

Study of Synthetic Fertilizer Chili and Organic Fertilizer Watermelon on Relay Cropping Fields

Avisema Sigit Saputro^{1*}, Dewi Ratna Nur Hayati¹

¹Department of Agrotechnology, Faculty of Agriculture, Slamet Riyadi University, Surakarta, Central Java, Indonesia

*Corresponding author: avis_sigit@yahoo.com

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ABSTRACT

Chili is an agricultural commodity with prices that tend to fluctuate. Chili-watermelon relay cropping is one way to overcome this problem and reduce losses when chili prices fall. Watermelon has a relatively short lifespan, so it can be a substitute when chili prices fall. Chili and watermelon are almost the same age. This research aims to assess how well the tandem cultivation of chili and watermelon in a relay cropping system is performed. The study employed a factorial randomized block design for experimentation. The research consisted of 2 experiments, namely chili and watermelon, cultivated on the same land. Experiment with 2 factors in chili, namely variety and type of NPK. The watermelon experiment involved 2 factors: variety and concentration of liquid organic fertilizer. All experiments were repeated four times. The data analysis proceeded by conducting Duncan's multiple range test at a significance level of 5%. Parameters for observing plant height, when flowers appear, fruit weight, number of chilies per plant, and watermelon fruit circumference. The results showed that chili and watermelon relay cropping could be harvested simultaneously without competition between plants. There was no interaction between chilies and watermelon. Chili has the highest weight in the Columbus variety with NPK Mahkota fertilizer. The watermelon with the highest weight was in the Baginda variety, with a liquid organic fertilizer concentration of 60 ml/liter. The relay cropping of chili and watermelon plants was effective simultaneously, and there was no decrease in yield.

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1. Introduction

Generally, Agricultural commodities have prices that tend to fluctuate and are unstable, including chili (Handono *et al.*, 2013). One way to deal with unstable chili prices and reduce losses when prices fall is by cultivating chili-watermelon relay cropping. Relay cropping is a planting method by inserting one or several types of plants other than the main plant. This type is usually developed to intensify land. Therefore, the ability of land to produce food products is increasing. Watermelon has a relatively short lifespan, so it can be a substitute when chili prices fall. Farmers in Indonesia grow chili (*Capsicum annum* L.) extensively due to its lucrative market value.

Chili is a horticultural commodity with crucial economic value in Indonesia (Dermawan *et al.*, 2019). Its high economic value is an attraction for the development of chili cultivation for

farmers (Babara Dalimunthe *et al.*, 2017). Chili, synonymous with a spicy taste, has been a component of spices in every dish for a long time. The Central Statistics Agency, also known as BPS, has reported that chili production in Indonesia is projected to reach 1.36 million tons in 2021. This represents a growth of 96,381 tons or a 7.62% increase compared to the previous year, 2020. From 2011-2021, large chili production tends to experience an increasing trend. The decline in crop production only occurred in 2015 and 2016.

Meanwhile, the highest large chili production occurred in 2021. Meanwhile, the lowest production in a decade was 888,852 tons in 2011. West Java is Indonesia's largest large chili producer in 2021, namely 343,067 tons. This amount is equivalent to 25.2% of the national large chili production. North Sumatra followed with a large chili production of 210,220 tonnes or 15.45%. Then, the production of large chilies in Central Java was 169,282 tons or 12.44% (Central Bureau of Statistics, 2022).

The high demand for chilies in the market must be anticipated with agricultural intensification and extensification. One of the intensifications of agriculture in chili cultivation is fertilizing. Fertilizer is an essential component supporting chilli plants' growth and yield. Many kinds of fertilizers can be used on chili plants. One of the most frequently used synthetic fertilizers is compound fertilizer. Compound fertilizer is a fertilizer that contains several types of macro and micronutrients. In this study, compound NPK fertilizer contained high and balanced N, P, and K. The large number of compounds NPK fertilizers circulating in the market requires testing the effectiveness of their use and which type of fertilizer is suitable for chili plants.

Chili plants are generally planted in mounds 100 m long, about 20 cm from the right and left edges. So, in 1 bundle, chili plants are planted in 2 rows. Between the 2 rows of chili, plants are generally left as open space and not utilized. The planting space can be used to grow watermelons. Between the 2 rows of chili plants, 1 watermelon plant is planted to optimize land intensification. Watermelon plants have a relatively short lifespan of 60 days, and chili 90 days. The chili seeds are planted first in the field, and after 30 days, the watermelon seeds are planted on the same land. Chili and watermelon plants can be harvested simultaneously on the same land. Relay cropping involves planting multiple plants within a single planting area, optimizing land usage and boosting overall land productivity. The cultivation of seasonal crops frequently involves the utilization of a relay cropping method. (Raditya Warman & Kristiana, 2019). In this study, watermelon and chili plants were planted together on the same land in a relay cropping manner. This research aimed to investigate how effective it is to plant chili and watermelon together in a relay cropping system.

2. Methodology

The investigation occurred between June and September 2021, specifically at the Research Center and Collection Gardens located within the Faculty of Agriculture at Slamet Riyadi University in Surakarta. The study area featured Grumosol soil and was situated at an elevation of 96 meters above sea level. The research consisted of 2 experiments, namely chili and watermelon, cultivated on the same land. Experiment with 2 factors in chili: Variety (Colombus and Balebat) and type of synthetic fertilizer NPK (not fertilized/controlled, Mahkota, Mutiara, and Phonska). The watermelon experiment involved 2 factors: variety (Punggawa and Baginda) and concentration of liquid organic fertilizer (not fertilized/controlled, 20, 40, and 60 ml/l). All experiments were repeated four times. There were 8 treatment combinations for

chili and 8 treatment combinations for watermelon. Each treatment combination had 4 replications. Each treatment combination was taken in 3 samples. A factorial randomized block design (RBD) was employed in the chilli and watermelon experiments. The collected data underwent an analysis of variance, and if the results were statistically significant, Duncan's multiple range test at the 5% significance level was conducted. The treatment was repeated four times for all experiments. Observation parameters include plant height when flowers appear, fruit weight, and productivity. Chili and watermelon seeds are sown in small poly bags. Plants 15 days old are transplanted to land that has formed mounds and is covered with silver-black plastic mulch. Fertilizer treatment was given by watering/leaking into the planting hole according to the type of fertilizer and concentration. Data was collected between 10 and 60 days following the planting.

3. Results and Discussion

3.1 Plant Height

The height of chili plants was observed on days 30, 45, and 60 following their initial planting. Chilies grew well, and plant height increased from 30 days after planting (DAP) to 60 days after planting (DAP), from an average of 35.29 cm to 54.90 cm at the end of the observation. According to the variance analysis results, it was determined that there was no interplay observed between the different types of chilies and the NPK fertilizer used to plant height. NPK Crown fertilizer 2 g/plant has a good effect on plant height variables (Madjid, 2019). Age > 30 days after planting to 30 days after planting, the plant height increased by 19 cm. While concluding the observation 60 days after planting, there was evident no height growth. Growth theory divides growth into three phases: slow, fast, and sloping or constant growth (Taiz *et al.*, 2015). The impact of NPK Phonska fertilizer exhibited a notable and substantial variation in plant height when observed at both 30- and 45 days post-planting (Widodo *et al.*, 2016). The results of previous research (Prasetya, 2014) disclosed that the utilization of Mutiara NPK fertilizer had a noticeable impact on plant height at both 40 and 60 DAP and on the maturity of the harvested plants. However, it did not have a significant effect on plant height 20 DAP, the number of branches, flowering time, the number of fruits per plant, or the weight of fruit per chili plant.

Figure 1 showed that compound NPK fertilizer could provide macro-nutrient needs for plants. Chili's response is different to various kinds of compound NPK fertilizers. Based on graph 1 shows that chili plants reach optimal growth at the age of 45 DAP. At 60 DAP, the chili showed no more growth and even decreased. The highest average yield was obtained on the Balebat variety using Mutiara NPK fertilizer in all treatment replications. Plant height growth occurs due to the division and elongation of merismatic tissue cells at the point of growing stems. In cell division, sufficient carbohydrates are needed to form cell walls and protoplasm (Ratna Shanti, 2020).

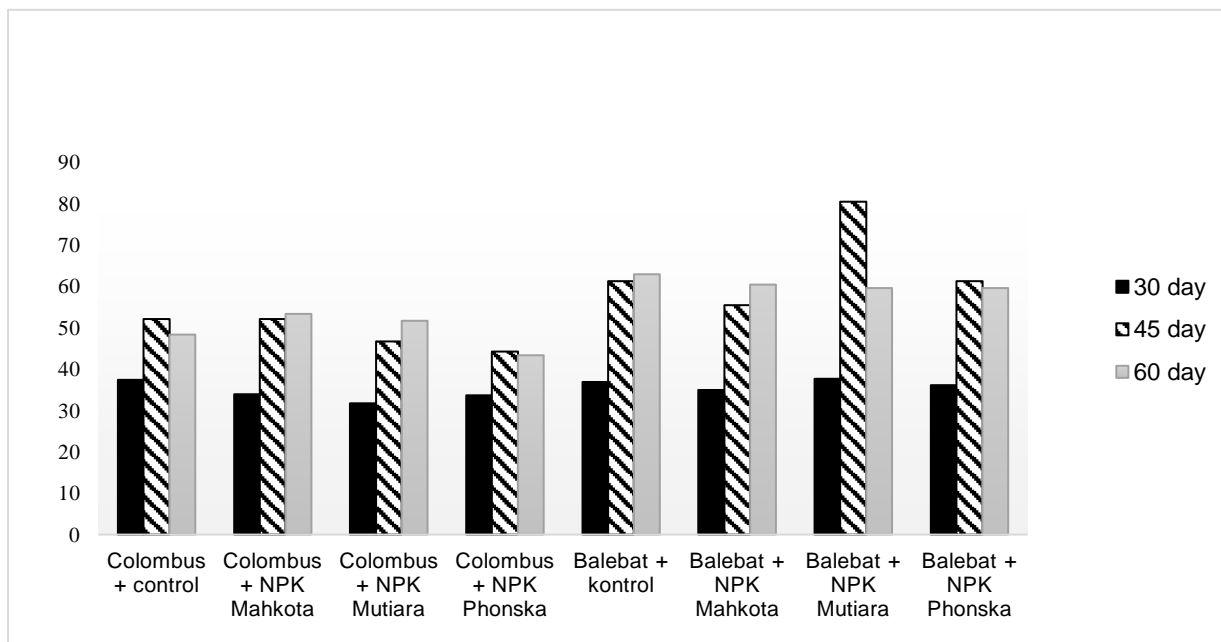


Figure 1. Height of Chili Plants on Types of NPK Fertilizers. 400x Magnification

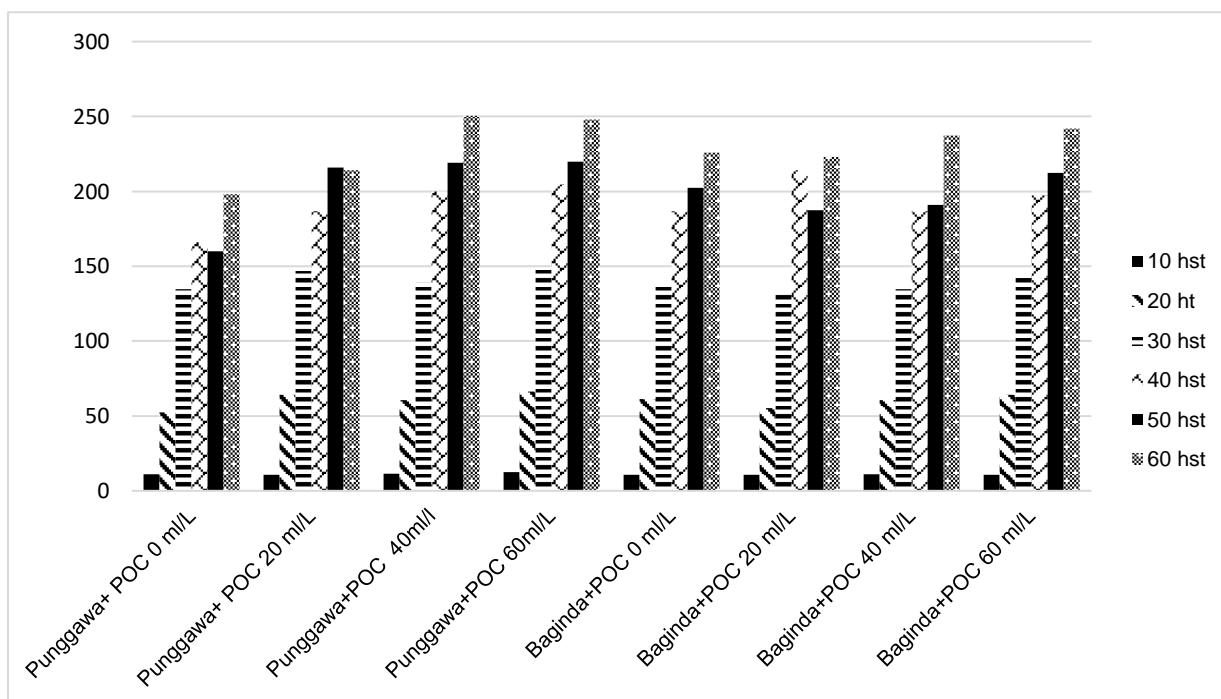


Figure 2. Watermelon Plant Height with Liquid Organic Fertilizer Concentration Treatment

Watermelon grows in vines. Determining watermelon plant height involves measuring the length of the plant from the lower stem's base to its highest point. The length of this plant is used to calculate the height of the plant. Watermelon plants increase gradually, starting from 10 DAP until reaching peak growth at 60 DAP. According to the variance analysis, there was no observable interaction between different watermelon varieties and the various doses of organic fertilizer on plant height. The most significant yield, measuring 250.50 cm, was achieved by the Punggawa variety when using liquid organic fertilizer at a concentration of 40

ml/l. The lowest yield was the Punggawa variety without fertilizer (control) 198.17 ml/l. In a study conducted by (Masriyana *et al.*, 2020), The application of 20 tons/ha of chicken and cow manure resulted in enhanced growth and yield of watermelon plants, as evidenced by improvements in plant height, the number of female flowers, fruit length, and fruit diameter.

Initially, plant growth progresses sluggishly but gradually accelerates until it attains its peak. Finally, the growth rate decreases. The growth rate in the vegetative phase accelerates initially as more plant cells are added but subsequently decelerates and may eventually stabilize. Plant development remains relatively steady across all plants, though occasional variations can arise due to environmental differences. A plant's ultimate size, look, and form are shaped by a blend of genetic and environmental elements (Salisbury, 2022). The growth of chili means do not deviate.

3.2 Flowers Blooming

When flowers bloom, all treatments coincide at 21 days after planting. Observations during flowering were carried out once, namely when the first flowers on the chili plants appeared. Calculation of the time of flowering is done by recording the number of days when the flowers appear for each plant expressed in days after planting. According to the variance analysis, there was no observable interaction between different chili varieties and the types of NPK fertilizer regarding flower appearance. Fertilizer or variety application has no impact on the appearance of flowers. The results of observations for all treatments showed the same time of appearance of flowers at the age of 21 DAP. Flowering is a vegetative transition period for plants to the generative phase, namely the formation of flower buds. When flowers appear, they are influenced by environmental factors. Environmental factors that influence include light and day length (photoperiod). Generally, the physiological and morphological processes that lead to flowering and fruiting are a response to day length (Gardner *et al.*, 2021). Chili plants can grow optimally if not covered by shade plants around them. The presence of shade in the form of trees around the planting can inhibit the process of photosynthesis.

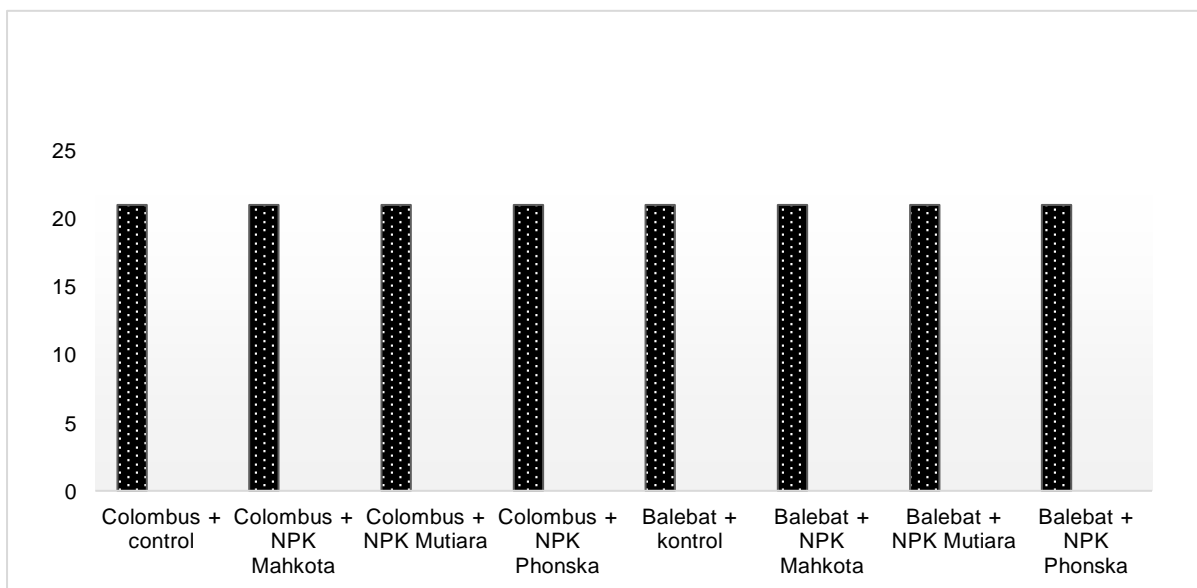


Figure 3. When Chili Appear on Types of NPK Fertilizer

Based on the picture, it can be seen that in all treatment combinations of chili varieties and types of NPK fertilizer, the flowers appear almost simultaneously. Flowers appear when the plants are 23 and 24 days after planting. Flowering is also influenced by the fulfilment of nutrients, especially the element phosphate (P), which encourages plants to enter the generative phase. Lack of phosphate elements causes plants to be in the vegetative phase longer. The generative phase is marked by the formation of primordial flowers, which develop into flowers ready to pollinate (Puspasari *et al.*, 2018). The findings from Nursakina and colleagues' research in 2020 regarding the appearance of flower variety indicated that neither the application of NPK fertilizer nor the use of organic mulch had a notable impact on the appearance of flowers within a specific timeframe. When the first flowers appear on watermelon plants, varies between 20 to 24 DAP.

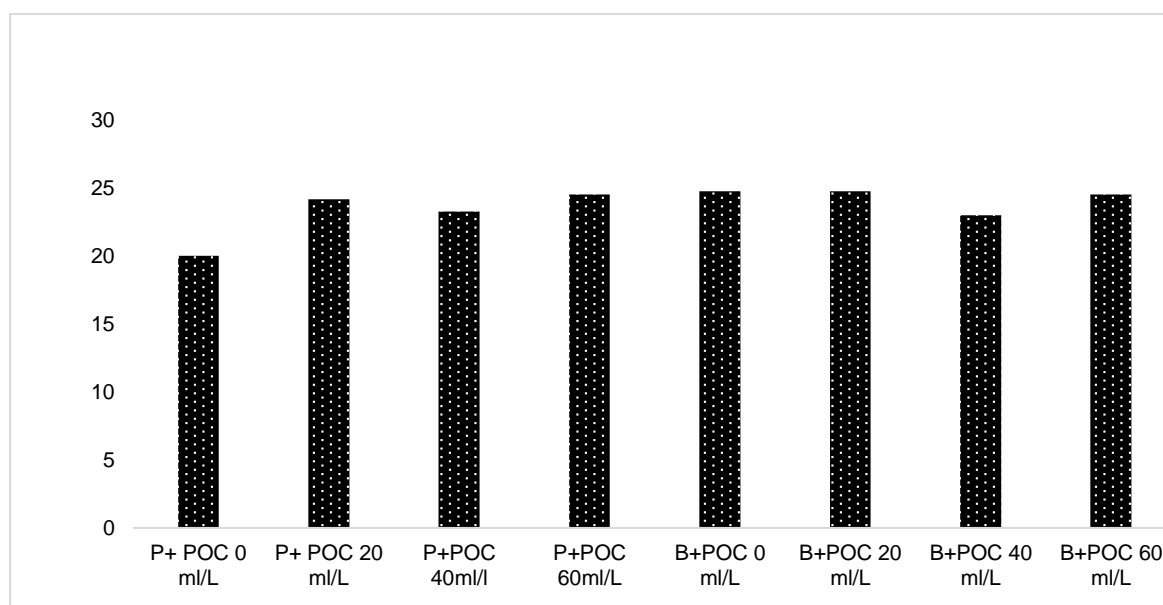


Figure 4. Watermelon Plant Flowers Appear With Liquid Organic Fertilizer Concentration Treatment

3.3 Fruit Weight

Fruit counts were conducted progressively from 45 days post-planting to 100 days. Statistical analysis indicated notable differences among the various varieties used, but there were no significant distinctions in the outcomes of the fertilizer treatments. Additionally, there was no observable interaction between the treatments and the NPK compound fertilizer treatment. The average weight of 1 chili fruit is 2 grams. Increasing the nutrient supply to meet plant needs can lead to optimal plant productivity. Plant yields are affected by the nutrients nitrogen, phosphate, and potassium. A deficiency or excess of one of these elements can reduce crop yields.

Table 1. Weight of Chili Fruit on Types of NPK Fertilizers

Treatment	Control	NPK Mahkota	NPK Mutiara	NPK Phonska	average
Columbus	17.50	22.70	16.80	17.10	18.53 ^a
Balebat	13.23	11.73	13.54	6.33	11.21 ^a
Average	15.37 ^{ab}	17.22 ^b	15.17 ^{ab}	11.72 ^a	

Source : Primary data, 2021

Description : Numbers followed by different lowercase letters in the same column show significantly different at the 5% level according to Duncan's test

Table 1 shows the highest average fruit weight variable of 22.7 g in the Columbus and NPK Mahkota varieties, and the lowest yield was in the treatment of 66.33 g in the Balebat and NPK Phonska varieties. The variety with the highest yield was in Columbus, and the highest NPK fertilizer was in NPK Mahkota. The results of previous research (Nur *et al.*, 2018) showed an effect of NPK on growth and yield as indicated by the number of tillers, plant weight, and plant height. For the best dose of NPK Mutiara 16:16:16 30 g/plant (Sianturi, 2019). The most effective NPK Phonska fertilizer for achieving maximum growth and yield is 1200 kilograms per hectare (Hutubessy, 2020). Giving NPK Crown 50g can increase the growth of stem diameter, number of fruits, plant height, and number of branches (Reshi & Same, 2019).

Table 2. Weight Of Watermelon Fruit In Liquid Organic Fertilizer Concentration Treatment

Treatment	Control	Fertilizer 20 ml/L	Fertilizer 40 ml/L	Fertilizer 60 ml/L	Average
Unggawa	3276.67	4530.33	3149.99	4290.340	3811.83 ^a
Baginda	3484.33	3430.67	3275.33	4717.670	3727 ^a
Average	3380.50 ^a	3980.50 ^a	3212.66 ^a	4504.005 ^a	

Source : Primary data, 2021

Description : In the same column, numerical values accompanied by distinct lowercase letters indicate statistically significant differences at the 5% significance level as per Duncan's test

3.4 Number of Chili Fruits per Plant

Hyphae Chili plant productivity with the parameter of the number of chilies per plant. In chili plants, the fruit produced is large and does not appear simultaneously. The highest number of chilies was in the NPK Mahkota fertilizer treatment with the Columbus variety of 11.35 grams when harvested at the age of 80-90 days. Meanwhile, the lowest number of chilies was in Phonska NPK fertilizer with the Balebat variety averaging 1.47. Another study by Ralahalu in 2013 also showed that the number of large chilies at harvest without organic fertilizer was 10, 10.08 1 ml/l of fertilizer, and 12.5 2 ml/l of fertilizer. In this study, the number of fruits formed by the relay cropping system was standard. This follows research conducted by (Flowrenzhy, 2017) that 1 plant can produce 5-10 fruits 3 months after planting.

Table 3. Number of Chili Fruits on Types of Npk Fertilizers

Treatment	Control	NPK Mahkota	NPK Mutiara	NPK Phonska	Average
Columbus	8.75	11.35	8.40	8.55	9.26 ^a
Balebat	6.63	5.86	6.77	1.47	5.18 ^a
Average	7.69 ^{ab}	8.61 ^b	7.59 ^{ab}	5.01 ^a	

Source : Primary data, 2021

Description : In the same column, numerical values accompanied by distinct lowercase letters indicate statistically significant differences at the 5% significance level as per Duncan's test

**Figure 5.** Relay Cropping Chili and Watermelon Plants

3.5 Circumtance of Watermelon

In watermelon, only 1 fruit is maintained for optimal results in one plant. Watermelon plants can produce much fruit on each plant. Only 1 to 2 fruits per plant are grown on watermelon plants to produce uniform fruit quality (Wijaya *et al.*, 2021). The lowest fruit circumference was on the Baginda variety without liquid organic fertilizer. This fruit an appeal to farmers because of its advantages, namely fast reproduction (approximately 3 months old), relatively short plant life (dwarfing) with a harvest age of around 70 to 80 days, can function as a rice field planting plant, and its planting can be carried out using conventional, semi-intensive, and intensive methods (Wahyudi, 2013). The research results related to watermelon circumference show that the circumference of watermelons with liquid organic fertilizer is the same as that of synthetic fertilizer. Watermelon circumference generally ranges from 130-170 cm.

Table 4. Circumference of watermelon (cm)

Treatments	Control	Fertilizer 20 ml/L	Fertilizer 40 ml/L	Fertilizer 60 ml/L	Average
Punggawa	142.67	159.00	137.340	159.00	149.503 ^a
Baginda	140.34	148.66	147.330	158.99	148.830 ^a
Average	141.505 ^a	153.83 ^a	142.335 ^b	158.995 ^a	

Source : Primary data, 2021

Description : In the same column, numerical values accompanied by distinct lowercase letters indicate statistically significant differences at the 5% significance level as per Duncan's test.

A study conducted by Nursakina and colleagues in 2020 demonstrated that using a specific type of rice straw mulch yielded the most favourable outcomes when assessing watermelon fruit weight. This study used silver-black plastic mulch because it was combined with chili plants. The highest watermelon circumference was in the Punggawa variety, with a liquid organic fertilizer concentration of 60 ml/L of 159 cm

4. Conclusion

The highest chili weight in the relay cropping system was the Columbus variety. The watermelon with the highest weight in relay cropping was the Baginda variety. Relay cropping chilies with watermelon showed the same results as the monoculture system. The number of fruits per chili plant is standard, and the circumference of the watermelon is also standard. The relay cropping of chili and watermelon plants was effective simultaneously, and there was no decrease in yield. So, this relay cropping system is adequate for limited land use, which produces 2 different commodity harvests.

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