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Growth and Yield Dynamics of Rainfed Rice Fields by Providing Municipal Solid Waste Compost

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ABSTRACT

The rice productivity in Panai Tengah was still relatively low, producing 4.75 Mg ha^{-1}, compared to the national production of 5 to 6 Mg ha^{-1}. Low rice productivity was caused by limiting factors in land use, namely, physical and biological factors, soil chemistry, and agricultural systems. Providing organic fertilizer or municipal waste compost is one way to overcome the constraints on the soil's physical, biological, and chemical characteristics. This study aims to determine the response to the growth and yield of rainfed rice fields in Kecamatan Panai Tengah with a dose of Municipal Solid Waste Compost (MSWC). This research was conducted by taking soil samples in the rainfed rice fields and then analyzing them in the experimental field at the Faculty of Science and Technology, Labuhanbatu University. The analysis stage was for six months, from seeding to harvesting. The methodology for this study was a non-factorial randomized block design consisting of 7 treatments. The result showed that applying MSWC at a dose of 18 Mg ha^{-1} showed high yields. The recommendation to farmers was to give 18 Mg ha^{-1} of MSWC to increase the yields of their rice fields.

Keywords: Organic fertilizer, *Oryza sativa*, rainfed rice fields, rice yield

INTRODUCTION

Rice (*Oryza sativa* L.) is a food plant that produces rice as the staple food source of most Indonesians. The need for rice as a staple food material continues to increase in line with the increasing population. Therefore, rice production must be increased to fulfill food needs in Indonesia. Badan Pusat Statistik (2023), Labuhanbatu rainfed rice production has only reached 3.0-4.0 Mg ha^{-1}. Land productivity can be enhanced by applying location-specific technology based on domestic resource potential and considering environmental aspects.

The low productivity of Labuhanbatu, Sumatera Utara rice is due to the cultivation technique, which is not as intensive as the existing agriculture in other areas in Indonesia, including the use of superior varieties, which are still very limited, fertilization, which still does not include recommendations and control of pests and diseases which are still carried out traditionally. In addition, the agricultural system is still ineffective; rainfed ricefields and tidal and irrigated rice fields determine ricefield production in Labuhanbatu (Dirjen Tanaman Pangan, 2020). High yielding variety rice is one of the main technology components which is a very dominant in increasing domestic rice productivity and production (Saidi et al., 2020).

Cultivation of rice using organic rainfed rice fields has more significant potential because the soil is semi-dry. Incidentally, N fertilizers have recently been scarce, so organic fertilizers are getting more potential. Organic fertilizers derived from household waste, such as compost for municipal waste, livestock or poultry, composted rice straw or other plant residues, manure in waterways, cakes, and green manure, can replace N.

Organic fertilizers or organic materials are the primary source of soil nitrogen and significantly improve soil's physical, chemical, and biological properties and environment (BPT, 2005). In the soil, organic fertilizers will be broken down by organisms into humus or soil organic matter. One of the organic fertilizers is municipal waste compost. However, the information on the use of Municipal Solid Waste Compost (MSWC) still needs to be improved, so the quantity or amount of use is unknown to obtain optimum growth and yield. Therefore, research is needed on the effect of MSWC on the growth and yield of rainfed rice fields. This research aims to determine the response to the growth and yield of rainfed rice fields in Panai Tengah District with a dose of municipal waste compost. Thus, this research needs to be carried out to determine the response to growth and yield of rainfed rice fields in Panai Tengah District with a dose of municipal waste compost.

MATERIALS AND METHODS

Research materials were soil samples, plastic pots, rice seeds, Inpari 10 variety, and MSWC. This research was conducted in the Faculty of Science and Technology, Labuhanbatu University, Sumatera Utara, Indonesia, for six months, from seeding to harvesting 28 meters above sea level.

This study used the RCBD method, consisting of 7 treatments with four replications and each replication consisting of three plant samples. The research treatment is the dose of each MSWC: Control (KS0), 3 Mg ha^{-1} MSWC (KS1), 6 Mg ha^{-1} MSWC (KS2), 9 Mg ha^{-1} MSWC (KS3), 12 Mg ha^{-1} MSWC (KS4), 15 Mg ha^{-1} MSWC (KS5), and 18 Mg ha^{-1} MSWC (KS6).

The research implementation included preparing planting media, seeding, planting, irrigation, fertilizing, weeding, and harvesting. Variables observed during the study included plant height (cm), maximum tillers (stem), productive tillers (panicles), number of grains per hill (grains), percentage of filled grains per panicle (grain), weight 1000 grains (g), weight of grain per hill (g) and environmental observations consist of temperature, humidity and rainfall.

Statistical analysis of non-factorial if the results of variance showed that the treatmenMg had a significant effect, then proceed with the 5% DMRT test, which aims to determine the difference between each treatment.

Regression analysis is a mathematical equation that states the functionalities between characters. The data obtained were analyzed using simple linear regression to obtain the relationship form of an equation between the independent character and the bound character. The analysis used the Statistical Product and Service Solutions (SPSS) software version 23.

RESULTS AND DISCUSSION

The results showed that two factors, internal and external, influenced the growth of rice plants. Internal factors that affect rice growth are genetic factors such as plant height, as shown in the study with descriptive data. The external factors that affect the growth and yield of rice are temperature, rainfall, and humidity. Nevertheless, on external factors, the results of research observations from the growing requirements of rice plants are very supportive, namely by research observations at an average

Table 1. Plant height (cm), number of grains per hill (grains), percentage of filled grains per panicle (%), weight 1000 grains (g), weight of grain per hill (g).

Treatments	Plant height (cm) 56 dap	Number of grains per hill (grains)	Percentage of filled grains per panicle (%)	Weight 1000 grains (g)	Weight of grain per hill (g)
KS0	81.54 a	1245.32 a	59.87 a	18.92 a	22.23 a
KS1	81.99 a	1242.65 a	61.88 ab	19.71 ab	23.87 a
KS2	80.66 a	1110.66 a	58.18 a	18. 81 a	18.87 a
KS3	82.33 a	1418.73 a	63.11 ab	19.83 ab	27.11 a
KS4	86.41 a	1461.41 a	64.57 ab	19.39 a	28.58 a
KS5	90.49 a	1951.33 a	79.34 ab	20.70 ab	42.17 a
KS6	92.16 a	1988.99 a	84.96 b	21.81 b	41.64 a

Notes: The numbers followed by the same letter are not significantly different in the 5% DMRT test temperature of 28.89 - 30.33 °C, the average rainfall is 209.3 - 358.5 mm, and humidity is 85.97 - 90.77%.

The rice growth is closely related to genetic factors of the rice plant itself when viewed from the data on plant height and maximum sum of panicle. In addition, the maximum sum of panicles was higher than compared to the description. Observations taken for plants in each treatment in the growth response and yield of rainfed rice in Panai Tengah District with municipal waste compost are presented in Table 1.

A regression analysis was carried out between one growth character and another based on the data obtained. The regression analysis results showed that the growth of rainfed rice had a positive regression coefficient function. The regression function of rainfed rice can be seen in Table 2. Based on Table 2, each observed character has a positive regression coefficient value with other characters. The plant height character has a positive regression coefficient with the number of grains per hill, percentage of filled grains per panicle, weight of 1000 grains, and weight of grain per hill. This means that each increase in plant height will be followed by an increase in the number of grains per hill by 0.013, the percentage of filled grains per panicle by 0.433, the weight of 1000 grains by 3,896, and the weight of grains per hill by 0.489, as well as other characters.

The sum of the panicles was influenced by the spacing of the more expansive rainfed fields and the planting pattern of 1 stem in the planting hole. The number of tillers in rainfed rice fields is higher because the seeds planted are young (8 days) after sowing, planting one seed in 1 hole, and this condition stimulates the formation of many tillers. Soil conditions were not inundated, causing areas around the roots to allow phyllo chrons of rice plants to develop (continue to form tillers).

The increase in the dosage of MSWC given to rice plants caused a relatively significant increase. Excessive nitrogen elements will cause photosynthate (carbohydrates) to combine with Nitrogen compounds so that some carbohydrates will be converted into protein and protoplasm to support the growth of plant vegetative cells. Organic matter can be a source of energy and food for soil microorganisms. Along with the decomposition of organic matter by microorganisms, plants will release nutrients such as N, P, and K, which plants need (Hardianita et al., 2015; Jacoby et al., 2017; Allamah et al., 2018). In line with result of Tarigan et al (2020), showed that the provision of organic fertilizer give the best growth

Table 2. Linear regression function of rainfed rice.

No	Dependent character (X)	Independent character (Y)	Function	R^2
1	Plant height	Number of grains per hill	Y = 65.795 + 0.013X	0.944
		Percentage of filled grains per panicle	Y = 55.873 + 0.433X	0.935
		Weight 1000 grains	Y = 7.628 + 3.896X	0.784
		Weight of grain per hill	Y = 70.806 + 0.489X	0.937
2	Number of grains per hill	Plant height	Y = - 4708.797 + 72.838X	0.944
		Percentage of filled grains per panicle	Y = -728.901 + 32.891X	0.959
		Weight 1000 grains	Y = -4538.507 + 303.145X	0.845
		Weight of grain per hill	Y = 386.120 + 37.738X	0.994
3	Percentage of filled grains per panicle	Plant height	Y = -116.285 + 2.159X	0.935
		Number of grains per hill	Y = 24.015 + 0.029X	0.959
		Weight 1000 grains	Y = -119.480 + 9.401X	0.916
		Weight of grain per hill	Y = 35.364 + 1.097X	0.948
4	Weight 1000 grains	Plant height	Y = 2.753 + 0.201X	0.784
		Number of grains per hill	Y = 15.733 + 0.003X	0.845
		Percentage of filled grains per panicle	Y = 13.310 + 0.097X	0.916
		Weight of grain per hill	Y = 16.814 + 0.105X	0.837
5	Weight of grain per hill	Plant height	Y = -133.961 + 1.918X	0.937
		Number of grains per hill	Y = -10.000 + 0.026X	0.994
		Percentage of filled grains per panicle	Y = -29.037 + 0.864X	0.948
		Weight 1000 grains	Y = -129.313 + 7.973X	0.837

response of cocoa seedling. In addition, the decomposition of organic matter will produce organic acids such as humic and fulvic acids, which play an essential role in chelating soil Fe and Al, so that P availability will increase (Mindari et al., 2014; Suhardjadinata et al., 2015; Nardi et al., 2021). Phosphorus stimulates growth and the formation of tillers or shoots in rice plants. This condition also impacts plant height growth, the maximum number of tillers, and productive tillers that require nutrients, primarily N and P (Singh, 2012). Nitrogen and phosphorus elements plants need in the vegetative phase are often contained in MSWC.

The beneficial microorganisms and other organic compounds found in MSWC can increase the diversity and microbial activity in the soil. It will increase the availability of nutrients and support plant growth, including the number of rice tillers (Harahap et al., 2020).

The observation data shows that the results of the number of grains per hill (grains), the percentage of filled grains per panicle (%), the weight of 1000 grains (g), and the weight of grain per hill (g) show the KS_0, KS_1, KS_2, KS_3, KS_4, KS_5, and KS_6 treatments were not significantly different.

In terms of the amount of grain per hill, MSWC has nutrients for the needs of the reproductive phase, but it still needs to increase the amount of grain. The lack of availability of one nutrient in MSWC during the reproductive period significantly affects grain filling through its function in photosynthesis. Organic matter can improve soil structure, increase the ability of the soil to absorb water, a source of microelements, and change the solubility of soil P (Neina, 2019). Suppose municipal solid waste is given in insufficient amounts. In that case, the ability of organic matter to suppress the fixation of P by Al, Fe, and Mn is also low, resulting in P elements becoming unavailable to plants (Abolfazli et al., 2012).

In general, organic compounds in plants contain Nitrogen and Phosphorus. Among these are amino acids, nucleic acids, enzymes, and materials that channel energy, such as chlorophyll, ADP, and ATP (Malhotra et al., 2018; Baslam et al., 2021). Plants cannot metabolize without N and P to form these essential materials. Thus, a significant shortage of N and P will stop the growth and production process (Razaq et al., 2017). The P element is needed by rice plants during their growth, from the beginning of vegetation growth to the formation and maturation phase of seeds.

The weight of 1000 grains in the research results, which is 20.04 g, is still low compared to the description; the weight of 1000 heads of 28 g, it is assumed that the plant's need for Phosphorus and Potassium nutrients from the organic matter of MSWC is not fulfilled optimally and is balanced until harvest time. The weight of rice grain is closely related to the photosynthesis process that occurs in leaves. Besides, variation of irradiation intensity has a significant effect on the photosynthesis process indicated by the parameter the number of tillers, the number of productive tillers, weight of grain per plot and weight of grain (Alridiwirsah et al., 2015).

The lack of pithiness in the filling of rice grains is caused by the available nutrients thaMg have been absorbed during the vegetative phase of the plant, so in the generative phase of rice grains. It results in a deficiency of one nutrient. The nutrients that play a vital role in filling the grain are P and K. Most of the photosynthetic products are stored in seeds (grains). In addition, nitrogen is also needed to form grain protein. These proteins could noMg have been arranged without photosynthesis (Kohli et al., 2020).

The application of MSWC has not been able to meet the nutrient needs of rice plants in the reproductive phase; this can be seen in the results of the percentage of filled grain per panicle, and the weight of 1000 grains produced is still low from the description data, this is not given inorganic fertilizers (NPK) as additional fertilizers to meet the nutrient needed by plants to support the reproductive phase. Other factors also influence the increase in grain weight per hill, number of productive tillers per hill, percentage of filled, and 1000 weight grains. The increase in these factors is supported by the availability of nutrient elements needed in every process of optimal growth and development and adequate soil physical, chemical, and biological conditions. On the weight of grain per hill, the provision of waste compost is closely related to the availability of nutrients in the soil. Municipal waste compost positively affects physical and chemical properties and encourages the life of soil microorganisms (Singh et al., 2011; Hossain et al., 2017). The availability of nutrients such as N, P, and K plays a vital role in the filling process of the fruit so that the composition of the starch becomes solid. Municipal waste compost can supply nutrients such as N, P, and K but cannot meet plant needs. In this case, N, P, and K are essential in filling seeds or grains.

CONCLUSIONS

The dosage of MSWC on rice plants with rainfed rice has a significant effect on plant height (cm), number of grains per hill (grains), percentage of filled grain per panicle (%), weight of 1000 grains (g) and weight of grain per clump (g), but on the maximum number of tillers (stems) and productive tillers (panicles), the provision of MSWC had no significant effect.

The dosage of MSWC in the KS_1 treatment was not significantly different from the KS_2, KS_3, KS_4, KS_5, and KS_6 treatments on the results of plant height (cm), number of grains per hill (grain), percentage of filled grain per panicle (%), and weight of 1000 grains (g), and weight of grain per hill (g). The application of MSWC for chicken manure on rice plants with rainfed rice has yet to meet the nutrient needs of rice plants, so the results obtained still need to be higher when compared to the descriptive data.

The recommendation to farmers was to give 18 Mg ha^{-1} dose of MSWC to increase the yields of their rice fields. Further research is necessary by adding inorganic fertilizers with a certain dose level. Municipal waste compost can supply nutrients such as N, P, and K but cannot meet plant needs. In this case, N, P, and K are very important in filling seeds or grains.

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