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Effect of Poultry Manure and Ethephon on Growth, Yield, and Quality of Cayenne Pepper (*Capsicum frutescens* L.) 'Ratuni UNPAD'

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ABSTRACT

The production of 'Ratuni UNPAD' cayenne pepper can be increased using organic chicken manure. However, the application of ethephon is needed during fertilization due to the significantly slow flower initiation. Therefore, this study aims to determine the interaction between chicken manure and ethephon on the growth, yield, and quality of the 'Ratuni UNPAD' cayenne pepper. Planting is carried out 829 meters above sea level (masl), and a factorial randomized block experimental design comprises 2 factors with 3 replications. The first factor is the dose of chicken manure (10, 20, 30, and 40 t/ha), while the second is the ethephon concentration (0, 500, 1000, and 1500 ppm). The results showed no interaction between poultry manure and ethephon on the growth, yield, and quality of the 'Ratuni UNPAD' cayenne pepper. According to the doses of chicken manure, 40 t/ha significantly affects the flower initiation, fruit number, weight, length, and diameter, as well as capsaicin and dihydrocapsaicin. The 30 t/ha shows the highest value for the number of leaves and productive branches, while 20 tons dose/ha influences flavonoids, phenolics, and total carotenoids. The ethephon concentration of 1500 ppm significantly affects the flower initiation, fruit length, diameter, capsaicin, and dihydrocapsaicin.

INTRODUCTION

Cayenne pepper (*Capsicum frutescens* L.) is one horticultural crop cultivated in tropical countries, including Indonesia. This fruit can be used in the medical and pharmaceutical industry (Emmanuel-Ikpeme et al., 2014) and as a spice in household cooking and on an industrial scale due to its spicy taste. Nowadays, information regarding the quality components of agricultural commodities is quite essential (Kusumiyati et al., 2019a). Thapa et al. (2009) state that capsaicin levels in several types of cayenne pepper in Nepal range from 314 mg/100 g to 1117 mg/100 g. Furthermore, Othman et al. (2011) note that the capsaicin and dihydrocapsaicin contents are 842 mg/100 g and 448 mg/100 g, respectively. Based on Gurnani et al. (2016), the total phenolic and flavonoid content of cayenne pepper in India is 795 mg GAE/100 g – 2615 mg GAE/100 g and 464 mg GAE/100 g – 1284 mg GAE/100 g. Olatunji & Afolayan (2019) also state that cayenne pepper contains total flavonoids and phenolics of 867.241 mg QE/g and 221.21 mg QE/g DW, respectively.

The extensive use of cayenne pepper causes the demand to increase. However, several environmental factors can cause decreased productivity and crop failure in efforts to increase production. One of these factors is the decline in soil fertility due to the excessive use of inorganic fertilizers. This makes it necessary to improve the soil fertility by applying the appropriate diesel of

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organic fertilizers, such as chicken manure, with higher NPK value to increase the production of cayenne pepper. A previous report by Dani et al. (2021) established that applying 20 t/ha chicken manure dose increased yields on shallot plants.

Increasing the quality and yield of cayenne pepper is defined by the variety, which influences the characteristics of agricultural commodities. One variety of cayenne pepper that can be used is 'Ratuni UNPAD' due to its numerous advantages, including a capsaicin content of up to 1424.72 mg/100 g. Another study reports that 40 genotypes of this crop have the highest capsaicin of 356.1 mg/100 g. The 'Ratuni UNPAD' variety's flower initiation with an average of 52-58 days after planting (DAP), while others have 30-40 DAP. This shows the need to speed up the flowering using growth regulators (GR) such as ethrel. The active ingredient ethephon can help accelerate bud break, thereby reducing the flower initiation time and stimulating flowering and fruit ripening (Ban et al., 2007). Wall et al. (2003) report that the application of ethephon three weeks before harvest accelerated flower initiation and obtained better results on the quality of kiwi fruit (Bal & Kok, 2007). The reduction in the duration of flowering initiation resulted in rapid fruit development and ripening, providing several benefits for farmers, customers, and the agricultural sector. The decrease in the duration of flowering initiation can offer several prospective advantages for farmers, customers, and the agriculture sector. Reducing the flowering initiation period leads to faster fruit development and maturation, enabling farmers to have more planting cycles. Moreover, increased cycles is correlated with higher yields and improved farm efficiency. Farmers also harvest and bring produce to market more frequently to boost income. Efficient flowering initiation often results in more synchronized and uniform fruit development to ehnance the quality and appearance of the produce. Generally, customers prefer fruits that are consistent in size, shape, and ripeness, leading to increased marketability and consumer satisfaction.

The acceleration of the flowering process potentially reduces resource inputs such as water and fertilizers to achieve sustainable practices in the agricultural sector. The reduction in resource input is in line with environmentally conscious farming, contributing to the broader goal of sustainable agriculture. Faster crop turnover allows farmers to adapt more quickly to changes in market demand. Farmers respond quickly to shifts in consumer preferences or market demand for specific crops to achieve resilience and competitiveness in a dynamic market.

The reduction in the duration of flowering initiation offers practical benefits for farmers, customers, and the agriculture sector. This process enhances economic gains, improves the quality of produce for consumers, and promotes sustainable farming practices to achieve overall adaptability and efficiency. Hence, this study aims to determine the interaction between doses of chicken manure and ethephon concentrations on the growth, yield, and quality of the 'Ratuni UNPAD' cayenne pepper. The result is expected to yield the correct dose that will shorten the flower initiation time and improve the characteristics of the crop.

MATERIALS AND METHODS

Field Experiment

Planting was performed in a screen house at the Faculty of Agriculture, Universitas Padjadjaran, Indonesia, at an elevation of 829 masl. Fruit quality analysis was conducted at the Horticulture Laboratory, Faculty of Agriculture, Universitas Padjadjaran, Indonesia. The cayenne pepper variety used is 'Ratuni UNPAD'; the design was a factorial randomized block design (RBD) consisting of two factors. The first factor was the chicken manure dose at concentrations of 10, 20, 30, and 40 t/ha, while the second factor was ethephon with concentrations of 0, 500, 1000, and 1500 ppm. Each treatment was repeated 3 times to obtain 48 experimental units of 2 plants each.

The planting medium preparation was conducted by mixing soil and chicken manure according to the treatment and placing it in a polybag measuring 40 cm x 40 cm. Each polybag filled with planting media was watered, neatly arranged in line with the experimental plot, and stored for one week before the planting stage. Chili seedlings that produced 4-5 leaves were transferred to polybags. The spacing between plants was 50 cm x 50 cm, the plots measured 50 cm x 50 cm, and the distance between repeats was 100 cm.

Fertilization using Urea (N) is 3.67 g/plant, TSP (P_2O_5) 3.67 g/plant, and KCl (K_2O) 2.94 g/plant. Follow-up fertilizers that were applied included Urea 250 kg/ha (7.35 g/plant), TSP 250 kg/ha (7.35 g/

plant), and KCl 200 kg/ha (5.88 g/plant). The inorganic fertilizer was applied at the planting time of 21 DAP, 28 DAP, and 35 DAP. Therefore, the dose given was divided into three for each treatment. Ethephon was applied with a concentration of 0, 500, 1000, and 1500 ppm, while spraying was carried out at 21 DAP to stimulate flowering, and the cayenne pepper was harvested at 110 DAP.

Growth and Yield Assessment

The number of productive branches was observed at 35, 63, and 91 DAP. The observation process was carried out when the first flower appeared by calculating the plant's age at the flower initiation. The number of fruits per plant was calculated from the first to the last harvest. The samples used for quality analysis should meet several criteria, including pest-free and uniform (Suhandy et al., 2019). The fruit weight was calculated by weighing all the fruit harvested. Fruit length was assessed from the base to the tip, while the diameter was determined by measuring from the base to the middle and the tip of the fruit, which was further averaged.

Measurement of Water Content

The sample weighed approximately 4 g and was carefully placed in aluminium foil. The sample was dried in an oven at 105ºC for 3 hours (Memmert Schutzart DIN 40050-IP 20, Schwabach, Germany). Subsequently, the percentage value of water content was evaluated by calculating the decrease in sample weight obtained from the drying process (Kusumiyati et al., 2019b).

Sample Extraction

Each cayenne pepper sample consisted of ± 50 g. Samples were dried using an oven at 50ºC for 14 hours. Furthermore, the sample was mashed to facilitate the extraction process. As much as 0.05 g of the sample was put into a 10 ml vial, followed by adding 10 ml of methanol, and then sonicated using an ultrasonic cleaner (Baku BK-2000, Guangzhou, China) for 20 minutes at 65ºC. The filtrate was transferred into a 10 ml volumetric flask, and methanol was added to the mark.

Moreover, centrifugation was performed for 10 minutes at a speed of 4000. The results analyzed capsaicin, dihydrocapsaicin, flavonoids, and phenolics. The sample extraction procedure for the total carotenoids analysis closely mirrored that of capsaicin, dihydrocapsaicin, flavonoids, and phenolics, with the only difference being using acetone as the solvent.

Measurement of Capsaicin and Dihydrocapsaicin

Measurement of capsaicin and dihydrocapsaicin was carried out using HPLC (high-performance liquid chromatography) (Shimadzu, LC 20AT Prominence, Tokyo, Japan) and referred to the procedure of González-Zamora et al. (2015).

Measurement of Total Flavonoids and Phenolics

Total flavonoid measurement followed the procedure Sytar et al. (2018) outlined. The 1 ml extracted sample, 0.1 ml aluminium chloride, 1.5 ml methanol, 2.3 ml distilled water, and 0.1 ml potassium acetate was put in a test tube. In the reaction step, methanol served as the blank, and quercetin standards at various concentrations were prepared and reacted similarly to the blanks and samples. Subsequently, each blank, sample, and standard added with reagent was homogenized and incubated at room temperature for 30 minutes. Standards and samples were assessed utilizing a UV-Vis spectrophotometer at a 432 nm wavelength. The regression equation of the standard calibration curve was employed to calculate the total sample flavonoids (quercetin equivalent).

Total phenolics were measured utilizing the Folin-Ciocalteu method and referred to the procedure of Lim & Murtijaya (2007). As much as 0.1 ml of the extracted sample was combined with 0.4 ml of methanol, adding 2.5 ml of Folin and 2 ml sodium carbonate (7.5 g/100 ml). Each sample, blank, and gallic acid standard added to the reagent were homogenized and incubated for 60 minutes at room temperature. Standards and samples were then assessed utilizing a UV-vis spectrophotometer at 765 nm. The regression equation of the standard calibration curve was employed to determine the total phenolic sample (gallic acid equivalent/GAE).

Measurement of Total Carotenoids

Extracted samples were measured utilizing a UV-vis spectrophotometer at 449 nm. Different concentrations of β-carotene standards were prepared and subsequently measured at the identical wavelength as the samples. The total carotenoid concentration in the sample, expressed as β-carotene equivalent, was determined by substituting the sample's absorbance value into the equation of the standard curve.

Data Analysis

Statistical data analysis utilised SPSS version 25 software (IBM-SPSS Inc, Armonk, New York, USA). Subsequently, an analysis of variance was carried out to determine the effect of treatment on yield, growth, and quality parameters. At the same time, subsequent tests were performed using the DMRT (Duncan Multiple Range Test) at a significance level of 5%.

RESULTS AND DISCUSSION

Number of Leaves, Productive Branches, and Time of Flower Initiation

The analysis shows no interaction between the chicken manure dose and the ethephon concentration on the number of productive leaves and branches. Nevertheless, the dose application has a significant effect, as presented in Table 1 and Table 2.

In the number of leaves aged 35 DAP to 91 DAP, the 30 t/ha chicken manure dose is significantly different and displayed a higher number of leaves and productive branches parameters than others. These results are the same as the parameters for the number of fruitful branches aged 43 DAP to 85 DAP. This aligns with Enujeke (2013), stating that 30 t/ha of chicken manure fertilizer yielded the highest number of leaves compared to treatments at 10, 20, and 40 t/ha.

Table 1. Effect of chicken manure doses and ethephon concentration on leaf number at 35, 63, and 91 DAP

Treatment	Number of leaves		
	35 DAP	63 DAP	91 DAP
Chicken manure			
10 t/ha	10.83 a	90.83 a	248.50 a
20 t/ha	9.67 a	87.17 a	254.83 a
30 t/ha	13.08 b	108.42 b	285.75 b
40 t/ha	9.63 a	85.00 a	254.79 a
Ethephon			
0 ppm	11.00 a	89.04 a	252.42 a
500 ppm	10.58 a	89.46 a	263.21 a
1000 ppm	10.83 a	95.92 a	261.92 a
1500 ppm	10.79 a	97.00 a	266.33 a

Remarks: The average value followed by the same letter is not significantly different based on the Duncan Multiple Range Test at the 5% level

Table 2. Effect of chicken manure dose and ethephon concentration on the number of productive branches at 29, 43, 57, 71, and 85 DAP

Treatment	Number of productive branches					Flower Initiation (DAP)
	29 DAP	43 DAP	57 DAP	71 DAP	85 DAP	
Chicken Manure						
10 t/ha	3.08 ab	7.33 a	17.42 a	50.33 a	97.71 a	54.35 b
20 t/ha	2.17 a	6.63 a	14.21 a	54.00 a	103.46 a	55.24 b
30 t/ha	4.50 b	11.17 b	22.96 b	68.75 b	119.71 b	54.92 b
40 t/ha	2.83 a	6.92 a	14.38 a	51.88 a	92.29 a	50.86 a
Ethephon						
0 ppm	2.75 a	7.50 a	16.88 a	55.33 a	99.21 a	55.00 b
500 ppm	2.67 a	6.92 a	17.42 a	52.88 a	105.04 a	55.72 b
1000 ppm	3.92 a	8.42 a	17.58 a	60.42 a	111.08 a	54.67 b
1500 ppm	3.25 a	9.21 a	17.08 a	56.33 a	97.83 a	49.98 a

Remarks: The average value followed by the same letter is not significantly different based on the Duncan Multiple Range Test at the 5% level

The application of ethephon does not influence the number of productive leaves and branches at 29 – 85 DAP, indicating its inability to determine the productive branches formed. This is due to environmental influences, plant characteristics, and nutrient dominance. Applying ethephon concentration is expected to suppress the number of productive branches and inhibit leaf production. This can happen because ethephon can inhibit vegetative growth. Thereby, assimilation for growth is diverted to generative development, characterized by flower initiation (Khan et al., 2008; Thappa et al., 2011).

The analysis of variance shows no interaction effect between the chicken manure dose and ethephon concentration at the flower initiation time. Still, a single factor for chicken manure and ethephon concentration significantly affects the initiation. In Table 2, the flower initiation shows that the 40 t/ha chicken manure dose application significantly affects flowering faster than doses of 10, 20, and 30 t/ha. It has a higher P element than other animal manure fertilizers. Ndubuaku et al. (2014) stated that applying chicken manure fertilizer can accelerate the initiation time in Moringa plants. P and K accelerated the beginning of flowering (Ye et al., 2019). It was also discovered that elements K and P contribute to the process of flowering and fertilization and the ripening of seeds and fruit. Plants need N, P, and K elements to produce leaves during photosynthesis and enhance flowering. Element N promotes photosynthesis in leaves and increases yield by improving photosynthesis in leaves (G. Li et al., 2012; Wei et al., 2016; Liu et al., 2018; Xu et al., 2020). Furthermore, N, P, and K influence energy metabolism through respiration, photosynthesis, and phosphorylation regulation charge equilibrium (Jiaying et al., 2022).

Pandey et al. (2019) stated that an ethephon concentration of 1500 ppm affected flower initiation. Administration of higher concentrations resulted in faster flowering processes. At optimal concentration levels, plants transitioned quickly into the flowering phase and bloomed faster due to abundant ethylene content. Studies have demonstrated that using ethephon induced a shift in the hormonal balance due to its importance in speeding the transition from the vegetative to generative growth phase. Analysis has also been conducted on hormonal and transcriptional responses associated with promoting femaleness in pumpkins induced by ethephon. Results indicated that ethephon changed the genes' transcription rates related to ethephon synthesis, signalling, and auxin-responsive genes. Thus, ethylene served as an activating force in various hormone signalling pathways; 4.2% of the identified differentially expressed genes (DEGs) involved multiple hormone signalling processes and/or ethylene production were included as differentially expressed genes (Q. Li et al., 2021). Ethylene is essential in plant aging, from fruit ripening and flower organ identity development to leaf senescence (Iqbal et al., 2017). Ethephon also helps determine sex expression early in stamen development (Yamasaki et al., 2003). Ethephon induces a shift in hormonal balance, with ethylene taking a more dominant role, triggering the transition from the vegetative to the generative phase. Assimilation, usually for vegetative growth, is diverted for generative development, generally marked by flower initiation.

Number of Fruits, Fruit Weight of Cayenne Pepper per Plant, Fruit Length, and Diameter

The analysis of variance shows no interaction between chicken manure and ethephon on the number of fruits per plant, length, weight, and diameter. However, the chicken manure dose varied significantly, while ethephon application only differed with fruit length and diameter. Based on Table 3, the results of treatment 20, 30, and 40 t/ha doses are not significantly different in the number of fruits per plant parameter. Regarding fruit weight per plant, the 40 t/ha dose has different results than other treatments and is more prominent. This is attributed to providing optimum N, P, and K nutrients for cayenne pepper, which plays a role in metabolic processes and increased photosynthetic activity. Therefore, the result will be the photosynthate accumulation and the weight of the fruit produced. According to Ghourab et al. (2000), photosynthate translocation is influenced by the nutrient K, which improves the photosynthate distribution process from leaves to fruit. This is related to a high energy supply for the size development and fruit quality, thereby increasing the fruit weight. Cochrane & Cochrane (2009) state that K is identified as an essential plant nutrient for vital functions such as enzyme activity, charge balance, and osmoregulation. It is also discovered that applying organic fertilizers produced more fruits per plant with longer sizes (Marzouk & Kassem, 2011). In contrast, the ethephon concentration does not give significantly different results in the number of fruits and their weight but affects plant color changes (Taghipour et al., 2011).

The 40 t/ha chicken manure dose shows the highest fruit length compared to 10, 20, and 30 t/ha. Furthermore, DMRT results of fruit diameter show a significantly higher value than other treatments. This indicates that chicken manure increased the length and diameter of cayenne pepper fruit. Components of crop yields can be increased using chicken manure, which improves soil fertility and productivity. The K nutrient in chicken manure can increase fruit size (Naz et al., 2021), weight, and diameter (Ruiz, 2006). A previous study also discovered this, where K fertilizer induces fruit diameter (Amjad et al., 2014). The ethephon concentration gave significantly different results at a concentration of 1500 ppm, showing the highest fruit length and diameter compared to other treatments. Reis et al. (2020) stated that the advantages of ethephon include the formation and growth of fruit by increasing the average length and diameter.

Table 3. Effect of chicken manure doses and ethephon concentration on the number of fruits and fruit weight per plant

Treatment	Number of Fruit per Plant	Fruit Weight per Plant (g)	Fruit Length (cm)	Fruit Diameter (cm)
Chicken Manure				
10 t/ha	309.42 a	411.77 a	4.20 a	0.81 a
20 t/ha	317.50 ab	411.62 a	4.14 a	0.87 ab
30 t/ha	318.71 b	416.76 a	4.04 a	0.88 ab
40 t/ha	320.54 b	428.02 b	4.45 b	0.97 b
Ethephon				
0 ppm	316.17 a	410.74 a	4.08 a	0.83 a
500 ppm	317.67 a	416.54 a	4.20 a	0.89 a
1000 ppm	313.63 a	415.21 a	3.98 a	0.82 a
1500 ppm	318.71 a	415.68 a	4.58 b	0.99 b

Remarks: The average value followed by the same letter is not significantly different based on the Duncan Multiple Range Test at the 5% level

Table 4. Effect of chicken manure doses and ethephon concentrations on capsaicin and dihydrocapsaicin cayenne pepper plantings

Treatment	Capsaicin (mg/100 g DW)	Dhydrocapsaicin (mg/100 g DW)
Chicken manure		
10 t/ha	555.30 a	203.50 a
20 t/ha	548.89 a	212.07 a
30 t/ha	552.40 a	201.88 a
40 t/ha	702.92 b	280.96 b
Ethephon		
0 ppm	553.25 a	216.60 a
500 ppm	565.76 a	197.66 a
1000 ppm	542.41 a	221.22 a
1500 ppm	698.10 b	262.94 b

Remarks: The mean value followed by the same letter is not significantly different based on the Duncan Multiple Range Test at the 5% level

Capsaicin dan Dihydrocapsaicin

The analysis of variance demonstrates no interaction between the treatment of chicken manure and ethephon. However, both treatments significantly affected the capsaicin and dihydrocapsaicin levels in cayenne pepper, as shown in Table 4. Furthermore, it was discovered that the 40 t/ha chicken manure dose is significantly different and has a higher effect than others. This shows that chicken manure can increase capsaicin and dihydrocapsaicin, which are the secondary metabolites of the alkaloid group. Therefore, increasing the dose of nitrogen fertilizer leads to an increase in the total alkaloid content. According to a previous investigation, the capsaicin content in chili was affected by the environment and the degree of maturity (Rahman et al., 2012). It was reported that capsaicin is the most significant component, comprising 69% of the total capsaicinoids, followed by 22% dihydrocapsaicin, 7% nordihydrocapsaicin, as well as homocapsaicin and homodihydrocapsaicin present in minimal concentrations at 2% (Barbero et al., 2006). Subsequently, the application of ethephon concentrations shows significant results on capsaicin levels. The 1500 ppm concentration has capsaicin levels of 738.93 mg/100 g, which is different and higher than others. This is in line with Yang et al. (2021), stating that treatment with ethephon significantly increased the synthesis of capsaicin.

Fruit Water Content

The analysis of variance indicates no interaction between chicken manure and ethephon on water content. The DMRT results at the level of 5% show a significant effect of both treatments on fruit moisture content, as presented in Table 5. Furthermore, it was discovered that the water content in cayenne pepper ranged from 73.61% to 75.00%. The dose of chicken manure fertilizer for water content is also not significantly different, according to Thepsilvisut et al. (2022). In this study, cayenne pepper has more than 70% moisture content and was included as an easily damaged or spoiled commodity. Meanwhile, the ethephon application does not affect the water content in the fruit, as supported by Ismail et al. (1999).

Total Flavonoids and Phenolics

Other secondary metabolites contained in cayenne pepper include flavonoids and phenolics. The analysis of variance indicates no interaction between chicken manure and ethephon. Chicken manure fertilizers significantly affect the results of flavonoids and phenolics. Moreover, DMRT results for the analysis of flavonoids and phenolics are presented in Table 5.

Table 5. The effect of chicken manure and ethephon concentration doses on water content, total flavonoids, phenolics, as well as carotenoids in cayenne pepper

Treatment	Water content (%)	Total flavonoid (mg QE/100 g DW)	Total phenolic (mg GAE/100 g DW)	Total carotenoids (mg/100 g DW)
Chicken manure				
10 t/ha	74.35 a	113.20 b	1399.40 a	16.30 a
20 t/ha	73.99 a	179.21 c	1514.56 b	21.29 b
30 t/ha	73.61 a	125.34 bc	1336.26 a	15.47 a
40 t/ha	75.00 a	92.28 a	1368.59 a	16.83 a
Ethephon				
0 ppm	74.33 a	105.53 a	1418.50 a	17.52 a
500 ppm	74.01 a	145.09 a	1340.59 a	16.75 a
1000 ppm	74.47 a	109.12 a	1444.94 a	18.80 a
1500 ppm	74.15 a	110.27 a	1414.78 a	16.82 a

Remarks: The mean value followed by the same letter is not significantly different based on the Duncan Multiple Range Test at the 5% level. QE : Quercetin equivalent, GAE: Gallic acid equivalen.

Table 5 indicates that chicken manure significantly affects total flavonoids. The 20 t/ha dose has a considerably higher yield of 179.21 mg QE/100 g compared to others, while the lowest yield is 92.28 mg QE/100 g at a dose of 40 t/ha. The chicken manure effect on total phenolics indicates that the dose of 20 t/ha has significantly different results and is higher than other treatments. Therefore, the dose is optimal to increase total flavonoids and phenolics. It Is also discovered that the formation of secondary metabolites that are antioxidants derived from phenolic and flavonoid groups is affected by fertilization. The 20 t/ha dose can increase metabolite compounds such as phenolic content and secondary antioxidant capacity in bell peppers (Moreno-Reséndez et al., 2016).

Moreover, Nitrogen (N) is an essential nutrient that directly contributes to metabolic processes due to increased phenolic content (Nguyen & Niemeyer, 2008). Furthermore, organic fertilizers have shown effectiveness in improving the media's ability to hold water and nitrogen content. It will accelerate the plant's metabolic processes and the availability and absorption of more N, causing the flavonoid and phenolic content of cayenne pepper to increase. In this study, the application of ethephon concentrations does not yield statistically significant differences compared to other treatments. It is similar to Joaquim et al. (2008), reporting that applying ethephon concentrations does not affect the synthesis of total flavonoids and phenols in *Echinodorus grandifloras*. Khorshidi & Davarynejad (2010) also said that ethephon application does not affect phenol levels in cherry varieties (*Prunus cerasus*). However, different results were obtained using the ethephon application on bananas and grapes. Applying ethephon 1000 ppm significantly affected total flavonoids and phenolics (Maduwanthi & Marapana, 2021), stimulating the production of phenolic compounds (López et al., 2021).

Total Carotenoids

The analysis of variance shows no interaction between the doses of chicken manure and ethephon. The DMRT results in Table 5 indicate that chicken manure significantly affected total carotenoids. The 20 t/ha treatment had a higher effect, indicating optimal dose. According to Chenard et al. (2005), applying N fertilizer can increase carotenoids' content due to the presence of K nutrients. However, K deficiency can cause a decrease in carotenoid synthesis by activating some enzymes that regulate carbohydrate metabolism, namely *phosphofructokinase and pyruvate kinase* (Dumas et al., 2003; Fanasca et al., 2006). The application of ethephon concentrations shows that they are not significantly different. This aligns with Wisutiamonkul et al. (2017), Huang et al. (2021), and Wisutiamonkul et al. (2015), where ethephon does not affect the content of carotenoids.

CONCLUSION

The results show that the 40 t/ha chicken manure dose gives the best yield during the first flower initiation, fruit length, number, diameter, weight, capsaicin content, and dihydrocapsaicin. The 30 t/ha dose is optimal for monitoring the number of productive branches, while the 20 t/ha dose yields the highest flavonoids, phenolics, and carotenoids. Meanwhile, the ethephon concentration of 1500 ppm gives the best results on the flower initiation time, fruit length, fruit diameter, capsaicin, and dihydrocapsaicin levels.

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