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Placement Precision of Organic Fertilizer Based on Soil Conservation in Taro Cultivation

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ABSTRACT

One of the things that are important to consider when fertilizing is how to place the fertilizer so that plants can consume nutrients efficiently. The research objective was to assess the precision of soil conservation based on fertilizer placement so that fertilizers could increase the production of taro effectively. This study applied four treatments, namely without fertilizer, placing manure in the planting hole, placing manure in the biopore, and placing manure on the borders. The three treatments were given 1 kg of goat manure. The treatment was performed with six replications. Harvesting is carried out in 8 months after planting. The results showed that the placement of manure on the borders was the most effective treatment with the highest yield of wet tubers of 21.4 Mg/ha and was not different from the treatment of manure in biopore 18.3 Mg/ha. This yield was different significantly as compared to that of resulted from treatments where fertilizer was placed in the planting hole (15.9 Mg/ha) or the production of taro without manure application (11.57 Mg/ha).

1. INTRODUCTION

The high rate of population growth makes Indonesia have to diversify its food. Some of the efforts that can be made are using other food sources that have the potential as a source of carbohydrates, namely tubers. Taro tuber (*Colocasia esculenta* L. Schott) is among several tuber crops that can be used as an alternative food source which is healthy and safe, other than rice (Nurilmala & Mardiana, 2019; Syarif *et al*., 2017)

Taro plants have high economic value because almost all parts of the plant can be used for human consumption and even for animal feed (Adejumo, 2013; Pongener & Daiho, 2016). Taro can be grown in almost all tropical regions of the world and it will play a crucial role in food security (Juang *et al*., 2021). Based on the high level of utilization of taro tubers followed by increasing public awareness of quality food sources, the demand for taro tubers has increased (Temesgen, 2015). However, this increase has not been fulfilled as a result of the low level of tuber productivity. According to (Nurchaliq *et al*., 2014), taro productivity is low while its potential can reach 20 ton Mg/ha.

The main problem with the taro cropping system is the limited water retention capacity and absorption of nutrients in the soil (Mangallo *et al*., 2018). The function of water is a nutrient transport agent to the roots (De Oliveira *et al*., 2007). Several factors that influence the effectiveness of nutrient absorption are the method of placing the fertilizer, the type of fertilizer given, the timing of applying the fertilizer, and the fertilizer dosage. The correct placement of fertilizers can help move nutrients to the root surface or accelerate root growth to the nutrient solution.

Cultivation of taro can cause a decrease in essential nutrients through harvest, mainly when cultivated continuously. Thus the fertility of soil will continue to decline, to achieve a state where the addition of nutrients through fertilization is essential to obtain profitable taro yields. Therefore, the fertility of a soil is directly related to plant growth, so an assessment of soil fertility is absolutely necessary.

Conservation of land management is carried out to increase groundwater reserves and water availability for plants, water conservation strategies are directed by increasing water reserves in the plant root zone through controlling runoff which is usually destructive by carrying out surface runoff harvesting actions, increasing infiltration, and reduce evaporation (Liu *et al*., 2013). Water scarcity is one of the obstacles in the production process (Bardhan *et al*., 2021), arid land, especially during the dry season (Nurchaliq *et al*., 2014). One way to increase fertilizer effectiveness is to increase the storage capacity of water in the soil by carrying out proper soil conservation management. Thus, in the dry season, there is no scarcity of water. Plant resistance to drought is influenced by several factors, including the nature and ability of plant roots to extract water from the soil optimally (Donjadee & Tingsanchali, 2016). Low water content in the soil and the implementation of drought stress causes stunted plant growth and low productivity (Rop *et al*., 2019). Lack of water significantly affects the physiological processes and metabolism of plants. One of the mechanical soil conservation techniques to increase the effectiveness of using fertilizers that farmers can easily apply is through biopore pore and bordered manure. This study aims to determine the effect of precision placement of organic fertilizer on soil moisture levels and taro crop production.

2. MATERIALS AND METHODS

2.1. Study Site and Materials

The research was carried out for eight months, from November 2019 to July 2020. The research location was administratively included in the West Bogor sub-district, Bogor Municipality, between –6.595859 Lat and 106.773703 Long. The observation area is at 400 m above sea level, topography with a flat land surface, Inceptisol soil type, slightly acidic soil at a pH of 5.5. The average rainfall is 3500 mm per year, and the average daily temperature is 28 ^{o}C with an average minimum of 22 ^{o}C and a maximum of 32 ^{o}C.

2.2. Planting Material

The research was started with the preparation of the planting area. The plants used in the study were taro Febi521 variety, planted at a spacing of 70 cm x 50 cm. Taro seeds come from seeds that are developed through tissue culture. This taro Febi521 variety has good taste and is not itchy (Nurilmala & Mardiana, 2019).

2.3. Experimental Design

Four treatments were tried, namely (1) without giving manure (MN); (2) manure is placed in the planting hole (MH) (10 cm depth and 20 cm diameter); (3) the manure was placed in the biopore (BP) (30 cm depth and 10 cm in diameter) placed at a distance of 20 cm from the plant; and (4) the manure was placed inside the border (MB). The border is made from a pot cut from the bottom (30 cm pot height and 40 cm pot diameter). In the manure treatment, each goat manure is given as much as 1 kg of manure per plant or the equivalent of 28.6 Mg/ha. The treatment was performed with six replications and arranged using a completely randomized design.

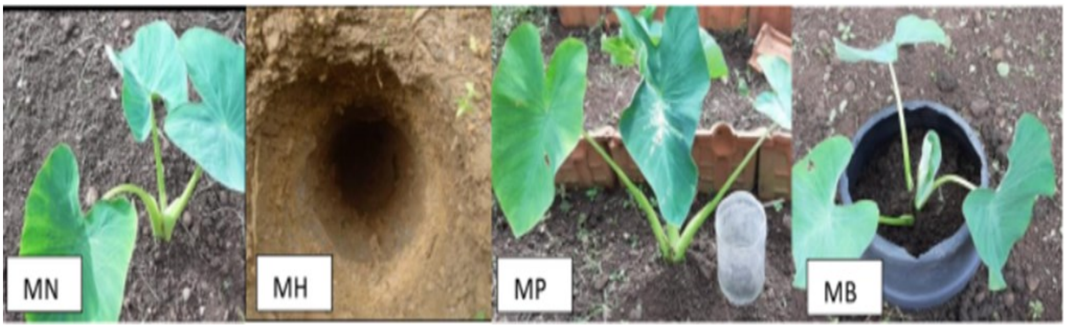

Figure 1. The display of the four treatments, namely without giving manure (MN), manure is placed in the planting hole (MH), the manure was placed in the biopore (MP), and the manure was placed inside the border (MB)

2.4. Data Collection and Analysis

2.4.1. Soil moisture and field capacity

Observation of soil physical properties included soil moisture level and soil water content at a field capacity. Measurements were made at the same time as harvest. Soil moisture content was set at a depth of 0-15 cm. Soil samples were taken, which were determined randomly using a slit pipe in a tunnel, put in a closed container then measured the moisture content gravimetrically. Furthermore, the soil sample was weighed as much as 50 g and then dried in an oven at a temperature of 105 ^{o}C.

To measure the water content of the field capacity, the soil sample was saturated with water in a 3 kg volume perforated pot container. The soil sample was left to stand for 24 hours, or until there is no more water dripping at the bottom of the pot, then a 50 g sample is taken and dried in an oven at 105 ^{o}C to determine its moisture content.

2.4.2. Growth and yield

Observation components in plants included plant height, leaf width and leaf length measured at the age of 8, 12, 16, and 24 weeks, while the measurement of fresh tuber production is carried out at 32 weeks of age which is expressed in kg per plant and then converted to tonnes per hektar.

2.4.2. Data analysis

Data were analyzed descriptively by calculating the mean and standard deviation/ standard deviation of each parameter using the STAR (Statistical Tool for Agricultural Research) application. ANOVA was carried out to identify or test whether there were differences between treatments toward the experimental parameters. The analysis was followed by the Tukey HSD test if there was a significant difference between variables. Tukey test results will be displayed in tabular form, and statistical differences will be differentiated by letter.

3. RESULT AND DISCUSSION

3.1. Soil Water Content

Statistical analysis showed that the application of manure placed inside the borders significantly maintained soil moisture and retained soil moisture content in field capacity (Table 1). The high soil moisture and soil water content in the field capacity of the MB treatment, presumably because the manure placed in the border, played a role in reducing evaporation (holding more water, especially at the field capacity). Soil moisture content was measured gravimetrically at the end of the plant observation at the time of harvest. This is to determine the effect of manure application on soil moisture levels for a long time after application.

Table 1. Effect of different methods of goat manure placement on soil moisture and field capacity

Treatment	Soil Moisture (%)*	Field Capacity (%)*
MP	28.72±1.73b	40.88±1.42b
MB	46.05±8.97a	62.22±2.18a
MN	29.37±0.80b	35.10±3.85c
MH	30.74±1.49b	38.96±3.09b

*The values are expressed as mean ± standard deviation. Mean values in the same column followed by different letters are significantly different ($p < 0.05$, one-way ANOVA with Tukey test).

3.2. Growth and Yield

The results in Tables 2-4 show that the position of the manure placement did not significantly affect plant height, length and leaf width at the age of the plant eight weeks after planting. The placement of manure within the border (MB) had a significant effect on plant height, length and leaf width at 12, 16 and 24 weeks after the plant (WAP) compared to MN and MH. Plant height in MP was consistently not significantly different from that of MB. Plant height increases until the age of 24 AWP. This result is in accordance with the research stated by (Boampong *et al*., 2020), which also shows that plant height increases until the age of 24 AWP. The MB treatment showed plant height 118.33 cm, highest leaf length 70.67 cm, and leaf width 51.67 cm significantly different from the MN and MH treatments.

Table 2. Effect of different methods of goat manure placement on plant height (cm) at the age of 8, 12, 16 and 24 weeks after planting (WAP)

Treatment	8 WAP*	12 WAP*	16 WAP*	24 WAP*
MP	49.50 ± 8.14	84.67 ± 6.15a	109.83 ± 1.60a	115.50 ± 2.81a
MB	53.17 ± 7.05	88.33 ± 10.23a	113.00 ± 6.03a	118.33 ± 7.00a
MN	48.67 ±8.31	79.83 ± 9.04ab	93.83 ± 3.19b	104.33 ± 4.37b
MH	49.33 ± 3.83	74.33 ± 7.45b	97.00 ± 7.59b	105.50 ± 5.21b

*The values are expressed as mean ± standard deviation. Mean values in the same column followed by different letters are significantly different ($p < 0.05$, one-way ANOVA with Tukey test).

Table 3. Effect of different methods of goat manure placement on leaf length (LL) at the ages of 8, 12, 16 and 24 weeks after planting (WAP)

Treatment	8 WAP*	12 WAP*	16 WAP*	24 WAP*
MP	46.50 ± 6.41	55.50 ± 4.59*b	68.83 ± 2.86a	70.00 ± 3.35a
MB	51.17 ± 6.34	61.17 ± 4.49a	70.17 ± 2.99a	70.67 ± 1.03a
MN	43.17 ± 3.82	51.00 ± 4.20b	56.83 ± 4.92b	54.50 ± 6.72c
MH	43.50 ± 4.32	51.00 ± 4.56b	59.00 ± 5.06b	62.17 ± 4.17b

*The values are expressed as mean ± standard deviation. Mean values in the same column followed by different letters are significantly different ($p < 0.05$, one-way ANOVA with Tukey test).

Table 4. Effect of different methods of goat manure placement on leaf width (LW) at the ages of 8, 12, 16 and 24 weeks after planting (WAP)

Treatment	8 WAP*	12 WAP*	16 WAP*	24 WAP*
MP	34.00 ± 4.69	41.50 ± 3.21ab	49.17 ± 2.40a	53.83 ± 2.32a
MB	34.67 ± 3.27	45.17 ± 3.54a	52.17 ± 4.07a	51.67 ± 7.45ab
MN	30.83 ± 3.71	38.00 ± 4.82b	39.17 ± 2.86b	40.50 ± 6.66c
MH	32.00 ± 2.83	40.50 ± 4.51ab	40.83 ± 4.12b	46.00 ± 7.46bc

*The values are expressed as mean ± standard deviation. Mean values in the same column followed by different letters are significantly different ($p < 0.05$, one-way ANOVA with Tukey test).

Manure placement position has a significant effect on crop production (Figure 1). The highest yield was found in the treatment of manure placed inside the border of 21.43 Mg/ha, not different from the results of the position of manure in the biopore (18.29 Mg/ha), separate from the results in the position of manure placed in the planting hole 15.86 Mg/ha and the lowest yields were found in the treatment without manure, 11.57 Mg/ha. The best production is manure treatment which is placed inside the border. Production on MB is insignificant with MP. The high production of MB can be due to the superiority of the border, namely it can maintain soil moisture levels. The border function can prevent the loss of nutrients contained in manure caused by surface runoff. In addition, as stated by (Miyasaka *et al*., 2001) that the role of manure in addition to meeting the nutrient needs of plants can also function as a mulch to reduce evaporation so that it can maintain or increase soil moisture.

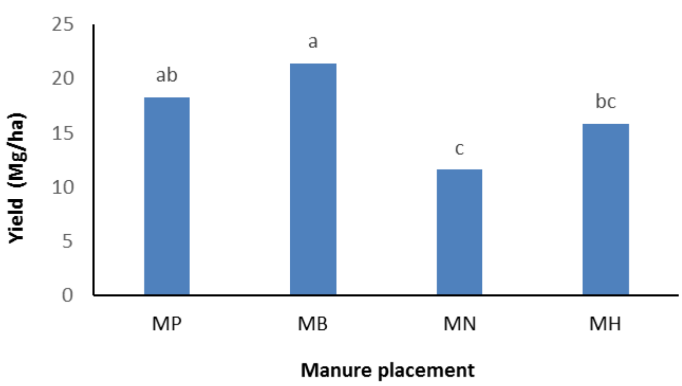

Figure 1. Effect of different methods of goat manure placement on plant production (Mg/ha)

The regression equations (Figure 2 and Figure 3) show that an increase in soil moisture level and field capacity moisture content increases tuber yield. This is because manure has a higher water retention capacity and is stored longer. The highest soil moisture was found in the manure inside the border treatment (MB) of 46.05%, which was significantly different from the soil moisture in the other three treatments. Likewise for the highest field capacity water content level in the MB treatment of 62.22%. The lowest water content capacity in the treatment without manure was 35.10%. Complete data on soil moisture levels, field capacity water content and crop yields for each unit of observation can be seen in Table 5.

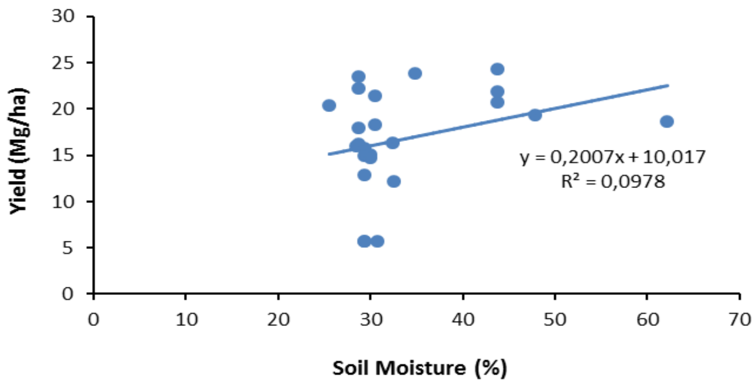

Figure 2. The relationship of soil moisture and tuber yield resulted from the placement of goat manure on taro cultivation

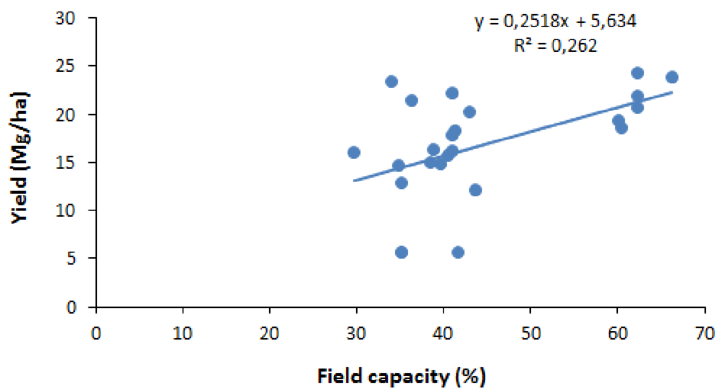

Figure 3. The relationship of field capacity water content and tuber yield resulted from the placement of goat manure on taro cultivation

Soil water content is an environmental factor that plays a very important role in increasing crop production. The application of manure can improve the physical properties of the soil by improving the soil structure that maintains the level of soil moisture. The results of this study indicate that without the application of manure, the production of taro plants only reached 11.57 Mg/ha, almost two times lower than the application of manure by the border method, which was 21.4 Mg/ha. The border function protects the manure from surface runoff scouring, so that the manure lasts longer. It can retain soil moisture. Another function of the border is that it can support plant stems so they don't collapse quickly, and to avoid weeds.

Table 5. Relationship of soil moisture levels and field capacity water content to the crop yield of taro

Replications	Treatments	Soil moisture (%)	Field capacity (%)	Yield (Mg/ha)
1	MN	30.81	41.69	5.7
1	MH	29.37	40.45	15.7
1	MP	30.01	38.45	15.0
1	MB	62.19	60.41	18.6
2	MN	28.82	33.91	23.4
2	MH	30.50	36.37	21.4
2	MP	25.58	42.87	20.3
2	MB	47.90	60.06	19.3
3	MN	28.47	29.69	16.0
3	MH	32.50	38.86	16.3
3	MP	30.56	41.31	18.3
3	MB	34.96	66.19	23.9
4	MN	29.37	35.10	12.9
4	MH	29.37	39.67	14.9
4	MP	28.72	40.88	22.1
4	MB	43.76	62.22	24.3
5	MN	29.37	35.10	5.7
5	MH	30.03	34.84	14.7
5	MP	28.72	40.88	17.9
5	MB	43.76	62.22	20.7
6	MN	29.37	35.10	5.7
6	MH	32.65	43.57	12.1
6	MP	28.72	40.88	16.1
6	MB	43.76	62.22	21.9

4. CONCLUSIONS

Our results concluded that goat manure placed inside the borders increased soil moisture and moisture content in the field capacity. On average, production increases with increasing soil moisture and water content in the field capacity. The treatment of placing manure inside the border increases the plant growth rate (plant height, leaf length and width) and the highest production. The placement of manure with borders was the most effective treatment, showed the highest yield of wet tubers of 21.4 Mg/ha, was not so different from the treatment of manure in biopore pores 18.3 Mg/ha and was different significantly in the placement of fertilizer in the planting hole of 15.9 Mg/ha. In comparison, the production of taro without manure is only 11.57 Mg/ha.

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