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Response of Growth and Yield of Chili to the Doses of NPK Fertilizer Application

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ABSTRACT

The addition of NPK fertilizer has the potential to increase productivity. This research aims to obtain the optimum dose of compound NPK fertilizer to increase the growth and yield of chilli. This experiment was conducted in the chili fields of Sendangijo Village, Selogiri District, Wonogiri Regency, Central Java from May-September 2023. The method used was a Randomized Complete Block Design (RCBD) non factorial and four replications. The factor used dose of compound NPK (0, 50, 100, and 150 kg ha^{-1}). The variables observed were plant height, leaf area, number of dichotomous branches, fresh and dry weight of stover, fruiting age, fruit length, number of fruits per plant, and fruit weight per plant. Data analysis was carried out using analysis of variance (ANOVA) on the level of α5%. If there is a significant difference, then further testing is done with an orthogonal polynomial test. The results showed that dose of NPK fertilizer did not show a significant effect on plant height, leaf area, number of branches, fruiting age, fruit length, number of fruits per plant and fruit weight per plant of chilli.

Keywords: Cow manure; Dichotomous branches; Fruit length; Macronutrient; *Solanaceae*

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INTRODUCTION

Chili peppers are an important horticultural commodity. That offer significant economic potential due to consistently rising market demand. The Directorate General of Horticulture, BPS-Statistics Indonesia (2021), stated that the total national chili consumption requirement in 2020 was 1,095,412 tons. This figure represents an increase compared to 2019, when the total chili consumption requirement was only 934,915 tons. Chili consumption continues to increase annually, but productivity is not matched by increases.

Low soil chemical fertility is a common problem, necessitating intensification efforts, one of which is the application of fertilizer (Zamzami et al. 2016). Adequate nutrient availability is a crucial component of crop cultivation. The application of fertilizer technology can increase soil nutrient levels. According to Waskito et al. (2018), fertilization is a technology that can significantly impact chili productivity, as chili peppers are highly responsive to fertilizer application. The most influential nutrients in chili cultivation are N, P, and K. These three elements can determine the productivity and quality of chili yields.

Based on the above, it is necessary to determine the appropriate application dosage of compound NPK fertilizer to achieve optimal chili growth. This research was conducted to determine the optimal dosage of compound NPK fertilizer to increase chili growth and yield. With these results, it is hoped that farmers can apply it to increase chili productivity. This research aims to determine the optimal dosage of compound NPK fertilizer to increase chili growth and yield.

MATERIALS AND METHODS

The location of this research was a chili field in Dukuh Kedung Banteng RT 01/RW 04, Sendangijo Village, Selogiri District, Wonogiri Regency, Central Java. This experiment was also conducted at the Ecology and Crop Production Management Laboratory, Faculty of Agriculture, Universitas. This research activity was conducted from May to August 2023. The materials used in this experiment included chili seeds of the TM 999 variety, organic cow manure, foliar manure, and a 16-16-16 NPK fertilizer. The tools used in this experiment included an analytical balance, a lux meter, and a thermohygrometer. The design used in this experiment was a non-factorial Randomized Complete Block Design (RAKL), with four levels of compound NPK fertilizer doses: 0, 50, 100, and 150 kg ha^{-1}. This study used four replications. The research implementation included initial soil analysis, seeding, land preparation and mulching, transplanting and replanting, fertilization, maintenance, and harvesting. Observation variables included

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environmental conditions, soil chemical properties, plant height, number of dichotomous branches, leaf area, fresh and dry weight of fruiting-age stover, fruit length, number of fruits per plant, and fruit weight per plant. Observation data were analyzed using analysis of variance (ANOVA) at the α=5% level. If there were significant differences, further testing was carried out using the orthogonal polynomial test.

RESULT AND DISCUSSION

Environmental conditions

The environment plays a crucial role in plant growth and yield. This is because plant physiological functions are highly dependent on environmental conditions. Data on environmental conditions, including temperature, humidity, light intensity, and rainfall at the research site, are presented in Table 1.

Table 1. Environmental conditions in the research field

Variable	Average	Min	Max
Temperature (ºC)	32.38	30.1	34.67
Humidity (%)	39.39	33.33	47.67
Light intensity (lux)	32339.58	16000	48600
Rainfall (mm bulan^{-1})	2	0	5

The environmental temperature conditions in the research area were too high, reaching 34ºC (Table 1), thus inhibiting the growth of chili peppers. According to Devianto et al. (2023), the ideal temperature for chili pepper growth is around 24-27ºC, while for fruit formation it is 16-30ºC. The humidity and rainfall conditions in the research area were too low, thus inhibiting the growth and production of chili peppers. According to Rajametov et al. (2021), the ideal humidity for chili pepper growth ranges from 65-70%. Meanwhile, the ideal rainfall for chili peppers, according to Imtiyaz et al. (2017), ranges from 100-200 mm month^{-1}. The light intensity in the research area fluctuates greatly, some are too low but the majority meet the growing requirements. This ensures sufficient light intake for the plants. According to Siahaan et al. (2023), the optimum light intensity for chili pepper growth ranges from 30,000-50,000 lux.

Plant height

The results of the diversity analysis showed that the compound NPK dose up to 150 kg ha^{-1} was unable to increase plant height (Table 2). The height of chili plants due to the compound NPK fertilizer dose showed that chili plants with 50 kg ha^{-1} had a higher plant height than the others. The average plant height with the highest and lowest yields only showed a difference of 7.17%. The results of this experiment are the same as Idris (2022), that the application of compound NPK fertilizer can produce a chili plant height of 57.25 cm and is not significantly different from without compound NPK fertilizer. This is because with the type of vertisol soil with moderate N nutrient content, the application of compound NPK fertilizer doses in the land is less than optimal to increase plant growth. The vegetative phase of chili plants really requires a large supply of N elements. Nimatu et al. (2022), the application of sufficient amounts of NPK fertilizer can increase plant height by 2% compared to the control. This is because nitrogen plays a crucial role in chlorophyll formation and amino acid, protein, and nucleic acid synthesis. Therefore, a lack of nitrogen in plants can stunt their growth (Qibtyah 2015).

Furthermore, the dry season makes the soil in the research area quite hard due to repeated water shortages, making it difficult for chili plant roots to penetrate the soil to obtain the nutrients and water needed for growth. Tuapattinaya and Tutupoly (2014) note that plant height is also influenced by metabolic activity within the plant. This metabolic activity requires sufficient nutrients for optimal growth. Aphids and thrips attack chili plants by sucking the sap from young leaves and stems, causing stunted and curly plants, thus inhibiting plant growth.

Leaf area

According to the results of the analysis of the diversity of compound NPK doses up to 150 kg ha^{-1}, there was no effect on the leaf area of chili plants (Table 2). The highest leaf area was 18.34% higher than the lowest value. This is consistent with Setiawan (2016), who stated that the application of 2.5 g NPK fertilizer per plant resulted in an average leaf area of 19.7 cm2, with no significant effect on the leaf area of chili plants compared to other treatments.

Table 2. Plant height, leaf area, number of dichotomous branches, fresh and dry weight of chili stover with compound NPK fertilizer dosage

NPK (kg ha^{-1})	Plant height (cm)	Leaf area (cm^2)	Number of dichotomous branches	Fresh weight (g)	Dry weight (g)
0	48.69±2.75	28.69±3.05	79.07±7.39	133.42±7.77b	44.57±6.99b
50	52.45±4.65	27.76±2.8	86.16±15.21	87.17±12.37a	30.72±5.15a
100	52.37±6.51	23.90±0.96	89.94±14.84	219.80±28.98c	75.68±13.56c
150	51.36±2.41	29.39±2.97	75.07±4.19	157.18±24.5b	53.10±8.83b
Sig.	0.913	0.576	0.866	0.0001	0.001
KK(%)	17.1	15.7	32.5	38.9	42.8

Remarks: Numbers followed by the same letter are not significantly different based on ANOVA at the α=5% level. Sig: Significance, KK(%): Coefficient of Diversity

Leaves are the site of photosynthesis, which converts sunlight energy into energy and food storage in plants. As plant organs responsible for synthesizing food reserves, they require a large supply of nutrients, especially nitrogen. Munar et al. (2018) found that the greater the supply and uptake of nitrogen by plants, the greater the encouragement of leaf area formation and growth, as vegetative plant growth is stimulated by the availability of nitrogen. Leaf growth is also influenced by photosynthesis, which requires a sufficient supply of nitrogen. According to Ulya et al. (2020), the availability of nutrients and water will affect leaf photosynthesis and photosynthates formation in the leaves. Soil P content can also impact plant photosynthesis. According to Bechtaoui et al. (2021), photosynthetic rate and stomatal conductance decrease when plants are deficient in P.

K acts as an enzyme activator in plant metabolism and helps open and close stomata, thereby increasing plant photosynthates production. According to Rahmawan et al. (2019), applying fertilizer containing K can increase leaf area and root number, as K plays a crucial role in photosynthesis. Adequate K in plants facilitates photosynthesis and increases the translocation of photosynthetic products to other organs, resulting in rapid plant growth. High soil K availability, coupled with NPK fertilization, can lead to excess K, which can negatively impact plant growth.

High aphids and thrips infestations on chili plants can inhibit leaf area growth. These two pests attack the leaves by sucking the liquid, causing the chili leaves to become wrinkled or curly, stunted, turn yellowish and unable to grow optimally.

Number of dichotomous branches

The results of the analysis of variance showed that compound NPK fertilizer doses of up to 150 kg ha^{-1} did not affect the number of dichotomous branches (Table 2). The highest average number of branches for chili plants with compound NPK fertilizer doses differed by 16.47% from the lowest. This finding aligns with the findings of Hasan et al. (2019) that the application of several NPK fertilizer doses did not significantly differ and resulted in a branch count ranging from 74 to 88. Branch count is also affected by pest attacks on chili plants. Aphids and thrips, which attack chili plants by sucking sap from young stems and leaves, stunt most chili plants in the study area, inhibiting the growth of dichotomous branches.

Fresh weight

Based on the results of the analysis of variance at a 5% level, it shows that the dose of compound NPK fertilizer has an effect on the fresh weight of chili plant stover (Table 3). The dose of compound NPK fertilizer of 100 kg ha^{-1} gave the highest yield, and 50 kg ha^{-1} gave the lowest yield. Nugroho et al. (2022) showed that the administration of a dose of compound NPK fertilizer to chili plants resulted in a fresh stover weight of 212.47 g. The results of further tests showed an orthogonal polynomial equation, namely y= 0.816x + 118.8 (Figure 1). The results of the orthogonal polynomial test on the effect of administering compound NPK doses on the fresh weight of the stover. The results of the orthogonal polynomial test on the effect of administering compound NPK doses on the fresh weight of the stover). The correlation coefficient value obtained from the orthogonal polynomial results was 0.409, which means there is a fairly close relationship between the treatment of compound NPK fertilizer doses and the fresh weight of stover. The dose of compound NPK fertilizer has an effect on the fresh weight of stover by 16.8%, which is shown in the R2 value.

The absorption of water and nutrients N, P, and K can increase plant growth rates and increase plant fresh weight, especially for photosynthesis. According to Pusparini et al. (2018), the fresh weight of plant stumps is determined by the process of photosynthesis. Ayu et al. (2019) also explained that the optimal availability of nutrients N, P, and K can increase chlorophyll formation, assisting in nutrient and water absorption, thereby increasing the rate of plant photosynthesis.

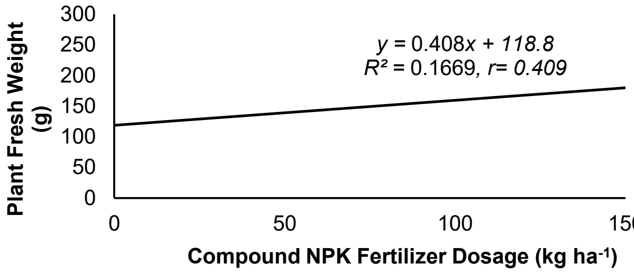

Figure 1. The results of the orthogonal polynomial test on the effect of administering compound NPK doses on the fresh weight of the stover

Dry weight

The dose of compound NPK fertilizer based on the results of the 5% level of diversity analysis showed that it was able to increase the dry weight of chili plant stover. Table 3 shows that 100 kg ha^{-1} gave the highest yield, and 50 kg ha^{-1} gave the lowest yield. Suprapti et al. (2023), stated that increasing the dose of NPK fertilizer can increase the dry weight of stover up to 92.58 g plant^{-1}. The results of further tests produced an orthogonal polynomial equation formed, namely y = 0.284x + 40.465 (Figure 2. The results of the orthogonal polynomial test on the effect of administering compound NPK doses on the dry weight of the stover.). The correlation value obtained from the results of the orthogonal polynomial was 0.378, which means that there is a fairly close relationship between the treatment of compound NPK fertilizer doses and dry weight of stover. While the R2 value obtained was 0.143, which means that the dose of compound NPK fertilizer has an effect on dry weight of stover by 14.3% while 85.7% is influenced by natural or genetic factors.

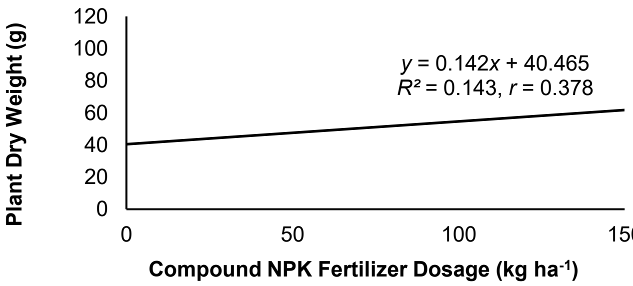

Figure 2. The results of the orthogonal polynomial test on the effect of administering compound NPK doses on the dry weight of the stover.

Table 3. Age of fruiting, fruit length, number of fruits per plant, fruit weight per chili plant due to administration of compound NPK fertilizer doses

NPK (kg ha^{-1})	Fruiting age (DAT)	Length of fruit (cm)	Number of fruits per plant (fruit)	Fruit weight per plant (g)
0	88.13±0.63	12.10±0.36	30.19±2.72	61.17±10.87
50	89.46±0.86	11.24±0.45	31.75±7.72	62.78±18.28
100	89.76±0.83	11.39±0.63	24.00±5.86	49.39±11.55
150	88.59±0.75	11.64±0.41	29.22±4.29	55.42±16.33
Sig.	0.517	0.667	0.816	0.993
KK(%)	2.13	9.74	44.65	59

Remarks: DAT: Days After Transplanting. Sig.: Significance; KK(%): Diversity coefficient.

Fitrianti et al. (2018) stated that optimal supply of compound NPK fertilizer during the vegetative phase of the plant can increase plant root development, allowing the plant to optimally absorb available nutrients. This is because the plant's ability to absorb nutrients is strongly supported by good rooting. Singh et al. (2022) showed that the application of 75% of NPK fertilizer can increase chili stover yield, because NPK fertilizer can increase plant development in the form of plant cell division. The availability of balanced N, P, and K nutrients for chili plants can play a role in the formation of enzyme molecules and chlorophyll so that they can be utilized by plants for metabolic processes and can increase photosynthetic activity to produce optimal photosynthate. Syamsuwirman et al. (2023) stated that plant metabolism greatly affects the dry weight of plant stover; if metabolism increases, the dry weight of the plant will increase, and vice versa.

Fruiting age

The results of the diversity analysis of 5% doses of compound NPK fertilizer up to a dose of 150 kg ha^{-1} on chili plants did not show any significant differences in the age of chili fruiting (Table 3). These results can be caused by two factors, namely nutrient factors and environmental factors. According to Waskito et al. (2018), the availability of nutrients, especially N, P, and K, can accelerate the process of flowering, fruiting, and the formation of seeds, carbohydrates, fats, and proteins. According to (Luo et al. 2020), the supply of N elements can change the time of the vegetative phase of the plant to the generative phase. Phosphorus nutrients have an important role in the fertilization process. Environmental factors greatly influence the process of chili fruit formation. Too high temperatures cause the evapotranspiration process to increase so that the plant loses a lot of water. This condition causes chili flowers to fall and the pollination process fails.

Fruit length

The results of the 5% variability analysis of fruit length from NPK doses up to 150 kg ha^{-1} did not affect chili fruit length (Table 3). Chili fruit length from compound NPK fertilization showed a 7.11% difference in the highest average compared to the lowest average. Fuadi et al. (2018) found that applying 100 kg ha^{-1} of compound NPK fertilizer only produced 9.67 cm long red chilies.

Chili fruit length is strongly influenced by nutrient availability. Mahmud et al. (2020) showed that applying higher doses of N fertilizer increased chili fruit length by 1 cm compared to the control treatment. Phosphorus and potassium are the nutrients that significantly influence chili fruit length. Entering the generative phase, chili plants require an adequate supply of phosphorus and potassium. Fruit length is strongly influenced by the presence of phosphorus in the soil. According to Wibowo et al. (2016) explained that chili fruit size is strongly influenced by the availability of P and K nutrients. Higher availability of these two elements will increase fruit size, both in terms of length and diameter. Potassium is adequately available in the soil, but phosphorus is low.

Temperature and humidity can influence fruit size. A suitable temperature, especially during fruit formation, can increase fruit size. The ideal temperature for chili fruit formation is around 24-27^{o}C. The temperature in this study ranged from 30-35^{o}C, making it less suitable for fruit formation and potentially resulting in smaller fruit size. Humidity is crucial for fruit formation. Nurjayanti et al. (2012) explained that humidity can influence fruit size. Chili plants with appropriate humidity will produce larger fruit. The ideal humidity for chili fruiting is around 85%. In this study, humidity was only around 33-48%. This humidity is less suitable because it is too low, potentially resulting in smaller fruit size.

Number of fruits per plant

The results of the diversity analysis showed that the dose of compound NPK fertilizer did not increase the number of chili fruits per plant (Table 3). The number of fruits per plant from the compound NPK fertilizer dose showed an average of 24.41% more fruits than the lowest number of fruits. Nugroho et al. (2022) stated that administering a dose of compound NPK fertilizer of 3.74-11.25 g plant^{-1} was able to produce a range of 24.95-34.81 fruits per plant. Chili fruit production is influenced by nutrient availability both in the vegetative and generative phases. Wahocho et al. (2016) provided a higher nitrogen dose that could increase the number of fruits per plant to 142 fruits. In addition, the environmental conditions of the research area with high temperatures and a lack of water supply for irrigation caused disruption to the process of flower formation into fruit. According to Nurwanto et al. (2017), high temperatures and lack of water will result in flower and fruit loss. The average temperature in the research area during June-September is around 30-34°C, while the optimal temperature for chili plant growth is 18-32°C (Amalia and Ziaulhaq 2022). The temperature in the research area is not suitable for chili growth because it is too high, which can cause rapid transpiration. This condition is exacerbated by the lack of water supply for irrigation of the chili plants, which inhibits the fruiting process. Furthermore, the high intensity of thrips and aphids attacks on chili plants since the vegetative phase, which absorb fluids from the stems, leaves, and flower stalks of chili peppers, causing many chili flowers to fall off.

Weight of fruit per plant

Variance analysis showed that compound NPK fertilizer dosage did not increase chili fruit weight per plant (Table 3). Fresh fruit weight per plant from compound NPK fertilizer showed a percentage difference between the highest and lowest average fruit weight values, namely 21.33%. Purwanto (2020) explained that the application of compound NPK fertilizer at a dose of 1 g per polybag resulted in a fresh chili fruit weight of 61.5 g, but this result was not significantly different from the control.

Fresh fruit weight is strongly influenced by the elements N, P, and K, which must be available in sufficient quantities. Compound NPK fertilizer significantly influences chili fruit weight per plant. Setiawan et al. (2016) found that applying 75% nitrogen fertilizer can increase fruit weight per plant by up to 389.08 g. Each element, N, P, and K, plays a role in increasing chili fruit weight per plant. The nutrients N, P, and K will help increase plant growth and biomass production, as well as increase chili fruit production (Laili et al. 2020). Low rainfall conditions in the research area can affect temperature, humidity, and soil water availability. High and low temperatures can increase evapotranspiration. Drought conditions accompanied by high evapotranspiration cause water shortages and inhibited fruit production.

Furthermore, aphids and thrips attacks on chili plants reduce fruit production and cause many chili flowers to fall off. In addition to aphids and thrips, fruit fly attacks cause some chili fruits to rot, rendering them unsuitable for harvest, thus reducing chili fruit production.

CONCLUSIONS AND SUGGESTIONS

Conclusion

The conclusion of this study is that the administration of a compound NPK fertilizer dose of up to 150 kg ha^{-1} can increase the fresh weight of the stover and the dry weight of the stover of chili, but is unable to increase the height, leaf area and number of dichotomous branches of chili. The administration of a compound NPK fertilizer dose of up to 150 kg ha^{-1} is unable to increase the yield of chili plants.

Suggestion

The provision of compound NPK fertilizer should also be supplemented with the provision of biofertilizer to improve soil texture and encourage better plant growth.

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