The application of various types of organic fertilizer and N, P, K combination on soil fertility, growth and yield of black rice

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Abstract. Black Rice is a source of carbohydrates foodstuff that is a local natural wealth of Indonesia. Black Rice contains a lot of aleurone and endosperm which produce anthocyanin (functions as an antioxidant and antidote to free radicals) so that it has dark purple to black colour. Beside, this black rice also contains fewer sugar levels, more fibre and vitamin E. Other advantages of black rice. It can be used as natural medicine or natural functional food ingredients to treat the body from degenerative diseases such as cancer. Potential yield of black rice is around 4–5 t/ha. Fertilizer is one of the most important factors besides land, labour and capital. Balanced fertilisation has an important role to improve agricultural products. In this study, the extent of the role of various types of organic fertilizers (straw compost, cattle manure, chicken manure and sheep manure) and N, P, K fertilizers on soil quality, the growth and yield of black rice were investigated. The experimental design was carried out using a Randomized Block Design (RBD) consisting of 10 treatments with triplicates. The combination of treatment consisted of straw compost, cattle manure, chicken manure, sheep manure and 0-100% N, P, K. The results showed that the combination of various types of organic fertilizers and N, P, K fertilizers had an effect on plant height, number of tillers and black rice yield (dry grain weight). The application of chicken fertilizers which was added with N, P, K fertilizers for one recommendation gave grain weight of 55.40 g/tiller(7.09 ton/ha).

Keywords: Black rice, organic fertilizer, anthocyanin

1. Introduction
Fertilizer is one of the most important factors of production besides land, labour and capital[10]. Balanced fertilization plays an important role in improving agricultural products. Recommendations for fertilizations must be made to be more balanced and rational based on the ability of the soil to provide nutrients and the plants’ necessities, so that the effectiveness and efficiency of the use of fertilizer and production increase without damaging the environment due to excessive fertilization[22]. Organic fertilizer is one of the type of fertilizers which is believed not to have a negative impact on the environment and yield, so that products from organic farming are safe for consumption. However, the organic fertilizer needed is still very high 7-10 t/ha as recommended in System Rice Intensification (SRI)[1][13].

The organic fertilizers that are tried are manure fertilizers and straw compost. Rice straw compost is the best soil conditioner compared to others, another added values can utilize this plant waste to increase soil fertility [1][13]. Currently, chicken fertilizer is widely used by farmers, due to the large number of chicken farms in Indonesia provides an opportunity to use chicken manure as fertilizer.
From the results of the study, chicken fertilizer has a very good influence on soil fertility and plants’ growth, even better than large animal manure fertilizers such as cattle and sheep [2]. Manure fertilizer contains humic acids, fulvate, growth hormones and others that are stimulating plant growth so that nutrient uptake by plants will increase [2]. Utilization of the manure fertilizer for rice field is far less than for dry land (food and vegetables). The maximum amount of manure fertilizer that is commonly used by rice farmers is < 2 t manure fertilizer ha-1 [2]. The results of the research on the application of manure fertilizer in paddy fields combined with organic fertilizers can increase the organic fertilizer using efficiency in the range of 2 - 20%[3]. The application of 500 kg/ha manure fertilizer combined with the application of organic fertilizer with a composition of N: P: K (150: 50: 50) kg/ha (50% of the recommended amount of NPK fertilizer) is able to significantly increase the yield of dry grain milled, which is increased by 20.6% compared to non-organic fertilizer treatment [3].

Black Rice is one of sources of carbohydrates foodstuffs that is the natural wealth of Indonesia [4]. Black Rice contains a lot of aleurone and endospermia which produce anthocyanin (functions as an antioxidant and antidote to free radicals) so that it has dark purple close to black color [5][12]. In addition, black rice also contains fewer sugar levels, more fibre and vitamin E. This black rice can be used as natural medicine or natural functional foodstuff as a cure for degenerative diseases (cancer). Anthocyanins function as antioxidants that can have anticancer activities [5][15]. The pigment contains of active material of flavonoids and the level is five times that of white rice and plays a very large role in preventing the hardening of the arteries and preventing the formation of uric acid in the body. Black rice contains carbohydrates, vitamins, micro elements (Fe, Zn, and Mn) and amino acids [5]. Black rice can also increase immunity, improve liver function, prevent impaired kidney function, clean cholesterol in the blood, etc.

Seeing the superiority of black rice compared to other kind of paddies and with the potential yield of black rice around 4-5 t/ha, black rice is feasible to be developed as a functional foodstuffs in supporting the development of Agro-industry [4][16]. Based on the description of the effect of organic fertilizer and NPK fertilizer on black rice plants, the following problems can be formulated: (1) whether the types of organic fertilizers and NPK fertilizers affect the growth and yield of black rice; (2) which organic fertilizer and NPK fertilizer can provide the best growth and yield for black rice cultivation.

2. Materials and Methods
The research methods of this study is experimental method using Randomized Block Design (RBD) consisting of 10 treatments with three replications, with two experimental units (maximum vegetative and generative). The total number is 2x30 = 60 pots. The black rice seeds used are local Tasik varieties. The research was conducted at the screen house in Jatinangor. Supporting data for this study are analysis of organic fertilizer and soil analysis.

The treatment given in this experiment is the application of various types of organic fertilizers and N, P, K fertilizers. The combination of each treatment is as follows: (A) Control (without organic fertilizer and without N, P, K fertilizer); (B) Straw compost+ 1/2 N, P, K; (C) Straw compost+ 1 N, P, K; (D) Chicken fertilizer + 1/2 N, P, K; (E) Chicken fertilizer + 1 N, P, K; (F) Cattle fertilizer + 1/2 N, P, K; (G) Cattle fertilizer + 1 N, P, K; (H) Sheep fertilizer + 1/2 N, P, K; (I) Sheep fertilizer + 1 N, P, K; (J) N, P, K fertilizer 100%[18][20].
Explanation:
1 N, P, K: 300 kg Urea/ha; 50 kg SP-36/ha; 50 kg KCl/ha [6].
Organic fertilizers each 10 tons /ha (calculation based on organic C content in the soil)

Materials and tools
Materials used were paddy fields, types of organic fertilizers, organic insecticides and N, P, K fertilizers. Tools used in soil processing in the field and analysis in the laboratory[22].
This experiment was conducted in the screen house of the Faculty of Agriculture, Padjadjaran University in Jatinangor
The variables observed included the characteristics / variables of growth (Plant Height; Number of Tiller per Clump). Component Results {Dry Grain Harvest Weight and Dry Grain Milled per pot and converted to tonnes/ha}.
The data obtained was analyzed using analysis of variance (ANAVA) and if significantly different continued with DMRT test at the level of 95%.

3. Result and Discussion
The implementation of the research started from the initial soil analysis, analysis of organic fertilizers and nursery preparation for planting media, planting, fertilizing, maintaining and harvesting
Preliminary analysis of soil, soil samples used in the study were Inceptisols[14] orders from Ciparanje.
Samples used composite from several points taken diagonally, then weighed 10 kg each, put into the pot and continue with lubrication. The analysis showed that the soil was low in fertility which was characterized by a rather acidic pH (5.58), low C-organic (1.89%), moderate N-total (0.24%), low K-dd (0.37 cmol / kg), low Na-dd (0.11 cmol / kg) but moderate CEC (20.76 cmol / kg) and high available P (19.08 ppm)[9]
The organic fertilizer sample was stirred until homogeneous and sieved with a 2 mm sieve. Material that did not pass through the sieve was a follow-up material (plastic, glass, gravel, etc.) separated, fertilizer samples are weighed. All analyzes used fertilizer samples that passed the 2 mm sieve (fine example) except for the initial water content of the sample and the content of the following ingredients. Conclusions from the results of the analysis were as follows: The highest organic C was in sheep manure (31.34%), the highest C/N was in cattle manure (11), the highest pH was in compost (8.93), the highest N-total was in compost (2.68%), total P2O5, total K2O and highest Si contained in chicken manure each (14.90%, 1.35% and 12.50 ppm), as a whole the chicken manure contained better nutrient than other organic fertilizers[9].
At the first stage, performed nursery before planting, the black rice seed varieties from Tasikmalaya used in the nursery were selected first by putting them in the water. The sinking seeds were then soaked in water for 24 hours. The seedling media used was soil and compost with a ratio of 1: 2. The seedling media was mixed until homogeneous then put in the container / tray. Rice seeds were sown on seedling media. Nursery was carried out until the seed was 14 days after seeding (HSS).
The planting medium used was Inceptisol soil around Ciparanje Experimental Garden. The soil taken was then dried for one week, smoothed and filtered. As much as 10 kg of soil from the filtering process were then mixed with organic fertilizer in accordance with the treatment and put in a pot and added water until it was flooded. After the soil was inundated, the lubrication was carried out by stirring repeatedly until mud conditions were formed.
After the planting media was ready, then planting was done, by planting one black rice seed for each pot. The seeds used were of uniform height, the seeds looked healthy with no yellow color in appearance, and there were no symptoms of disease attack. Planting was done at a depth of 3-5 cm.
Maintenance activities include water management, fertilization according to treatment and observations in the form of plant height and number of tillers. Water was given when the plant was 1 day old. The pot was irrigated to a height of 3 cm and no addition of water for the next 2 days. The watering process was continued on the 4th day until the inundation was 3 cm high. This method was continuously carried out until the final vegetative phase. From the panicle formation phase to the
filling of seeds, the soil was maintained in saturated soil condition. For ± 15 days before harvest, the water supply was stopped and allowed to dry naturally [7].

Inorganic fertilization (Urea, SP-36 and KCl) was carried out according to each treatment. The application of SP-36 and KCl fertilizer was given when the plant was 7 days after planting (DAP), while Urea fertilizer was carried out at the age of 7 DAS, 21 DAS and 42 DAP. Urea fertilizer needed to be given three times, so that N fertilizer was more efficient absorbed by rice plants. Giving Urea fertilizer was done by sprinkling on the side of the plant, while for SP-36 fertilizer and KCl sprinkled on different sides. No soil watering activity in a few days before fertilization in order to keep the soil in the saturated soil condition during fertilization[16].

Maintenance activities carried out in the form of regulating water, weeding, plant embroidery, observation and the management of pests. Weeding was done by immersing weeds into the planting media. Embroidery was carried out until the age of the plant was 12 DAP. The main pests that harm plants were grasshoppers, stem borers and stem borer worms. Efforts to control grasshopper pests were carried out by capturing and then releasing them to locations far away from the rice plants.

Pesticides spraying to control the stem borers was performed when the population or damage has exceeded the threshold. The threshold for stem borer is 6% (deadhearts) in vegetative phase and 9% (white heart) in generative phase), while for stem borer worms, the threshold is 25% damaged leaves (vegetative phase) and 15% damaged leaves (generative phase) . The type of pesticide being performed was Decis 25 EC by dissolving 2-4 mL into 1 L of water.

Observation of plant height (cm), and number of tillers were carried out every week until the final vegetative period. The measurement of plant height was done by using a meter which started from the part of the plant that was right above the planting media to the highest part of the leaf when vertically straightened. Calculation of the number of tillers was done by calculating the number of tillers of rice part in one clump. If there were 20 sticks in the clump, then the number of tillers of rice plants were 19 because the remaining one was the parent rice plant [8]. Calculation of the panicle number of each clump was done when the whole panicle had appeared.

Soil fertility

Based on the results of statistical tests due to the application of various types of organic fertilizers and N, P, K fertilizers showed an increase in soil fertility, characterized by organic C-elements, N-total, P-available, K-potential and pH. On average, the results of statistical test on the analysis of soil acidity values (pH) increased in the treatment of the application of manure fertilizer. This was caused by the addition of manure fertilizer to the soil would be further decomposed or mineralized, releasing minerals in the form of base cations (Ca, Mg, Na, K) which cause the increasing of OH-ion concentrations resulting in the rising of pH [9][19].

Table 1. Effect of the application of various types of organic fertilizer and N, P, K fertilizer on soil fertility (pH, C, N-total, available P and K potential soil)

| Treatment                  | pH  | C (%) | N-total (%) | P-available (ppm) | K-pot (mg/100g) |
|----------------------------|-----|-------|-------------|-------------------|-----------------|
| A (without fertilizer)     | 6.55 ab | 1.55 a | 0.16 a       | 19.08 b           | 3.07 a          |
| B (straw compost + 1/2 N,P,K) | 6.48 a | 2.31 b | 0.17 a       | 12.55 a           | 20.04 d         |
| C (straw composit+ 1 N,P,K) | 6.62 abc | 2.61 b | 0.22 a       | 19.93 b           | 15.97 bc        |
| D (chicken fertilizer + 1/2N,P,K) | 6.76 bc | 2.34 b | 0.25 a       | **22.36 c**       | 18.92 ed        |
| E (chicken fertilizer + 1 N,P,K) | 6.86 c | 2.43 b | 0.22 a       | 19.87 b           | **44.23 f**     |
| F (cattle fertilizer + 1/2 N,P,K) | 6.85 c | 2.18 b | 0.23 a       | 19.46 b           | 16.04 bc        |
| G (cattle fertilizer + 1 N,P,K) | 6.79 bc | 2.61 b | 0.24 a       | 19.53 b           | 41.15 e         |
| H (sheep fertilizer + 1/2 N,P,K) | 6.87 c | 2.76 b | 0.24 a       | 20.22 b           | 40.70 e         |
| I (sheep fertilizer + 1 N,P,K) | 6.85 c | 2.43 b | 0.21 a       | 19.38 b           | 18.83 ed        |
| J (1 N, P, K fertilizer)   | 6.85 c | 2.37 b | 0.17 a       | 19.32 b           | 13.65 b         |

Description: Numbers followed by the same letters are not significantly different according to Duncan’s
Multiple Range Test at the level of 5%

As shown in Table 1, the application of organic fertilizers and N, P, K fertilizers increase soil fertility (N, P and K elements). The E treatment (Chicken fertilizer + 1 N, P, K) gives the highest K-potential soil yield compared to other treatments which is 44.23 mg K$_2$O / 100 g. The potential K-value is included in the high category based on the criteria for assessing soil chemical properties. The average soil K-potential values in the treatment H (Sheep fertilizer + 1/2 N, P, K) and G (Cattle fertilizer + 1 N, P, K), which are 40.70 and 41.15 mg K$_2$O / 100 g respectively, in the criteria for assessing soil chemical properties also included in the high category. The results of further tests showed that treatment E (Chicken fertilizer + 1 N, P, K) had the best influence on the average K-potential value of Jatinangor Inceptisols soil.

The availability of high P nutrients in the soil other than because the fertilization process can also be due to the nutrients that have not been maximally absorbed by the plants. The available form to plants or the amount that can be taken by plants is only a small part of the amount that is in the soil. The accumulation of P elements in the soil occurs due to the immobile nature of P elements, so that it is less available to plants. The unavailability of this element is also because the P element is easily bound to Al and Fe elements in acid soils [10][23]. This condition results in low P fertilization efficiency.

Giving organic material to paddy fields can increase K in the soil through decomposition of organic material[17]. In addition, potassium will also be available in the soil for plants and is not easily washed. In addition, the application of inorganic fertilizer K, in this case KCl, can also increase K in the soil. The nature of inorganic fertilizers that are easily soluble in water can cause 15% K$_2$O contained in this fertilizer to dissolve in the soil. The dissolution will produce K cations in the soil solution that will be available to plants [9].

Plant height, Number of tillers and Dry Grain Harvest Weight

Based on the results of the overall statistical test, it was explained that the application of various types of organic fertilizers (compost, chicken, cattle and sheep fertilizers) and inorganic fertilizers (N, P and K) on plant height at the age of 2,4,6,8 and 10 WAP (Week After Planting) showed a significant difference between treatments. The results of statistical tests in detail can be seen in Table 2. Likewise, the effect of types of organic fertilizers combined with N, P and K fertilizers on the number of tillers showed significantly different based on Duncan’s Multiple Range Test. The results of statistical tests in detail can be seen in Table 3.

The statistical test results of the effect of various types of organic fertilizer and inorganic fertilizers (N, P and K) on Dry Milled Grain weight showed a significantly different effect between controls and other treatments, can be seen in Table 4.

Plant height

As shown in Table 2, the highest rice plants at the age of 2, 4, 6 and 8 WAP was due to the application of combination of chicken fertilizer and 1 N, P, K, while the lowest plant height was due to the application of combination of sheep fertilizer and 1 N, P, K. This can happen because the content of nutrient in chicken manure is higher than other organic fertilizers.

| Treatment | Plant height (cm) at the age of |
|-----------|-------------------------------|
|           | 2 WAP | 4 WAP | 6 WAP | 8 WAP | 10 WAP |
| A (without fertilizer) | 39.25 ab | 62.17 a | 68.42 ab | 68.83 a | 71.75 a |
| B (Straw compost + 1/2 N,P,K) | 40.83 b | 64.25 ab | 70.92 b | 72.50 ab | 77.92 ab |
| C (Straw compost + 1 N,P,K) | 38.92 ab | 66.67 ab | 74.42 c | 77.42 b | 81.75 b |
| D (chicken fertilizer + 1/2 N,P,K) | 40.58 ab | 67.50 ab | 72.92 bc | 75.25 ab | 78.50 ab |
| E (chicken fertilizer + 1 N,P,K) | 44.50 c | 70.17 b | 76.58 c | 79.17 b | 86.00 b |
As shown in Table 2, the highest rice plants at ages 2, 4, 6 and 8 WAP were due to the combination of chicken fertilizer and one N, P, K, while the lowest plant height was due to the combination of sheep manure and one N, P, K. This can happen because chicken manure has higher nutrients than other organic fertilizers.

The highest plant height was influenced by a combination of chicken manure and one N, P, K fertilizer recommendation but was not significantly different when compared with other treatments except by giving a combination of sheep manure and one N, P, K fertilizer recommendation. At the age of 6 WAP, the influence of straw compost and N, P, K, one fertilizer recommendation and one N, P, K fertilizer recommendation started to appear, it was seen that plant height at 10 WAP with the application of fertilizer one N, P, K recommendation was not significantly different compared to all treatments except the one with control (without fertilizer) which looks significantly different. The conclusions were the application of organic fertilizer (straw compost, chicken manure, sheep manure and cattle manure) with the addition of N, P, K fertilizer ½ recommendations could match only with the application one N, P, K fertilizer recommendation.

**Number of tillers**

As shown in Table 3, the number of tillers at the age of 2 and 4 WAP still has no noticeable difference between treatments but there is a tendency of the increasing number of tillers if N, P, K fertilizer is applied. The highest number of tillers is caused by the application of N, P, K fertilizer one recommendation (treatment J). In Table 3, the influence of the types of organic fertilizer and fertilizer N, P, K on the number of tillers show treatment J (one N, P, K fertilizer recommendation) the highest number of tillers and significantly different when compared with controls (without fertilization).

**Dry Grain Milled Weight**

Based on the results of statistical tests in Table 4, it is explained that the application of various types of organic fertilizer and fertilizer N, P, K to the dry grain weight of black rice shows a significant
difference between treatments. The lowest grain weight is seen in treatment A (control or without fertilization), while the highest is seen in treatment E (combination of chicken fertilizer + 1 N, P, K fertilizer) of 55.40 g /tiller is not significantly different from J treatment (fertilizer 1 N, P, K application).

The treatment of the application of chicken fertilizer and one dosage of N, P, and K fertilizer gave the best value for K-potential soil and K uptake in plants. According to [11], potassium can increase the number of grains / panicles, the number of filled grains / panicles and dry grain milled (MPD). Some results of the research on the application of chicken fertilizer always respond to the best plants in the first season. This happens because chicken feed is relatively decomposed and has sufficient nutrient content compared to the same number of units as other manure [17].

| Treatment          | Dry Milled Grain Weight (g/tiller) |
|--------------------|-----------------------------------|
| A (without fertilizer) | 18.33 a                          |
| B (Stray compost + 1/2 N,P,K) | 49.00 c                          |
| C (Stray compost + 1 N,P,K) | 41.77 b                          |
| D (chicken manure + 1/2 N,P,K) | 42.70 b                          |
| E (chicken manure + 1 N,P,K) | **55.40 d**                      |
| F (cattle manure+ 1/2 N,P,K) | 38.17 b                          |
| G (cattle manure + 1 N,P,K) | 37.77 b                          |
| H (sheep manure + 1/2 N,P,K) | 40.77 b                          |
| I (sheep manure + 1 N,P,K) | 42.30 b                          |
| J (fertilizer 1 N, P, K ) | 49.17 c                          |

Description: Numbers followed by the same letters are not significantly different according to Duncan's Multiple Range Test at the level of 5%

Components of grain yields and results are influenced by plant photosynthesis, the proses in which affected by nutrients N, P, and K. N-60% in the initial stage and 40% in the final stage leads to the increasing of N availability at the final growth stage which can affect leaf metabolism during seed filling [11]. P element plays a role in the supply and transfer of energy throughout the rice biochemical process, one of which is to accelerate the ripening and growth of grain so that grain weight increases [10]. The K element serves to form sugar, starch and various types of enzymes so that the amount of grain per panicle and percent of grain content can be increased [6].

4. Conclusion
Based on the results of the first phase of the research, conclusions can be taken as follows:

Giving various types of organic fertilizer and N, P, K fertilizers has an effect on increasing soil fertility, plant growth (plant height, number of tillers) and black rice yield (Dry Milled Grain Weight). The application of chicken fertilizer added with N fertilizer, P, K, one recommendation gave Dry Grain Milled Weight of 55.40 g /tiller (7.09 tons/ha) assuming the population per ha was 128 000 tillers.

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