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Quality and Productivity Analysis of Wet Rice Field on the Rice Production Central Area

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ABSTRACT

Rice field is the main source of staple food and income for the most population. Therefore the obstruction of ecologic and economic balance due to improper management on rice field will disturb both of quality and productivity on such land. Lower quality of the rice field causes lower productivity of land and higher production cost expended by the farmers and government, which at last will influence the economic value of the rice field. The objectives of this research were to analyze the quality and productivity of intensive rice field, semi-intensive rice field and rain-fed rice field. In addition, this research intended to analyze the effect of applying nutrients such as N, P, K and land quality on the unshelled paddy production. Results of the research showed that: Qualities of the intensive, semi-intensive, and rain-fed rice fields were significantly different. Quality of the intensive rice field was lower than semi-intensive one, and quality of rain-fed rice field was lower than the intensive and semi-intensive ones. Average productivities of the intensive, semi-intensive, and rain-fed rice fields were 5,471 kg ha^{-1}, 5,967 kg ha^{-1}, and 3,370 kg ha^{-1}, respectively. Dummy variable of the intensive rice field was statistically showed significant and negative influence with the coefficient value was -0.208, while dummy variable for semi-intensive showed positive and significant influence with the coefficient value was 0.125. Interpretation of these values showed different level of average yields, in which the intensive one showed decreasing average yields and semi-intensive showed increasing yields.
KEYWORDS: land quality, soil fertility, productivity, technical efficiency, intensification.

INTRODUCTION

The objective on production increasing of national rice is to fulfill rice demand in own country which continuously increases. The average consumption of rice per-capita of Indonesia population is high enough. It is more than 130 kg per-capita per-year with the increasing rate approximate to 1.4-1.7 % per-year. The complexity of rice production problem which is more and more increasing causes the production of national rice is slowly increasing, that was 1.08% per-year [1]. The General Directorate of Food Cropping has recommended the production objective of national rice in the 2009 was 60.8 million ton GKG. However, rice productivity has to be increased from the average of 4.6 ton/ha to 5.3 ton/ha [2]. In addition, there was needed the quality improvement and balanced nutrition due to the demand and consumption preference through the approach of using improvement on the production utilizer and post harvest technology.

Sidrap Regency is one of the rice production centre in South Sulawesi. Some policy programs were applied which intended to increase the productivity and quality of rice for fulfilling food demand which continuously increased. The application of some technology parcel really gave impact to the quality decreasing of wet rice field especially the decreasing of land fertility. In the usage and management of wet rice field, the farmers have a trend to useover dosis of anorganic nutrients (like Urea, TSP, and KCl), so that will cause the decreasing of land quality. According to BPTP of South Sulawesi [3], nowadays, part of the land condition of wet rice field on centre area of rice production in Sidrap Regency, South Sulawesi had low organic content (the content of C-land organic < 2%). This condition indicated that the management process of wet rice field has the degradation of land fertility. The impact of this condition caused the land became hard and clay so it was difficult to be prepared, response of fertility was low, and not responsive ti the certain nutrition. The next impact was the lower productivity and the increasing of production cost.

Based on the description as above, this research intended to analize the difference of land quality and productivity among the intensive rice field, semi-intensive rice field and rain-fed rice field. In addition, this research wanted to know the effect of using the nutrient of N, P, K, and land fertility to the wet rice filed production.

MATERIALS AND METHODS

This research was conducted in Sidrap Regency of South Sulawesi. Location of study was pueposively determined due to some considerations. Sidrap Regency historically was as the bigger centre area of rice

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production in South Sulawesi, because there had natural resource that supported the development of rice production. Generally, some districts has the slope less than 8% so that the whole area can be intensively managed for seasonal cropping. At about 39.703 ha (20.9%) of the area has as plain topography (< 3%) and 30.746 ha (16.2$) is waved (slope 3-8 integrated cropping). Analysis of soil sample was conducted in Laboratory of Soil Chemic and Physic, Department of Soil Science, Faculty of Agriculture, University of Hasanuddin, Makasar. This research was carried out from March 2011.

Population in this research included wet rice filed soil and rice farmer in Sidrap Regency, Province of South Sulawesi. Determination of sample location point is based on the overlay of three characteristic maps such as landuse map, soil type map, and slope map for determining unit area/ soil map unit (SPT). Soil sample was taken at 10 SPT which represented intensice rice field, semi intensive rice field, and rain-fed rice field.

Evaluation of area quality

Evaluation of area quality used limitor approch method. This method divided the limitor level of an suitable area and class into 5 groups [4]. Analysis of quality index used Index Square Road Method [4] which was modified due to the criteria of land use condition for irrigated and rain-fed rice cropping [5]. The characteristic of soil fertility that was used in this study included capacity of cation change, base satiation, pH of H_2O, content of soil C-organic, and available nutrition of N, P, and K. The usage of Index Square Road Method (I) was fitted to the growing condition of rice cropping in the wet rice field with the formula as follow:

$$I = R\ min \times \sqrt{A/100 \times B/100 \times C/100} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Note: I= index; R min = rating minimum, and A,B,C is the weight of each quality characteristic of KTK, KB, pH, C-organic, nutrient of N, P, and K.

Productivity of area

The size of area productivity which was used in this research was partial productivity value (yield per-ha). Test of Kruskal-Willis was used to compare the quality difference among the intensive rice field, semi intensive rice field, and rain-fed rice field. Type of the test was one way analysis of variance. The test was carried out by using SPSS 16.0 with the hypothesis as follow:

H_o: $\mu_1 = \mu_2 = \mu_3$

H_1: minimum one is not the same average

Note:

μ_1 = quality of intensive rice field

μ_2 = quality of semi intensive rice field

μ_3 = quality of rain-fed rice field

Analysis of production function

Estimation on fertility factor of Nitrogen, Phosphor, and Kalium, and area quality factor which influenced rice production was used production function analysis of Cobb-Douglas that was transformed to the form of linear natural logarithmis with the formula as follow:

$$\ln Yi = \beta_0+\beta_1 \ln X_{1i}+\beta_2 \ln X_{2i}+\beta_3 \ln X_{3i}+\beta_4 \ln X_{4i}+ \delta_1 \ln D_1 i+ \ldots+ \delta_3 \ln D_3 i \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

Note:

Y = rice production of intensive rice field, semi intensive rice field, rain-fed rice field (kg)

X_1 = nutrient of N (kg)

X_2 = nutrient of P (kg)

X_3 = nutrient of K (kg)

X_4 = index of soil fertility

D_1 = dummy of intensive rice field

D_1 = 1, for the strata of intensive rice field

D_1 = 0, for the others

D_2 = dummy for semi intensive rice field

D_2 = 1, for the strata of semi intensive rice field

D_2 = 0, for the others

D_3 = dummy of rain-fed rice field

D_3 = 1, for the strata of rain-fed rice field

D_3 = 0, for the others

Input of nutrient which was used in this analysis included the total nutrient (N, P, K). The total nutrient was calculated based on nutrient content of given nutrient. Given nutrient content was as follow:

Urea	= N content of 46%
SP_{36}	= P_2O_5 content of 36%
Nutrient of NPK	= N content of 15%, P_2O_5 of 15%, K_2O of 15%
ZA	= N content of 21%
Nutrient of manure	= N content of 0.78%, P_2O_5 content of 4.6%

RESULTS AND DISCUSSION

Quality of area

Description of area unit

Based on the overlay result of slope map, land use map, and soil type map, there was obtained 10 units of soil maps. Then, there were taken purposively 10 points samples in the intensive rice field, semi intensive rice field, and rain-fed rice field.

Condition of soil fertility

The observed area characteristic in this study included area characteristic which related to the condition of rice cropping growth such as the characteristic of soil fertility. The characteristic of soil fertility included capacity of cation change (KTK), base satiation (KB), pH of soil, soil of C-organic, and available nutrients like macro nutrient content of N, P, and K. Nitrogen, Phogpor, and Kalium were as primary nutrients for cropping.

The capacity of cation change in the soil of Sidrap Regency was shown as in Table 1. Capacity of cation change (KTK) in cmol/kg in this study was in the area suitability cathegory S_1 (> 16 cmol/kg) for rice cropping. The value of KTK at the three strata of rice field management had almost the same value. It was fitted with the class of soil texture (type of clay). The value range of KTK in rice field soil was evaluated enough to support nutrient dasorption through fertilizing. According to Djaenuddin [6], the optimal value of soil KTK for irrigated rice field cropping as well as rain-fed one was in the range of more than 16 cmol/kg for S_1 and 16 cmol/kg for S_2.

The value of base satiation which was expressed in the unit of percentage in this study location was in the area sutability cathegory of S_2 (< 35%) for rice cropping. According to Sys *et.al.* [5] and Djaenuddin *et.al.* [6], the condition of base satiation which based on the area suitability criteria for rice cropping in the irrigated rice field as well as rain-fed one was in the range of more than 36% for S_1; 20-35% for S_2; and less than 20% for S_3.

The soil condition in Sidrap Regency had variated enough of pH from acid cathegory pH of 4.5-5.5 until netral pH of 5.5-7.0. The pH average of intensive rice field (with 3 times rice cropping/ year) was higher than semi intensive rice field (with 2 times rice cropping/ year), but it was lower than rain-fed one (with 1 time rice cropping/year). According to Djaenuddin *et.al.* [6] that the optimal value of pH for rice cropping was in the range of 5.5-7.5. Based on the criteria of area suitability for irrigated rice filed as well as rain-fed one, the pH was in the range of 5.5-7.0 for S_1 and 7.0-8.0 for S_2; and then < 4.5 and > 8.0 for S_3. Therefore, it could be expressed that for the three types of rice fields (intensive, semi intensive, rain-fed) had the optimal value of pH for rice cropping growth.

The content of soil organic material (in the form of C-organic) was generally in the low cathegory (1-2%) until very low cathegory (< 1%). The average of soil C-organic condition in study location was very low, and it was in the area suitability class of S_3 (< 0.8%) for rice cropping growth. The intensity of rice cropping along the year caused the soil nutrients was missing because the nutrients was transporting together with high enough of harvest, so that the content of soil C-organic was low. In addition, because of stubbles treatment after harvest, most of farmers had burned or sold the stubbles after rice harvest. According to Djaenuddin *et.al.* [6], the value of soil C-organic based on the criteria of area suitability for irrigated rice field as well as rain-fed one was in the range of > 1.5% for S_1; 0.8-1.5% for S_2; and < 0.8% for S_3. Therefore. It could be said that for the three types of rice field soil (intensive, semi intensive, rain-fed) had the very low content of soil C-organic for rice cropping growth. The content average of nitrogen (N) in rice field was low (0.1-0.2%). The lower nutrient status of N was caused by the characteristic of N was very mobile, easy voltalisation, and leaching, though in general the farmers had used the urea nutrient with high enough of dosis. The lower content of soil nitrogen was correlated with the content of organic materials. According to FAO [7], the missing of N was easily occured with the high rainfall and in the soil with low content of organic materials. This condition showed that the system of soil preparation was not good enough, especially the application of fertilizing technology and the management of organic materials.

The available of phospor (P) in the soil of rice field was in the low cathegory (5-10 ppm). According to Department of Soil Research [8], the condition of soil P in P_2O_5 was very low (< 10 ppm P), low (10-25 ppm P), medium (26-45 ppm P), and high (46-60 ppm P). Then, the available of Kalium (K) in the soil of rice field was averaged in the medium cathegory (21-40 mg/ 100 g). Based on the Department of Soil Research [8], the condition of K_2O was very low (< 10 mg/ 100 g), low (10-20 mg/ 100 g), medium (21-40 mg/ 100 g), and high (41-60 mg/ 100 g).

Index of area quality

Based on the cryteria of Sys *et.al.* [5], there was determined the index of area quality. The cryteria was carried out to abtain the index value of area in the three strata of rice field area by giving the weight of area characteristic which was fitted to the condition of rice cropping growth. The result of being weight and area index value was presented as in Table 2.

Index of area quality in intensive rice field, semi intensive rice field, and rain-fed rice field were significantly difference. Based on the test of one way variance analysis, it indicated that the P-value was 0.045

with significant level of 0.05, so that Ho was not accepted. It meaned that there were difference among the three strata of rice fields. Then, the numerical analyses produced that the average of area quality for intensive rice field was 28.61, for semi intensive one was 34.04, and for rain-fed field was 22.54. Based on the index of area quality, the intensive and semi intensive of rice field were in the area suitability class of S_3 (fitted to the marginal) and the rain-fed rice field was in the class of N area suitability (it meaned that it was not suitable).

Productivity

Productivity of rice in intensive, semi intensive, and rain-fed rice field for the cropping season of 2010/2011 were presented as in Table 3. The productivity among the intensive, semi intensive, and rain-fed rice field were significantly different. Based on the test of one way variance analysis, it indicated that the P-value was < 0.021 with significant level of 0.05, do that Ho was not accepted. It meaned that there were productivity difference among the sthree strata rice fields. The average of rice productivity in intensive as well as semi intensive rice field in the cropping season III (type of "gadu" or dry rice) was higher that cropping season II (type of "rendengan" or rainy rice). It was caused that the intensity of sun radiation in the dry season was higher than in the rainy season. This condition caused the activity of photosynthesa was better occured and the result was saved higher in the form of rice. This result was fitted with the research of Yang [9]. Yang [9] presented that the productivity of rice in dry season was 8.21 ton/ha. It was higher than in rainy season that was 6.08 ton/ha. According to Peng [10], the productivity of rice had positive correlation with the daily intensity average of sun radiation during the growth period.

The rice productivity in intensive rice field was lower than in semi intensive one, and in rain-fed field was lower than in intensive and semi intensive one in the dry season as well as rainy season. The average of rice productivity in intensive rice field was 5.471 kg/ha. It was lower than in semi intensive rice field (5.967 kg/ha), and in rain-fed rice field was 3.970 kh/ha. This result was still under potential production of 6.435 kg/ha.

Table 1 Retention condition of nutrients (KTK, KB, pH, and C-organic) and intensity of rice cropping in Sidrap Regency

SPT	Frequency of rice cropping in one year	Retention of nutrients			
		KTK (emol kg^{-1})	KB (%)	pH H_2O	C-organic (%)
1	3 kali	24,22	24,98	6,29	1,16
2	3 kali	20,24	17,14	6,27	0,61
3	3 kali	21,45	17,08	5,44	0,80
4	2 kali	20,85	30,89	6,13	0,25
5	2 kali	22,12	24,44	5,41	0,45
6	2 kali	21,64	15,53	5,80	1,03
7	2 kali	20,86	14,44	5,70	0,59
8	1 kali	22,48	13,54	6,46	0,39
9	1 kali	20,68	20,30	4,48	0,77
10	**1 kali**	**21,61**	**17,45**	**6,84**	**0,49**

Source: Analysis result of primary data, 2011

Table 2 Characteristic weight of rice field and the value of area index

SPT	TP r-year	k/r	Retention of nutrients				Available nutrients			Index value
			KTK	KB	pH	C-org	N	P	K	
	3x	kr	24,22100	24,9870	6,29100	1,1666	0,2085	11,2262	20,1785	35,82
	3x	kr	20,2493	17,1457	6,27100	0,6160	0,1164	11,6962	21,7288	24,96
	3x	kr	21,4595	17,0857	5,4476	0,8060	0,2286	11,0762	20,2785	25,05
	2x	kr	20,8594	30,8980	6,13100	0,2560	0,1164	12,5862	32,1293	35,34
	2x	kr	22,1297	24,4470	5,80100	0,8560	0,1780	11,2662	19,2184	31,91
	2x	kr	21,6496	15,5370	5,80100	1,0372	0,2286	11,2562	25,9587	37,30
	2x	kr	20,8694	14,4470	5,7093	0,5960	0,2186	11,1862	20,8185	31,60
	1x	kr	22,4897	13,5452	6,46100	0,3960	0,1778	12,8963	28,6188	26,09
	1x	kr	20,6894	20,3060	4,4870	0,7760	0,0858	11,8362	19,3784	21,50
	1x	kr	21,6196	17,4557	6,8492	0,4960	0,0350	11,1461	24,2787	23,40

Table 3 Rice productivity in intensive, semi intensive, rain-fed rice field in the cropping season of 2010/2011 in Sidrap Regency

No	Cropping season	Productivity (kg ha^{-1})			Productivity in regency (kg ha^{-1})
		Intensive (n=30)	S. Intensive (n=30)	Rain-fed (n=30)	
1.	Cropping season I	5.234	0	0	6.355
2.	Cropping season II	5.478	5.661	3.970	6.475
3.	Cropping season III	5.702	6.274	0	6.475
4.	The average of productivity (kg ha^{-1})	5.471	5.967	3.970	6.435
5.	**Tiling (kg ha^{-1})**	**4.640**	**5.040**	**3.775**	-

Source: Analysis of primary data, 2011

The effect of using NPK nuttrients and area quality

Empirical model of production function by using double linear regression was used for evaluating the hypothesis that expressed the effect of using N, P, K nutrients, area quality index, and dummy of rice fields due to the rice productivity. The accuracy of double linear regression model was based in the determination coefficient (R^2). The result of R^2 was 0.706. It indicated that independent variable of N, P, K nutrients, soil fertility, and dummy variables of intensive, semi intensive, and rain-fed rice fields could describe variability on dependent variable of rice productivity was 70.6% and the rest was described by the other variable. The value of F-calculated was > F table in the significant level of 1 % as well as 5%, so that Ho could be not accepted. It meaned that the independent variables of using N, P, K nutrients, soil fertility, and dummy variables of intensive, semi intensive, and rain-fed had significantly influence together to the dependent variable of rice productivity.

Table 4 Result of double linier regression test

Variable	β	t_{ratio}	Sig.	Note
Constant	1,878	9,694**	0,000	**Sig.**
Nutrient of N	0,689	10,811**	0,000	**Sig.**
Nutrient of P	0,003	0,741^{ns}	0,461	**Non Sig.**
Nutrient of K	0,004	1,296^{ns}	0,199	**Non Sig.**
Soil fertility	0,299	1,931*	0,156	**Sig.**
Dummy of Intensive	-0,208	-4,619**	0,000	**Sig.**
Dummy of Semi Intensive	0,125	2,632**	0,010	**Sig.**
Dummy of Rain fed	0,002	0,510^{ns}	0,611	**Non Sig.**
R_{square} : 0,706 **$F_{calculated}$: 28,11**				

Table 4 showed that the variable of using nutrient of N significantly influenced to increase rice productivity with significant level of 1% and regression coefficient of 0.689. But the using of P and K did not significantly influence to the rice productivity. The using average of SP_{36} nutrient by the farmers was more than the recommendation of PPL, but the using of K nutrient which only came from NPK nutrients were used in average by the farmers and there were lower than the recommendation of PPL.

Variable of soil fertility indicated positive significantly influence to the percentage of rice productivity and it would increase 0.29%. This condition could be carried out through the condition improvement of soil fertility by adding organic material in rice field and balanced fertilizing especially in using the an-organic nutrient. Then the dummy variable of intensive rice field indicated negative significantly influence with the coefficient of -0.208, but dummy variable of semi intensive rice field indicated positive significantly influence with the coefficient of 0.125. Interpretation of the value indicated that there was level difference of average productivity such as intensive rice field indicated that the average productivity was more decreasing but in the semi intensive rice field indicated that the average productivity was more increasing.

Based on the result as above, there gave interpretation as follow: 1) level difference of technical efficiency which was reached by the farmers indicated that the more intensive of rice field management caused the less technically efficiency especially in using the nurients of N. P. And K. The using on production facility of N. P. K nutrients in semi intensive rice field was in average more efficient than intensive and rain-fed rice field; 2) level of soil fertility was positive significantly influenced rice productivity. It meaned that the better soil fertility would increase rice productivity; and 3) the average productivity in intensive rice field was more decreasing, in semi intensive rice field was more increasing, but in rain-fed rice field had very small and not significantly increasing.

CONCLUSION

1. The quality of area was significantly different among in intensive, semi intensive, and rain-fed rice field. The quality of intensive rice field was lower than semi intensive and in rain-fed rice field was lower than intensive and semi intensive rice field. It was caused by the area limiting in intensive rice field was higher that was the lower condition of soil organic material and available N and P nutrients.
2. The productivity was significantly different among in intensive, semi intensive, and rain-fed rice field. The productivity in intensive rice field was lower than semi intensive rice field, and in rain-fed rice field was lower than in intensive annd semi intensive rice field. The average productivity in intensive rice field was 5.967 kg/ha, but in rain-fed rice field was 3.370 ton/ha. It was caused by the soil fertility in intensive rice field was low as the impact of rice cropping intensity was continuously 3 times per-year. Periodical irrigating could decrease the content of soil nutrient.
3. The using of Nitrogen, Phosphor, and Kalium nitrients in semi intensive rice field indicated positive significantly influence to the rice productivity. It meanded that the increasing of nutrient using could increase the productivity. In intensive rice field, the increasing of Nitrogen and Phoephor nutrients became decrease (there was decreasing of marginal product), but in rain-fed rice field, the using of Phosphor and Kalium nutrients were not significantly influenced rice productivity.
4. Variable of area quality (as indicator of soil fertility) indicated that there was positive significantly influence to the rice productivity with regression coefficient of 0.29. The dominant influenced variable was Soil C-organic and Nitrogen nutrient. The better level of soil fertility would increase the productivity so that was nacceassary to be carried out the improvement of soil fertility by adding organic material in rice field and balanced fertilizing.
5. Dummy variable in intensive rice field indicated negative significantly influence with regression coefficient of -0.208, but for semi intensive and rain-fed rice field indicated positive significantly influence with coefficient of 0.125. Interpretation of this value indicated that the average productivity was more decreasing, but in semi intensive rice field indicated the productivity was more increasing.

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