hectare. The example of organic fertilizer application such as shown from study results by [14] showed that Pusri organic fertilizer enriched with biofertilizer at dose of 15 ton/ha could increase the production of string bean, mustard greens, lettuce and chilly. In addition, study results by [15] showed that biofertilizer (rice straw compost enriched with N_2 fixation bacteria, BPF and growth stimulator at dose of 300 to 400 kg ha^{-1} in combination with 75 % inorganic fertilizer could increase absorption of N, P and K nutrients as well as production of rice dry weight at lowland swamp soil. Furthermore, study results by [2] showed that organic fertilizer from animal dunk used for organic rice cultivation was at dose of 10 $ton.ha^{-1}$.

The decrease of organic fertilizer volume addition can be done by extraction of organic fertilizer into humate acid so that its application volume become less (kg ha^{-1}), whereas its nutrients content can be increased by addition of materials containing nutrients from minerals of natural fertilizer and inorganic fertilizer known as plus organic fertilizer model [17].

The objectives of this research were to study the effect of Baranik (organic coal) fertilizer addition on improving soil quality and rice yield in irrigated paddy field area.

II. MATERIALS AND METHOD

This research was conducted from April to August 2014 on irrigated paddy field of Belitang, OKU Timur District

by using Factorial Randomized Completely Design with nine treatments combination and three replications with 10 sample plants. The treatment factors were consisted of fertilizer type with three levels: P_0: recommended chemical fertilizer (250 kg urea ha^{-1} +150 kg SP-36 ha^{-1} + 50 kg KCl ha^{-1}), P_1: organic fertilizer of plant waste at dose of 5 $ton.ha^{-1}$ and P_2: organic coal) fertilizer (Baranik) with dose of 750 kg ha^{-1} as well as rice varieties with three levels: V_1: Mentik Wangi, V_2: Gogo Aromatik and V_3: Ciliwung.

Land preparation was conducted by clearing the land from weeds and previous left over crops. This land subsequently was flooded, plowed and harrowed so that soil became more loose and had even surface. The next step was development of 27 plots having size of 3 m x 2 m per plot with planting distance 30 x 30 cm and the distance between replications was 1 m. Rice seeds of Gogo aromatic, Mentik wangi and Ciliwung varieties were germinated for 21 days. The P_1 treatment was conducted by spreading organic fertilizer from crops waste at dose of 5 ton ha^{-1} at the same time as initial soil tillage period, i.e. 2 weeks before planting operation. N fertilizer was given two times with half dose at 7 days after planting (HST) and the rest was applied at 42 days after planting. P and K fertilizers at required doses were applied at 7 days after planting. Irrigation was done since crops had about 5 cm in height until their age was 10 days after planting. Irrigation was subsequently managed according to crops growth. Weeds control was done manually during crops age was 15 days after planting and subsequent weeds control was done according to weeds condition in the field. Pest and disease control was done preventively by using organic pesticides of local formula. Harvest was done when crops age was 90 days after planting.

Observations in this research were consisted of soil quality and vegetative growth in term of crop height, tiller numbers per clump and leave numbers per clump. Observation data for generative phase was consisted of stem numbers per clump, weight of 1000 grains, unhulled rice yield per harvested plot and unhulled rice yield per hectare. Data was analysis by using analysis of variance (F test) at α level of 5%. The differences amongst treatments were done by using LSD test at α level of 5%.

III. Results and Discussion

A. Soil Quality of Research

Table 1 sowed that soil fertility before research implementation was relatively low with pH of 4.36 so that an effort was needed to improve this soil fertility. One of efforts to increase soil fertility is by fertilizer addition. According to [12], one of efforts to increase soil fertility was by fertilizer application.

Table 2 showed that Baranik fertilizer addition at dose of 750 kg ha^{-1} at the study location could increase low soil fertility status into relatively high soil fertility status. This finding showed the increase of soil quality represented by the increase of soil C-organic content from 1.44% before research implementation to 2.90% after research implementation. It was estimated that humate acid availability was capable to increase soil organic matter content after research implementation because humate acid was put up with soil micro-organisms activities. This was in accordance to opinion of [3] which stated that humate acid availability within soil would increase soil organic matter content and was resist to soil micro-organisms activities which in turn would improve physical, chemical and biological properties of soil. Moreover, [9] had explained that addition of organic fertilizer could improve physical properties of soil because organic matter is cementing agent for loosened soil grains or stabilizing agent for soil aggregates that help root's crop to penetrate deeper which in turn capable to absorbs more nutrients and water. In addition, organic fertilizer can improve rhizosphere environment so that it can maintain nutrients, improve exudation by root's crop which in turn capable to increase degradation of soil organic matter and N mineralization [11].

The addition of Baranik fertilizer would improve physical, chemical and biological properties of soil. According to [18], organic matter can increase biological activity of soil as well as soil water availability. The availability of soil water would improve absorption and transportation of nutrients as well as photosynthesis rate which in turn capable to increase food supply for better growth of plant [13].

B. Vegetative Growth of Crop

The effect of fertilizer types and rice varieties combination on all variables of crop vegetative growth was shown in Table 3.

Table 3 showed that variables of crop height and tiller numbers per clump for Baranik fertilizer treatment at dose of 750 kg ha^{-1} was significantly different than that of organic fertilizer from crops waste, but was not significantly different than that of recommended synthetic fertilizer. The lowest values of crop height, rice tiller numbers and leave numbers per clump were found on treatment of organic fertilizer from crops waste at dose of 5 ton ha^{-1}. Results of Ciliwung variety treatment showed highly significant different than that of other varieties in term of crop height, tiller numbers per clump and leave numbers per clump variables.

In term of leave numbers per clump, Baranik fertilizer treatment at dose of 750 kg ha^{-1} was significantly different than that of treatment of organic fertilizer from crops waste at dose of 5 ton ha^{-1} and control treatment (recommended synthetic fertilizer), but treatment of organic fertilizer from crops waste at dose of 5 ton ha^{-1} was not significantly different than that of control treatment.

Table 4 showed that Baranik fertilizer at dose of 750 kg ha^{-1} had higher organic matter content and nutrients content than that of organic fertilizer from crops waste at dose of 5 ton ha^{-1}, but it had relatively lower NPK nutrients content than that of recommended synthetic fertilizer. This was shown by the highest vegetative growth on treatment of Baranik fertilizer at dose of 750 kg ha^{-1}. The recommended synthetic fertilizer had high NPK nutrients but it had no other macro nutrients and micro nutrients required by crops, whereas Baranik fertilizer had

complete nutrients either macro nutrients or micro nutrients. Organic fertilizer from crops waste had high organic matter content, but it had lower macro nutrients and micro nutrients than Baranik fertilizer. Therefore, vegetative growth of crop was higher on Baranik fertilizer treatment at dose of 750 kg ha^{-1} than that of other treatments.

The highest growth rate was found on Ciliwung variety treatment because this rice variety is superior variety for paddy field rice so that its growth was better than that of Gogo Aromatik and Mentik Wangi varieties that generally planted at rain fed land area.

Table 1. Results of soil analysis before research implementation at irrigated paddy field of Belitang

Analysis types	Units	Analysis results	Criteria
pH (H_2O)	-	4.36	Relatively acid
N-Total	(%)	0.20	Acid
C-Organic	(%)	1.44	Low
P-Bray	(ppm)	20.5	Low
K-dd	(me/100	0.23	High
Na	g)	0.33	Low
Ca	%	0.70	Low
Mg	%	0.18	Very low
C/N	%	10.05	Very low
Soil texture	%		
Sand		11.03	
Loam	%	40.50	
Clay	%	48.05	

Source: Laboratory of Soil Chemical, Biological and Fertility, Faculty of Agriculture, Sriwijaya University, Indralaya 2014.

Table 2. Results of soil analysis after research implementation at irrigated paddy field of Belitang

Treatments	Nutrients content			
	C-organic (%)	N-total (%)	Available P (ppm)	K- Total (%)
P0	1.44	0.20	9	0.55
P1	3.00	0.20	24	0.65
P2	2.90	0.44	23	0.80

Source: Laboratory of Soil Chemical, Biological and Fertility, Faculty of Agriculture, Sriwijaya University, Indralaya. 2014.

Table 3. The effect of fertilizer types and rice varieties combination on all variables of crop vegetative growth.

Treatments	Observation data of crop vegetative growth		
	Crop height (cm)	Tiller numbers per clump	Leave numbers per clump
Fertilizer types			
-P0: Control (recommended chemical fertilizer	116.97 b	28.50 ab	65.83 a
-P1: Organic fertilizer of crops waste at dose of 5 ton ha^{-1}	102.02 a	28.36 a	65.78 a
-P2: Baranik fertilizer at dose of 750 kg ha^{-1}	111.92 b	29.60 b	66.05 b
Rice Varieties			
-V1 : Mentik Wangi	103.87 a	29.67 b	66.31 b
-V2 : Gogo Aromatk	99.87 a	27.59 a	65.29 a
-V3 : Ciliwung	117.18 b	30.84 c	66.86 b

Remarks: Numbers followed by the same letters showed not significantly different based on LSD test at level α = 5%.

Table 4. Chemical Analysis Results of Coal Organic Fertilizer (Baranik)

Parameters	Units	Magnitude	Quality Standard of SNI NO 70/SR-140/10/2011
pH	-	7.40	4 – 9
water content	%	11.07	8 – 20
C – Organic	%	15.08	Min. 15
N concentration	%	14.05	Min. 4
P concentration	%	6.71	Min. 4
K concentration	%	5.01	Min. 4
Mg concentration	%	1.10	-
Ca concentration	%	3.69	-
S concentration	%	0.09	-
B concentration	ppm	0.08	250 – 5000
Mo concentration	ppm	0.10	2 – 10
Fe concentration	ppm	0.975	Max. 500
Mn concentration	ppm	0.0440	Max. 5000
Cu concentration	ppm	0.003	250 – 5000
Zn concentration	ppm	0.577	Max. 5000
Co concentration	ppm	0.002	5 – 20

Source: Laboratory of Soil Chemical, Biological and Fertility, Faculty of Agriculture, Sriwijaya University, Indralaya 2014.

C. Crop Yield Observation Data

In term of generative variables of crop which consisted of unhulled rice numbers per stem, weight of 1000 grains, unhulled rice yield per plot and unhulled rive yield per hectare, Baranik fertilizer treatment at dose of 750 kg ha^{-1} was not significantly different than that of recommended synthetic fertilizer, but it was significantly different than

that of organic fertilizer from crops waste at dose of 5 ton ha^{-1}. Moreover, it can be seen that unhulled rive yield on Ciliwung variety treatment was higher than that of Gogo Aromatik variety and Mentik Wangi variety (Tabel 5). This result showed that Baranik fertilizer treatment at dose of 750 kg ha^{-1} had effect on improvement of soil fertility or soil quality represented by the increase of soil C-organic content with magnitude 1.14 % before research implementation to 2.9 % after research implementation so that its generative variables of crop were better than that of other treatments.

Application of Baranik fertilizer at dose of 750 kg ha^{-1} showed higher rice yield than that of recommended synthetic fertilizer and organic fertilizer from crops waste at dose of 5 ton ha^{-1}. This was due to the fact that soil fertility at research location was low so that application of recommended synthetic fertilizer was ineffective because of low soil C-organic content (1.44%) which results in low nutrient holding capacity of soil. In addition, synthetic fertilizer has fast rate in releasing available nutrients so that more nutrients have lost and only small quantity of nutrients is absorbed by crop. This was in accordance to opinion from [6] which stated that synthetic fertilizer was lost due to surface flow leaching (21 %), evaporation (19 %), fixation by clay minerals (30 %), leaching (13 %), immobilization by microbe (5 %) and only 12% was utilized by crop.

Application of Baranik fertilizer at dose of 750 kg ha^{-1} gave higher yield than that of recommended dose of synthetic fertilizer because it has fast rate in releasing available nutrients so that more nutrients will also quickly lost within water, fixation by clay minerals, immobilization by microbe and other ways. Most of nutrients from coal organic fertilizer (Baranik) can be absorbed by crops because this fertilizer has slow release characteristics. Organic fertilizer is characterized by slow release of nutrients so that crop growth process has occur in slowly and certainly manners [11].

Baranik fertilizer is made from humate acid of immature coal as well as minerals of natural fertilizer and inorganic fertilizer so that it has higher nutrients content than that of organic fertilizer from crops waste at dose of 5 ton ha^{-1}. This is in accordance to the study results by [8] which showed that application of bokhasi or organic fertilizer from chicken dunk in combination with half dose of recommended synthetic fertilizer was capable to increase crop production and saving in inorganic fertilizer usage. Furthermore, [16] had stated that application of organic fertilizer in combination with half dose of recommended synthetic fertilizer was capable to increase the growth and production of rice crop.

In addition to proper application of fertilizer, other factor that determines the increase of rice crop production is rice variety. According to [1], variety is one of main factors in increasing of rice production. Results of this research showed that Ciliwung variety had gave high yield on irrigated paddy field because this variety is superior variety recommended to be planted on paddy field area. Ciliwung variety was superior to Gogo Aromatik and Mentik Wangi varieties which are usually grown on dry land as rainfed rice. According to [4], genotype of rainfed rice is more tolerance to dryness condition than that of paddy field rice so that crop growth environment has significant effect on rice crop production. Improvement of crop growth due to the use of variety that has good adaptation to planting location as well as proper fertilization results in increase of rice crop height, increase of productive tiller numbers and increase of 1000 grains weight which in turn increase the weight of mill dry unhulled rice [10].

The success of this research was assessed by comparing its results to description results of Ciliwung rice variety on irrigated land. The research results showed that production of Ciliwung rice variety was 7.62 ton ha^{-1}, whereas average production based on Ciliwung rice variety description was 6.5 ton ha^{-1}. It showed that production achieved in this research was higher than that of Ciliwung rice variety description. In conclusion, application of Baranik fertilizer in this research was capable to increase rice crop production on irrigated land.

Table 5. The effect of fertilizer types and rice varieties combination on all variables of rice crop yield.

Treatments	Observation data of crop yield			
	Unhulled rice numbers per stem (grains)	Weight of 1,000 grains (g)	Unhulled rice Yield per plot (kg)	Unhulled rice yield per ha (ton ha^{-1})
Fertilizer types				
-P0: Control (recommended chemical fertilizer)	141.29 ab	31.77 ab	3.30 ab	5.50 ab
-P1: Organic fertilizer of crops waste at dose of 5 ton ha^{-1}	112.47 a	29.16 a	2.65 a	4.41 a
-P2: Baranik fertilizer at dose of 750 kg ha^{-1}	172.09 b	32.25 b	4.33 b	7.17 b
Rice varieties				
-V1 : Mentik Wangi	140.35 ab	30.75 ab	3.52 ab	5.87 ab
-V2 : Gogo Aromatik	134.12 a	29.10 a	2.68 a	4.47 a
-V3: Ciliwung	164.37 b	32.20 b	4.57 b	7.62 b

Remarks: Numbers followed by the same letters showed not significantly different based on LSD test at level α = 5%.

IV. Conclusion

Application of Baranik fertilizer at dose 750 kg ha^{-1} was capable to increase paddy field soil quality with C-organic content of 2.9 % compared to C-organic content of 1.44 % before research implementation. Application of Baranik fertilizer at dose 750 kg ha^{-1} was capable to increase rice crop production of Ciliwung variety with magnitude of about 7.62 ton ha^{-1}, whereas average production based on Ciliwung rice variety description was 6.5 ton ha^{-1}.

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