Soil Fertility and Yield of Rice During Two Season on Organic and Inorganic Fertilized

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Abstract. The objective of the research was to investigate the soil fertility and yield of rice during two season on organic and inorganic fertilized. The experiment was conducted at rice field in Karawang and Bogor, West Java. The experiment used one factor in randomized block design consisted of three replications with 13 treatments. The first 6 treatments were 0, 2, 4, 6, 8, 10 ton organic fertilizer ha^{-1}, and the other 6 treatments were 0, 2, 4, 6, 8, 10 ton organic fertilizer ha^{-1} combined with 2 L biological fertilizer ha^{-1} and as control treatment was application of anorganic fertilizer with the rate of 400 kg NPK (30-6-8) ha^{-1}. Plot size was 15 m x 10 m, with a double row spacing. The results showed that the variables on first season such as number of tillers and leaf color in inorganic fertilizer treatment was higher when compared with the organic fertilizers. Soil fertility on organic fertilizer treatment increased in the second season and yield decreased in the second season.

Keywords: inorganic, organic, soil fertility, two season, yield.

1 Introduction

The use of inorganic fertilizers continuously resulting in negative effects on the soil and the environment [1] as resulting in paddy soil becomes solid, decreasing porosity, soil density (bulk density) increases, and declining soil fertility [2] and increased pest and disease [3]. Soils condition and its health status was vital part for the agricultural production [4]. The decline in soil fertility can be seen from declining of soil organic matter and pH [5]. Public awareness of the negative impacts of excessive inorganic fertilizer, the society is slowly making the transition to organic farming.

One of the components of organic farming is organic and biological fertilizers. Organic fertilizers play a role in improving and enhancing soil fertility [6], good chemical, physical, and biological of soil [7] and it can give macronutrients and micronutrients [8]. Biological fertilizers

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play a role in influencing the availability of macro and micro nutrients, nutrient uptake, enzyme system performance, increase metabolism, growth and yield [9]. One of the advantages of biological fertilizer that can improve nutrient uptake, if fertilizer is combined with organic fertilizers is expected to reduce the dose of organic fertilizer in the next planting season. The goal of this experiment was to study the soil fertility and yield of rice for two seasons on organic and inorganic fertilized.

2 Materials and methods

Field trials conducted in January-September 2012 at Karawang Wetan, Karawang Wetan District of Karawang Timur, West Java, Indonesia at an altitude of 15 meters above sea level during the two growing seasons. Soil analysis carried out in the Laboratory of Chemistry and Soil Fertility Department of Soil Science and Land Resources IPB. This experiment uses a single factor design with 13 treatments were arranged in a randomized block design with three replications. Treatment consisted of 13 treatments were 0, 2, 4, 6, 8, 10 tons of organic fertilizer ha-1, and 0, 2, 4, 6, 8, 10 tons of organic fertilizer ha-1 each plus 2 L fertilizer biological treatment ha-1 and 400 kg NPK inorganic fertilizer (30-6-8) ha-1.

Experimental plot size was 15 m x 10 m. The Menthik Wangi seeds sowing in seedbed, after 10 days transferred to the experimental plots with 2 plant per hole. The spacing used a double row space (legowo 2: 1) (25 cm x 15 cm x 50 cm). Organic fertilizer given before planting and biological fertilizers sprayed through the leaves at the age of 4 and 6 week after planting (WAP) respectively at 50% dose, and the NPK fertilizer given at planting time.

The parameters observe were soil analysis (pH, organic C, N, P, and K), number of tillers, leaf color, number of productive tillers, 1000 grain weight, the panicle length, number of grains per panicle, percent empty grains, and yield. The statistical data analysis using analysis of variance, if the level of $\alpha = 0.05$ level indicates a real effect, then continued by DMRT. Data calculations were performed using SAS (Statistical Analysis System).

3 Result

The results of the soil analysis showed that the soil before the experiment has a neutral pH, low levels of organic C, N, K level, and very high levels of P (Table 1). Low organic C content was in line with reportson organic treatment [10]. Table 1 showed that during the first and second growing season decline in soil pH values from neutral at the beginning of the experiment becomes slightly acid at the first planting season and acid in the second growing season. Organic C levels increased during the initial trial experiments, low organic C at first season and moderate organic C the second season. The organic fertilizer will increase the organic C content [12]. Soil N levels also increased during the two growing seasons. Soil P levels decreased in the first season to the second season.

Table 1. Analysis of the soil at different fertilizer treatments

Treatment	pH	C-org(%)	N-total(%)	P Olsen (ppm)	K (ppm)
Before treatment	**7.4 (N)**	**1.84 (L)**	**0.17 (L)**	**61.5 (VH)**	**151 (VL)**
			The end of the first planting season		
0 ton ha-[1] OF	5.7 (SA)	1.39 (L)	0.14 (L)	78 (VH)	78 (VL)
2 ton ha-1 OF	5.7 (SA)	1.34 (L)	0.15 (L)	40 (VH)	76 (VL)
4 ton ha-1 OF	5.4 (A)	1.39 (L)	0.16 (L)	0 (VL)	78 (VL)
6 ton ha-1 OF	5.2 (A)	1.41 (L)	0.15 (L)	0 (VL)	76 (VL)
8 ton ha-1 OF	5.6 (SA)	1.31 (L)	0.13 (L)	42 (VH)	103 (VL)
10 ton ha-1 OF	6.3 (SA)	1.13 (L)	0.13 (L)	34 (VH)	47 (VL)
0 ton ha-1 OF+BF	5.8 (SA)	1.28 (L)	0.14 (L)	55 (VH)	78 (Vl)
2 ton ha-1 OF+BF	5.7 (SA)	1.25 (L)	0.13 (L)	52 (VH)	63 (VL)
4 ton ha-1 OF+BF	5.6 (SA)	1.36 (L)	0.16 (L)	49 (VH)	76 (Vl)
6 ton ha-1 OF+BF	5.5 (A)	1.33 (L)	0.16 (L)	49 (VH)	92 (Vl)
8 ton ha-1 OF+BF	5.7 (SA)	1.64 (L)	0.18 (L)	73 (VH)	151 (VL)
10 ton ha-1 OF+BF	5.3 (A)	1.32 (L)	0.14 (L)	0 (VL)	89 (VL)
Inorganic	5.6 (SA)	1.28 (L)	0.13 (L)	43 (VH)	63 (VL)
			The end of the second planting season		
0 ton ha-1 OF	5.17 (A)	2.26 (M)	0.21ab (M)	11.17abc (L)	97.50bc (VL)
2 ton ha-1 OF	5.20 (A)	1.72 (L)	0.17ab (L)	9.03bcd (VL)	102.09abc (VL)
4 ton ha-1 OF	5.0 (A)	1.83 (L)	0.19ab (L)	7.90cd (VL)	120.50abc (VL)
6 ton ha-1 OF	5.00 (A)	2.76 (M)	0.25a (M)	7.40d(VL)	135.88abc (VL)
8 ton ha-1 OF	5.07 (A)	2.10 (M)	0.20ab (L)	13.30a (L)	113.83abc (VL)
10 ton ha-1 OF	5.20 (A)	1.99 (L)	0.19ab (L)	12.17ab (L)	88.42c (VL)
0 ton ha-1 OF+BF	5.30 (A)	1.68 (L)	0.16ab (L)	12.37ab (L)	82.18c (VL)
2 ton ha-1 OF+BF	5.37 (A)	1.93(L)	0.19ab (L)	11.90ab (L)	90.25c (VL)
4 ton ha-1 OF+BF	5.13 (A)	1.96 (L)	0.22ab (M)	13.03a (L)	145.53ab (VL)
6 ton ha-1 OF+BF	5.03 (A)	1.61 (L)	0.16b (L)	11.43ab (L)	124.03abc (VL)
8 ton ha-1 OF+BF	5.20 (A)	1.83(L)	0.17ab (L)	12.13ab (L)	101.34abc (VL)
10 ton ha-1 OF+BF	5.43 (A)	1.74(L)	0.17ab(L)	6.33d(VL)	151.75a (VL)
Inorganic	5.20 (SA)	2.20 (M)	0.22ab (M)	12.633 ab(L)	70.08c (VL)

Note:

- OF: organic fertilizer, BF: 2 L ha-1 biological fertilizer
- (SA): slightly acid, (A): Acid, (L); low, (VL): very low, (M): Medium, (VH): very high, based on the criteria of soil analysis Soil Research Center (2008).
- Values followed by different letters within a column are significantly different at 95% DMRT.

The number of tillers in the first season on the treatment of inorganic fertilizers is highest one, but in the second season, the number of tillers of organic fertilized equivalent to inorganic fertilizer treatment (Table 2). This is presumably due to the role of organic fertilizers on the plant will begin to appear on the next season effect [7].

Table 2. Number of tiller at different fertilizer treatments

Treatment	Number of tillers (week after planting)					
	3	4	5	6	7	8
	First season					
0 ton ha-^{1} OF	20.4ab	30.1ab	29.7ab	29.1b	27.5ab	19.3a
2 ton ha-^{1} OF	20.9ab	28.2ab	27.5b	27.1b	25.9ab	18.7a
4 ton ha-^{1} OF	17.4b	28.7ab	27.5b	25.4b	25.2ab	18.4a
6 ton ha-^{1} OF	16.9b	27.5b	24.9b	28.6b	27.2ab	18.1a
8 ton ha-^{1} OF	18.1b	26.3b	25.8b	25.2b	25.9ab	18.1a
10 ton ha-^{1} OF	17.6b	29.7ab	26.5b	27.0b	25.3ab	19.1a
0 ton ha-^{1} OF+BF	18.2b	29.4ab	26.8b	27.1b	29.2a	20.0a
2 ton ha-^{1} OF+BF	19.6ab	26.4b	25.5b	25.5b	27.9ab	18.1a
4 ton ha-^{1} OF+BF	17.4b	27.0b	24.1b	24.9b	23.6b	17.7a
6 ton ha-^{1} OF+BF	19.1b	29.3ab	28.8ab	29.1b	26.4ab	18.6a
8 ton ha-^{1} OF+BF	16.8b	27.5b	24.6b	25.7b	24.3ab	17.7a
10 ton ha-^{1} OF+BF	19.1b	27.1b	26.1b	27.3b	25.5ab	18.5a
Inorganic	25.3a	35.6a	33.8a	34.4a	29.3a	20.8a
	Second season					
0 ton ha-^{1} OF	13.7a	22.1a	27.2a	24.8a	21.9a	19.1a
2 ton ha-^{1} OF	8.9a	18.7a	19.9a	21.6a	19.4a	16.5a
4 ton ha-^{1} OF	10.5a	19.1a	23.1a	25.9a	23.3a	19.4a
6 ton ha-^{1} OF	8.7a	21.6a	23.4a	28.1a	24.5a	20.8a
8 ton ha-^{1} OF	10.4a	19.1a	23.1a	25.4a	22.8a	18.9a
10 ton ha-^{1} OF	10.0a	22.0a	22.9a	26.1a	23.1a	18.4a
0 ton ha-^{1} OF+BF	12.1a	21.1a	22.5a	24.0a	21.1a	18.1a
2 ton ha-^{1} OF+BF	13.3a	21.4a	22.5a	24.7a	23.4a	19.4a
4 ton ha-^{1} OF+BF	12.2a	23.0a	25.5a	27.8a	22.7a	26.7a
6 ton ha-^{1} OF+BF	10.5a	20.2a	33.5a	26.4a	22.0a	17.3a
8 ton ha-^{1} OF+BF	8.1a	18.9a	19.9a	22.5a	20.9a	19.7a
10 ton ha-^{1} OF+BF	12.8a	21.9a	22.2a	25.2a	22.5a	19.5a
Inorganic	10.7a	23.0a	26.3a	26.6a	31.0a	20.0a

Note:

- OF: organic fertilizer, BF: 2 L ha-1 biological fertilizer
- Values followed by different letters within a column are significantly different at 95% DMRT.

In contrast to the plant height and number of tillers, leaf color variables on the first season and second season continued to show that the treatment of inorganic fertilizers have more color dark green leaves when compared with organic fertilizer treatment (Table 3). Leaf color chart

shows the level of adequacy of nutrient nitrogen. Nitrogen is needed for growth and yield [7]. Organic and biological fertilizer suspected could not provide enough nitrogen for the plants due to organic fertilizer slow provides nutrients [12], while inorganic fertilizers was having a a high nutrient content and quickly available to plants.

Table 3. Leaf color at different fertilizer treatments

Treatment	Leaf color (week after planting)					
	3	4	5	6	7	8
	First season					
0 ton ha-^{1} OF	2.48b	2.12e	2.33b	2.37c	2.50bc	2.57b
2 ton ha-^{1} OF	2.62b	2.38abcde	2.50b	2.38bc	2.43c	2.58ab
4 ton ha-^{1} OF	2.62b	2.45abc	2.50b	2.50b	2.52b	2.55b
6 ton ha-^{1} OF	2.55b	2.52ab	2.50b	2.42bc	2.45bc	2.55b
8 ton ha-^{1} OF	2.62b	2.13de	2.50b	2.37c	2.50bc	2.62ab
10 ton ha-^{1} OF	2.57b	2.35bcde	2.50b	2.47bc	2.45bc	2.52b
0 ton ha-^{1} OF+BF	2.57b	2.18cde	2.50b	2.47bc	2.47bc	2.62ab
2 ton ha-^{1} OF+BF	2.57b	2.40abcd	2.50b	2.38bc	2.52b	2.60ab
4 ton ha-^{1} OF+BF	2.43b	2.52ab	2.50b	2.47bc	2.50bc	2.53b
6 ton ha-^{1} OF+BF	2.43b	2.45abc	2.50b	2.50b	2.48bc	2.62ab
8 ton ha-^{1} OF+BF	2.55b	2.15de	2.50b	2.50b	2.50bc	2.52b
10 ton ha-^{1} OF+BF	2.53b	2.47ab	2.50b	2.50b	2.50bc	2.52b
Inorganic	2.97a	2.63a	2.83a	2.87a	2.70a	2.67a
	Second season					
0 ton ha-^{1} OF	2.0d	2.1e	2.2c	2.2f	2.3	2.0b
2 ton ha-^{1} OF	2.2c	2.3d	2.4bc	2.2f	2.4	2.0b
4 ton ha-^{1} OF	2.3bc	2.3d	2.5b	2.5bcd	2.4	2.0b
6 ton ha-^{1} OF	2.2bc	2.3d	2.5b	2.2f	2.6	2.0b
8 ton ha-^{1} OF	2.4bc	2.3d	2.4bc	2.3def	2.5	2.0b
10 ton ha-^{1} OF	2.2c	2.3d	2.4bc	2.4bcdef	2.3	2.0b
0 ton ha-^{1} OF+BF	2.4bc	2.4cd	2.3bc	2.4bcdef	2.2	2.1b
2 ton ha-^{1} OF+BF	2.4bc	2.4cd	2.4bc	2.3def	2.6	2.1b
4 ton ha-^{1} OF+BF	2.4bc	2.6b	2.4bc	2.5bcd	2.6	2.2b
6 ton ha-^{1} OF+BF	2.5b	2.5bc	2.4bc	2.5bcd	2.6	2.0b
8 ton ha-^{1} OF+BF	2.5b	2.5bc	2.4bc	2.6b	2.6	2.0b
10 ton ha-^{1} OF+BF	2.5b	2.5bc	2.5b	2.5bcd	2.7	2.0b
Inorganic	2.93a	2.8a	3.0a	2.8a	2.8	2.8a

Note:

- OF: organic fertilizer, BF: 2 L ha-1 biological fertilizer
- Values followed by different letters within a column are significantly different at 95% DMRT.

The yield components variables such as panicle length, number of grains per panicle, and 1000 grain weight on non fertilizer treatment was the lowest one, whereas in the second season two only the 1000 grain weight were influenced by fertilizers. The organic fertilizer was able to increase the weight of 1000 grains [13].

Table 4. Components of yield rice at different fertilizer treatments

Treatment	Number of productive tillers	Panicle length (cm)	Number of grain per panicle (grain)	1000 weight grains (g)	Empty grain (%)
			First season		
0 ton ha-^{1} OF	15.3b	24.1cb	109.5c	24.3b	5.6
2 ton ha-^{1} OF	16.3ab	25.3abc	132.8abc	30.0a	4.5
4 ton ha-^{1} OF	17.2ab	25.4abc	133.1abc	29.3a	4.9
6 ton ha-^{1} OF	16.8ab	25.4abc	131.5abc	30.0a	5.4
8 ton ha-^{1} OF	14.6b	24.9abc	136.5ab	30.0a	6.7
10 ton ha-^{1} OF	15.5b	24.9abc	132.5abc	30.0a	4.5
0 ton ha-^{1} OF+BF	17.8ab	23.1c	111.3bc	31.0a	4.9
2 ton ha-^{1} OF+BF	14.8b	23.8bc	120.0abc	30.0a	5.5
4 ton ha-^{1} OF+BF	15.2b	24.3bc	125.2abc	29.7a	4.3
6 ton ha-^{1} OF+BF	14.9b	24.9abc	134.0abc	30.0a	4.9
8 ton ha-^{1} OF+BF	15.9ab	25.8ab	137.7a	30.0a	5.1
10 ton ha-^{1} OF+BF	16.3ab	26.7a	142.2a	29.7a	4.9
Inorganic	19.6a	24.8abc	133.1abc	29.3a	4.2
			Second season		
0 ton ha-^{1} OF	17.9	28.8	89.2	28.79ab	5.52
2 ton ha-^{1} OF	16.3	21.3	92.1	31.66ab	3.20
4 ton ha-^{1} OF	14.7	23.2	105.0	31.19ab	3.38
6 ton ha-^{1} OF	16.8	23.1	101.9	33.41ab	3.14
8 ton ha-^{1} OF	15.5	23.0	104.2	31.58ab	4.68
10 ton ha-^{1} OF	13.7	23.3	109.3	30.79ab	2.16
0 ton ha-^{1} OF+BF	13.3	22.2	93.6	27.92b	2.85
2 ton ha-^{1} OF+BF	15.4	22.1	99.4	27.97b	3.65
4 ton ha-^{1} OF+BF	15.7	22.7	100.1	28.86ab	2.26
6 ton ha-^{1} OF+BF	14.1	23.1	127.0	31.62ab	2.54
8 ton ha-^{1} OF+BF	13.2	23.3	107.3	33.60a	2.38
10 ton ha-^{1} OF+BF	15.2	22.5	104.2	31.95ab	3.08
Inorganic	15.4	29.7	105.5	31.29ab	5.55

Note:

- OF: organic fertilizer, BF: 2 L ha-1 biological fertilizer
- Values followed by different letters within a column are significantly different at 95% DMRT.

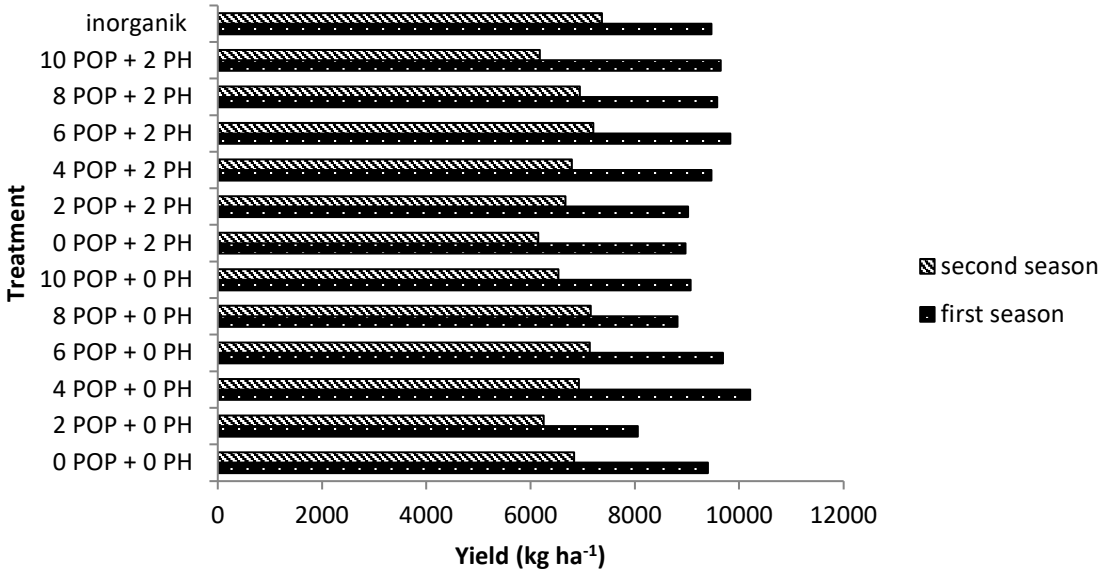

Figure 1. Yield in first and second season

Table 5. The NPK Levels of leaf and grain on different fertilizer treatment

Treatment	Leaf (%)			Grain (%)		
	N	P	K	N	P	K
0 ton ha-1 OF	1.32 (D)	0.27 (O)	1.69 (O)	1.19 (L)	0.38 (E)	0.30 (VL)
2 ton ha-1 OF	1.36 (D)	0.32 (O)	1.52 (O)	1.19 (L)	0.39 (E)	0.28 (VL)
4 ton ha-1 OF	1.41 (D)	0.33 (O)	1.61 (O)	1.24 (L)	0.40 (E)	0.30 (VL)
6 ton ha-1 OF	1.18 (D)	0.33(O)	1.62 (O)	1.23 (L)	0.40 (E)	0.32 (VL)
8 ton ha-1 OF	1.50 (D)	0.34 (O)	1.54 (O)	1.14 (L)	0.38 (E)	0.31 (VL)
10 ton ha-1 OF	1.26 (D)	0.34 (O)	1.60 (O)	1.18 (L)	0.40 (E)	0.41 (VL)
0 ton ha-1 OF+BF	1.22 (D)	0.34 (O)	1.41 (O)	1.11 (L)	0.40 (E)	0.38 (VL)
2 ton ha-1 OF+BF	1.37 (D)	0.35 (O)	1.45 (O)	1.16 (L)	0.40 (E)	0.37 (VL)
4 ton ha-1 OF+BF	1.20 (D)	0.34 (O)	1.53 (O)	1.20 (L)	0.39 (E)	0.36 (VL)
6 ton ha-1 OF+BF	1.15 (D)	0.29 (O)	1.52 (O)	1.22 (L)	0.40 (E)	0.50 (VL)
8 ton ha-1 OF+BF	1.40 (D)	0.30 (O)	1.58 (O)	1.18 (L)	0.39 (E)	0.43 (VL)
10 ton ha-1 OF+BF	1.25 (D)	0.30 (O)	1.50 (O)	1.15 (L)	0.39(E)	0.40 (VL)
Inorganic	1.32 (D)	0.28 (O)	1.74 (O)	1.31 (L)	0.40 (E)	0.34 (VL)

Note:

- OF: organic fertilizer, BF: 2 L ha-1 biological fertilize
- (D): nutrient deficiency, (O): optimum, (L): limited, (SL): very limited, (E): excess

Figure 1 showed that the yield per hectare was not affected by fertilizer treatment either in the first season and second season. It showed that the wet yield per hectare in the second season was lower than the first season. It was suspected that the first season was existence of nutrients stored in the soil. This is indicated by the P is very high before first season and decreased in the first and second season (Table 1).

4 Discussion

Decrease in soil pH can occur due to decomposition of organic materials provided on the ground can produce organic acids [14]. A decreasing in soil pH can occur as a result of organic matter in the soil weathering given to the role of microorganisms that produce plant nutrients, organic acids, CO2 and energy [15]. In general, the levels of N-total at the higher end of the study compared to prior studies, except in the treatment of 8 tons of organic fertilizer ha-1 + 2 L ha-1 biological fertilizer. The increased levels of N and K in the soil experiment is mainly due to the possibility of the addition of N and K from organic fertilizers are slow available. One of the properties of the organic material is slow to provide nutrients [12].

Based on the analysis of pH, the soil in the sour category, so there was the possibility of soil acidity resulting in a low P availability. In acid soils (low pH) elements Fe and Al are dissolved in the soil will bind to P so that phosphorus becomes unavailable or availability of P will be reduced [16].

The leaf color scores in the treatment of inorganic fertilizers is higher than the organic fertilizer treatments. This is due to the slow nature of the organic matter provides nutrients [7]. Leaf color scores on all treatments showed less than 4 and N content of leaves showed criterion deficiency (<2%) (Table 5). Leaf color value in all treatments remained below the critical point was <4 shows the inadequacy of nutrient N in plants [17]. In plants that fulfilled the needs of nitrogenous nutrients will have dark green leaves. Treatment without or with organic fertilizer biological fertilizer affects variables 1000 grain weight. Table 4 shows the weight of 1000 grains grow in line with increasing doses of organic fertilizer ($P < 0.05$), with the highest 1000 grain weight in the treatment of 8 tons ha-1 organic fertilizer + biofertilizer. The organic fertilizer can increase the weight of 1000 grains [13,18, 19,20]

Yield was not affected by the treatments because of the low availability of N, which can be seen from the color of the leaves are small [21] as well as the nutrient content of N in the leaves are small. Based on the criteria of nutrient adequacy rice plants, organic rice crop deficiency of N, but contains enough P and K (Figure 16) [22]. P and K content of leaves including sufficient criteria, but less leaf N content, thus making nitrogen becomes the limiting factor. The nitrogen effect on plant height, number of tillers and yield. The growth of the rice plant is determined by the adequacy of N and P, whereas for root growth is determined by the adequacy of P [22].

5 Conclussions

The variables first season such as number of tillers and leaf color in inorganic fertilizer treatment was higher when compared with the organic fertilizers. Soil fertility increased in the second season in organic treatment and yield of rice decreased in the second season.

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