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Incubation Time of Liquid Organic Fertilizers and Doses of Nitrogen on Growth and Yield of Cherry Tomatoes (*Lycopersicum esculentum*)

Lama Inkubasi Pupuk Organik Cair dan Dosis Nitrogen terhadap Pertumbuhan dan Produksi Tomat Cherry (*Lycopersicum esculentum*)

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ABSTRACT

The aim of the experiment was to evaluate the effect of incubation time of liquid organic fertilizer and nitrogen doses on the growth and production of cherry tomatoes. The experiment was conducted at the sreen house of Department of Agriculture of Semarang City and at the Ecology and Crop Production Laboratory of the Faculty of Animal and Agricultural Sciences, Diponegoro University from May-September 2017. A completely randomized design of 3x3 factorial patterns was used throughout the experiment. The first factor consisted of the incubation time of liquid organic fertilizer 6, 12 and 18 days, respectively for I_1, I_2 and 1_3 treatments. The second factor was the doses of nitrogen that consisted of three levels 36, 72 and 180 kgN/ha as D_1, D_2 and D_3 treatments, respectively. Observed data included plant height, fresh and dry weight of stover, harvest index, fruit production and fruit sets. Obtained data were analyzed statistically by using ANOVA and continued with the smallest significant difference test at 5%. On the basis of the experiment it may be concluded that all of LOF with different of incubation time at dose of 72 kg N/ha may be recommended for cherry tomatoes cultivation.

Keywords: cherry tomatoes, cow's urine, fruit and vegetable waste, local microorganisms, liquid organic fertilizer

ABSTRAK

Tujuan penelitian adalah untuk mengevaluasi pengaruh waktu inkubasi pupuk organik cair dan dosis nitrogen terhadap pertumbuhan dan produksi tomat ceri. Percobaan dilakukan di rumah kaca Dinas Pertanian Kota Semarang dan di Laboratorium Ekologi dan Produksi Tanaman, Fakultas Peternakan dan Pertanian, Universitas Diponegoro dari Mei-September 2017. Rancangan acak lengkap pola faktorial 3x3 digunakan selama percobaan. Faktor pertama terdiri dari waktu inkubasi pupuk organik cair 6, 12 dan 18 hari, masing-masing untuk perlakuan I_1, I_2 dan 1_3. Faktor kedua adalah dosis nitrogen yang terdiri dari tiga level 36, 72 dan 180 kgN/ha masing-masing sebagai perlakuan D_1, D_2 dan D_3. Data yang diamati meliputi tinggi tanaman, berat segar dan kering brangkasan, indeks panen, produksi buah, dan set buah. Data yang diperoleh dianalisis secara statistik dengan menggunakan ANOVA dan dilanjutkan dengan uji perbedaan signifikan terkecil yaitu 5%. Berdasarkan percobaan dapat disimpulkan bahwa semua LOF dengan waktu inkubasi yang berbeda dengan dosis 72 kg N/ha dapat direkomendasikan untuk budidaya tomat ceri.

Kata kunci : tomat ceri, urin sapi, limbah buah dan sayuran, mikroorganisme lokal, pupuk organik cair

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INTRODUCTION

Cherry tomatoes (*Lycopersicum esculentum*) are horticultural plants that are round or elliptic in shape, red or yellow in color, small size with diameters ranging from 10-15 mm, easily adaptable, resistant to disease and root rot, although to obtain optimal production should be treated seriously, especially in increasing yield and fruit quality (Wuryani *et al.,* 2014). Cherry tomatoes contain abundance of vitamins and minerals so these are very useful for preventing disease and strengthening the immune system (Wasonowati, 2011). Therefore, cherry tomatoes are widely consumed by the community because these contain higher vitamin C, sweets and fresher tastes than other varieties of tomatoes (Kailaku *et al.,* 2007).

Cherry tomatoes have a high economic value with relatively high and stable selling prices, which are very feasible to be cultivated and commercialized (Fitriani, 2012). The production of cherry tomatoes in Indonesia during 2010-2014 was fluctuative, respectively, 891,616 tons, 954,046 tons, 893,463 tons, 992,780 tons and 915,987 tons were in 2010, 2011, 2012, 2013 and 2014 (Directorate General of Horticulture Ministry of Agriculture , 2015).

The increasing public demand for organic products affects the activities of organic vegetable farming. Meanwhile, the use of agricultural waste including cow urine is one of the organic wastes that may be used as liquid organic fertilizers (LOF). This is may be due to the fact that cow urine contains high levels of N, P and K, and therefore it can be used as a substitute for nutrients in the soil (Affandi, 2008). However, to improve the quality of cow urine various efforts should be made to incubate cow urine by empowering local microorganisms (LoM), while LoM may be generated from rotten fruits and vegetables. In the process of incubation LoM acted as decomposers during the process of LOF making (Widjajanto *et al.,* 2017).

Producing LOF of cow urine requires a fermentation process using Local microorganisms (LoM). Local microorganisms may be generated from the fermentation of various sources of fruits and vegetables such as papaya, mango, banana, cucumber. The LoM contains various microorganisms such as bacteria and fungi which roles as a decomposer organic matter. Factors that influence the quality of the LoM are fermentation media, the shape and nature of active microorganisms in the fermentation process, pH, temperature, fermentation time, raw material or substrate content and C/N ratio of the requirements for the process of LoM (Mulyono, 2014; Widjajanto *et al.,* 2017).

MATERIALS AND METHODS

The experiment was conducted at the green house of the Semarang City Agriculture Office, Gunungpati Subdistrict, Semarang city and at the Ecology and Plant Production Laboratory of the Faculty of Animal and Agricultural Sciences, Diponegoro University. It was conducted for 5 months, from May to September 2017. The experimental site was located at ordinate location 07°03'57"-07°30'00" S and 110°14'55" -110°39'03" E, at about 348 m above the sea level with a monthly temperature range from 19 to 30°C, relative humidity 70 to 95%, and rainfall 2,200 mm per year (The BMKG Semarang Climatology Station, 2019). The land was taken from the land owned by the Semarang City Agriculture Office which is located around the experimental location. The soil type is reddish dark brown latosol (Semarang City Government, 2011).

The materials used at the experiment were cherry tomato seeds, cow urine, fruit and vegetable wastes and various materials needed in producting LoM according to the procedure of Widjajanto *et al.* (2017).

A completely randomized design of 3x3 factorial patterns was used throughout the experiment. The first factor consisted of the incubation time of liquid organic

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fertilizer 6, 12 and 18 days, respectively for I_1, I_2 and 1_3 treatments. The second factor was the doses of nitrogen that consisted of three levels 36, 72 and 180 kgN/ha as D_1, D_2 and D_3 treatments, respectively.

The experiment was started by producing LoM (Widjajanto et *al.,* 2017), making LOF, preparation of planting media, seeding, planting, fertilizing, maintaining, collecting data and harvesting. Seeding was carried out in the seed tray for 14 days. Subsequently the 14-day of age of tomatoes crops were transferred to the polybag. During the growth periods, crops were irrigated while weeds, pests and diseases were controlled. Fertilization was conducted based on the doses of nitrogen that suitable to the treatment. It was carried out every 7 days for 12 times with LOF volume of 50, 100 and 150 ml/plant per week, respectively for the doses of 36, 72 and 108 kg N / ha.

The parameters observed included plant height, fresh weight (FW) and dry weight (DW) of stover, harvest index, fruit yield per plant and the percentage of flowers set to fruit (fruit set). Plant height was observed every week until the first flower appeared or the end of the vegetative phase, FW of stover was measured by weighing stover after harvest, while DW of stover was measured by weighing FW stover and ovened at 105ºC for 48 hours, the harvest index was calculated by using the formula of Florentina *et al.* (2015). Fruit yield per plant was obtained by weighing the total weight of fruit in one crop at the first harvest. The percentage of fruit set was calculated by comparing the number of flowers with the number of fruits formed in the first harvest.

Collected data were processed using analysis of variance, followed by the Least Significant Difference Test of 5%.

RESULTS AND DICUSSION

Based on environmental characteristics data that are collected from the experimental location such as height of place, daily temperature and humidity and annual rainfall, it may be concluded that the research location is suitable for the cultivation of cherry tomato plants. The degree of nutrients content and acidity soil used of were presented at Table 1.

Based on the results of initial analysis (Table 1), the N contents of the soil and LOF of all incubation times were categorized as low criteria, while the N contents of the fertilizer were as high criteria. The P and K contents of all materials except manure and husk were categorized as very high criteria. The C content was very high in manure and husk, medium in soil and low in LOF at all incubation times. Based on the results of the C and N analysis, the C: N ratio of the soil, manure, and all of LOF were very high, very low and low, respectively (Soil Research Institute, 2017).

Table 1. The degree of nutrient content and acidity of initial soil, fertilizers, husks and liquid organic fertilizer at various incubation time

Samples	Nutrients content (%)				C : N ratio	pH
	N	P	K	C		
Soil	0.11$^{(l)}$	0.29$^{(vh)}$	0.10$^{(vh)}$	2.94$^{(m)}$	27.8$^{(vh)}$	6.1$^{(sa)}$
Organic fertilizer	0.72$^{(h)}$	-	-	29.5$^{(vh)}$	4.1$^{(vl)}$	-
Husks	-	-	-	8.93$^{(vh)}$	-	-
LOF-Inkubation for 6 days	0.12$^{(l)}$	0.05$^{(vh)}$	0.55$^{(vh)}$	1.37$^{(l)}$	9.4$^{(l)}$	4.4$^{(va)}$
LOF-Inkubation for 12 days	0.14$^{(l)}$	0.06$^{(vh)}$	0.42$^{(vh)}$	1.10$^{(l)}$	8.1$^{(l)}$	4.4$^{(va)}$
LOF-Inkubation for 18 days	0.20$^{(l)}$	0.03$^{(vh)}$	0.27$^{(vh)}$	1.05$^{(l)}$	5.3$^{(l)}$	4.2$^{(va)}$

Source: Soil Science Laboratory, Faculty of Animal and Agricultural sciences, Diponegoro University (2017)

Note : nutrient content criteria, very low (vl), low (l), moderate (m), high (h), very high (vh); criteria for the degree of acidity of the soil, very acidic (va), acidic (a), slightly acidic (sa), neutral (n), slightly alkaline (sal), very alkaline (vsal) (Soil Research Institute, 2017)

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Plant height

The results showed that treatment of nitrogen doses were not significantly different on plant height, but there were significantly different due to the treatment of LOF incubation times and the interaction between nitrogen doses and LOF incubation time on plant height (Table 2).

Table 2. Plant Height at LOF Incubation time and Various Nitrogen Doses

LOF incubation times (days)	Nitrogen doses (kg N/ha)			
	$D_1 = 36$	$D_2 = 72$	$D_3 = 108$	Average
	----------(cm)----------			
$I_1 = 6$	82.7 ± 4.0^{abc}	82.7 ± 5.5^{abc}	78.0 ± 2.6^{bc}	81.1 ± 2.7^{b}
$I_2 = 12$	84.0 ± 1.0^{ab}	85.0 ± 1.0^{ab}	87.7 ± 7.6^{a}	85.6 ± 1.9^{a}
$I_3 = 18$	68.7 ± 3.1^{d}	82.0 ± 2.6^{abc}	76.3 ± 6.7^{bc}	75.7 ± 6.7^{c}
Average	78.4 ± 8.5^{b}	83.2 ± 1.6^{a}	80.7 ± 6.1^{ab}	

Figures followed by different superscripts in the same column and row showed significant differentces (P <0.05)
Figures followed by different superscripts in the interaction column and row showed significant differences (P <0.05)

The results showed that the plant height at the 12-day incubation of LOF was significantly higher than the 6-day and the 18-day incubation of LOF. Meanwhile, plant height at the 6-day incubation time was significantly higher than the 18-day of incubation time. Incubation time affected content of LOF nutrients such as N, P, K and C/N ratio. This is in accordance with Wijaksono *et al.* (2016) who stated that incubation time reduced organic matter content.

Changes of C/N ratio during incubation were caused by the use of C as an energy source and lost in the form of CO_2. Plant height at a treatment dose of 72 kg N/ha was significantly higher than plant height at a dose of 36 kg N/ha, but it did not significantly differ from plant height at a dose of 108 kg N/ha. The results showed that the interaction effect of 12-day incubation time and dose of 108 kg N/ha determined the best results on plant height (87.7 cm). Different doses of N contributed different responses to plant height. This is in accordance with Lakitan (2010) who found that the amount of nutrient required by crop is related to plant needs so that plants may grow optimally.

Fresh and Dry Weight of Stover

The results showed that nitrogen doses, LOF incubation time and the interaction between these two treatments were significantly different on fresh weight (FW) and dry weight (DW) of stover. The results of FW and DW observations of stover were presented at Tables 3 and 4.

Tabel 3. The FW of stover at the LOF incubation time and various doses of nitrogen

LOF incubation time (days)	Nitrogen doses (kg N/ha)			Average
	$D_1 = 36$	$D_2 = 72$	$D_3 = 108$	
	----------g/pot----------			
$I_1 = 6$	362.2 ± 3.9^{c}	364.8 ± 19.1^{b}	445.2 ± 32.8^{a}	390.7 ± 47.2^{a}
$I_2 = 12$	233.9 ± 28.2^{c}	439.5 ± 21.4^{a}	249.3 ± 40.7^{c}	307.6 ± 114.5^{b}
$I_3 = 18$	152.0 ± 26.2^{d}	208.7 ± 42.0^{c}	244.7 ± 51.5^{c}	201.8 ± 46.7^{c}
Average	249.4 ± 105.9^{b}	337.7 ± 117.8^{a}	313.1 ± 114.3^{a}	

Figures followed by different superscripts in the same column and row showed significant differentces (P <0.05)
Figures followed by different superscripts in the interaction column and row showed significant differences (P <0.05)

Table 4. The DW of stover at the LOF Incubation Time and Various Doses of Nitrogen

LOF incubation time (days)	Nitrogen doses (kg N/ha)			Average
	$D_1 = 36$	$D_2 = 72$	$D_3 = 108$	
	----------g/pot----------			
$I_1 = 6$	260,6±39,6^{b}	262,9±20,8^{a}	316,1±13,3^{a}	279,9±^{a}
$I_2 = 12$	176,2±10,1^{bc}	307,9±16,6^{a}	186,5±59,3^{b}	223,5±^{b}
$I_3 = 18$	116,4±34,8^{c}	167,6±56,9^{bc}	179,7±42,3^{bc}	154,6±^{c}
Average	184,4±72,4^{b}	246,2±71,6^{a}	227,4±76,9^{b}	

Figures followed by different superscripts in the same column and row showed significant differentces (P <0.05)
Figures followed by different superscripts in the interaction column and row showed significant differences (P <0.05)

The results (Table 3.) showed that the FW of stover at nitrogen dose of 108 kg N/ ha was higher than the nitrogen doses of 36 and 72 kg N / ha. The nitrogen dose of 108 kg N/ha was the most optimal dose to increase FW of stover. This is probably due to the fact that nutrient content of LOF was low, so it may not be used to support plant growth optimally. Hadisuwito (2012) stated that LOF is a source of decay of organic materials that has various nutrients in very low levels. High doses of nitrogen may increase FW of plant because it is able to supply nutrients to increase the rate of photosynthesis and the formation of important organs of the plant. Nio and Torey (2013) stated that the use of high dosages of LOF may be used by plants for photosynthesis despite poor environmental conditions. Conversely, low-dose of fertilization has limited nutrient content, so it may not be used by plants optimally.

The DW of stover (Table 4) showed the same trend as FW of stover. Plant DW is a buildup of photosynthesis yield in plant cells and tissues that function for plant growth and production. Nitrogen dose 108 kg N / ha was the most optimal dose to increase DW of stover. Proper fertilization may increase plant growth and production, because the photosynthesis process is efficient, and consequently it may increase the DW of stover. This is in accordance with Novizan (2005) who stated that an efficient photosynthesis process and the provision of proper nutrition may increase plant growth.

Nitrogen dose of 108 kg N/ha with 6-day incubation time increased DW of stover compared to that of nitrogen dose of 36 and 72 kg N/ha with the exception of 12-day incubation time. The DW of stover was affected by the N content of LOF. Nitrogen improved plant growth such as roots, stems and leaves, so the higher the N absorbed by the plant may increase the growth of plant better. Nitrogen plays an important role in supporting the growth of roots, stems, branches and leaves as well as the formation of proteins, fats and other compounds. Nitrogen is involved in increasing the activity of cell division, thereby increasing the DW of stover. When the incubation time of LOF take too long it may reduce content of N in fertilizer. This happens because N in fertilizer may be used by fermentative microorganisms to decompose organic matter, besides N has volatile properties so long incubation processes may decrease the N content.

Harvest Index

The results showed that the dosage of nitrogen did not affect the harvest index. Meanwhile, the incubation time treatment has a significant effect on the harvest index parameters. There were no significant

effects of the interaction between the incubation time of LOF and the doses of N on the harvest index. The results of observations of the harvest index were presented at Illustration 1.

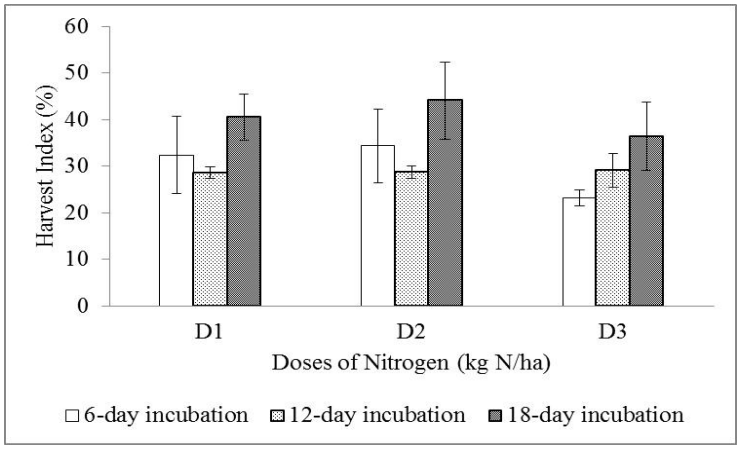

Illustration 1. Harvest Index at various incubation time of LOF and doses of Nitrogen

The results (Illustration 1) showed that there was no significant differences of harvest index due to the combination of incubation time and N doses. The addition of LOF did not affect the harvest index. This is probably due to the fact that the mineralization process was not finished yet. This is in accordance with Hardjowigeno (2003) who stated that the lost of N in the soil may be carried out by soil microorganisms. Nitrogen that is still in the form of NH_4^+ which is still bound by clay minerals so that it cannot be absorbed by plants. Meanwhile, the leaching may be occurred because N in the form of NO_3^- which is easily washed and drainaged. In addition, the air movement may generate denitrification and volatility of N in the form of NH_3.

Harvest index at nitrogen doses of 36, 72 and 108 kg N/ha showed no significant difference. The incubation time of LOF determined a different response on the harvest index. Harvest index at the 18-day incubation time was significantly higher compared to that of the 6-day and 12-day incubation time. Yuniwati *et al.* (2012) stated that the longer the incubation, the higher the chance of microbes to decompose organic matter. Nitrogen roles increase the percentage of harvest index, because optimally available N will increase the speed of cell elongation and division, and directly increase FW and plant yield. Setiawan (2007) agreed that addition of N to accelerate cell division and elongation, growth buds, stems and leaves more quickly. Plant weights are also determined by available K, in accordance with Rosniawaty *et al.* (2015) who stated that K has the role of the synthesizing of protein and stomata movement.

Production and Percentage of fruit sets

The results showed that there was a significant difference of the single treatment of LOF incubation time and N doses on fruit yield per plant, but there was no significant difference of the interactions of these two treatments. Meanwhile, all treatments showed no significant difference on the fruit sets. Fruit yield per plant and percentage of fruit sets, consecutively were presented at Table 5 and Illustration 2.

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Table 5. Fruit yield per Plant at different Incubation time of LOF and Nitrogen Doses

LOF incubation time (days)	Nitrogen doses (kg N/ha)			Average
	$D_1 = 36$	$D_2 = 72$	$D_3 = 108$	
	----------(g/pot)----------			
$I_1 = 6$	178.5±65.9^{ab}	194.9±59.9^{a}	134.5±6.6^{bcd}	169.3±31.3^{a}
$I_2 = 12$	109.1±17.3^{cd}	157.6±25.7^{abcd}	101.0±2.5^{d}	122.6±30.6^{b}
$I_3 = 18$	102.1±3.5^{d}	164.6±36.1^{abc}	138.3±23.8^{abcd}	135.0±31.4^{ab}
Average	129.9±42.2^{b}	172.4±19.8^{a}	124.6±20.5^{b}	

Figures followed by different superscripts in the same column and row showed significant differentces (P <0.05)
Figures followed by different superscripts in the interaction column and row showed significant differences (P <0.05)

Fruit yields per plant (Table 5) showed that the 6-day incubation of LOF was significantly higher than the 12-day of incubation LOF, but it was not significantly different from the 18-day incubation of LOF, while there was no significant difference between the 12-day and the 18-day incubation of LOF. This may be due to the fact that LOF incubation time affected the phosphorus content needed by plants in increasing fruit production. This is in accordance with Mawardi and Purnomo (2015) who stated that phosphorus is used by plants to influence the growth of flowers, fruit and seeds, and accelerate fruit maturation. The combination of 6-day incubation of LOF with N dose of 72 kg N/ha (I1D2) was significantly higher than other treatments with the exceptions of I_2D_2, I_3D_2 and I_3D_3 treatments. in this case, plants may absorb nutrients but does not according to the plant needs, and therefore fertilizing doses that are not in accordance with the needs of plants are likely to affect plant growth and production.

Fruit yield per plant at 72 kg N/ha was significantly higher than at 36 and 108 kg N/ha doses, meanwhile there was no significant difference in fruit yield per plant between N 36 doses and 108 kg N/ha. Luthfyrakhman and Susila (2013) found that the higher the concentration of LOF was applied, the higher the content of nutrients that absorbed by crops. In addition, Rizqiani *et al.* (2007) reported that the higher the application of LOF fertilization, the higher nutrient content obtained by plants and may affect growth and decrease crop yield.

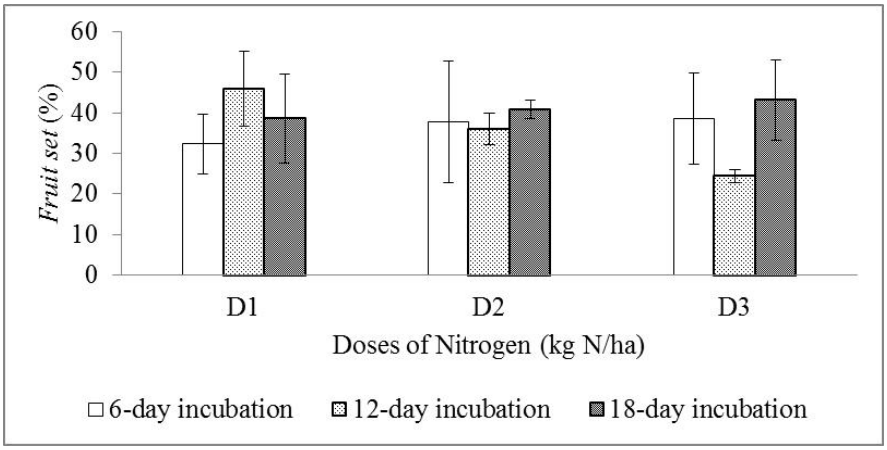

Illustration 2. Percentage of Fruit Sets at various LOF incubations and Nitrogen Doses

The percentage of fruit set (Illustration 2.) at the combination of the 12-day incubation of LOF with nitrogen dose of 108 kg N/ha showed lower yields than the other treatments. The doses

of fertilizer should be in accordance with the needs of plant nutrients. Application of fertilizer that does not meet the plant needs may cause nutrient deposite in the soil so that it inhibits plant growth and production. This is in accordance with Kandil (2010) that fertilization with high concentrations may poison plants, as a result plasmolysis may occur which may affect the weight and number of fruit. Phosphorus in LOF was thought to increase the percentage of fruit formation. The 12-day incubation of LOF was able to decompose the elements of LOF, making it easily absorbed by plants and increasing plant growth. Nur *et al.* (2016) showed that longer process of incubation time increased the phosphorus content in LOF of household organic waste treated with EM4 bioactivators. The increased availability of nutrients was due to the varied composition of organic waste that affects the composting process.

CONCLUSION

Based on the results of the study it may be concluded that the LOF incubation time provides an optimal contribution to plant height and fruit yield per plant. The combination of LOF incubation time and nitrogen doses contributes significantly to plant height, FW and DW of stover and fruit yield per plant. In contrast, the combination of LOF incubation time and nitrogen doses had no effect on the fruit set. All of LOF incubation time at dose of 72 kg N/ha may be recommended for cherry tomato cultivation.

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