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Research Article

Application of manure, nitrogen fertilizer, and EM4 to improve growth and yield of red chili (*Capsicum annuum* L) on an Alfisol

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Abstract: Red chili is commodity of vegetable that has high economic value, but still has low productivity. The objective of this study was to elucidate the effect of goat manure and Urea application with EM4 and to obtain the best dose of combination in order to improve growth and yield of red chili. The study was conducted at Jatikerto-Malang from January to June 2015. The research applied Factorial Randomized Block Design that comprised of two factors by three replications. First factor: Goat manure and Urea, 25% N PKK + 75% N Urea (A1), 50% N PKK + 50% N Urea (A2) and 75% N PKK + 25% N Urea (A3). Second factor: Doses of EM4 0 L/ha (E0), 30 L/ha (E1), 40 L/ha (E2) and 50 L/ha (E3), and one control treatment (100% N Urea). Results of the study showed that combination of 50% N PKK + 50% N Urea and EM4 at levels 30 and 40 L/ha produced the best and optimal plant height, numbers of branches and number of flowers. Separately, application of 25% N PKK + 75% N Urea produced 292.67 fruits per plant, fruits weight per plant 389.08 g per plant and fruits weight per hectare 10.92 t/ha. EM4 at level 30 L/ha showed the best and optimal fruits weight per hectare, 12.27 t/ha. The control showed better growth but not significant compared with combination of 25% N PKK + 75% N Urea with EM4 at level 30 and 40 L/ha. Combination treatment produced number of fruits 26.01%, fruits weight per plant 21.53% and fruits weight per hectare 25.15% higher than control.

Keywords: *Capsicum annuum* L, *goat manure, nitrogen fertilizer, EM4, growth and yield*

Introduction

Red chili (*Capsicum annuum* L) is one of horticulture crops that belong to *Solanaceae* family. In Indonesia, chili is spicy ingredient that has high economical value and contains good nutrient for health (Khasmakhi *et al.*, 2009). Production of red chili is still low, in which the average productivity had just 8.35 t/ha in 2014, while the potential productivity reached 16-25 t/ha (BPS, 2014).

The increasing production of red chili has still faced some obstacles, both genetic and environmental factors, such as low contents of organic materials and nutrients, less absorption of nutrients, reducing quality of the soil and high pests and diseases.

Increasing production can be done by improving fertilizer application techniques, providing balanced application between goat manure and urea. Maghfoer et al. (2013) reported that combination of urea 75% and goat manure 25% reduced the application of urea and produced the best yield of eggplants for about 48.70 t/ha. According to Adil et al. *(*2006), the application of organic fertilizer could improve soil fertility. Asiah (2006) added that the application of organic materials could increase yield productivity and reduce intensity of pest and disease.

EM4 is required to accelerate the decomposition process of goat manure and to increase N absorption. EM4 is an inoculant of microorganism as a result of mixed cultures, which is beneficial for plants growth and productivity. According to Higa (1998), the application of EM4 could improve physical and chemical properties of the soil, as well as increase microbial diversity, soil fertility, nutrient absorbability, increase quality and yield. According to Maghfoer et al. (2013), application of EM4 at the level 30 l ha^{-1} could accelerate the decomposition process of goat manure, nitrogen

mineralization in the soil, and produce the best yield of eggplants.

The objective of this study was to elucidate the effect of goat manure and Urea application with EM4 and to obtain the best dose of combination in order to improve growth and yield of red chili.

Materials and Methods

The research was conducted at the experimental farm, Faculty of Agriculture, University of Brawijaya, Jatikerto-Malang, on an Alfisol, soil pH is 7.2 and at altitude ± 330 m above sea level. The study was done from January to June 2015. The research used seeds of red chili, PILAR F1 variety, goat manure, EM4, palm sugar, Urea, digital sliding caliper, Leaf Area Meter, Soil Plant Analysis Development, microscope, analytic scales, and oven.

The study applied Factorial Randomized Block Design which comprised of two factors and three replications. The first factors: goat manure (PKK) and Urea, included 3 levels, i.e. A1: 25% N PKK + 75% N Urea (39+117 kg N/ha), A2: 50% N PKK + 50% N Urea (78+78 kg N/ha), A3: 75% N PKK + 25% N Urea (117+39 kg N/ha). The second factors: doses of EM4 (E) included 4 levels, i.e. E0: 0 L/ha, E1: 30 L/ha, E2: 40 L/ha, E3: 50 L/ha, and one control by 100% N Urea (156 kg N/ha).

Red chilies were planted on farming area of 510 m^2 by spacing of 60 x 50 cm. There were 39 treatment plots in which each plot comprised of beds of 1.5 x 5 m in size, and each plot was planted with 32 plants, so total plants were 1,248. First stage application of goat manure and EM4 were applied before planting. The second until fourth stage of EM4 was given by interval once in 14 days after planting and applied in the afternoon. Urea was applied in 3 stages, the first stage was given at 7 days before planting, the second and the third stage were repeated once in 14 days after planting.

The observation was done non-destructive on plant height (cm per plant) and chlorophyll index (% per plant) which observed at 14, 28, 42, 56 and 70 dap (days after planting), number of branches (branches per plant) and number of flowers (part per plant) observed at 28, 42, 56 and 70 dap. The destructive observation included stomatal density (mm^2 per plant), N content in leaf (ppm per plant) observed at 14, 28 and 112 dap, number of fruits per plant (fruit per plant), fruit weight per plant (g per plant) and fruits weight per hectare (t/ha) observed at 84-112 dap by interval once in 7 days. Data was analyzed using analysis of variance (Anova) with F at the level 5%. If any significant influence was found between those treatments, it was continued with LSD (Least Significant Difference) Test at the level 5%, and used contrast orthogonal test to compare between combination and control.

Results and Discussions

Plant height, number of branches, and number of flowers per plant

Results on analysis of variance showed some interaction between combination of goat manure and Urea with EM4 toward parameters of plant height, number of branches, and number of flowers at 56 and 70 dap. The application of 25% N PKK + 75% N Urea combined with EM4 at the level 30 and 40 L/ha have produced higher plant, more branches, and flowers in comparison with the plants without the application of EM4 and EM4 at the level 50 L/ha. However, such treatment did not have significant effect if the application of goat manure increased and dose of Urea reduced become 50% N combined with EM4 30 and 40 L/ha (Table 1). It was due to supply of nutrients from the application of high dose Urea and result of the decomposition process on goat manure by bacteria from the application of EM4 have been able to fulfill the requirements of essential nutrients, particularly sufficient and balance N during plants growth and development. Besides that, the application of goat manure and EM4 could provide P_2O_5 and K for the plants, improve soil aeration, and reduce nutrient leaching, as well as pathogenic infestation. Along with result of the research by Sumarni et al. (2010), the application of organic fertilizer could improve physical and chemical properties, as well as microbes, and as ameliorant in the soil. Moreover, as suggested by Ferawati et al. (2014), the applications of specific dose of organic fertilizer and microbes have produced the best plant height of red chili. The application of EM4 could inhibit development of parasite, such as the cause of bacterial wilt (*Fusarium* sp) (Sutariati and Wahab, 2010).

The increasing dose of goat manure 75% N and reducing dose of Urea 25% N without the application of EM4 and given EM4 by concentration of 30, 40 and 50 L/ha tended to show less number of branches and plant height, as well as ability of the plant to form the new organs are very slow. As stated by Nyak Pa et al. (1998), reducing dose of N could inhibit the growth and reduce the production due to the organ formation was not maximum during the vegetative growth.

Table 1. Mean of plant height (cm per plant), number of branches (branches per plant) and numbers flower (part per plant) due to interaction between combination of goat manure and Urea with EM4 and result of contrast orthogonal test.

Treatment	Plant height (cm per plant) (dap)		Number of branches (branches per plant) (dap)		Number of flowers (part per plant) (dap)	
	56	**70**	**56**	**70**	**56**	**70**
Control (100% N Urea)	75.50 b	80.42 b	125.92 b	167.71 b	115.31 b	89.46 B
Combination	69.71 a	73.87 a	117.00 a	148.91 a	104.15 a	73.30 A
LSD 5%	2.22	1.96	3,32	7.01	3.87	3.25
Goat manure + Urea + EM4						
25% N PKK+75% N Urea + without EM4	73.25 cd	77.83 cd	116.54 c	151.42 bc	99.54 a	65.83 ab
25% N PKK+75% N Urea + EM4 30 L/ha	83.54 e	86.79 e	134.04 e	181.54 d	129.50 b	88.93 d
25% N PKK+75% N Urea + EM4 40 L/ha	77.58 de	83.63 de	131.38 e	180.42 d	125.79 b	88.70 d
25% N PKK+75% N Urea + EM4 50 L/ha	67.38 bc	67.38 bc	118.38 cd	151.42 bc	92.54 a	83.38 cd
50% N PKK+50% N Urea + without EM4	63.92 ab	67.42 ab	112.54 bc	127.54 ab	92.33 a	62.24 ab
50% N PKK+50% N Urea + EM4 30 L/ha	76.45 de	80.42 de	130.88 e	175.17 cd	118.38 b	87.54 d
50% N PKK+50% N Urea + EM4 40 L/ha	76.53 de	80.79 de	129.88 de	175.25 cd	124.71 b	84.10 cd
50% N PKK+50% N Urea + EM4 50 L/ha	67.25 cb	70.96 b	107.63 abc	134.88 ab	91.83 a	72.97 bc
75% N PKK+25% N Urea + without EM4	57.63 a	61.67 a	100.50 a	124.21 a	88.96 a	59.79 a
75% N PKK+25% N Urea + EM4 30 L/ha	64.04 ab	66.67 ab	111.71 abc	127.88 ab	99.13 a	60.42 a
75% N PKK+25% N Urea + EM4 40 L/ha	63.50 ab	68.13 ab	101.04 ab	127.75 ab	96.58 a	63.08 ab
75% N PKK+25% N Urea + EM4 50 L/ha	65.42 b	69.25 b	107.33 abc	133.46 ab	90.54 a	62.63 ab
LSD 5%	7.68	6.79	11.50	24.48	13.39	11.27

Notes : PKK= goat manure; dap= days after planting; Numbers followed by the same letter at the same column are not significant based on LSD test and contrast orthogonal test at the level 5%.

Based on result of the contrast orthogonal analysis (Table 1), the application of 100% N Urea (control) had significant effect with mean of combined treatments toward plant height, number of branches, and number of flowers. Growth differentiation was due to different supply of N on each period of growth. Different growth of the plants has not seen at the beginning of vegetative phase, but it can be seen at 28-42 to 56 dap and early of 70 dap. The control showed the increasing plant height, number of branches, and greater number of flowers in comparison with the combination with the increasing of each by 7.66%. 7.08% and 9.68% at 56 dap and 8.14%. 11.21% and 18.06% at 70 dap. According to Berova et al. (2010) and Rorie et al. (2011), the plants required high macronutrients (N) during the initial growth, therefore the plants that gain high supply of N would increase the vegetative growth.

N content in leaf, stomatal density, and Index of chlorophyll

N content in leaf kept increasing along with the increasing age of the plants. The separate application of goat manure and Urea showed significant effect at 28 and 112 dap toward N content in leaf. The treatment of 25% N PKK + 75% N Urea was higher for about 13.15% and 17.56% (28 and 112 dap) in comparison with the treatment of 75% N PKK + 25% N Urea (Table 2). It was due to sufficient N supply from the application of Urea and optimal ability of the organs in absorbing nutrients and water, as well as photosynthetic process that has ran well, therefore it could increase metabolism in the tissues. According to Aladakatti (2011), N content in leaf has positive correlation with N availability, and it could be absorbed by rhizospher of the plant. According to Hardjowigeno (2010), the plants absorb N in inorganic ions, such as sodium nitrate (NO_3^-) and sodium nitrite (NO_2), as well as in ammonium ions form (NH_4^+).

Under observation on stomatal density (Table 2), it showed different effects, in which high application of goat manure (75% N PKK) and low application of Urea (25% N Urea) had denser stomatal density for about 12.02% and 16.33% at 28 and 112 dap in comparison with low application of goat manure (25% N PKK) and high application of Urea (75% N Urea). It is assumed that high application of goat manure could absorb much water and CO_2 absorption will increase, so that stomatal density in foliar tissues will be denser as well. High application of Urea has increased the vegetative growth of the organs, so that stomatal sizes become widely spaced. According to Xu and Zhou (2008), stomatal density is highly affected by water content in the tissues, CO_2 absorption, and ionic accumulation of potassium (K^+). Stomata will open along with the increasing turgor pressure on both guard cells. Such increasing is due to the water goes through the guard cells. Under high temperature on the tissues, stomata will close and inhibit CO_2 diffusion. Low concentration of CO_2 will reduce the photosynthetic process rate, so that the photosynthate production would not be optimal (Zeiger et al., 1987). High and low content of N affect the chlorophyll index, higher N will increase the chlorophyll index (Schlemmer et al., 2005).

Results of the research showed that chlorophyll index of red chili (Figure 1) increased along with the increasing N in tissues of the crops and increasing Urea application. The application of 25% N PKK + 75% N Urea resulted higher values for the chlorophyll index that include 23.40%, 12.11%, 20.01%,16.13% and 11.09% (14, 28, 42, 56 and 70 days), respectively, in comparison with the treatment of 75% N PKK + 25% N Urea. According to Cosentino et al. (2007), high and low contents of N in leaves are highly affected by condition and N supply, as well as ability of the roots to absorb nutrients and water in the soil. Under condition of less water in tissues, N content in leaf will high, as well as respiration and photosynthetic processes will increase, so that they will increase the chlorophyll index values and carbohydrate in tissues. EM4 application by different concentrations did not show different chlorophyll index between doses of treatment from the initial observation to the age of 70 dap.

Based on Table 2 and Figure 1, results of the contrast orthogonal test showed significant difference toward the resulted values of the chlorophyll index between the combined treatments and the control during the first observation (14 dap), but it was different from the resulted N content in leaves and stomatal density, in which during the first observation at 14 dap, different N contents were not found in tissues and stomatal density.

The control plants that having high N supply during the period of vegetative growth could utilize the available nutrients optimally to the end of observation (70 dap) by having higher chlorophyll index in comparison with the combined treatments. Higher values of chlorophyll index were supported by high N

content in leaves at 28 dap and the increasing dose of Urea. The control plants produce higher N in the plant tissues in comparison with the combined treatments. However, in early of 112 dap, the control plants showed decreasing N in comparison with the combined treatments. Meanwhile, high application of Urea on the control plants has created more widely spaced stomatal density in comparison with the combined treatment by the application of low Urea at 28 and 112 dap.

Table 2. Mean of N content in leaf (ppm per plant) and stomatal density in leaves of red chili (mm^2 per plant) as a result of combined treatments of goat manure and Urea with EM4 and results of the contrast orthogonal test on the whole ages of observation

Treatment	N content in leaves (ppm per plant) (dap)			Stomatal density (mm^2 per plant) (dap)		
	14	**28**	**112**	**14**	**28**	**112**
Control (100% N Urea)	4.64 a	6.58 b	5.88 a	27.27 a	35.26 a	53.12 a
Combined Treatment	3.95 a	5.57 a	6.77 b	28.71 a	40.11 b	69.10 b
LSD 5%	ns	1.86	0.32	ns	3.63	6.86
Goat manure + Urea						
25% N PKK + 75% N Urea	4.11 a	6.06 b	7.35 b	28.56 a	37.84 a	63.82 a
50% N PKK + 50% N Urea	3.93 a	5.39 a	6.90 ab	28.44 a	39.49 ab	67.22 a
75% N PKK + 25% N Urea	3.80 a	5.27 a	6.06 a	29.15 a	43.01 b	76.27 b
LSD 5%	ns	0.60	0.64	ns	4.36	8.24
Dose of EM4						
0 L/ha	4.06 a	5.62 a	6.40 a	27.85 a	39.14 a	63.35 a
30 L/ha	4.04 a	5.64 a	7.17 a	29.46 a	40.58 a	70.36 a
40 L/ha	4.02 a	5.85 a	6.97 a	28.52 a	40.11 a	69.42 a
50 L/ha	3.87 a	5.51 a	6.35 a	28.83 a	39.33 a	69.89 a
LSD 5%	ns	ns	ns	ns	ns	ns

Notes : PKK= goat manure; dap= days after planting; ns= not significant; Numbers followed by the same letter in the same column are not significant based on LSD test and contrast orthogonal test at the level 5%.

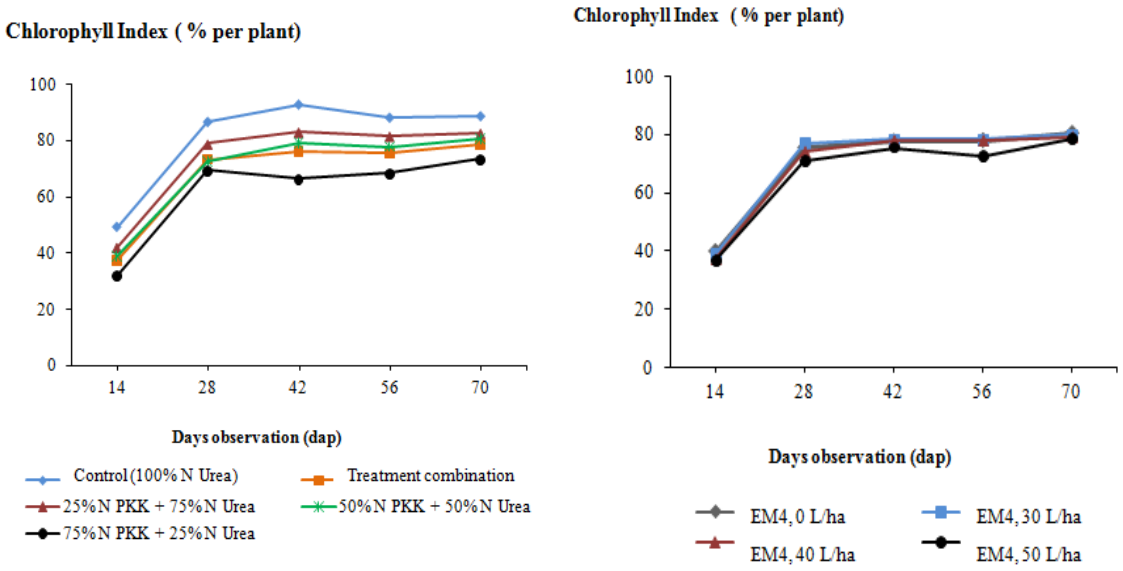

Figure 1. Chlorophyll index of red chili under the treatment of goat manure and Urea (left) by dose of EM4 (right)

Number of fruits, fruit weight per plant, and fruit weight per hectare

Proportionally, number of fruits and fruit weight are affected by number of the formed flowers. By the treatment of 25% N PKK + 75% N Urea, it produces greater number of fruits per plant, higher fruit weight per plant, and fruit weight per hectare in comparison with the treatment of 75% N PKK + 25% N Urea (Table 3). According to Hayati et al. (2012), the application of compost fertilizer produced the best growth and yield of red chili. Moreover, Ghifari *et al.* (2014) stated that combination of goat manure 75% and bitter grasses (*paitan*) 25% have produced optimal production. According to Pikul et al. (2005), the increasing number of fruits and fruit weight due to the increasing ability of the organs to absorb nutrients, water, and energy, as well as fixation of nitrogen and CO_2, so that the photosynthetic process would optimal in producing assimilate. High assimilate is required as energy source for the plant growth, in which a part of it is kept as food reserves (fruit), accumulation of polysaccharide compounds affect the fruit development such as length and diameter of the fruit (Karanatsidis and Berova, 2009). High carbondioxide in the plant tissues increase the photosynthetic process rate and produce more photosynthates and maximum development of endosperm, so it produce more fruits (Gardner et al., 2008).

The increasing number of fruits per plant and fruit weight are supported by the increasing parameters of plant height, numbers of branches, and number of flowers, as well as number of fruits. The application of 25% N PKK + 75% N Urea showed higher fruits weight per plant and fruits weight per hectare for about 18.68% and 20.16% compared with combination of 75% N PKK + 25% N Urea (Table 3). However, yield in this research was still below the potential productivity of red chili, 16-25 t/ha (BPS, 2014). It is due to plants had been attacked by fruit flies and anthraxnose, so that the harvest time is faster. Rosliani et al. (2004) stated that the application of horse manure and biofertilizer increase the yield of red chili and increase nutrient absorption. According to Liestiany and Fikri (2012), the application of organic fertilizer and organic pesticide could reduce intensity of Anthraxnose for about 6.12% on red chili.

The increasing fruits weight per plant is due to optimal availability of nutrients in the soil, besides that micro ability of EM4 to disperse faster the goat manure and activate enzymes, such as Auxin, Cytokinine and Gibberellin hormones in tissues, so that the plant will grow and absorb the *nutrients optimally. According to Moraditochaee et al.* (2011), nitrogen application could fulfill the requirement for N and increase number of fruits per plant, fruit length, and total yield.

The increasing fruit weight per hectare was supported by the increasing number of fruits and fruit weight per plant. Development of the fruit organs was due to the increasing photosynthetic rate, so that carbohydrate translocation to the fruit will be optimal. Besides that, the nutrient supply has been fulfilled due to the application of EM4 will accelerate the decomposition process of goat manure (Higa, 1994). Bacteria in EM4 (*Streptomyces* sp, *P. fluorencens, Bacillus* spp, and *Serratia* spp) could inhibit development of both pathogens and viruses (Mujoko et al., 2008; Sutariati and Wahab, 2010; Soesanto et al., 2014).

The application of EM4 could increase number of fruits, fruit weight per plant and fruits weight per hectare as supported by optimal growth on vegetative phase. Application of EM4 at level 30 L/ha produced number of fruits 304.33 fruits per plant, fruit weight per plant 409.96 g per plant and the best fruit weight per hectare for about 12.27 t/ha higher than without and with EM4 at level 50 L/ha (Table 3). It is due to EM4 could maximize functions of roots and other organs in absorbing the available nutrients optimally. Besides, bacteria in EM4, *Rhodopseudomonas* sp could synthesize N and produce metabolic compounds that could be absorbed by plant, increase N absorption from the air and *Lactobacillus* sp could suppress pathogen. The availability of microbes from the application of EM4 could improve physical, chemical, and biological properties of the soil, and accelerate the dissolving of N, P and K, as well as other micronutrients (Yulhasmir, 2009). According to Syafruddin and Safrizal (2013), the application of EM4 by concentration of 15 mL/L with application interval once in 2 weeks could increase fruit weight of red chili. Moreover, Maghfoer et al. (2013) stated that the application of EM4 by dose of 30 L/ha would produce the highest yield of eggplants.

Application of high Urea on control causes the growth becomes too fertile and the vegetative growth takes longer and inhibit the flower development process, so that the production will reduce. It can be seen on less number of fruits, low fruit weight per plant and per hectare in comparison with the combination treatment (Table 3).

Table 3. Mean for number of fruits (fruit per plant), fruit weight (g per plant), and weight of fruits per hectare (t/ha) by the application of goat manure and Urea with EM4, results of contrast orthogonal test on some parameters of observation.

Treatment	Number of fruits (fruit per plant)	Fruit weight (g per plant)	Fruit weight per hectare (t/ha)
Control (100% N Urea)	203.33 a	272.08 a	7.36 a
Combined Treatment	274.81 b	346.75 b	9.81 b
LSD 5%	21.98	28.01	0.78
Goat manure + Urea			
25% N PKK + 75% N Urea	292.67 b	389.08 b	10.92 b
50% N PKK + 50% N Urea	287.08 ab	334.78 a	9.79 ab
75% N PKK + 25% N Urea	244.67 a	316.39 a	8.71 a
LSD 5%	43.98	56.01	1.57
Dose of EM4			
0 L/ha	241.00 a	302.12 a	8.17 a
30 L/ha	304.33 b	409.96 c	12.27 c
40 L/ha	294.89 b	355.32 b	9.82 b
50 L/ha	246.44 a	309.59 ab	8.70 ab
LSD 5%	38.07	48.51	1.36

Notes : PKK= goat manure; dap= days after planting; Numbers followed by the same letter in the same column are not significant based on LSD test and contrast orthogonal test at the level 5%.

Conclusion

1. The application of goat manure and urea with EM4 showed interaction on growth components and yield. The application of urea had positive correlation with N content and chlorophyll index of the leaf. The increasing level of goat manure had positive correlation with stomatal density.
2. The application of goat manure and EM4 made the application of chemical fertilizer (Urea) 25% more efficient in comparison with the control. Combination of 50% N PKK + 50% N Urea with EM4 at level 30 L/ha produced the best growth and yield.
3. The application of goat manure 25% N and Urea 75% N produced the best fruit weight per hectare 10.92 t/ha and increased 20.35%. Dose of EM4 30 L/ha produced the highest fruit weight per hectare for about 12.27 t/ha and increased 33.71%.

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