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The Effect of Fertilizers on Some Growth and Physiological Aspect of Chili Cultivar: a review

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A B S T R A C T

Chili is a type of plant that is consumed almost every day by almost all of the world's population. Increasing the yield of chili plants will ensure the availability of chilies on the market. One effort to increase the amount of chili production is by choosing the right fertilizer based on the type of chili planted. In this review article, we discuss the influence of chemical and or non-chemical fertilizer types which are related to physiological aspects, for example the number of leaves, plant height, and total chlorophyll content. By knowing a lot of information regarding fertilization of chili plants, it is hoped that it can help in efforts to increase production so that it can meet people's needs for chilies.

INTRODUCTION

Chili is an important agricultural commodity in various countries. According to BPS data for 2023, the amount of chili consumption in Indonesia will reach 0.08 ounces per capita per week, while in 2022, the amount of chili consumption in Indonesia will reach 0.07 ounces per capita per week (1). This showed an increase in chili consumption per capita per week in Indonesia in the last 2 years. Chili consumption should be balanced with the amount of production. BPS data for 2023 shows that the amount of chili production in Indonesia in 2023 will reach 3,061,260 tons. This number increased from the previous year which reached 3,020,262 tons (2).

The production of a plant cannot be separated from endogenous and exogenous factors. One exogenous factor that can influence the production of a plant is fertilizer. Fertilization can be interpreted as adding nutrients to the planting medium, either on leaves or soil, so that it can be useful for plant growth and development (3). With fertilizer, it is hoped that plants can grow more fertile so that production will increase as well.

Fertilizer can be categorized into two types, namely chemical fertilizer and non-chemical fertilizer. Chemical fertilizer is defined as fertilizer made chemically, while non-chemical fertilizer can be said to be fertilizer derived from organic materials. Non-chemical fertilizers usually have a larger pore volume, resulting in increased soil porosity so that nutrients remain retained in place, which in turn can be better used for plant growth (3). It is better to apply chemical fertilizers alternately with non-chemical fertilizers with the aim of improving the chemical properties of the soil (4) and this is in accordance with research results (5) which show that the combined application of non-chemical and chemical fertilizers has been proven to increase soil fertility compared to the overall application of chemical fertilizers. .

The addition of nutrients to the soil, especially through the application of non-chemical fertilizers, can reportedly improve soil quality so that sufficient nutrients are available for plant growth and development. The elements nitrogen (N), phosphorus (P), and potassium (K) are the most important elements for plant growth and development (6). These three main elements are contained in chemical and non-chemical fertilizers (7).

Physiological aspects include plant height, dry weight, stomatal density and conductivity, and respiration rate, and all of these things are closely related to plant growth. Plant height can be related to the plant's response to growth and this can be seen that plants with sufficient nutrients will grow well, for example by looking at the plant height which can reach optimal results due to the

application of sufficient nutrients. Furthermore, according to (8), indicators of good plant growth can be seen from the dry weight of the plant, namely a measure of plant growth and development which is correlated with nutritional conditions due to the plant's success in synthesizing organic compounds. Stomata density is known to be proportional to increasing temperature, the amount of CO_2 fixed by the plant, and light intensity (9). This stomata density can then be related to stomatal conductivity, namely the ability of leaves to release water through the stomata, thereby influencing the transpiration process (10). Furthermore, decreased stomata conductivity will result in a decrease in CO_2 concentration resulting in a decrease in the rate of photosynthesis.

Based on the background above, the author hopes that this article can provide scientific information regarding the effect of fertilization on chili plants in terms of morphological and physiological aspects. With this knowledge, the author hopes that this article can be used as a view or insight for researchers or chili farmers in developing research on chili plants. Finally, at least the author hopes that chili farming in Indonesia in particular can develop better in line with the increase in demand for chilies both domestically and abroad.

METHODS

This literature search article was compiled by searching for research articles related to chili growth with the keywords: chili, growth, physiology, morphology and fertilization in the google.com data browser.

DISCUSSION

Number of Leaves

Leaves are a very vital plant organ, namely as a place for photosynthesis to carry out the anabolism process to form starch. A large number of leaves is believed to play a role in supporting plant growth because the more leaves there are, the more photosynthesis process is expected so that the amount of photosynthesis will also increase (11). The results of research (12) showed that application of biological fertilizer with a concentration of 5 to 15 mL.L-1 had no effect on the number of leaves per plant at 34 to 62 days after planting (DAT). Providing a combination of 75% manure + organic fertilizer added with 25% chemical fertilizer gave the highest results in the number of leaves per plant, namely around 85.33 leaves per plant for the Shandar variety of chili. Furthermore, the second best result was when Shandar variety chili plants were treated with a combination of non-chemical fertilizer (cage + compost) with chemical fertilizer, and 100% manure treatment gave the lowest results for the

number of leaves parameter, namely 56.33 leaves per plant (13). Furthermore, the number of leaves of open pollinated chili varieties Stret and Taruna was reported to have the highest number of leaves, namely around 197.5 leaves per plant when treated with a combination of chemical (NPK Phonska) and non-chemical (leaf compost) fertilizers alternately compared to the hybrid varieties Pelita and Dewata43 (14).

Non-chemical fertilizers are indeed more environmentally friendly so their ability to improve soil fertility is more effective than chemical fertilizers, although chemical fertilizers are considered more practical to use (15). The results of research (16) showed that there is an effect of applying several types of fertilizer, namely manure, compost, NPK fertilizer, and humic acid on the number of leaves of chili plants. The results of this research also showed that the combination of 50% NPK fertilizer and 250 grams of humic acid produced the highest number of leaves compared to other variable fertilizer treatments, namely 427.45 leaves/plant. The results of applying fertilizer to chili plants, which only contained 250 grams of humic acid, showed the lowest number of leaves, namely in the range of 210 leaves per plant.

Worm compost solution or better known as vermi-tea is a type of non-chemical fertilizer in solution form. This type of organic fertilizer is reported to support the growth of plants such as corn (17) and cucumber (18). The results of research (13) regarding the effect of providing several types of fertilizer, namely vermi-tea, cow dung fertilizer, chemical fertilizer on the number of leaves planted on chili plants. In this research, several combination treatments of different fertilizer concentrations were given. Providing a combination of fertilizer concentrations of 25% chemical fertilizer, 25% worm compost, 25% cow dung, and 25% vermi-tea solution turned out to produce the highest number of leaves compared to other fertilizer combination treatments, i.e. 85.33 leaves per plant. In the treatment of giving cow dung fertilizer at a dose of 100%, it turned out to produce the lowest number of leaves, i.e. only 56.33 leaves per plant.

Tofu liquid waste is reported to still contain organic substances, such as 1.36% nitrogen, which can support plant growth (19). Research on the use of tofu liquid waste as fertilizer, for example by applying it to chili plants by fermenting it for 10 days with coconut water and EM4 with the formula of 1L of tofu waste added with 500 mL of coconut water and 30 mL of EM4. The results of this research were reported by (20) and the results showed that the application of tofu waste liquid fertilizer had a significant effect on plant height, namely a concentration of tofu waste liquid fertilizer with a concentration of 20% resulted in the best plant height, i.e. around 8.3 cm, while the control treatment gave results Lowest. Furthermore, in terms of the number of leaves parameter, it

turned out that the highest number of leaves occurred in plants given liquid fertilizer from tofu waste with a concentration of 10%, namely around 7.25 leaves per plant, while the control treatment gave the lowest results, namely 5.3125 leaves per plant.

The effect of applying chemical and non-chemical fertilizers was also carried out on red chili plants (21). The results of the research showed that in terms of leaf number parameters, the NPK chemical fertilizer treatment turned out to give the best results at 35-DAP, namely around 134.06 leaves per plant, which was very slightly different from the commercial organic liquid fertilizer treatment (Asri Nature Bio) which ranked second with the highest number of leaves, namely 134.02 leaves per plant. However, the increase in the number of leaves from 28-DAT to 35-DAT turned out to be greater in the treatment with commercial organic fertilizer, namely around 77.56 leaves per plant, whereas in the treatment with NPK chemical fertilizer it was only 65.25 leaves per plant. These results indicated that the use of organic fertilizer can also be considered for application to red chili plants because apart from being environmentally friendly, it also has the ability to encourage the growth and development of red chilies.

Plant height

One type of non-chemical fertilizer that can be used to fertilize chili plants is organic liquid fertilizer (POC) which comes from the fermentation of earthworms, sugar and EM4. The use of earthworm POC was reported by (22) and showed that the use of worm POC with a concentration of 400 mL/polybag gave the best results in plant height parameters, i.e. around 120 cm compared to a lower concentration of worm POC at 8 weeks after planting. Still related to earthworms, worm fertilizer or worm compost is reported to contain a lot of phosphorus, nitrogen, calcium, magnesium and potassium which are good for plant growth (23). Furthermore, POC with earthworms was reported to accelerate soil enrichment so that fertility can be increased and increase plant resistance to pest attacks (24).

The Shandar variety of chili was grown in an area of Pakistan at an altitude of 184 m above sea level. It turned out there was a significant difference between the type of fertilizer given and the height of the plant. The highest chili plant height was achieved when given fertilizer mixture treatment with a composition of 25% chemical fertilizer and 75% mixture of manure + organic fertilizer with various compositions, while the control treatment showed the lowest results in plant height parameters, i.e. 37 cm (13). From the research data, it turns out that the more combinations of fertilizers given, the higher the height of the chili plants

will be, so that the best growth is obtained by inducing the plants with various types of fertilizer.

Commercial liquid organic fertilizers, for example POMI fertilizer, are widely used to increase soil fertility. Outside of the growing season, the Dewata 43 hybrid chili variety given POMI fertilizer showed the best results in the parameters of plant height and number of leaves, compared to other brands of foliar fertilizer, namely X-ZO, Meroke Fitoflex, Bayfolan, and Meroke Flex-g (25). . Still in the treatment of being planted out of season, together with another type of hybrid chili (Pelita) and two types of open cross chili (namely: Sret, and Taruna), it turned out that the Taruna variety gave the best high yields when organic foliar fertilizer was applied with a concentration of 1% (14). Different things were reported by (12) that chili plants that were treated with 5-15 mL.L-1 of biological fertilizer did not have significantly different results. Furthermore, this research also showed that the frequency of giving biological fertilizer with a concentration of 5-15 mL.L-1 per week, every two weeks, or every three weeks also does not show a significant difference.

Other types of organic fertilizer, such as Bokashi fertilizer, have also been added to the planting medium for propagating cayenne pepper plants (26). Bokashi is known as a method of making compost by adding starter microorganisms, a source of sugar, or rice husks (27) and this starter microorganism can be EM4 which consists of Lactobacillus, yeast, photosynthetic bacteria and fungi (28). The results of research on the response of cayenne pepper plants to which various kinds of organic fertilizer were added showed that the treatment of giving bokashi fertilizer gave the best results in terms of plant height parameters at 42-HST observations with a height of around 29.36 cm (26).

Regarding the type of soil used for planting chilies, peat soil has unique characteristics. This uniqueness includes the high acid content and lack of nitrogen, phosphorus, potassium, magnesium and calcium (29), so special treatment is needed so that this type of soil can be planted. Furthermore, chili plants are known as plants that are very easy to develop in all types of soil with irrigation and aeration conditions in the good category (30). Several studies of chili plants grown on peat have been reported, for example regarding the addition of manure in the form of chicken droppings to peat soil as a growing medium for cayenne pepper (31). In this research, it was seen that at HST-28, cayenne pepper plants planted in peat soil treated with chicken manure of 750 grams/polybag turned out to give the best results in terms of plant height parameters followed by treatments of 1000 grams/polybag, 250 grams/polybag, and 500 grams/polybag. In addition, the results of this study also showed that

the control treatment gave the lowest results for the plant height parameter, i.e. 30.28 cm.

Humic acid can also be added to planting media for agricultural crops. One of the reasons for using humic acid as a fertilizer mixture is the rich nutrient content of animal and plant residues so that it is very beneficial for plant growth and development (32). One of the uses of humic acid in chili plant fertilizer was reported by (16) who stated that giving a combination of 50% NPK fertilizer and 250g humic acid produced the best chili plant height, namely in the range of 28 cm, followed by the treatment of adding 50% NPK with manure and 50% NPK with compost. The control treatment in this study gave the lowest results in the chili plant height parameter, i.e. only around 17.72 cm.

The effect of applying several types of fertilizer, organic waste, biochar, NPK, commercial liquid organic fertilizer (POC) (brand: Asri Nature Bio) on chili plant height has been reported (21). In this research, several types of fertilizer were applied 3 times, namely when the red chili plants reached 21 day after culture (DAC), 42 DAC and 63 DAC. When the chili plants were 21 DAC, it showed that there was an effect of giving commercial POC, which resulted in the best plant height, namely 41.52 cm. In chili plants that entered 42 DAC, it turned out that the application of commercial POC fertilizer still showed the best results compared to other fertilizer variables, namely as high as 68.81 cm. Finally, when observed at 63 DAC, chili plants treated with NPK fertilizer showed the best results, i.e. 68.81 cm.

The use of organic waste as plant fertilizer has also been widely reported because scientifically the POC of organic waste, for example the POC of tofu liquid waste fermented with maja fruit, turns out to contain nutrients such as 1.05% nitrogen, 0.47% phosphorus, 0.48% potassium, and 20.8% C-organic. (33). Furthermore, research related to varying fertilizer concentrations from tofu liquid waste on the growth of cayenne pepper plants (*Capsicum frutescens* L.) showed that there was an effect on plant height (20). The highest result of the effect of this fertilizer on plant height was at a concentration of 20% with a plant height of around 8.30625 cm. In contrast, application of fertilizer with a concentration of 0% liquid tofu waste (control) showed the lowest plant height, i.e. only 6.0125 cm.

Flower

Flowers are known as a means of generative reproduction which will then develop into fruit (34). Number of chili flowers per plant on the Pelita hybrid variety given fertilizer from leaves (15% C-organic composition, N, P, K, several micro elements, *Bacillus sp*., *Lactobacillus sp*., *Saccharomyces* sp., *Streptomyces sp*., *Pseudomonas sp*., *Azospirillium sp*., *Azotobacter sp*. and *Rhizobium sp*. at 1% showed the highest number, followed by the Dewata 43, Taruna, and Sret varieties, namely 180 respectively; 161.43;67.6; and 63.8 flowers per plant. This result is similar to the flower fall parameter, i.e. Pelita (13.4), Taruna (18.1), Sret (22.5), and Dewata 43 (23.1) (14) had the lowest flower fall, respectively. This showed that in terms of flower parameters, the Pelita chili variety, which is a hybrid variety, has the ability to produce lots of flowers and does not fall off easily.

A large number of flowers is expected to produce a high quantity of fruit. Flower loss is one of the limiting factors for fruit formation and according to (35), chili flower loss can be caused by several factors such as low air humidity, dryness, shade, high air temperature, and lack of micro nutrients such as calcium, manganese, iron, or magnesium. The low content of magnesium, nitrogen, phosphorus, calcium and molebdenum and the high solubility of aluminum, iron and manganese are characteristics of ultisol soil. One effort to increase the productivity of ultisol soil is by providing non-chemical fertilizers as reported by (36), it can be seen that chili plants planted in ultisol soil with the addition of 30 tons of manure per hectare give the best results in terms of the number of flowers per plant, which is around 29.97. flowers per plant compared to control plants. Apart from that, flower loss can also be minimized by using fertilizer containing potassium, as reported (37) with research results showing that the number of flowers that became fruit reached 49.67 flowers per plant in the treatment with the addition of 6 grams of potassium fertilizer per plant, compared to the control treatment. which only produces flowers into fruit around 34.03 flowers per plant.

Providing non-chemical fertilizer in the form of POC fertilizer (banana peel, shallots, banana stems, egg shells) to cayenne pepper plants was reported to have a significant effect on flower number parameters at 35-DAC (38). The results of this research showed that the highest number of flowers occurred in the treatment with pineapple peel POC with a concentration of 2%, namely 7 flowers per plant, followed by the 1 and 3% POC treatments with a total of 5 flowers per plant, and the lowest results occurred in the control treatment with a total of 1 flowers per plant. This shows that the nutrient content contained in POC is able to support the growth and development of cayenne pepper plants.

Fruit

Fruit is a development of the successful pollination process of a plant. According to (39), fruit formation and fruit filling with carbohydrates produced from the photosynthesis process are influenced by nutrient uptake and photosynthetic index in the leaves. Thus, there is a positive relationship between sunlight, quantity of photosynthate, and percentage of successful fruit formation (40).

The number of fruit can be influenced by the application of fertilizer as a growth regulator, both chemical and non-chemical. The results of research (41) show that fertilization using chemical fertilizers actually has an effect in increasing the amount of fruit production, namely when P fertilizer is applied at a dose of 125 kg. 150 kg.Ha-1. However, in the aspect of fruit production, it can be seen that P fertilization at a dose of 150 kg.Ha-1 actually gives the best results, namely around 115 grams per plant compared to the two other of P-fertilizer concentrations.

Still related to the effect of using chemical fertilizers on fruit quantity, the results of research (21) showed that the application of NPK fertilizer had the best effect on the number of fruit, i.e. 40.67 pieces per plant, whereas the control treatment only produced 24.10 pieces per plant. In the parameter of fruit weight per plant, NPK fertilizer showed the best results compared to other fertilizers, i.e. 611.93 g per plant, while the control treatment produced the lowest number of fruit, i.e. around 378.14 g/plant. Furthermore, in the parameter of fruit weight per hectare, the best fruit weight was shown in the NPK fertilizer treatment, i.e. 24.48 tons/ha, while the lowest yield was shown in the control treatment, i.e. around 15.13 tons/ha.

The floating and non-floating NPK chemical fertilizer application system apparently had an influence on the growth of chili plants, namely the non-floating NPK fertilizer treatment of 15 g per polybag gave the best results in fruit weight parameters, i.e. around 32.78 g per plant (42). The results of this research also showed that the treatment of floating NPK fertilizer of 5 g per polybag gave the lowest results in fruit weight parameters, i.e. around 11.93 g per plant. These results indicate that the floating system causes the media to become more humid so that the roots will find it more difficult to breathe due to low oxygen diffusion.

The effect of non-chemical fertilizer on chili fruit production has also been widely reported, one of which is the results of research (25) which showed that the Dewata 43 hybrid variety chili plants treated with POMI foliar fertilizer

turned out to give the best results in the number of fruit planted category, i.e. reaching 400.3 fruit/plant, in the fruit weight category it reached 1066.7 g weight per plant and fruit weight per plot was 13.1 kg per plot. This result was the best result for Dewata 43 chili plants that were treated with foliar fertilizers such as X-ZO, Meroke Fitoflex, Bayfolan, and Meroke Flex-g. The use of foliar fertilizer and the like has recently become quite popular among farmers because it is not only environmentally friendly but also because of its effectiveness in stimulating plant growth, although repeated applications are required to get optimal results (43).

The effect of applying non-chemical bokashi fertilizer on the fresh weight of chili fruit apparently showed that applying bokashi fertilizer with the rule of 1.0 kg bokashi/10 kg soil can result in the best fresh fruit weight, i.e. around 638 grams per plant, followed by the treatment of giving 1.4 kg bokashi /10 kg of soil with a yield of around 632 grams per plant, while the control treatment gave the lowest yield, namely around 380 grams per plant (44). This showed the specific needs of chili plants for nutrient content to support their growth and development. Apart from that, the effect of non-chemical fertilizer application on chili fruit production was also reported by (12) and the results of the study showed that the highest fresh weight of fruit per large chili plant was achieved when large chili plants were given 5 mL.L-1 of biological fertilizer, compared to treatment 10 and 15 mL.L-1. However, the parameter of fresh weight (g) of fruit was not significantly different between the three treatments given, with the highest results achieved when treated with 5 mL.L-1 of biological fertilizer.

Different things were reported by (13) that the Shandar variety of chilies planted in the lowlands of Pakistan showed that the treatment of giving a mixture of manure and organic fertilizer of 75% which was added with chemical fertilizer of 25% gave the highest number of fruit per plant (19.33 fruit per plant) compared to that given 100% manure (10.00 pieces per plant). Furthermore, in the fruit weight parameters in this study, it was seen that the fresh fruit weight and dry weight of the Shandar variety of chilies showed the best results, i.e. around 30.33 grams and 8.41 grams respectively in plants treated with a combination of 25% chemical fertilizer and the rest was a mixture. worm compost, cow dung, and vermi-tea.

Vermi-tea is another product from worm compost which contains lots of nitrogen, phosphorus, micronutrients, hormones and other substances. Vermi-tea also contains roundworm enzymes which are useful for increasing plant growth and resistance to pests and diseases (45). Vermi-tea was also reported to have a good impact on plant vigor and increase crop yields (46).

Root

Roots are one of the main organs in plants which are important in the process of absorbing water, mineral nutrients and important substances that will be used in plant growth and development. Optimal root growth will support plant growth and development, whereas abnormal root growth will also inhibit plant growth (47). The results of research (31) showed that the largest root volume of chili plants planted in peat soil with the addition of organic chicken manure with the formula 1000 g per polybag showed a value of 32.13 mL. The second to smallest root volume was obtained when chili plants were planted with the addition of chicken manure respectively at 750 g per polybag, 500 g per polybag, 250 g per polybag, and without the addition of chicken manure. This shows that chicken manure contains active compounds that can stimulate the growth of chilies in peat soil in terms of plant root volume. Based on (48), chicken manure can improve the physical, chemical and biological properties of soil so that the soil structure becomes better. This situation will then make the roots healthier and able to carry out their proper role because the soil conditions become more crumbly and loose.

The wet weight and dry weight of roots in cayenne pepper treated with the addition of solid or liquid organic fertilizer turned out to show that the control treatment gave the best results, i.e. 7.40 g per plant and 4.29 g per plant with the addition of solid organic fertilizer, respectively, and 7.40 g per plant and 4.50 g per plant respectively when adding liquid organic fertilizer (49). This is likely due to the specific needs of the chili plants in this study for nutrients because before applying organic fertilizer, both solid and liquid, the planting medium had been treated with basic fertilization using Mutiara NPK fertilizer (16:16:16) as much as 13,125 g per polybag at 7-HST. .

In terms of root length parameters, the treatment with the addition of 10 $mL.L^{-1}$ of golden snail POC resulted in the best average increase in root length at 28 DAC i.e. around 2.6 cm, followed by the treatment with the addition of 30 $mL.L^{-1}$ golden snail POC and 20 $mL.L^{-1}$ water is in length of 2.1 cm and 1.9 cm respectively. The control treatment showed the lowest average increase in root length, i.e. around 1.5 cm (50). This shows that the need for nutrients, especially those contained in the POC of golden snails, is specific for cayenne pepper plants. According to (51), it turned out that golden snails contain a number of organic elements such as nitrogen, phosphorus and potassium which are good for plant growth. Furthermore, the length of fermentation also influenced the levels of organic elements in the POC of golden snails, namely the fermentation time of 4 weeks showed the best results for nitrogen and potassium levels, the

fermentation time of 2 weeks showed the best results of phosphate levels and carbon-nitrogen ratio, while the fermentation time of 3 weeks showed the best C-organic content results (52).

Wet weight and dry weight of the plant

Plant wet weight can reflect the process of absorption of water and nutrients from the soil by plants (53). Providing rice straw bokashi fertilizer to hybrid chili plants planted in peat soil apparently did not have a significant effect on wet weight and this is likely due to the high organic C content in peat soil and rice straw bokashi fertilizer, which slows down the soil decomposition process which ultimately results in excess plants. water and become damp (54). Chili plants treated with NPK chemical fertilizer gave the best results in terms of plant wet weight parameters, i.e. around 336.3 grams per plant, followed by treatment with the addition of POC from Kepok banana waste of 300 mL per polybag, namely around 119.63 grams per plant (55). This showed that POC from Kepok banana waste may not be able to provide nutrients for chili plants, especially nitrogen and potassium, because chili plants require 31% sodium and 40% potassium to support their growth and development (56).

In contrast, measuring plant dry weight as an indicator of growth and development is preferred by experts because the results more accurately reflect the accumulation of organic compounds formed (53). The dry weight of chili plants planted in peatland with the addition of chicken manure in various concentrations turned out to provide significant results. The largest dry weight was obtained when chili plants were treated with the addition of 1000 grams of chicken manure/polybag, followed by successive treatments with the addition of chicken manure/polybags of 750 grams, 500 grams, 250 grams, and the smallest dry weight results were obtained in chili plants treated as a control (31). The influence of the large concentration of bokashi fertilizer also had a significant effect on the dry weight of hybrid chili plants, i.e. the best results were achieved by applying bokashi fertilizer at a rate of 600 grams/polybag and the lowest dry weight results were obtained by chili plants treated as controls (54).

Nutrient levels

Nutrient levels absorbed by plants as a result of certain treatments reflect the nutrients absorbed and processed by plants (57) 58). Several studies related to this have been reported, especially on chili plants. The results of research (41) showed that the nutrient levels of N, P, and K in "Laris" variety chili plants showed variations in yield, i.e. the highest N levels were seen in plants treated with SP-36 (36% P2O5) fertilizer of 100 kg.Ha- 1, while the highest P levels were

found in plants added with NPK fertilizer of 150 kg.Ha-1, and the highest K levels were seen in plants added with NPK fertilizer of 125 kg.Ha-1 (41).

Research on the analysis of nutrient levels contained in cayenne pepper plants planted in ultisol soil and treated with chemical fertilizers and zeolite showed that the highest levels of nitrogen in the roots are achieved when cayenne pepper plants are added with 0.423 g urea per polybag, 0.045 g phosphate per polybag, 0.258 KCl. g per polybag, and zeolite 10.5 g per polybag, and the lowest yield occurred in control plants and when cayenne pepper plants were treated with the addition of 0.21 g urea per polybag, 0.021 g phosphate per polybag and 0.021 g KCl per polybag without addition zeolite. This shows that cayenne pepper plants require the nutrients nitrogen, phosphate, potassium, aluminum and barium, the availability of which is very limited in ultisol soil (59).

The effect of a combination of chemical and non-chemical fertilizers on nitrogen uptake in cayenne pepper plants shows that the treatment of 1 part POC plus ¾ NPK fertilizer gave the best nitrogen uptake results, namely around 9.95% and the lowest results were achieved in the control treatment. The best phosphorus uptake in this study was achieved when chili plants were treated with 1 part POC plus ¾ NPK fertilizer, i.e. 15.61%, followed by treatment with 1 part NPK fertilizer, namely 14.57% and the control treatment gave the lowest results. In terms of potassium uptake parameters, the best treatment was 4.05 g, followed by 1 part NPK treatment, which was 3.75 g, while the control treatment gave the lowest results (58).

Stomata

Stomatal conductivity is the ability of stomata to exchange gases in leaves. The exchange of CO_2, O_2, and H_2O and other gases is influenced by the opening and closing of stomata, the CO_2 concentration in the atmosphere, the CO_2 concentration on the leaf surface, and the CO_2 concentration in the chloroplasts. The more stomata are open, the greater the possibility of gas exchange (60). In research (13) regarding the effect of giving several types of fertilizer, cow dung, worm compost, vermi-tea, and chemical fertilizer on stomatal conductivity, it showed that the combination treatment had a concentration of 25% chemical fertilizer, 25% worm compost, 25% cow dung, and vermi-tea 25% apparently produced the highest stomatal conductivity, i.e. 76.00 mmol $m^{-2}.s-1$ compared to several other treatments. Furthermore, the lowest stomatal conductivity was obtained when 100% cow dung fertilizer was given, namely only producing a stomatal conductivity of 63.66 $m^{-2}.s^{-1}$.

Large red chili plants that were treated with 4500 Hz sound exposure and POC of 2.25 mL.L^{-1} of water turned out to give the best results on the parameter of stomata opening area, i.e. around 264.87 μm2, followed by the treatment of 3.25 mL.L^{-1}, 3.75 mL of POC. .L-1, and 2.75 mL.L^{-1} with stomatal opening areas of 255.15 μm2, 160.38 μm2, and 143.37 μm2 respectively (61). The results of this research showed that the combination of fertilizer and physical signals in the form of sound can have a positive impact on the area of stomata opening. Thus, the combination of these two treatments has been proven to increase the growth of large red chili plants which in turn can increase their productivity.

The element silica is also an important element for the growth of chili plants, but this element is rarely contained in commercial fertilizers or non-chemical fertilizers. One way to add silica elements to the soil is by applying nanosilica fertilizer and research related to this has been reported on green cakra green cayenne pepper varieties (62). The results of this research showed that the best stomata width and length were achieved when green cakra variety cayenne pepper plants were treated with 7.5 mL of nanosilica fertilizer per L of water, i.e. 21.74 μm and 33.42 μm respectively. The lowest results for stomata width and length occurred in the control treatment, i.e. 17.91 μm and 30.10 μm respectively. This showed that it is scientifically proven that the addition of nanosilica fertilizer can affect the growth of the green chakra variety of cayenne pepper plants.

Non-chemical fertilizer in the form of vegetable fern leaf extract apparently has an influence on the average stomata density and stomatal index of cayenne pepper plants. The 15% vegetable fern leaf extract treatment gave the best results in these two parameters, i.e. 0.52 and 0.29 respectively, with the control treatment giving the lowest results in these two parameters. This showed that administration of vegetable fern leaf extract can increase the number of epidermal cells and stomata, resulting in greater stomatal density and index which will ultimately increase the growth and development of cayenne pepper plants.

Total chlorophyll content

Chlorophyll is known as one of the dyes in plants which plays a role in the photosynthesis process (63). Optimal photosynthesis is supported by many factors, one of which is chlorophyll content. The more chlorophyll, the more optimal the photosynthesis process will occur so that plant growth will occur well.

The results of research (13) regarding the effect of giving several types of fertilizer, i.e. cow dung, worm compost, vermi-tea, and chemical fertilizer on the total chlorophyll content of chili plants, showed that giving a combination of

fertilizer concentrations, namely 25% chemical fertilizer, 25% worm compost, manure beef 25%, vermi-tea 25% showed the best results on the total chlorophyll content parameters found, i.e. 4.24 mg.g^{-1} fwt. Furthermore, the lowest total chlorophyll content was shown in the treatment of 100% cow dung worm compost which only showed a total chlorophyll content of 2.43 mg.g^{-1} fwt. This showed that the application of a combination of fertilizers can support optimal growth of chili plants which can be proven by the total amount of chlorophyll content which is correlated with the photosynthesis process.

The effect of a combination of chemical and non-chemical fertilizers on chlorophyll content was also reported by (16). The results of this research showed that the application of several types of fertilizer such as manure, humic acid, compost fertilizer and NPK chemical fertilizer had a significant effect on the total chlorophyll content of chili plants. In this study, treatment with a combination of 50% NPK fertilizer concentration and 250 g of humic acid produced the highest total chlorophyll content, i.e. 37.06 mg L-1, while the lowest total chlorophyll content was shown by applying 1 kg of manure which only produced a total chlorophyll of 32.89 mg.L-1.

CONCLUSION

Providing chemical and or non-chemical fertilizers in general can affect the growth and development of various types of chili plants. With certain doses, the use of chemical andor non-chemical fertilizers can affect several aspects of the morphology and physiology of chili plants, for example plant height, number of leaves, flowers, fruit, levels of organic elements, stomata and chlorophyll in chili plants. By choosing the right type of fertilizer, it is hoped that it can support optimal growth and development of chili plants so that the need for chilies can be met.

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