



# Biofertilizer in leaf and drip applications: an alternative to increase tomato productivity

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## Abstract

The tomato is a species of undetermined growth and extremely demanding in nutrients. Therefore, the search of new ways to maximize the use and supply of fertilizers sources and their application mechanisms are important to improve the tomato culture management. The aim of this study was to evaluate the application methods of liquid biofertilizer (BF) and the harvest times throughout cultivation. The experiment was carried out in a randomized block design, in a 3x6 factorial with subdivided plot and seven replications. The treatments were foliar and drip BF application and a control, without application of BF, and harvesting time (85; 92; 99; 106; 113; 120 days after transplanting-DAT). Leaf application resulted in a class I production increase in the second week of harvest (92 DAT), while drip application reflected higher class II and III production in the fourth week (106 DAT). In all treatments, at 92 DAT higher production of large fruits (class I) was observed. Production of average fruits (class II) occurred at 92 and 113 DAT and small fruit (class III) production was concentrated at 113 DAT. The adoption of BF, regardless of the application form, provides an increase in total productivity, with an income up to 35% higher. Therefore, biofertilizer is a good source for nutrition implementation aiming at yields and returns in the tomato production chain.

**Keywords:** *Solanum lycopersicum* L., fertilizer sources, organomineral, organic matter

## Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most widely grown vegetables in the world (Maham et al., 2020). The fruits are a great source of nutrients and bioactive compounds, essential to human diet, since has antioxidant and anticancer properties (Briones-Labarca et al., 2019) besides the expressive economic significance (Singh et al., 2020).

Tomato is one of the crops with higher agronomic complexity, which can lead to a high cost and economic risk (Filgueira, 2008; Mitra & Sharmin, 2019). The average yield of tomato production in Brazil is 62.9 kg ha<sup>-1</sup> (IBGE, 2016). The productivity is influenced by factors, such as adequate management of plant nutrition (Emrich et al., 2011).

The correction of acid soil and suitable fertilizer use potentiate tomato production, which meets market and product demands with low environmental impact.

Organic sources, traditionally underutilized, become interesting options, since they improve the physical, chemical and biological soil properties and make a positive effect on production (Corrêa et al., 2016).

Bissani et al. (2008) point out that organic fertilizers have low concentrations of N, P and K, and can be supplemented with mineral fertilization, so that plants can better utilize nutrients through the release timing throughout plant growth.

Some authors (Canellas & Olivares, 2014; Zandonadi et al., 2014; Prado et al., 2016) mention that biofertilizers (BF) improves the agronomic performance of many crops under conditions of nutritional or climatic stress.

The application of fertilizers through irrigation water (fertigation) is viable way of applying mineral nutrients to the plants. It is possible to maintain more uniform levels of nutrients in the soil, which contribute to

an increase in fertilization efficiency (Villas Boas et al., 1994).

Although foliar nutrient application is well disseminated researchers suggest the necessity of more studies, since the efficiency of the method can be affected by several factors, especially those related to nutrients source and formulations (Mógor et al., 2013; Carvalho et al., 2014).

BF is also increasing because is an alternative to minimize ecological imbalances caused by intensive vegetables fertilization with very soluble mineral fertilizers (Rady et al., 2016). It can be a way to take advantage of the wide range of alternative organic matter sources from residues produced in various industrial processes (Canfora et al., 2015). In addition, allow producers to develop sustainable tomato production (Garofalo et al., 2017).

In view of the above, the aim of this study was to evaluate methods of application of liquid biofertilizer (foliar and drip) and harvesting times, in the productivity and income of the Alambra tomato.

## Material and Methods

The experiment was carried out in Capão Bonito-SP. Tomato seedlings, cultivar Alambra, were produced in protected cultivation and transplanted to the field at 26 days after sowing, following the double row system, with cross-fence conduction, spaced 1.0 mx 1.2 mx 0.7 m, which resulted in a population of 13.000 plants ha<sup>-1</sup>.

The soil of the experimental area is classified as

Dark Red Latosol. The physical and chemical analysis of the 0-20 cm layer were as follows: pH H<sub>2</sub>O = 5.7; P = 1.8 mg dm<sup>-3</sup>; K = 83.2 mg dm<sup>-3</sup>; Ca = 1.6 cmolc dm<sup>-3</sup>; Mg = 1.8 cmol dm<sup>-3</sup>; Al = 0.2 cmol dm<sup>-3</sup>, M.O. = 1.9%, V = 45%, T = 4.6% (EMBRAPA, 1999).

The chemical fertilization followed the recommendations for the crop at São Paulo (Raij et al., 1996) and considering the soil nutrients. Two t ha<sup>-1</sup> of dolomitic limestone were applied before planting. In the base fertilization, 3.5 t ha<sup>-1</sup> of 04-14-08 were used. In the cover, 100 kg 1000 plants<sup>-1</sup> of single super phosphate and in fertigation, 2.5 kg of potassium chloride (KCl) associated with alternate rates between 1.1 kg of nitro calcium and 1.6 kg of monoammonium (MAP), were applied every 2 days from 25 days after the transplant (DAT) to the end of the cycle.

The experimental was a randomized block design with factorial arrangement (3x6) and plots subdivided in the time, with seven replications and 20 plants in a total area of 15.4 m<sup>2</sup> at each plot. The plots were constituted by treatments with BF in foliar and drip applications and one control, without application of BF and the subplots by harvesting times (85, 92, 99, 106, 113, 120 days after transplanting-DAT).

In the drip application (fertigation), the BF was composed of 437 g ha<sup>-1</sup> of organic matter, 253 g ha<sup>-1</sup> of organic carbon, 230 g ha<sup>-1</sup> of N and 23 g ha<sup>-1</sup> of K<sub>2</sub>O. In the foliar application, the applications were made at time of transplant and at 7, 14, 21, 28, 35, 42 and 56 days after transplanting-DAT (Table 1).

**Table 1.** Composition of liquid biofertilizer used in foliar application at days after transplantation (DAT).

DAT	TOM <sup>1</sup>	TOC <sup>2</sup>	Nitrogen (N)	K (K <sub>2</sub> O)	Others
g ha <sup>-1</sup>					
0	517.5	299.0	261.2	25.87	S: 78; Mg, B, Cu: 6.5
7 and 14	695.75	402.5	318.7	31.62	S: 78; Mg, B, Cu: 6.5; Mn: 8.62; Zn: 2.87
21	615.25	356.5	287.5	28.75	Mn: 8.62; Zn: 2.87
28 and 35	925.75	531.8	414.0	28.75	Mn: 5.75; Zn: 2.87; B: 5.75; Ca: 254.5
42	609.5	350.75	354.5	23.0	S:78; Ca: 221.75; B:9.35; Cu, Mg: 6.5
56	437.0	253.0	320.0	923.0	Ca: 378; Mg: 49.6; S: 62

<sup>1</sup>Total Organic Matter <sup>2</sup>Total Organic Carbon

Spraying was performed with a 20 L costly sprayer with working pressure of 4 Kgf, and an application drip irrigation was performed with the aid of a fertilizer injector Venturi type. Phytosanitary control was made with insecticides and fungicides recommended for tomatoes, when required.

Harvesting of tomato fruits started at 85 DAT and lasted for six weeks. The fruits were harvested manually classified and weighed. The classification was made according to the regional commercial standard (CEASA - CAMPINAS), defined as class I, II and III. The fruits classified

as I had diameter higher than 80 mm; those classified as II had a diameter between 50 and 80 mm and those classified as III had a diameter smaller than 50 mm.

Subsequently the data were extrapolated in order to obtain productivity per hectare. The economic analysis was based on the total produced (sum of classes) during each week of harvest per plot of treatment, estimating the result for a thousand plants. Thus, the number of boxes of tomatoes produced per thousand plants per week was obtained for each treatment. These results were multiplied by the value of the 22 kg tomato box

marketed by the owner of the crop, thus obtaining the gross income. By subtracting the cost of production and the cost of applying the BF, the income was obtained.

The production data obtained in each week and total production were submitted for analysis of variance (test F). The regression test was not used for harvest intervals, since the models did not fit the data set, and when there was some case of significance, they presented a low coefficient of determination. Therefore, the Tukey test was used for all factors evaluated. The SISVAR program at the 0.05 level of significance performed the analyses (Ferreira, 2014).

## Results and Discussion

The interaction between treatments and harvest weeks was significant for classes I, II and III (Table 2). Class I fruits (diameter higher than 80 mm) showed differences in yield at 92 and 106 harvest DAT. At 92 DAT the foliar application of BF yielded a higher productivity than the others (3601.11 kg ha<sup>-1</sup>) being the highest yield throughout the tomato cycle.

At 106 DAT plants that received BF (foliar and drip application) were higher than the control (2504.63 and 2363.45 kg ha<sup>-1</sup>, respectively) (Table 2).

**Table 2.** Weekly productivity (kg ha<sup>-1</sup>) of tomato Alambra, classes I, II and III as a function of foliar and drip application of biofertilizers at harvesting- days after transplantation (DAT).

		Class I (kg ha <sup>-1</sup> )					
		85 DAT	92 DAT	99 DAT	106 DAT	113 DAT	120 DAT
Controle <sup>1</sup>		1054.5 aD*	2608.9 cA	1901.6 aBC	1843.6 bBC	2162.0 aAB	1534.3 aCD
Foliar		1208.2 aC	3601.1 aA	1706.8 aC	2504.6 aB	2319.2 aB	1686.2 aC
Drip		1135.7 aE	3153.8 bA	1846.0 aCD	2363.4 aB	2072.6 aBC	1475.4 aDE
CV (%)		14.78					
		Class II (kg ha <sup>-1</sup> )					
		85 DAT	92 DAT	99 DAT	106 DAT	113 DAT	120 DAT
Control <sup>1</sup>		981.8 aB	2075.4 aA	1382.1 aB	1414.1 bB	2319.2 aA	1213.3 bB
Foliar		939.7 aC	2303.7 aA	1567.7 aB	1685.6 abB	2694.2 aA	1521.3 bB
Drip		1051.3 aC	2311.1 aA	1771.8 aB	2029.5 aAB	2471.2 aA	1977.7 aAB
CV (%)		17.50					
		Class III (kg ha <sup>-1</sup> )					
		85 DAT	92 DAT	99 DAT	106 DAT	113 DAT	120 DAT
Control <sup>1</sup>		609.7 aC	1461.9 aA	9276. aBC	1123.3 bAB	1488.1 aA	680.1 aC
Foliar		624.6 aD	1025.0 bBC	1020.4 aBC	1300.3 abAB	1556.0 aA	754.0 aCD
Drip		5733. aD	14.762 aAB	1113.1 aBC	1596.5 Aa	1699.4 aA	827.8 aCD
CV (%)		18.15					

\*Means followed by the same uppercase letter in the row and lowercase in the column do not differ by the Tukey test at 5% probability <sup>1</sup> Without application of biofertilizers

These data are important, especially considering that tomato price is determined by their size and quality. Thus, the highest fruit prices (the ones with the absence or few defects) are higher in the market, which can be benefitted by the application of BF, as observed in table 2. According to the experiment, it was observed that foliar and drip application of BF constituted in favorable practice to plants and fruit development consequently noticed by productivity increases.

The elements in foliar application (organic matter, organic carbon, macro and micronutrients), each with their functions in the plant metabolism as well as in the factors favoring nutrient aggregation and protection, proved to be interesting alternatives to tomato management. The research, in this sense, corroborates with Ogbomo (2011), who emphasized optimal growth and yield favored by nutrient supplementation through BF application.

In this way, the organic components present in BF formulation generally have the function of optimizing the

nutrients absorption contained in them, making the foliar fertilization more efficient.

Studies have shown that phosphorus concentration improvement tended to be higher in tomatoes fertilized with an association between organic and chemical fertilizers, due to the synergism between the sources (Tonfack et al., 2009; Mukhomorov et al., 2016). The synergism between the nutrients and the soil and plant dynamics were observed in this work through the response in the production of foliar and drip applications.

Similar results were observed for class II, where distinct productivity was observed at the fourth and sixth week. In them, drip application showed better results than the other treatments (2029.59 and 1977.73 kg ha<sup>-1</sup>, respectively). In all treatments the highest yields were in the second and fifth week (Table 2).

Regarding class III, the highest productivity occurred in the fourth week in drip application. In general, higher and lower productivity were observed in the fifth and first week, respectively (Table 2).

The BF application (foliar and drip) reflected an increased total productivity compared to the control (only mineral fertilizers). When analyzing total production

by classification, it was observed that drip provided a class III increase, which has lower commercial value (Table 3).

**Table 3.** Productivity per class and total (kg ha<sup>-1</sup>) of tomato Alambra and comparative economic analysis, estimated per thousand plants, according to biofertilizer application.

	Total Productivity (kg ha <sup>-1</sup> )		
	Control <sup>1</sup>	Foliar	Drip
Classe I	11105.28 b	13026.57 a	12047.00 ab
Classe II	9386.42 b	10712.28 a	11612.71 a
Classe III	6291.14 b	6280.57 b	7286.57 a
Total (I+II+III)	26782.57 b	30019.57a	30946.57 a
CV (%)	7,88		

  

Application	Gross Income/ 1000 plants	Cost 1000 plants	Cost with fertilizers 1000 plants	Liquid Income
Control <sup>1</sup>	\$ 2018.4	\$ 1162.8	-----	\$ 855.6
Foliar	\$ 2269.5	\$ 1162.8	\$ 48.4	\$ 1058.4
Drip	\$ 2344.5	\$ 1162.8	\$ 19.1	\$ 1162.6

\*\* Means followed by the same letter in the row do not differ by Tukey test at 5% probability <sup>1</sup> Without biofertilizers application

Luz et al. (2010) in a study of the effect of BF on tomatoes Debora Pto also found higher productivity in treatments containing BF. The same researchers, as well as Ogbomo (2011), found that BF application, although more expensive, is viable and profitable.

With the sum of productivity in all harvests, it was observed that, regardless of the application form, the BF provided an increase in productivity with income of 23.69 and 35.88% in foliar and drip application, respectively (Table 3).

It is important to note that the operational cost of fertigation requires a higher initial investment. In addition, some components and nutrients may represent a potential risk of drip obstruction, especially Ca and Mg (Reyes et al., 2008). It is therefore imperative that producers undertake a cost / benefit analysis and evaluate the components that will be used to take the benefits of each technology and management.

Mineral fertilization determines a certain annual variability of yields compared to BF, since organic support provides a steady increase in the evolution of fruit production. The improvement of tomato quality and the preponderance of superior quality classes reflects on the soil-plant system optimization (Heitz et al., 2011). The organic component, as it can be observed in the present work, guaranteed yield and productivity, which corroborates with fruit quality as higher contents of beta-carotene (Lahoz et al., 2016) superoxide dismutase activity and the significant increase in the ascorbic acid contents of mature (Oliveira et al., 2013; Kataok et al., 2017) due to fertilizers organic components.

In a study with cabbage varieties, better yield results were obtained from BF at the gradual supply of N

required by the crop during the whole cycle, first obtained through the rapid mineralization of N from inorganic fertilizers and later by the constant release of N by the fertilizer organic fraction (Carvalho et al., 2014; Olaniyi & Ojetayo, 2011). This attribute is interesting because it emphasizes that the organic components help maintain high fertility for long periods, which is beneficial for crops with indeterminate growth, such as tomato, that need a high nutrient intake because it has a long period of fruit formation and harvest.

Picolli et al. (2009) also observed positive results of BF application in a study with wheat. Olowokere (2014) recommends BF for better pepper production, nutrient composition and soil quality.

The favorable response of BF is related to higher nutritional availability and general conditioning, in relation to soil, water and plant, stimulating plant growth and development (Zandonadi et al., 2014; Prado et al., 2016). Moreover, organic use was considered an efficient way of regulating soil microbial community by promoting beneficial bacteria and suppressing pathogens (Li et al., 2017).

It is observed in the literature contrasting and variable results according to the culture, cultivar, region of cultivation and mainly, regarding the elements involved in the BF used. This reality occurs due to the reactions between the molecules and different metabolic activity, which interacts with the environment and the forms of cultivation, generating effects of synergism or competition among the factors involved.

The BF was considered promising by reducing by 50% the recommended rates of NPK fertilizers to beans, with low nutrition pollutants and health (Rady et al.,

2016). These same authors believe that BF is an urgent requirement to minimize the environmental pollution that has increased because of inadequate agricultural practices.

The answers obtained by the researchers add to the experiences of the producers. Based on the inferences of each analysis, it is possible to construct perspectives and actions towards a more economically, socially and environmentally viable agriculture. BF can be significant as an effective improvement in the physical, chemical and biological soil attributes and quality crop production attributes, as observed in the present study, as well as a way of using residues produced by the agricultural activity, giving better use and purpose for residues.

### Conclusions

The adoption of BF, regardless of the application form, provides an increase in total productivity, with an income up to 35% higher. Therefore, BF is a good source for nutrition implementation aiming at yields and returns in the tomato production chain.

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