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Number of Seedlings per Clump and NPK fertilization Effect on Growth and Yield of Lowland Rice Based on The Leaf-Color Chart

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Abstract

Excellent seedling selection and NPK fertilization can accelerate seedling, stem, leaf, and fruit growth. This study aimed to determine the effect of the number of seedlings and NPK-Phonska fertilizer on the growth and yield of lowland rice based on the leaf-color chart approach. This study was conducted from December 2021 to April 2022 in Puuroda Village, Baula, Kolaka. This study applied a randomized block experimental design with two-factor treatments, namely the number of seedlings and NPK-Phonska fertilizer dose. For the number of seedlings factor, there were one seedling per clump (B1), two seedlings per clump (B2), and three seedlings per clump (B3). The NPK-Phonska fertilizer factor contained two treatments, namely, without fertilizer treatment (M0) and fertilizer treatment based on the average dose of leaf-color chart (M1). The results of this study showed that two and three seedlings per clump had higher growth and yield of lowland rice, based on the plant height, maximum number of tillers, number of productive tillers, panicle length, dry grain yield (kg/plot), grain yield (ton/ha). The NPK fertilizer affects the growth and yield of lowland rice based on the leaf-color chart.

Keywords: Number of seeds, NPK Fertilization, leaf color chart

A. Introduction

Rice plant (*Oryza sativa* L.) is one of the important food commodities for the Indonesian community as most Indonesians utilize rice as a consumed staple food. In Indonesia, several rice plants have been applied by farmers, i.e. lowland rice plants. Therefore, these rice plants are highly recommended as an important and strategic plan for national food security (BALITPA, 2009).

According to the Southeast Sulawesi Bureau of Statistics (BPS Sultra, 2021), Southeast Sulawesi is one of the potential regions for lowland rice plant development, with a field area of 93,000 ha. The productivity of lowland rice plants in Southeast Sulawesi is considered as low, with an average production of 4.1 ton ha^{-1}. The lowland rice production in Kolaka District only reaches 3.8 ton ha^{-1}. This production value is below the average production of Southeast Sulawesi. The low production of lowland rice plants is caused by limited fertilized land, as the developing lands for lowland rice plants around Southeast Sulawesi are ultisol marginal lands Nurmas, Nofianti, Abdul, & Andi, 2014). Furthermore, Nurmas *et al*. (2014) also stated that these lands had extremely low carrying capacity levels due to poor nutrient contents, thus requiring fertilizer.

Obtaining an optimal level of seedling production is a highly influential component. However, many farmers still use seeds with a relatively large number of seedlings (7-9 seedlings per clump, even more than 10 seedlings per clump). According to Gani (2003) and Abdullah (2004), planting with relatively more seeds (5-10 seedlings per clump or > 10 seedlings per clump) causes intense competition among rice plants (inter-species competition) to obtain water, nutrients, CO_2, O_2, light, and space to grow, resulting in an abnormal growth in plants.

Lowland rice productivity faces various problems, including massive technological innovation in producing lowland rice cultivation systems and high farming cost reduction requirements. Using overdosed fertilizers imbalances the types and doses of fertilizers as nutrient supplies needed by plants. Instead of increasing crop productivity, this condition causes the lands to become increasingly depleted, and plants to grow improperly. Intensive and continuous utilization of rice fields for years can decrease the soil fertility level and damage the physical and chemical properties of the soil.

According to Sutedjo (1995), nitrogen, phosphorus, and potassium supplies in soil are limited for plant growth, thus, fertilization should be applied using N, P, and K fertilizers. The N, P, and K fertilizers have important roles in plant growth and production, whereas the interaction of these matters will support plant growth and production. The leaf-color chart (LCC) is useful for identifying the adequacy of N in lowland rice plants. If N is adequate, other nutrient requirements, such as P and K, will increase to compensate for the fast plant growth rate (Fairhurst, Dobermaan, Quijono-Guerta, & Balasubramanian, 2007).

The leaf-color chart (LCC) is a color scale that contains four color scales of leaves, whereas scale 2 possesses a yellowish-green color and scale 5 possesses dark green color. These scales are calculated based on the scales in the tool to measure an effective leaf chlorophyll content that can be used as a consideration for nitrogen fertilization in rice plants. This tool can also detect nitrogen contents in the leaves.

B. Methology and Method

This study was performed in Puuroda Village, Baula District, Kolaka Regency, Southeast Sulawesi, from December 2021 to April 2022. This study used a randomized block design in a factorial treatment pattern with two factors: the number of seedlings and NPK fertilizer dose factors. For the number of seedlings factor, there were three treatments applied, i.e. one seedling per clump (B1), two seedlings per clump (B2), and three seedlings per clump (B3). Two treatments are applied for the NPK fertilizer factor, i.e., without NPK fertilizer application (M0) and fertilizer application, based on the average recommended dose in LCC (M1).

The experiment was started by sowing the seedlings for 21 days and transplanting the seedlings to a 3 m x 4 m experimental plot with 25 cm x 25 cm spacing. Seedlings were maintained until the harvest period, followed by pest and disease control. The observed characters were plant height (cm), maximum number of tillers, number of productive tillers, 50% flowering age, panicle length (cm), number of grains per panicle, number of filled grains per panicle, weight of 1000 milled dry grains, total plant dry weight (gram), dried grain yield (kg/plot), and grain yield (ton/ha).

Data were analyzed using the analysis of variance, continued by Duncan's multiple range test, when the F-count was higher than the F-table at 95% and 99% degree of confidence. This test was proposed to obtain a significant or a highly significant difference among the treatments applied.

C. Result

Based on the analysis of variance results, no interaction occurred between number of seedlings and NPK fertilization factors on all observed variables in this study, namely plant height, maximum number of tillers, number of productive tillers, 50% flowering age, panicle length, number of grain per panicle, number of filled grains per panicle, weight of 1000 grains, total plant dry weight, dried grain yield (kg/plot), and grain yield (ton/ha).

The number of seedlings per clump has a highly significant effect on plant height, whereas the bigger the plant population, the higher plant height growth because the initial nutrients for growth have been fulfilled. Dangulo, Lapanjang, & Made (2017) stated that the highest plant height was produced in bigger plant populations in one stretch. Likewise, the fertilization treatment significantly affected plant height, indicating that the application of fertilizer is sufficient for the nutrient availability in the soil. Lakitan (1996) stated that light intensity was important for plant growth because it affected the photosynthesis process and height growth. However, the interaction between the two treatments had no significant effect on plant height.

Table 1. Growth variable observation

Treatment	**Variable**				
	Plant height (cm)	Maximum number of tillers	Number of productive tillers	50% flowering age	Total dry weight (gram)
B1	-	11.27^{q}	8.17^{r}	-	-
B2	-	14.53^{q}	15.67^{p}	-	-
B3	-	20.83^{p}	12.33^{q}	-	-
M0	112.88^{b}	13.22^{b}	11.33^{b}	54.56^{b}	346.11^{b}
M1	123.18^{a}	17.87^{a}	12.78^{a}	56.00^{a}	587.42^{a}

Note: The average numbers followed by similar superscript letters at the same line (a,b) or column (p,q) show a significantly different value, based on Duncan's multiple range with 0.05 degree of confidence.

The number of seedlings per clump significantly affects the number of productive tillers because a greater number of seedlings per clump will produce more productive tillers. However, the presence of rat pests that attack stems will reduce the maximum number of tillers and productive tillers. Number of seedlings per clump affected the existing population, growth of productive tillers, and rice production yield. The fertilization treatment significantly affected the maximum number of tillers and the number of productive tillers because applying fertilizer can provide the N, P, and K nutrients required by plants. According to Lingga and Marsono (2001), adding nitrogen (N) as a component in amino acids and proteins can stimulate vegetative growth in branches, stems, and leaves by assisting the cell protoplasm formation, thus stimulating growth. However, the interaction of the two factors had no significant effect on the maximum number of tillers and productive tillers.

The number of seedlings per clump had no significant effect on 50% flowering age. Genetic factors and environmental conditions influence the flowering age, so the number of seedlings per clump obtained no significant difference in the harvesting age. According to Susilo (2015), vegetative growth allows plants to accumulate greater photosynthetic results and possibly extend the flowering age, when environmental factors, such as light, temperature, and water are mutually supportive. The harvesting period is influenced by many factors, including plant genetics, temperature, rainfall, and light intensity received by the plants.

Table 2. Variable observation result

Treatment	Variable					
	Panicle length (cm)	Number of grains per panicle (grains)	Number of filled grains per panicle (grains)	Weight of 1000 grains (gram)	Dry grain yield (kg/plot)	Grain yield (ton/ha)
B1	-	-	134.17^{q}	-	5.05^{r}	4.23^{r}
B2	-	-	151.13^{p}	-	11.01^{p}	9.17^{p}
B3	-	-	148.28^{q}	-	9.25^{q}	7.71^{q}
M0	28.32^{b}	158.42^{b}	132.64^{b}	24.91^{b}	7.50^{b}	6.26^{b}
M1	29.93^{a}	180.13^{a}	147.91^{a}	25.72^{a}	9.38^{a}	7.81^{a}

Note: The average numbers followed by similar superscript letters at the same line (a,b) or column (p,q) show a significantly different value, based on Duncan's multiple range with 0.05 degree of confidence.

The fertilization treatment significantly affected the total plant dry weight, because fertilizer provides N, P, and K nutrients. The availability of macro-nutrients, e.g., nitrogen (N), phosphorus (P), and potassium (K) in the soil could activate the meristematic cells at the tip of the stem, facilitate photosynthesis, and increase the organic matter accumulation, thereby producing a maximum grain.

The number of seedlings per clump significantly affected panicle length as a small number of seedlings could utilize the available nutrients, sunlight, and water well. The panicle length also depends on the plant variety, which affects the number of grains per panicle. The amount of grain formed in each panicle is determined by the panicle length, as each can produce grain (Darwis, 1979). The fertilization treatment significantly affected panicle length, because this treatment could fulfill the nutrient availability in the formation of panicle length. By applying a proper fertilizer dose, plants can increase their panicle length optimally. Setyamidjaja & Wirasmoko (1999) stated that optimal fertilization efficiency was achieved if the fertilizer was stocked with an appropriate dose for plants. The panicle length influences the number of grains per panicle, whereas panicle length is influenced by the panicle initiation period, namely the cropping period. However, the fertilization treatment did not significantly affect the number of grains per panicle, the number of grains in each panicle was determined by the length of the panicle and the number of panicle branches, where each of which could produce grain (Masdar, 2005).

The number of seedlings per clump had a significant effect on dry grain yield (kg/plot) and grain yield (tonnes/ha). This condition was occurred because grain filling was ongoing along with the photosynthesis process. Based on Gardner, Pearce & Mitchell (1991), the photosynthesis process during the grain filling period is the most important part to gain an optimal yield. Before filling, the assimilate grains are used for the vegetative phase and flower formation. During the filling, most of the assimilate products are used for the filling process. The fertilization treatment significantly affected dry grain yield (kg/plot) and grain yield (ton/ha), because NPK fertilizer could provide sufficient nutrients for plant growth to reduce empty grain. A decreased empty grain indicates that rice plants responded to P and K fertilizers. Phosphorus absorbed by plants will be distributed to living cells, especially in the reproductive plant parts, such as stimulating the tiller development, increasing the number of grains per panicle, and accelerating the flowering period and seed formation.

D. Conclusion

Based on the results performed in Puuroda Village, Baula Sub-district, Kolaka District, this study concludes that:

1. The best seedlings per clump treatment is presented in 2 seedlings per clump. This treatment significantly affected the plant height, number of productive tillers, maximum number of tillers, panicle length, dry grain yield (kg/plot), and grain yield (ton/ha). However, no significant effect occurred in the 50% flowering period, panicle length, number of grains per panicle, number of filled grains per panicle, and weight of 1000 grains.
2. The NPK compound fertilizer had a significant effect on all observed variables, namely the plant height, maximum number of tillers, number of productive tillers, 50% flowering period, panicle length, number of grains per panicle, number of filled grains per panicle, weight of 1000 grains, dry grain yield (kg/plot), and grain yield (ton/ha).
3. There are no interactions between the number of seedlings per clump and *Phonska* NPK compound fertilizer on the growth and yield of lowland rice, based on the leaf-color chart.

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