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Effect of NPK Fertilizer and Foliar Fertilizer on Chili Growth and Yield

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ABSTRACT

Chili consumption in Indonesia has increased. Efforts to increase chili production need fertilization through roots and leaf fertilization. The research aimed to obtain optimum intervals of NPK (nitrogen, phosphor, potassium) fertilization and kinds of foliar fertilizer for the growth and yield of chili. The research was conducted from April to August 2020 in Gayam Village, Sukoharjo Regency, Central Java, Indonesia. This study used an experiential method with a Randomized Complete Block Design (RCBD) of 2 factors. The first factor was an interval of NPK fertilization (16-16-16) with a concentration of 25 $g.L^{-1}$ with a dose of 240 $mL.plant^{-1}$. The interval of NPK fertilization consists of 4 levels, NPK fertilizer which was applied every 5, 10, 15, and 21 days. The second factor was foliar fertilizer which consists of A foliar fertilizer, B foliar fertilizer, and C foliar fertilizer. The results showed that the interval of NPK fertilizer affected the number of dichotomous branches, dry stove weight, cumulative fruit, cumulative fruit weight, and fruit length at 1st harvest. NPK fertilization every 15 days increased the dichotomous branches by 23.16%, dry stove weight by 37.98%, cumulative fruits by 37.41%, and cumulative fruit weight by 41.46%. B foliar fertilizer and A foliar fertilizer gave the same performance in dichotomous branches. There was no interaction effect between the interval of NPK fertilization and the kind of foliar fertilizer on all growth and yield variables. NPK fertilization optimum intervals as supplementary fertilizers should be given every 15 days. This research can be used as a reference for farmers in fertilizing chilies.

Keywords: Compound fertilizer; Fruit weight; Nutrient; Photosynthetic

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INTRODUCTION

Chili is one of the horticultural commodities in high demand. The increasing population in Indonesia is followed by an increase in the consumption of chilies as well. In 2019, the consumption of large chilies in Indonesia reached 2 kg per capita (Ministry of Agriculture 2021). The latest data shows the production of large chilies in Central Java was 171,796 tons in 2018. Whereas in 2019, the production of large chilies was 164,906 tons (Ministry of Agriculture 2020). This data comparison indicates a decline in yield production. The decline in chili production is due to the decrease in chili farmers. Farmers were reluctant to plant chilies because of the large cultivation capital, high risk of crop failure, and chili cultivation which requires intensive care. Therefore, it is necessary to make efforts to increase chili yields to be able to meet market needs. Yanuarti and Afsari (2016) explain that in general, the price of chili is determined by the amount of supply and demand. If the supply of chilies is lower than the demand, there will be a price increase, whereas if the supply of chilies exceeds the demand, the price of chilies will decrease.

Fertilization is an effort to provide nutrients that are rarely available in nature for plants. Mantja et al. (2020) explained that the application of Nitrogen, Phosphor, and Potassium (NPK) fertilizer 4 g $plant^{-1}$ produced chili 1.17 tons ha^{-1}. The provision of sufficient N elements can provide good growth so that yields are higher. Phosphorus (P) influences growth, fruit color, fruit hardness, and vitamin content and accelerates fruit ripening. Elemental potassium can help in photosynthetic translocation, enzymes, photosynthetic activation, and starch synthesis, which helps in higher productivity (Abd El-Latif et al. 2011).

One of the most important elements influencing plant productivity is soil nutrition. Simultaneously, the availability of soil nutrients to plants varies widely among species (Elbasiouny et al. 2022). Nutrient nitrogen (N) is required, nutrients P and K depend on nutrient status. While the time of fertilization must be right and adjusted to the stage of plant growth.

In addition to giving NPK fertilizer, foliar fertilizers can also be applied to increase the chili yield. The application of foliar fertilizers in the vegetative phase fulfilled nutrients in the generative phase that can increase yield production. According to Asnijar et al. (2013), several factors determine the success of fertilization through leaves, namely the type of plant, the concentration of the solution, and the time of spraying.

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Fertilizing Nitrogen, Phosphor, and Potassium can increase plan. In addition, foliar fertilizers determine plant growth. Sufficient application of nitrogen fertilizer will increase chili yields, but an excessive application can also reduce yields (Khan et al. 2014). This study uses foliar fertilizers that have never been tested on chilies before. Therefore, it is important to do this research to determine the optimal interval of compound NPK fertilizer application, compare the optimal types of foliar fertilizers, and determine the effective combination of compound NPK interval and types of foliar fertilizers for growth and yield production.

MATERIALS AND METHODS

This research was conducted from April to August 2020 in the rice fields of Gayam Village, Sukoharjo Regency, Central Java, Indonesia. The research location is at latitude 7°41'15" SL dan 110°51'14" EL. The materials used in this study include curly chili seeds of the TM 999 variety, basic fertilizers in the form of cow manure, and NPK PhonskaTM fertilizer (15-15-15). Supplementary fertilizer in the form of NPK fertilizer (16-16-16), Gandasil DTM fertilizer, A foliar fertilizer, B foliar fertilizer, and C foliar fertilizer. Other materials needed were black silver polyethylene plastic mulch, stakes, Gramaxone™ herbicide, gempur™ herbicide, curacron™ insecticide, and anthracol™ fungicide.

Table 1. The content of foliar fertilizers A, B, and C based on the packaging description

Kinds of Foliar Fertilizer	Content
A	N 6%, P2O5 20%, K2O 30%, MgSO4 3%, Mn, B, Cu, Co, Zn
B	Coconut water, sugar, spirulina, mycobacteria cycle, essential amino acids, organic nutrients
C	Silicate (Si)

This study used an experimental method with a Randomized Complete Block Design (RCBD) of 2 factors. The first factor was the application of compound NPK fertilizer. The Interval of NPK fertilization consisted of 4 levels, namely the interval of compound NPK fertilization every 21 days as a control, every 5 days, every 10 days, and every 15 days. The application of NPK fertilizer was carried out by dripping with a concentration of 25 $g.L^{-1}$ at a dose of 240 $mL.tree^{-1}$. The second factor was foliar fertilizer which consists of A foliar fertilizer as a control, B foliar fertilizer, and C foliar fertilizer. Each treatment combination was repeated 3 times. The variables observed were plant height, dichotomous branch, leaf area, plant fresh weight, plant dry weight, net assimilation rate, number of fruits, fruit weight, and fruit length. The data obtained were analyzed with analysis of variance *F* test at 5% level. If the factors showed significant results, it was further tested with 5% DMRT (Duncan's Multiple Range Test) and regression tests were also carried out on the interval of NPK fertilizer application to determine the optimum interval of compound NPK fertilization.

The tillage was carried out with a tractor and then a bed was made with a length of 880 cm, a width of 110 cm, and a height of 40 cm. Basic fertilization was carried out using cow manure at a dose of 9.4 $tons.ha^{-1}$ and NPK phonskaTM fertilizer at a dose of 2.5 quintals ha^{-1}, chili is planted with a spacing of 60 cm x 60 cm. Maintenance of chili plants consisted of irrigation, installation of stakes, *perempelan* new shoots, fertilization, spraying pesticides, and weeding the plants were observed from the age of 4 WAP (weeks after planting) to 17 WAP. The variables observed were plant height, fresh weight of stover, dry weight of stover, leaf area, and several dichotomous. The criteria for chili that are ready to be harvested are the shape of the chili is intact, solid, shiny dark red. Yesterday Harvest started at the age of 11 MST to 16 MST.

RESULTS AND DISCUSSION

Chili growth

The interval of NPK fertilization and the type of foliar fertilizer was proven significantly affect the number of dichotomous branches singly (Table 2). Table 2 showed that the interval of compound NPK fertilization every 15 days and every 10 days resulted in the same response with the number of dichotomous branches in the range of 91.07-93.60 branches. NPK compound fertilization every 15 days was able to increase the number of dichotomous by 23.16% compared to the control. At this interval, it had been able to provide macronutrients needed by plants to support chili growth, thus providing more dichotomous branches. This research was in line with Fuadi et al. (2018) that the application of pearl NPK fertilizer at a dose of 200 $g.ha^{-1}$ gave the best results for the growth and yield of red chili plants. The number of dichotomous branches correlated with the cumulative fruit weight with a *r* value of 0.35. Chili fruit appeared in the dichotomous branching so the greater the number of dichotomous branches might increase the cumulative fruit weight of chilies.

The use of foliar fertilizer A and foliar fertilizer B gave the same response in the range of 87.51-88.09 branches (Table 2). This meant that foliar fertilizers A and B have the same performance in increasing the number of dichotomous branches The results were in line with Asnijar et al. (2013), application of Bayfolan fertilizer 2 cc L^{-1} can produce 68 branches of dichotomous branches. Macro and micronutrients contained in the A foliar fertilizer and B can be useful for promoting plant growth. B foliar fertilizer contains organic ingredients in the form of coconut water. According to Yong et al. (2009), coconut water contains auxin and cytokinin hormones which help in the formation of shoots or branches. In addition to containing ZPT, coconut water also has potassium levels of 14.11 mg per 100 mL, 24.67 mg per 100 mL of potassium, 13.17 $mg.100\ mL^{-1}$ of phosphorus, and 43.00 $mg.100\ mL^{-1}$ of nitrogen (Kristina and Syahid 2012). The micronutrients contained in coconut water are iron (Fe), copper (Cu), and chlorine (Cl). While the micronutrient content in A foliar fertilizer is manganese (Mn), boron (B), copper (Cu), cobalt (Co), and zinc (Zn).

Table 2. DMRT test results influence the interval of compound NPK fertilization on chili growth and yield production

Observation variable	Interval of compound NPK fertilization (days)			
	21 (control)	15	10	5
Plant height (cm)	84.47 a	89.19 a	88.44 a	85.11 a
Number of dichotomous branches	71.92 b	93.60 a	91.07 a	77.43 b
Fresh weight of stove (g)	139.89 a	187.50 a	169.13 a	162.89 a
Dry weight of the stove (g)	26.29 b	42.39 a	38.44 a	38.42 a
Cumulative fruit (fruit)	79.74 c	127.40 a	110.42 ab	93.32 c
Cumulative fruit weight (g)	193.64 c	330.78 a	286.77 ab	250.28 bc
1st harvest fruit length (cm)	11.80a ab	12.25 a	11.99 a	11.25 b
2nd harvest fruit length (cm)	12.24 a	12.73 a	12.60 a	12.44 a
3rd harvest fruit length (cm)	11.85 a	12.07 a	11.48 a	11.93 a
4th harvest fruit length (cm)	11.46 a	11.63 a	11.42 a	11.56 a
5th harvest fruit length (cm)	10.46 a	10.05 a	9.93 a	9.39 a
6th harvest fruit length (cm)	6.76 a	7.14 a	7.00 a	6.19 a

Note: Numbers followed by the same letter in the same line are not significantly different in the 5% *DMRT* test

The interval of application of compound NPK fertilizer had a significant effect on plant dry weight. Table 2 showed that the interval of compound NPK fertilization every 15 days, 10 days, and 5 days produced the same dry weight response in the range 38.42–42.39 g. These results were in line with Prasetyo's research (2014) the addition of 1 ton.ha^{-1} of NPK fertilizer and 20 tons.ha^{-1} of chicken manure resulted in a plant dry weight of 49.38 g. NPK fertilization every 15 days was able to increase the plant dry weight by 37.98% compared to the interval of 21 days (control). According to Adnan et al. (2015), the optimal availability of nitrogen, phosphor, and potassium for plants will increase the amount of chlorophyll. This will increase the photosynthetic activity which will produce more photosynthate which affects the dry weight of the plant. Fertilization was done to increase the nutrients needed by the plants. According to Wu et al. (2019) Nitrogen functions in the formation of chlorophyll cells where chlorophyll is useful in the process of photosynthesis to produce energy that cells need for activity division, enlargement, and elongation. Element P needed plants to improve root growth and plant generative development. Physiologically P plays a role in reactions in the dark phase of photosynthesis, respiration, and is part of the nucleotide.

The results showed that the interval of NPK fertilization and the type of foliar fertilizer had no significant effect on plant height and plant fresh weight. The factor presumed to influence this finding was the more dominant generative growth. This made the generative organs mostly utilize the nutrients given to plants. Andayani and Sarido (2013) stated that the generative phase of chili plants requires a lot of nitrogen and phosphorus nutrients. Plants absorb a lot of nitrogen and phosphorus to accelerate flowering at the time of the formation of flower buds.

The range of plant height at 12 WAP was 84.47–89.19 cm. The results of this study were the same of Asnijar et al. (2013) that the addition of Bayfolan leaf fertilizer 1 ml.L^{-1} of water on chili varieties TM 999 resulted in a plant height of 77 cm. In line with the research results of Sulistyowati (2019) which showed that NPK fertilization at a dose of 1000 kg ha^{-1} resulted in an average plant height of 78.3 cm. The plant height was still below the average TM 999 variety which was able to reach a plant height of 140 cm at optimum conditions. On plant fresh weight variables, the interval of NPK fertilization and types of foliar fertilizers gave the same response in the range 139.89–187.5 g. This was the same as the results of Fatmawaty et al. (2016) that the application of Gandasil B leaf fertilizer on tomato plants resulted in the lowest fresh weight of the stove, which was 132.59 g. One of the factors that affected plant fresh weight was temperature. Bueno et al. (2019) stated that high temperatures cause evapotranspiration to increase the fresh weight of the plant.

Chili yield

The results of the analysis of variance showed that the interval of compound NPK fertilization alone affected the cumulative number of fruits per plant (Table 2). The number of cumulative fruits is closely related to the cumulative fruit weight with a *r* value = 0.969. The number of fruits will affect the fruit weight per plant. The more the number of fruits, the higher the weight of the fruit per plant (Hapsari et al. 2017).

The interval of NPK fertilization every 15 days and once every 10 days gave the same response in the range of 110.42–127.40 pieces (Table 2). The results were the same as the research conducted by Waskito et al. (2018) that 100% NPK (16-16-16) fertilization produced the highest number of fruits, which was 102.83 fruits. The addition of compound NPK fertilizer was proven to increase the cumulative number of fruits per plant. According to Dubey et al. (2017) The addition of compound NPK fertilizer was proven to increase the cumulative fruits and cumulative fruit weight. The interval of NPK fertilization every 15 days increased the number of fruits by 37.41% compared to the interval of 21 days (control).

The results of the quadratic curve (Figure 1) that was formed showed that NPK fertilization every 13 days was the optimal interval in increasing the number of fruits by 113 fruits. The value of *r*= 0,79 means that was correlation between the interval of NPK fertilization and the number of chilies per plant. NPK supplementary fertilization in chili plants is able to provide sufficient nutrients to support plant metabolism such as photosynthesis The formation and filling of the fruit is influenced by the nutrients nitrogen, phosphor, and potassium used in the photosynthesis process was namely as a constituent of carbohydrates, fats, proteins, and vitamins that will be translocated to the fruit storage section (Suherman et al. 2018).

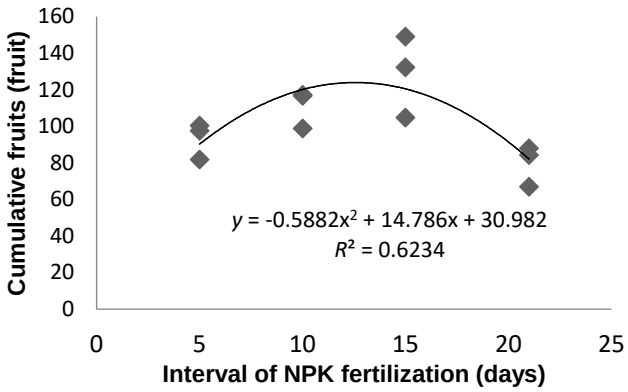

Figure 1. Effect of interval of NPK fertilization on cumulative fruit number

The mean number of cumulative fruits decreased at 21 days of NPK fertilization (control). This was because the nutrients given to plants are not sufficient for the plant's needs so that the fruit produced is also less. The interval of NPK fertilization every 5 days gave a lower response than the interval of once every 15 days. It is presumed that excessive fertilization caused the soil solution to become concentrated. According to Wolo et al. (2017), the addition of NPK, KCL, or Urea fertilizers that were too concentrated will cause plasmolysis which will damage the cell and disturb nutrient absorption.

The results of the DMRT test (Table 2) showed that the interval of NPK fertilization every 15 days and every 10 days gave the same cumulative fruit weight response in the range of 286.77–330.78 g. The interval of NPK fertilization every 15 days increased the cumulative fruit weight by 41.46% compared to the interval of 21 days (control). The average fruit weight in this study was higher than the research conducted by Asnijar et al. (2013) that chili varieties TM 999 produced a fruit weight per plant of 172.89 g.

Based on the results of the quadratic curve formed (Figure 2) the interval of NPK fertilization every 13 days was the optimal interval in increasing fruit weight per plant by as much as 321.1 g. The *r* value = 0.75 indicated that there was a correlation between the interval of NPK fertilization and chili fruit weight per plant. According to Cole et al. (2016), element N is used for protein formation, element phosphorus to improve skin color and flesh color, hardness, and vitamin C. While the element potassium can increase sugar, acid, carotene, and lycopene. The average cumulative fruit weight per plant decreased at the interval of NPK fertilization once every 21 days (control).

The results showed that the interval of NPK fertilization affected the length of the 1st harvest fruit and the type of foliar fertilizer affected the length of the 5th harvest. Table 1 shows that the interval of compound NPK fertilization every 10 days and once every 15 days gave the same response in the first harvest length range of 11.99–12.25 cm. The length of the fruit produced in this study is the same as the description of the TM 999 variety which has a fruit length of 12.5 cm. The results of this study are in line with the research conducted by Murwito et al. (2010) that fertilization of 1500 kg.ha^{-1} NPK and 375 kg.ha^{-1} ZA the best chili length was 13.57 cm. The addition of nutrients through NPK fertilization and foliar fertilizers produces good fruit. The content of element P in NPK fertilizer is useful for the formation of fruit and seeds. The research of Khandaker et al. (2017) showed that the more nitrogen fertilizer applied, the longer the fruit length which led to an increase in chili crop yields.

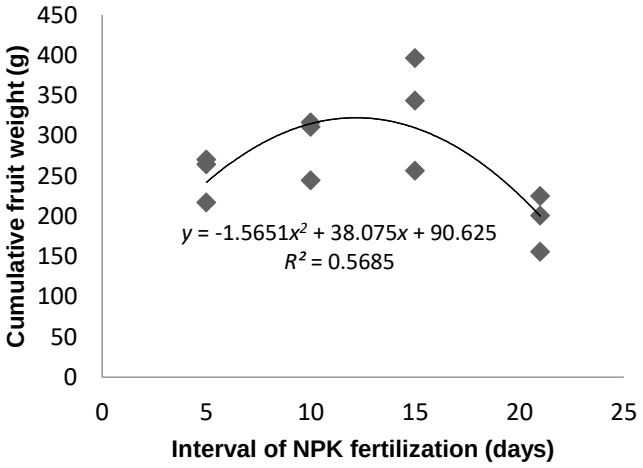

Figure 2. Effect of NPK fertilization interval on cumulative fruit weight

The results showed that leaf fertilizer A produced the 5th best fruit length of 10.19 cm (Table 3). The 5th harvest produced a lower fruit length when compared to the previous harvests. This showed that towards the end of the harvest period the fruit produced had a smaller size. According to Ashrafuzzaman et al. (2011), the formation of fruit length is influenced by photosynthate which is produced from the photosynthesis process. A foliar fertilizer has a composition of 6% nitrogen, 20% phosphorus, 30% potassium, and 3% magnesium. The nutrient content can meet the needs of chili plants, and plants can absorb the nutrients contained in the fertilizer to carry out metabolic processes properly.

The results showed that the interval of NPK fertilization and the type of foliar fertilizer had no significant effect on Net Assimilation Rate (NAR). The range of net assimilation rates is between 0.076–1.915 mg.cm^{-2}.day^{-1} (Table 4). The results were in line with Baharuddin's research (2016) which showed that the dose of NPK fertilizer had no significant effect on the net assimilation rate of chili plants at plant age 10-20 WAP. Treatment of 100% NPK 16-16-16 dose resulted in a NAR value of 1.24 mg.cm^{-2}.day^{-1}.

Table 3. DMRT results the effect of foliar fertilizers on chili growth and yield production

Observation variable	Kinds of Leaf Fertilizer		
	A	B	C
Plant height (cm)	87.19 a	88.66 a	84.63 a
Number of dichotomous branches	88.09 a	87.51 a	75.12 b
Fresh weight of stove (g)	165.33 a	149.75 a	181.00 a
Dry weight of the stove (g)	35.79 a	34.35 a	39.35 a
Cumulative fruit (fruit)	92.50 a	107.61 a	109.47 a
Cumulative fruit weight (g)	229.53 a	288.63 a	281.62 a
1st harvest fruit length (cm)	11.70 a	11.89 a	11.88 a
2nd harvest fruit length (cm)	12.57 a	12.39 a	12.57 a
3rd harvest fruit length (cm)	11.86 a	12.11 a	11.56 a
4th harvest fruit length (cm)	11.68 a	11.52 a	11.38 a
5th harvest fruit length (cm)	10.19 a	9.31 b	9.38 b
6th harvest fruit length (cm)	6.89 a	6.24 a	6.20 a

Note: Numbers followed by the same letter in the same line are not significantly different in the 5% *DMRT*

Table 4. LAB on various combinations of NPK fertilization interval treatments and types of foliar fertilizers

Net Assimilation Rate (mg.cm^{-2}.day^{-1})			
Interval of compound NPK fertilization (days)	Kinds of Leaf Fertilizer		
	A (control)	B	C
21	0.213	0.076	0.965
15	0.186	1.486	1.915
10	0.151	0.079	0.682
5	1.089	0.606	0.907

The leaf area was also closely related to the net assimilation rate of the plant. The leaves that actively carry out photosynthesis greatly affect the net assimilation rate of plants. Meanwhile, leaves that were not active, such as old or shaded leaves, will reduce the rate of net assimilation. Huez-López et al. (2011) explained that the net assimilation rate was related to leaf area and plant dry weight. The greater the leaf area value and the plant dry weight, the greater the net assimilation rate of the plant.

CONCLUSIONS AND SUGGESTION

The interval of NPK fertilization every 15 days until the chili plants were 17 WAP increased the dichotomous branches by 23.16%, dry weight by 37.98%, cumulative fruits by 37.41%, and cumulative fruit weight by 41.46%. Leaf fertilizer A foliar fertilizers and B foliar fertilizer gave the same performance in increasing the number of dichotomous branches by 14.72%. There was no interaction effect between the interval of NPK fertilization and the type of foliar fertilizer on chili growth and yield. The advice that can be given is the interval of compound NPK fertilization as supplementary fertilizer, it is optimum to apply it every 15 days.

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