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Role of Rice Straw Compost and Potassium in Controlling Blast Disease of Paddy Rice in South Sulawesi, Indonesia

Abdul Syukur Syarif[a*], Suryo Wiyono[b], Bonny P.W. Sukarno[c], Bambang S. Purwoko[d]

[a]Institute for Agricultural Technology of South Sulawesi, Makassar, Indonesia
[b,c]Department of Plant Protection, Bogor Agricultural University, Bogor, Indonesia
[d]Department of Agronomy and Horticulture, Bogor Agricultural University, Bogor, Indonesia
[a]Email: syukurbptpsulsel@gmail.com

Abstract

This research was aimed to evaluate the use of rice straw compost and potassium in controlling blast disease and increasing the yield of paddy rice in South Sulawesi. The experiment was conducted in endemic areas of blast disease, i.e. in Bantimurung Maros District of South Sulawesi province. The experiment was arranged using a randomized complete block design with two factors, i.e. application of rice straw compost and application of fertilizer KCl. Application of rice straw compost consisted of three levels: (J0) = 0 ton ha^{-1}, (J1) = 5 tons ha^{-1}, (J2) = 10 tons ha^{-1}. Application of KCl fertilizer consisted of four levels: (K0) = 0 kg ha^{-1}, (K1) = 50 kg ha^{-1}, (K2) = 75 kg ha^{-1}, (K3) = 100 kg ha^{-1}. Thus there were 12 treatments and each treatment was performed in four replications. Results showed that the application of 10 tons of rice straw compost ha^{-1} and 100 kg ha^{-1} of potassium was the optimum dose in the control of leaf blast and neck blast disease by 16.83% and 23.92%, respectively. However, the trend in the application of 5 tons of compost of rice straw ha^{-1} and potassium 50 kg ha^{-1} is a dose sufficient to control the leaf blast and neck blast disease. The decrease of leaf blast and neck blast disease occurred in the treatment of 5 tons of ha^{-1} and 10 tons of ha^{-1} of rice straw compost. The decrease in leaf blast and neck blast disease occurred along with the addition of potassium fertilization dose.

Keywords: blast disease; paddy rice; potassium; rice straw compost.

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* Corresponding author.

1. Introduction

The productivity of rice plant in Indonesia has not been as expected. The average productivity of new upland rice is 2.95 tons ha^{-1} and paddy rice is 5.08 tons ha^{-1} [7]. One cause of low production of rice is blast disease, caused by the fungus *Pyricularia oryzae* Cav. Blast disease can infect at all levels of the growth stage of the rice plant. The attack takes place starting from the nursery, vegetative stage, and generative stage by attacking the leaves, neck and collar [17]. In Indonesia, the disease reaches 1 285 000 ha or 12% of total rice areas [8]. According to reports BPTPH South Sulawesi (2014) attacks to blast over the period of the growing season 2004-2013 reached 12 056 hectares and 12 hectares have failed.

Farmers generally control the disease by using fungicides or using resistant varieties of rice plant. However, the use of fungicides can pollute the environment and costly. According to Wiyono and his colleagues (2014), the use of pesticides (insecticides, fungicides, herbicides and bactericide) on paddy rice may weaken the ecosystem resilience because of the death of natural enemies, damage to biodiversity and mesofauna microflora, and the destruction of the complex food webs in the fields. The use of resistant varieties is a very effective and efficient for controlling blast disease [4,10]. But this way inhibited by the presence of highly diverse pathogen virulence and the ability of the pathogen to form races (pathotypes) a new, more virulent so that the nature of the resistance of varieties is easily broken [11, 12].

The development of blast disease in rice crop is caused by the use of susceptible varieties, high use of pesticide, the straw is not returned, and uses un-sufficient potassium in fertilizating [20]. Cultivation practices by not returning rice straw into the fields cause a decline in soil organic matter, loss of essential nutrients for plants, N, P, K, Si, Ca and Mg and micronutrients. Fertilizers only use the N and P, while K is only given in the form of compound fertilizer, so the K is given in small amount. Decreasing the element potassium and silicate in rice crops can trigger an attack to blast disease.

According Fairhust (2007), potassium has a very important function in strengthening the cell walls of plants and improving disease resistance in plants. Potassium leds to the formation of the outer wall that is thicker in the of the epidermis cells. Dose of rice straw compost and potassium is a key success in controlling blast disease in rice crops. This study were aimed to evaluate the use of rice straw compost and potassium in controlling blast disease, and to increase the yield of paddy rice in South Sulawesi.

2. Materials and Methods

2.1. Time and Place

The experiment was conducted on farmers' fields in District Bantimurung, Maros, South Sulawesi, from April to August 2015. The District Bantimurung is the central area of the rice plant in Maros regency which is an endemic area for blast disease attack. The experiment was arranged using a randomized complete block design with two factors, i.e. utilization of rice straw compost and use of fertilizer KCl. All physical and chemical properties of the soil before the experiment and climate condition during the experiment are shown in Tabel 1, and Fig. 1 and Fig. 2, respectively.

Table 1: Physical and chemical properties soil before threatments of experiment, Maros, South Sulawesi, 2015

Parameters	Results	Criteria
Sand (%)	36	-
Silt (%)	47	-
Clay (%)	17	-
pH $_{H2O}$ (1 : 2.5)	5.76	Acid
pH $_{KCl}$ (1 : 2.5)	4.49	Acid
C organic (%)	1.33	Very low
N total (%)	0.09	Very low
C/N ratio	15	Very low
Total P_2O_5 (mg $100g^{-1}$)	57	High
Total K_2O (mg $100g^{-1}$)	54	High
P available (mg P_2O_5 $100g^{-1}$) (Olsen)	62	High
K available (mg K_2O $100g^{-1}$) (Olsen)	67	High
Ca (me $100g^{-1}$)	22.01	Very High
Mg (me $100g^{-1}$)	0.37	Very low
K (me $100g^{-1}$)	0.14	Low
Na (me $100g^{-1}$)	0.28	Low
KTK (me $100g^{-1}$)	14.95	Very low
KB (%)	>100	High

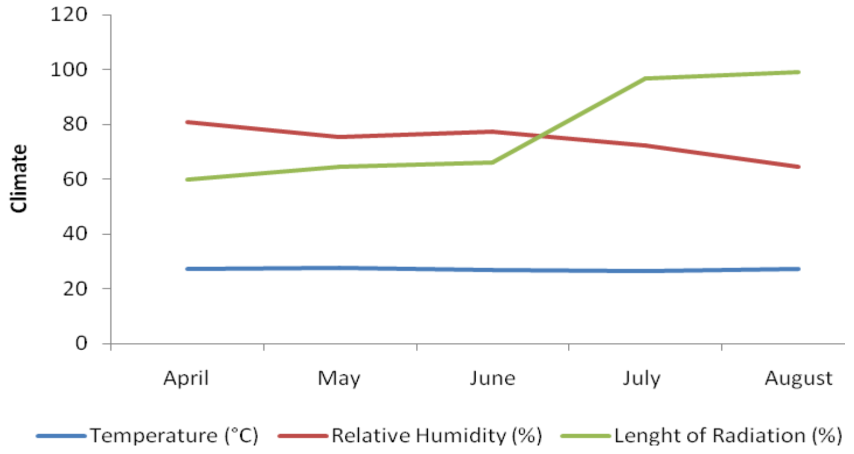

Figure 1: Temperature, Relative Humidity and Length of Radiation, Maros, South Sulawesi, 2015

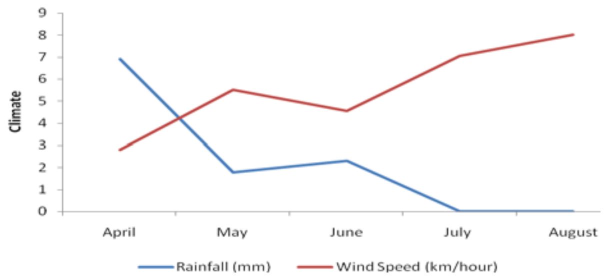

Figure 2: Rainfall and Wind Speed, Maros, South Sulawesi, 2015

2.2. Experimental Design

Application of rice straw compost was consisted of three levels: (J0) = 0 ton ha^{-1}, (J1) = 5 tons ha^{-1}, (J2) = 10 tons ha^{-1}. Applying of KCl fertilizer was consisted of four levels: (K0) = 0 kg ha^{-1}, (K1) = 50 kg ha^{-1}, (K2) = 75 kg ha^{-1}, (K3) = 100 kg ha^{-1}. Thus there were 12 treatments of the application and each treatment was repeated in four replications.

2.3. Preparation Procedure of Rice Straw Compost

Rice straw was fermented with PROMI®contain *Trichoderma harzianum* DT 38, *T. pseudokoningii* DT 39, *Aspergillus* sp, and decomposer. Ratio of PROMI® and rice straw was 1:500 (2 kgs of PROMI® in a ton of rice straw). The PROMI® was saluted in 300 liters of water and it was mixed homogenously. The rice straws were prepared in a portable template mold of bamboo in dimension 2x1x1 m. Those rice straws were watered in each 10 cm depth of it surface and they were pile up until 1 meter high. Furthermore, they were covered using black plastic and incubated in a month. They already becomes a fertelizer compost when those straws are going to be some of characteristics such as unsting, softened, moistered, and blackish brown. The analysis result of the compost was described in Table 2.

Table 2: Analysis of the rice straw compost

Parameters	Results
N-total (%)	1.48
P_2O_5 (%)	0.13
K_2O (%)	1.46
pH	6.48
C-organic (%)	12.04
Water content (%)	47.36
S_iO_2 (%)	11.50

2.4. Procedure of Cultivation

Tillage was done two weeks before planting by means of plowing, hoeing, and harrowing until padded. Experimental plots were arranged in size of 5 m x 4 m. Rice straw compost was applied before planting in conjunction with tillage and mixed thoroughly. Rice 14-day old seedlings were planted. Planting distance was 20 cm x 20 cm and two seedlings were planted per hill. Urea dosage was 200 kg ha^{-1}, SP36 was 100 kg ha^{-1} and KCl was according to treatment. Urea fertilizer was applied twice, while the SP36 and KCl only one time. SP36 and KCl were applied entirely at the age of 7 day after planting (DAP) along with the first stage urea as 100kg ha^{-1}. The second times of Urea was administered in active tillering and primordial phases as much as 100 kg ha^{-1}. Harvesting was done when it was approximately 90% panicles and the rice's flag leafs had been yellowed.

2.5. Disease severity

The severity of leaf blast disease was calculated starting at 30 DAP, 40 DAP, 50 DAP dan 60 DAP with the following formula:

$$DS = \frac{\sum(ni \times vi)}{Z \times N} \times 100\%$$

Where :

DS = Disease severity

n = Number of leaves infected

v = Value score of each category attack

N = Number of leaves observed

Z = Value of the highest score

The following disease rating scale was used to evaluate disease severity: 0 = No symptoms; 1 = Small brown specks of pin-point size or larger brown specks without a sporulating center; 2 = Small roundish to slightly elongated, necrotic gray spots, about 1-2 mm in diameter, with a distinct brown margin, with lesions found mostly on the lower leaves; 3 = Lesion type is the same as in 2, but a significant number of lesions on the upper leaves; 4 = Typical susceptible blast lesions 3 mm or longer, infecting less than 4% of the leaf area; 5 = Typical blast lesions infecting 4-10% of the leaf area; 6 = Typical blast lesions infecting 11-25% of the leaf area; 7 = Typical blast lesions infecting 26-50% of the leaf area; 8 = Typical blast lesions infecting 51-75% of the leaf area and many leaves dead; 9 = More than 75% of the leaf area affected [6]. The severity of neck blast disease was calculated by formula:

$$DS = \frac{a}{b} \times 100\%$$

Where :

DS = Severity neck blast disease

a = Number of infected panicles

b = Number of panicles not infected

2.6. Statistical Analysis

Data were analyzed using analysis of variance and followed by Duncan multiple range test at $P<0.05$ level of significance.

3. Results

3.1. Effect of Rice Straw Compost and Potassium to Leaf Blast Disease

Disease severity of leaf blast by using rice straw compost, potassium and their interaction are showed in (Table 3). The composition of rice straw compost and potassium can control leaf blast disease. The severity leaf blast disease can be controlled up to 16.58-18.11% with the optimum dosage of rice straw compost and potassium are 10 tons ha^{-1} and 100 kg ha^{-1}, respectively. While, the control plants that do not use rice straw compost and potassium has capability to control the severity leaf blast disease in 23,82-37,07%. Those percentage indicate that the higher percentage is the disease is getting higher and in reversely, the lower percentage indicates the disease is getting low. Along with the increasing age of plants also decreased blast disease. At the age of 40 DAP occurs the highest incidence, then age 50 DAP and 60 DAP gradually decreased. This is thought to be due to the effect of straw and potassium fertilization starting at 40 DAP.

Table 3: The Effect of rice straw compost and pottasium against leaf blast severity on Cigeulis variety in Maros, South Sulawesi, 2015

Treatment		Severity of Leaf Blast (%)			
Straw	Potassium	30 DAP	40 DAP	50 DAP	60 DAP
0 ton ha^{-1}	0 kg ha^{-1}	30.31 bc	37.07 c	23.97 c	23.82 c
	50 kg ha^{-1}	30.06 bc	36.74 c	23.97 c	24.07 c
	75 kg ha^{-1}	30.06 bc	36.74 c	23.72 c	23.82 c
	100 kg ha^{-1}	26.89 bc	31.07 bc	23.72 c	24.07 c
5 ton ha^{-1}	0 kg ha^{-1}	23.08 ab	28.19 bc	21.67 ab	20.86 bc
	50 kg ha^{-1}	22.83 ab	27.52 bc	20.92 ab	21.11 bc
	75 kg ha^{-1}	19.11 ab	21.52 ab	18.94 ab	19.38 ab
	100 kg ha^{-1}	18.53 ab	19.67 ab	18.39 ab	18.89 ab
10 ton ha^{-1}	0 kg ha^{-1}	18.28 ab	19.67 ab	18.39 ab	18.64 ab
	50 kg ha^{-1}	19.03 ab	19.67 ab	18.39 ab	18.89 ab
	75 kg ha^{-1}	17.67 ab	18.78 ab	17.08 ab	17.08 a
	100 kg ha^{-1}	17.17 ab	18.11 ab	16.58 ab	16.83 a

Description: The figures in each column followed by the same letter are not significantly different based DMRT 5%

3.2. Effect of Rice Straw Compost and Potassium to Neck Blast Disease

Disease severity of neck blast by using rice straw compost, potassium and their interaction are showed in (Fig. 3). The composition of rice straw compost and potassium can control leaf blast disease. The severity leaf blast disease can be controlled up to 23.92% with the optimum dosage of rice straw compost and potassium are 10 tons ha^{-1} and 100 kg ha^{-1}, respectively. While, the control plants that do not use rice straw compost and potassium has capability to control the severity leaf blast disease in 38.79 %. Those percentage indicate that the higher percentage is the disease is getting higher and in reversely, the lower percentage indicates the disease is getting low.

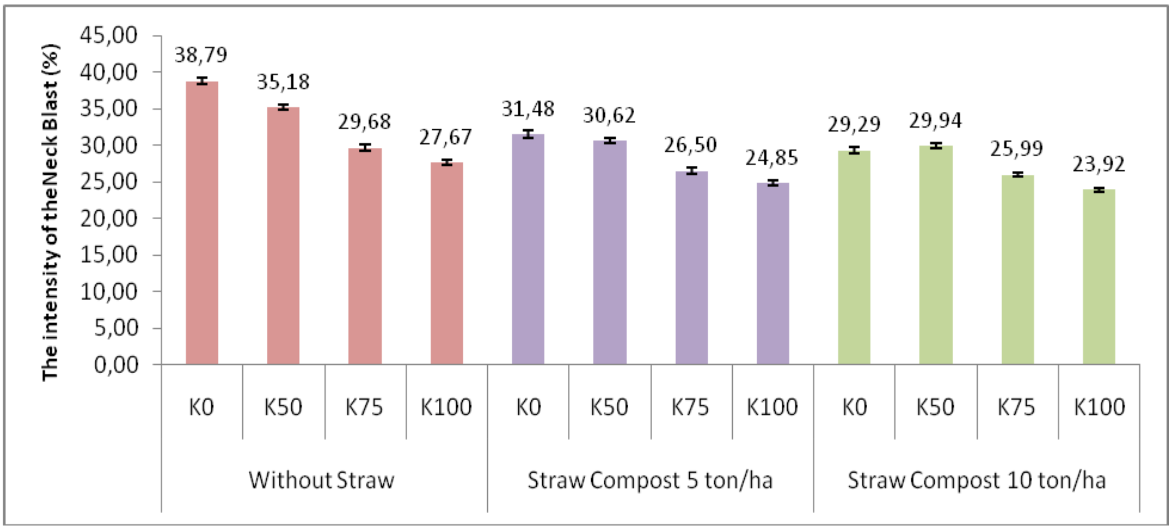

Figure 3: The Effect of rice straw compost and pottasium against neck blast severity on Cigeulis variety in Maros, South Sulawesi, 2015

4. Discussion

The result of this research shows straw rice compost and potassium can decrease leaf blast disease and neck blast disease severity. Increasing plant resistance is caused by the content of potassium and silicate that are compounded in straw compost and potassium fertilizer of each treatment. The rice straw compost contained as much as 10.50% SiO_2 and K_2O 1.46%. This condition seen in administring straw rice compost 10 tons ha^{-1} and potassium 100 kg ha^{-1} can decrease severity leaf blast disease up to 16.58% – 18.11% and neck blast disease 23.92%.

Silicate plays an important role in increasing plant resistance to blast disease. According to (Takahashi, 1995), the Si deposition in the epidermal tissue can block the invasion of the blast fungal hyphae physically. The higher levels of silica in the walls of the epidermis, the horder the plant cell walls, so the more resistant rice plants to blast disease. Mariana (2004) suggested that the higher the silica content would lower the intensity of leaf blast disease. Silica acts as a mechanical barrier that protects plants against penetration of appresoria. Makarim and his colleagues (2007) stated that the plants containing enough Si had leaves coated with silicate well, making them more resistant to incidences of various diseases caused by fungi or bacteria such as blast and bacterial leaf blight. Application of silicate can increase the concentration of silicate in the leaves or protecting leaves from blast attacks.

The role Si affects greatly the growth of the rice plant, has an impact on the strengthening of the stems of plants, plant protection from pests and diseases, strengthening the roots and others [13]. The rice plants were sufficient according to Yoshida (1985) resistant to rice stem borer and rice blast, efficient in capturing sunlight because the leaves pointing upward, efficient use of water and does not easily fall because it has a strong stem. This condition is consistent with the results of research Sumida (2002) which states that the supply of Si is enough on cereal crops capability of providing good, because adding Si improves the strength and durability of cells. Si supply helps for more erect leaves in the influence of high nitrogen fertilization conditions, so as to improve the rate of photosynthesis. Furthermore Nurhayati and his colleagues (2017) found that rice crops resistant to blast disease can reduce rice yield loss.

Besides silica, potassium also plays a role in increasing plant resistance to blast disease. According to Fairhust (2007), potassium has a very important function in strengthening the cell walls of plants and improving disease resistance in plants. K functions as osmoregulant, on activation of enzymes, pH adjustment at cellular level, the cation-anion balance the cellular level, regulate transpiration through the opening arrangement of stomata and assimilate transport. In addition, K also plays a role in strengthening the cell walls of plants and being involved in tissue sclerenchyme lignification associated with plant resistance to disease [18].

The containing nutrients in the compost especially silicates adds to increase resistance to blast disease, it can also improve physiological functions in plants. This condition can be shown on the height plant and tiller which has a significantly different result of applying straw rice compost 5 ton ha^{-1} dan 10 ton ha^{-1} with the control. According to Makarim and his colleagues (2007) Si is required which the plant has an upright leaf shape (no drooping), so that leaves capture effectively solar radiation and it is efficient in using of N which determines the level of yield. In addition, the plant stem is stronger, making it more resistant to stem borer attack, the brown plant hopper and tolerant to drought.

Potassium also plays an important role in increasing the capacity of photosynthesis and plant growth. According Dobermann and Fairhurst (2000), K in rice plants increases the leaf area and leaf chlorophyll content, and delays leaf senescence. Thus it increases the capacity of photosynthesis and plant growth.

The role of rice straw compost does not provide Si and K, but also improves the the physical, chemical and biological soil condition which are related primarily to the plant growth. In physically, the soil of the research location is categorized as sandy loam soil. This condition is highly related with drainage and aeration for the roots growing. Good dranage and aeration can improve the roots absorbing nutrients which are affecting to plant growth and disease severity on paddy rice. Wen (1985) suggested that the role of organic material among others as a source of plant nutrients, improves nutrient buffering capacity, and increases the cation exchange capacity. Furthermore, Hesse (1985) stated that the organic materials are used to improve soil structure, to increase soil temperature, to improve aggregate stability, to improve the ability for storing water, lower erosion sensitivity, and it is functioned as an energy source for microorganisms.

5. Conclusions

Use rice straw compost in proper proportion contribute to control blast disease attack in paddy rice. The fertilizers composition in this research has giving a significant effect in decreasing leaf and neck blast disease severity of treatment plants. Administring 5 tons of rice straw compost ha^{-1} and 50 kg ha^{-1} of potassium is a sufficient dosage in controlling leaf blast and neck blast diseases. Rice straw compost contains silicates and potassium which can increase the resistance of rice plants to blast disease. Besides, the composting of rice straw can break the cycle of blast disease because blast pathogen can survive on rice straw. Therefore, the use of rice straw compost is a cheap and sustainable blast disease control measures.

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