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Production of Mini Tomato Seedlings in Biodegradable Foams

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Abstract. The objective of this study was to analyze the influence of different types and fertilizer application in the development of mini tomatoes seedlings (*Lycopersicum* esculentum var. *Cerasiforme*) placed in biodegradable foamed recipients, manufactured with sugarcane fibers, cassava starch and plasticizer. Stalk diameters, seedling heights, quantity of leaves and the physical integrity of packaging at 30, 60 and 90 days after sowing were evaluated. The tomato productivity was significantly increased by the use of fertilizer incorporated into the substrate. This significance was not observed for the seedlings with fertilizer incorporated into the packaging – although, in general, these are higher and have more leaves when compared to those without fertilizer. All packaging remained intact up to 30 days after sowing. From this period on, as expected, the biodegradable packaging began to decompose. However, at 60 days, the tomato seedlings remained intact and suitable for planting in the soil.

INTRODUCTION

Interest in biodegradable packaging development from renewable natural sources is growing due to increased environmental concerns. It is a fact that all the world's cities produce huge amounts of solid waste and that drinking water is becoming progressively scarcer while we continue generating even more wastewater [1]. Among natural polymers, starch has been considered as one of the most promising materials because of the attractive combination of availability, price and performance [2,3]. Cassava (Manihot esculenta), in particular, is an important starch source in some countries like Brazil, which is the largest cassava-producing country [4], as well as in Thailand, Malaysia, Indonesia and some regions of Africa [5]. Starch-based foams can be produced by many techniques, including extrusion or hot mold baking [6-8]. In addition to improving the processability of starch, its mechanical properties can be enhanced by the incorporation of plant-based fibers (kenaf, jute, sisal, coconut, sugarcane bagasse, curauá and jute fibers, or cellulose fibers of wood) to obtain composites called "bio-composites" or "green composites" [9,10]. The use of natural fibers – obtained from agro-industrial or agricultural residues – to reinforce brittle polymers is not only a good alternate application for these agro-products (which would otherwise go to waste), but also clear advantages because of their renewability, abundant availability, biodegradability and relative low cost [11]. Biodegradable foams could have applications in agriculture, for instance, particularly as recipients for planting seedlings. Conventionally, these recipients are made of expanded polystyrene (EPS) and bags are produced using low-density polyethylene (LDPE) films. However, it is well known that the EPS and LDPE are not biodegradable and its recipients and bags are difficult to recycle due to the large amount of organic matter adhered to material [12]. Tomato is one of the most commercially important vegetable crops in Brazil with annual production of approximately 3.2 million tons in 63,000 ha of planted area and average production of 62,470 kg/ha, being the southeast region, mainly the São Paulo and Minas Gerais states the largest producers in the country [13]. In 2010, the tomato worldwide production was about 145 million tons, in an area of more than four million hectares [14]. Among different types of tomatoes, cherry (Lycopersicon esculentum var. Cerasiforme) belongs to a new group of cultivars for table, which has been growing in importance in the major cities`markets. Perhaps the best name for this group was 'mini tomatoes', because there are many materials fleeing the so-called 'cherry tomatoes' standards [15]. Fertilizers are extremely important factors in determining horticultural crop yield, quality and nutritional content [16]. The quality and productivity are influenced by the correct mineral nutrition [17], since the lack or excess of nutrients compromises the plant metabolism [18], directly or indirectly, contributing to changes in growth form, chemical composition, morphology and anatomy [19].The aim of this paper was to analyze the

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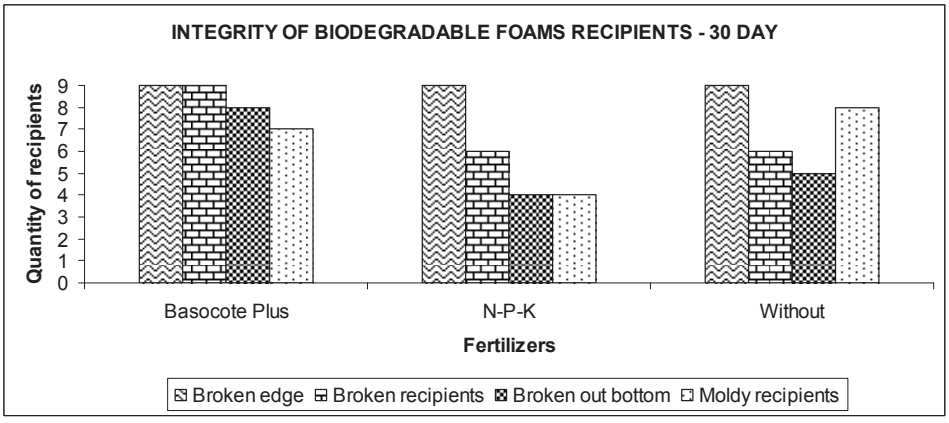
development of mini tomato seedlings (*Lycopersicum* esculentum var. *Cerasiforme*) in biodegradable foamed recipients, manufactured with sugarcane fibers, cassava starch and plasticizer.

EXPERIMENTAL PART

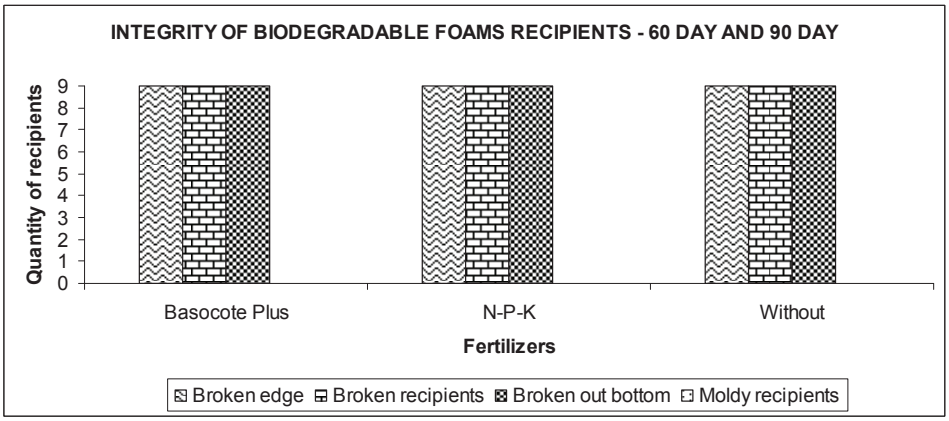
The experiment was performed from October 2014 to January 2015 in a greenhouse at Environmental and Chemical Centre of Nuclear and Energy Researches Institute, São Paulo, Brazil. The greenhouse is 6 m long and 3 m wide with planting area of 6 m^2 and covered with transparent polyethylene film. Four seeds of mini tomato Roxy (*Lycopersicum* esculentum var. *Cerasiforme*), purchased from 'Sementes Sakama', were planted and cultivated in 0.200 L biodegradable foamed recipients which were produced by extrusion and thermopressing from a mixture of sugarcane bagasse and cassava starch, with water and glycerol as plasticizers. All seedlings received equal amounts of substrate, hydrogel, sunlight and water, only differing in the types and fertilizer application. The irrigations were made three times a day through spraying equipment, using mini-sprinklers, and water flow lasting one minute every eight hours. Two different nutrient treatments were carried out for the tomato plants: (1) with 'Basocote Plus' commercial fertilizer which was mixed into the substrate and (2) with NPK 12-5-14 ($(NH_4)_2SO_4$ 12%; $KHPO_4$ 5%; KCl 14%) fertilizer solution incorporated into the biodegradable packaging structure by manual spraying – for comparison, some seedlings did not receive fertilizers. Nine sugarcane bagasse recipients were used for each treatment, totalizing 27 biodegradable packaging in this experiment. Stalk diameters, seedling heights, quantity of leaves and the physical integrity of packaging at 30, 60 and 90 days after sowing were evaluated. The tomato seedlings transplanting was not implemented in this study.

RESULTS AND DISCUSSION

Thirty days after sowing (Fig. 1 (a)), all recipients of each treatment (with and without fertilizer) had its broken edges. All the 9 foams with 'Basocote Plus' mixed in the substrate broke, 8 had their bottom broken out and in 7 of them occurred mold formation. From 9 packages which the NPK fertilizer solution was incorporated, 6 broke and 4 showed mold growth and broken out bottom. From those untreated (without fertilizers), 6 broke, 5 had their bottom broken out and 8 presented mold formation. Therefore, it may be stated that in general, although all recipients of the 3 groups studied in this work undergo physical changes thirty days after sowing, those with NPK fertilizer solution incorporated in its structure were the best maintained their physical integrity, while those which the 'Basocote Plus' commercial fertilizer was added to the substrate were the most damaged. Sixty days after sowing (Fig. 1 (b)) all sugarcane bagasse foams, irrespective of the type and use of fertilizers, totally lost their physical integrity on three of four aspects analyzed in this study (broken edge, broken recipients and broken out bottom), no longer observing mold formation (moldy recipients) - even after 90 days of sowing.



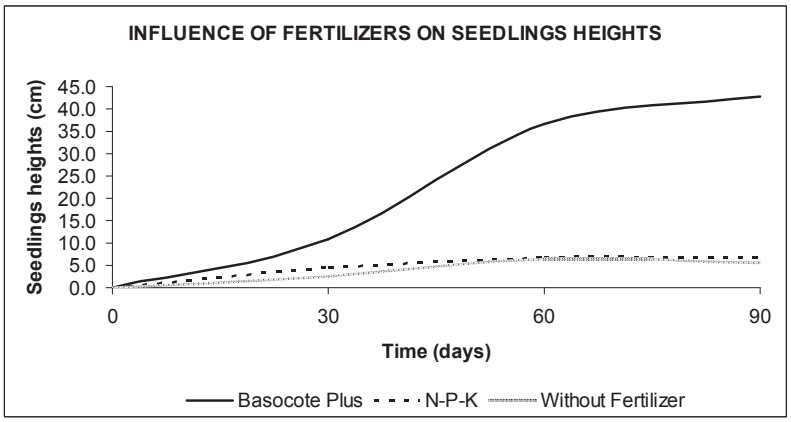
(a)



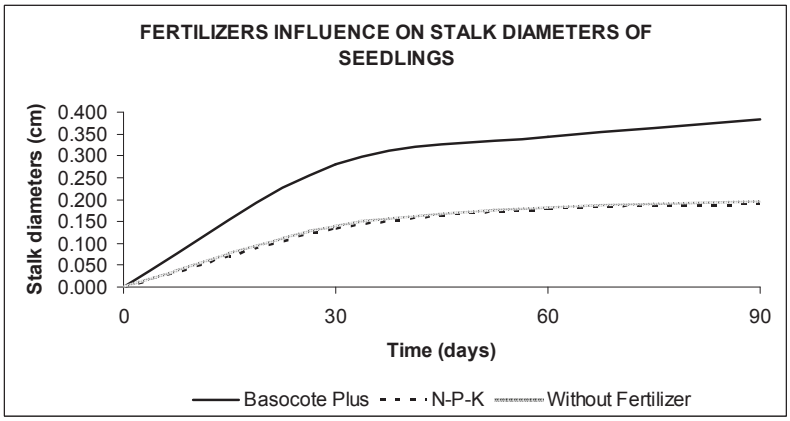
(b)

FIGURE 1. Physical integrity of biodegradable packaging at 30 (a), 60 and 90 (b) days after sowing, with two different nutrient treatments carried out for the tomato plants: (1) with 'Basocote Plus' commercial fertilizer and (2) with NPK 12-5-14 fertilizer solution; and without fertilizers. Nine sugarcane bagasse recipients were used for each treatment.

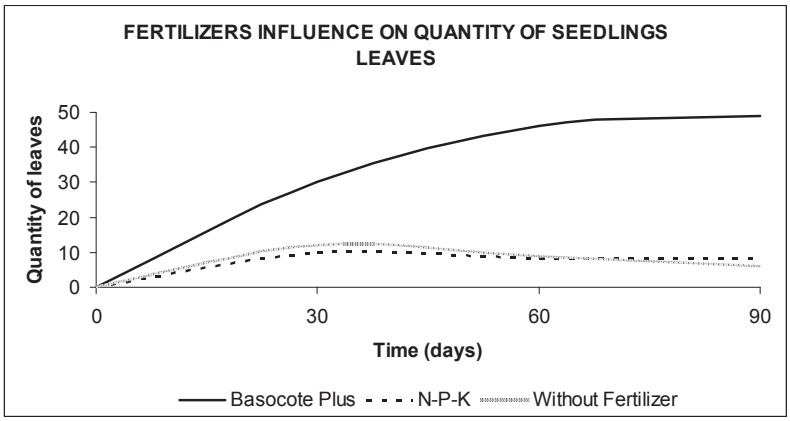
The addition of 'Basocote Plus' commercial fertilizer to substrate caused better and faster tomato seedlings development when compared to plants without fertilizers and those in which their recipients received NPK fertilizer solution (Fig. 2). Analyzing the seedlings heights, stalk diameters and leaves quantities (Fig. 2), plants in recipients containing NPK fertilizer solution and those without any nutrients treatment showed very similar behavior during 90 days of the experiment (after sowing). The mini tomato seedlings height for treatments with 'Basocote Plus', NPK solution and without fertilizers was respectively after (1) 30 days of sowing: 10.8 cm, 4.4 cm and 2.4 cm; (2) 60 days: 36.7 cm, 6.7 cm and 6.5 cm; and (3) 90 days: 42.7 cm, 6.6 cm and 5.6 cm (Fig. 2 (a)). The stalk diameter for "Basocote Plus', NPK solution and without fertilizers was respectively after (1) 30 days of sowing: 0.280 cm, 0.133 cm and 0.140 cm; (2) 60 days: 0.344 cm, 0.180 cm and 0.181 cm; and (3) 90 days: 0.383 cm, 0.191 cm and 0.196 cm (Fig. 2 (b)). The leaves quantity on seedlings to treatments with 'Basocote Plus', NPK solution and without nutrients was respectively after (1) 30 days of sowing: 30, 10 and 12; (2) 60 days: 46, 8 and 9; and (3) 90 days: 49, 8 and 6 (Fig. 2 (c)).



(a)



(b)



(c)

FIGURE 2. Seedling heights (a), stalk diameters (b) and quantity of leaves (c) at 30, 60 and 90 days after sowing, with two different nutrient treatments carried out for the tomato plants: (1) with 'Basocote Plus' commercial fertilizer and (2) with NPK 12-5-14 fertilizer solution; and without fertilizers.

The fact that all foams with commercial fertilizer 'Basocote Plus' mixed with substrate being the most damaged among the studied treatments after 30 days of sowing, may be associated with the elevated and rapid seedlings development – it means, increasing plant structure (height, stalk diameter and root length), more easily this type of packaging will be destroyed. Furthermore, one should take into account the recipients degradation issue. There are no studies that show us fertilizers influence in degradation process of foams made from natural and renewable material, but during this experiment it was observed the sugarcane bagasse recipients decomposition from the thirtieth day test, as a result of the action of living organisms or enzymes. Biodegradation generally allows for cheaper final disposal of plastic waste through composting and returns the polymer into the natural carbon cycle [20].

CONCLUSIONS

The tomato productivity was significantly increased by the use of 'Basocote Plus' commercial fertilizer incorporated into the substrate. This significance was not observed for the seedlings with NPK fertilizer solution incorporated into the packaging. All sugarcane bagasse foams remained intact up to 30 days after sowing. From this period on, as expected, the biodegradable packaging began to decompose and had changed in its physical integrity – especially those with the most developed plants (those with 'Basocote Plus' commercial fertilizer

mixed into the substrate). However, at 60 days, the tomato seedlings remained intact and suitable for planting in the soil.

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REFERENCES

1. L. Carrasco and C. D. Turner. "Evaluation of disinfection techniques in the treatment of advanced primary treated wastewater for Ciudad Juárez, México". Water Environ. Res., **78** (1), pp. 49–58 (2006).
2. H. Abdillahi, E. Chabrat, A. Rouilly and L. Rigal. "Influence of citric acid on thermoplastic wheat flour/poly(lactic acid) blends II. Barrier properties and water vapor sorption isotherms". Ind. Crops Prod., **50**, pp. 104–111 (2013).
3. O. V. López and M. A. García. "Starch films from a novel (Pachyrhizus ahipa) and conventional sources: development and characterization". Mater. Sci. Eng., **32**, pp. 1931–1940 (2012).
4. M. Leonel, S. B. Sarmento, M. P. Cereda and F. L. Cãmara. "Extração e caracterização de amido de jacatupé (Pachyrhizus ahipa)". Ciência Tecnol. Alim., **23**, pp. 362–365 (2003).
5. United Nations Conference on Trade and Development, http://www.unctad.info/en/Infocomm/AACP-Products/COMMODIRY-PROFILE—Cassava/2012. INFOCOMM Commodity Profile: CASSAVA.
6. Y. X. Xu, K. M. Kim, M. A. Hanna and D. Nag. "Chitosan–starch composite film: preparation and characterization". Ind. Crop. Prod., **21**, pp. 185–192 (2005).
7. R. L. Shogren, J. W. Lawton and K. F. Tiefenbacher. "Baked starch foams: Starch modifications and additives improve process parameters, structure and properties". Industrial Crops and Products, **16**, pp. 69–79 (2002).
8. N. Naime. "Embalagens ativas de fonte renovável", Master Thesis, São Paulo University, 2010.
9. L. Avérous and P. J. Halley. "Biocomposites based on plasticized starch. Biofuels, Bioproducts and Biorefining, **3**, pp. 329–343 (2009).
10. A. K. Mohanty, M. Misra and L. T. Drzal. "Sustainable bio-composites from renewable resources: Opportunities and challenges in the green materials world". Journal of Polymers and the Environment, **10**, pp. 19–26 (2002).
11. S. Kuciel and A. Liber-Knec. "Biocomposites on the base of thermoplastic starch filled by wood and kenaf fiber". Journal of Biobased Materials and Bioenergy, **3**, pp. 1–6 (2009).
12. T. G. Oliveira, G. L. A. Makishi, H. N. M. Chambi, A. M. Q. B. Bittante, R. V. Lourenço and P. J. A Sobral. "Cellulose fiber reinforced biodegradable films based on proteins extracted from castor bean (Ricinus communis L.) cake". Industrial Crops and Products, **67**, pp. 355–363 (2015).
13. Instituto Brasileiro de Geografia e Estatística, IBGE, http://www.ibge.gov.br/home/estatistica/economia/pam/2010/PAM2010_Publicacao_completa.pdf , 2011.
14. Food and Agriculture Organization, FAO, http://www.fao.org/statistics/en/ , 2012
15. E. S. Alessi. "Tomate seco obtido por energia solar convencional a partir de mini-tomates congelados". Master Thesis, São Paulo University, 2010.
16. M. C. Martinez-Ballestra, L. Lopez-Perez, M. Hernandez, C. Lopez-Berenguer, N. Fernandez-Garcia and M. Carvajal. "Agricultural practices for enhanced human health". Phytochemical Reviews, **7**, pp. 251–260 (2008).
17. J. L. S. Sasaki and S. Seno. "Importância da adubação na qualidade de algumas olerícolas (alho, cebola, couve flor, pimentão e tomate). In: E. Sá and S. Buzzti. Importância da adubação na qualidade dos produtos agrícolas. São Paulo: Ícone, 1994, pp. 331-343.
18. M. A. R. Alvarenga. "Tomate: produção em campo, em casa de vegetação e em hidroponia". Viçosa: Editora UFV, 2004, pp.302.
19. H. Marschner. "Mineral nutrition of higher plants". London: Academic Press, 1995.
20. M. M. Kamal, D. Habibah A.I.H. and M. K. Mansor. "Characterization of PVOH/Starch Film for use in Agriculture Application". Journal of Applied Science and Agriculture, **10**, pp. 24-28 (2015).