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BAGGING TOMATO FRUITS: A VIABLE AND ECONOMICAL METHOD OF PREVENTING DISEASES AND INSECT DAMAGE IN ORGANIC PRODUCTION

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Abstract

Tomato borers, especially *Tuta absoluta* (Lepidoptera: Gelechiidae), a pest introduced in southern Europe, northern Africa and the Middle East, and diseases can damage tomato (*Solanum lycopersicum*) fruit. This study tested the economic and technical feasibility of bagging tomato fruits clusters during organic production to protect them against insects and diseases. The experiment was randomized complete block (5 blocks) and 5 treatments: bagging with organza fabric, tissue non-tissue (TNT) covering, a micro-perforated plastic, brown paper bags and no bagging (control). Four clusters were bagged/plant at flowering, and evaluated for flower abortion, the total number of fruits set and the number of fruits damaged by insects or diseases during the sampling period. At harvest we evaluated fresh weight, size and color of the fruits and we determined their Brix degrees postharvest. Bagging of fruit with either organza fabric or TNT reduced insect borer damage by 99.7% and disease damage by 84.7%. Bagging fruit did not affect flower abortion, skin color and fruit fresh weight (average of 91.87g), but bagging either with organza or TNT delayed the harvest period by 3 days. About 350% more large fruits were produced either with TNT or organza fabric bags than in the non-bagged control. This difference represents about 30 tonnes/ha, which at an average price for organic tomatoes of US $5.15/kg, resulted in a net return of US $113,161/ha. Bagging of tomato fruit clusters with TNT or organza fabric may be an excellent option to reduce damage by insect borers and diseases for a significant economic gain. Additionally, these 2 bagging materials did not negatively affect the major qualitative and quantitative characteristics of tomato fruit.

Key words: *Alternaria solani*, *Erwinia* spp., *Solanum lycopersicum*, *Tuta absoluta*

Resumen

Barrenadores del tomate, en especial *Tuta absoluta* (Lepidoptera: Gelechiidae), una plaga introducida en el sur de Europa, norte de África y Oriente Medio, y las enfermedades pueden dañar frutos del *Solanum lycopersicum*. Este estudio probó la viabilidad económica y técnica de embolsado de frutos de tomate en cultivo orgánico para protegerlos de insectos y enfermedades. El experimento utilizó cinco bloques completos al azar y cinco tratamientos: embolsado con la tela de organza, no tejido que cubre el tejido (TNT), plástica microperforada, bolsas de papel marrón y no embolsado (controle). Cuatro racimos de frutos fueron embolsados o planta en floración, y se realizó una evaluación de aborto de flores, el número total de frutos producidos y número de frutos dañados por insectos o enfermedades durante el periodo de muestreo. La producción de tomates se evaluó mediante la medición de peso fresco, tamaño, color de la piel y Brix de frutas durante la cosecha. Embolsado de frutos con tela de organza o TNT redujo el daño del insecto barrenador de 99.70% y el daño por la enfermedad 84.73%. Frutos embolsados no afectaron el aborto de las flores, color de la piel y el peso de la fruta fresca (91.87g), pero organza o TNT ensacado retrasaron el período de cosecha por tres días. La producción de frutos más grandes fue de aproximadamente 350% mayor con TNT o bolsas de tela de organza en comparación con el control, o alrededor de 30 toneladas / ha con a un precio medio (tomate orgánico) de US $5.15/kg con un rendimiento neto de US $113,161.41 por hectárea. Embolsado de los racimos de frutos de tomate con TNT o tela de organza es una excelente opción para reducir los daños causados por los barrenadores de insectos y enfermedades con el beneficio económico significativo y no afectó negativamente a las principales características cualitativas y cuantitativas de los tomates.

Palabras Clave: *Alternaria solani*, *Erwinia* spp., *Solanum lycopersicum*, *Tuta absoluta*

Solanum lycopersicum L. (Solanaecae) fruit production is globally important with an annual production of 153 million metric tons with fresh tomatoes representing 75% of this total (FAO 2009). Tomato production requires significant investments with pest control accounting for 40% of the total cost. In Brazil pest control requires as much as 40 spray treatments/crop in the rainy season (Rodrigues Filho 2001). Continued pesticide use may select resistant insects, which can reduce fruit quality, and pesticides can contaminate the environment, the applicator and the consumer if not applied correctly (Picanço et al. 1998, 2007).

Integrated pest management, which involves careful monitoring of pests and the use of natural enemies, can reduce the number of spray treatments needed to control pests and diseases when producing tomatoes (Picanço et al. 2007). Treatments may include selective use of insecticides (Leite et al. 1998), mineral oil as an insecticide (Picanço et al. 1998), more effective and selective compounds (i.e., new insecticides) (Silvério et al. 2009), and plant extracts (Barbosa et al. 2011). Other techniques used to control pests and diseases include vertical staking of plants (Picanço et al. 1996, 1998), greater spacing between plants (Picanço et al. 1998), adequate fertilization (Leite et al. 2003), polyculture (Picanço et al. 1996), crop rotation (Leite et al. 2011) and mating disruption (Welter et al. 2005). Moreover, use of resistance to pests derived from wild tomato species and rustic accessions of *S. lycopersicum* (Leite et al. 1999, 2001; Oliveira et al. 2009), disease resistant varieties (Paula & Oliveira 2003), use of organic substances to attract or repel pests (Leite et al. 2011; Oliveira et al. 2009), natural and applied biological control (Barbosa et al. 2011; Pratissoli et al. 2005; Picanço et al. 2011), fruit bagging (Lebedenco 2006) and organic farming (Mitchell et al. 2007) are technique to control pests and or diseases.

The organic cultivation of tomatoes and other vegetable crops has been increasing approximately 10%/year in the world (Raynolds 2004). Tomato plants that have been well-nourished by organic matter are said to produce healthy fruit with higher dry matter content, flavonoid and ascorbic acid content than in conventional production (Mitchell et al. 2007; Premuzic et al. 1998; Stertz et al. 2005).

Borers and diseases increase production costs of organic tomatoes. These borers in Brazil include *Tuta absoluta* (Meiryck) (Lepidoptera: Gelechiidae), *Neoleucinodes elegantalis* (Guinée) (Lepidoptera: Crambidae) and *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae) (Picanço et al. 1998). The main pathogens affecting tomato plants in Brazil and theirs fruits are *Erwinia* spp. and *Alternaria solani* (Picanço et al. 1998 2007). Infection of tomato fruit by these pathogens occurs mainly because of injuries during crop management and handling and damage by insect borers (Bergamin Filho et al. 1995). Bagging tomato fruit can prevent damage by pests and diseases (Lebedenco 2006).

The use of waxed-paper, translucent plastic bags and tissue non-tissue fabric (TNT) to protect fruit starting when they are small (in general, after its formation) is one of the oldest and most effective control practices. These techniques have been to be effective in preventing attacks by fruit borers in *Annona crassiflora* Mart. (Annonaceae) (Leite et al. 2012), *Malus domestica* Borkh. (Teixeira et al. 2011), *Psidium guajava* L. (Myrtaceae) (Martins et al. 2007; Bilck et al. 2011), *Pouteria caimito* (Ruiz and Pavon) Radlk (Sapotaceae) (Nascimento et al. 2011) and *Mangifera indica* L. (Anacardiaceae) (Graaf 2010).

Bagging is not widely studied and consequently not used for protection of vegetables, but tomato clusters protected with paper exhibited 67% lower infestation rates by *N. elegantalis* compared to non-bagged tomatoes (Rodrigues Filho 2001). Bagging can prevent damage by insects and reduce pesticide use, without interfering with fruit formation and color development (Lebedenco 2006).

The objectives of this study were to evaluate the effectiveness of bagging tomato fruit clusters with 4 types of bagging materials to prevent damage by pests and diseases and to evaluate the economic costs and benefits of this technique in organic tomato production in open fields.

Materials and Methods

The experiment was conducted in the municipality of Montes Claros, Minas Gerais State, Brazil from Jul 2007 to Jan 2008. In Köppen's classification, the climate of this region is Aw-tropical savannah, with dry winters and rainy summers (Vianello & Alves 2000). The weather (Oct 2007-Jan 2008) conditions during tomato production averaged: 26.0 °C, 322 mm of total rainfall, and 52% RH.

The experimental design was a complete randomized block with 5 replications of the following 5 treatments: bagging with organza fabric, TNT, microperforated plastic, and brown paper sacks and no bagging (control). These bags were purchased at a local market. Each plot had 56 tomato plants 'Santa Clara I- 5300' (Santa Cruz group), with 50 plants per plot. The spacing was 0.50 m between adjacent plants and 0.90 m between rows. In Jul 2007, the area was previously cultivated with a mixture of green manures (seeds obtained from the local market): *Crotalaria juncea* L., *Raphanus sativus* L., *Avena sativa* L., *Stizolobium aterrimum* Piper & Tracy, *Canavalia ensiformis* (D.C.) and *Lolium multiflorum* Lam. The green manure seeds were mixed and broadcast sown in the rate of 100 kg ha^{-1}. When about 50% of these cover crop plants were flowering, the area was mowed and plant material was left on the soil until planting the main crop (≈ one month) (Souza 2003).

Tomato seedlings were produced from seeds in paper containers (volume 170 cm^3) with substrate of 1 part of soil and 1 part of cow manure (1:1, v.v–1), irrigated daily in a nursery and protected from aphids by anti-aphid screen. Plants at 25 days after seeding and with the fourth and fifth definitive leaves (fully expanded) were transplanted to the field (Oct 2007). These seedlings were sprayed with Bordeaux mixture (1%) before planting. Two liters of compost and 150 g of rock phosphate were placed in each planting pit (0.20 × 0.20 × 0.20 m) 1 wk before transplanting. The compost was prepared with cattle manure, cotton waste and rice husk (chemical analysis of compost in Toledo et al. 2011). The soil was a eutrophic red latosol and its chemical and physical properties are listed in Table 1.

Plants in the field were cultivated following standard cultural practices for organic tomatoes in Brazil (Souza 2003). Top dressing with a liter of cow manure/plant was done 20 days after transplanting. Foliar fertilization of tomatoes was done with a preventive liquid biofertilizer diluted at 800 mL per 20 L of water, and sprayed weekly until the onset of flowering. The liquid biofertilizer was produced by anaerobically fermenting a mixture of water, cattle manure, raw milk, sugar and micronutrients (copper sulphate, magnesium sulphate, zinc sulphate and boric acid) (Mesquita 2005). Drip irrigation was done in the mornings of alternate days. Plants were trellised with a ribbon. The soil was hilled up with organic compost. Side pruning was carried out weekly after plants reached 0.30 m in height and the apical meristem was pruned after the fourth fruit cluster had set (Picanço et al. 1998).

Insects that transmit viral diseases were controlled starting at the beginning of planting, and defoliators were monitored weekly and treated when their populations reached the threshold with 100 mL of neem oil *Azadiracta indica* A. Juss (Meliaceae)/20 L of water (Fernandes et al. 2005). Diseases were controlled preventively with Bordeaux mixture (2%) at transplantins (Fernandes et al. 2005) and every 21 days. Weeds were controlled by hand hoeing.

Four fruit clusters/plant were bagged in sequence as they flowered and when all flowers

TABLE 1. CHEMICAL AND PHYSICAL ANALYSIS OF SOIL IN THE AREA OF DEPLOYMENT OF THE EXPERIMENT ON PROTECTING TOMATO FRUITS FROM INSECTS AND PATHOGENS BY BAGGING.

Characteristics of soil	Value (00-0.20cm)	Value (00-0.40cm)	Evaluation
PH in water	6.8	7	High
P-Mehlich 1 (mg dm^{-3})	138.9	195.8	Very good
P-residual (mg l^{-1})	28.2	27.4	—
K (mg.dm^{-3})	340.0	240.0	Very good
Ca ($cmol_c$ dm^{-3})	7	5.4	Very good
Mg ($cmol_c$ dm^{-3})	3.8	3.6	Very good
Al ($cmol_c$ dm^{-3})	0.0	0.0	Very low
H+Al ($cmol_c$$dm^{-3}$)	0.76	0.94	Very low
SB ($cmol_c$ dm^{-3})	11.67	9.62	Very good
t ($cmol_c$ dm^{-3})	11.67	9.62	—
m (%)	0.0	0.0	Very low
T($cmol_c$ dm^{-3})	12.43	10.56	Good
V(%)	94	91	Very good
Organic matter (dag kg^{-1})	5.58	4.06	Good
Gross sand (dag kg^{-1})	4	3	—
Fine sand (dag kg^{-1})	42	45	—
Silt (dag kg^{-1})	36	32	—
Clay (dag kg^{-1})	18	20	Average Texture

SB = sum of basis, t = capacity of cationic exchange, m = aluminum saturation in cation exchange capacity; T = cation exchange capacity at natural pH 7.0; V = percentage of soil base saturation of the capacity of cationic exchange a pH 7.0. Gross sand (2-0.2 mm) (dag kg^{-1}), fine sand (0.2-0.02 mm) (dag kg^{-1}), silt (0.02-0.002 mm) (dag kg^{-1}), clay (< 0.002 mm) (dag kg^{-1}).

were open. Bags consisted of organza fabric (30 × 40 cm), TNT (30 × 40 cm), microperforated plastic (40 × 40 cm) or paper (30 × 40 cm). The bags were tied with white cotton string. Flower abortion, total number of fruit, number of fruit damaged by *N. elegantalis*, *H. zea* and *T. absoluta* and symptoms of *Erwinia* spp. and *A. solani* were evaluated weekly. The need to change the bags (torn or punctured) covering the 4 clusters/plant in each treatment was also evaluated weekly.

The mature green and colored fruits were harvested weekly from 4 Dec 2007 to 6 Jan 2008. Fresh fruit weights, size classes and types and the number of defects were determined. Commercial classification of fruit as "extra", "special category I" or "special category II" was made based on the number of defects such as "severe" (rot, damaged by frost or black spot) and "light" (stained, hollow, deformed, and immature), according to Decree Number 553/95 of the "Ministério da Agricultura, do Abastecimento e da Reforma Agrária (MAARA)" and Appendix XVII of the Ordinance SARC 085/02 of the "Ministry of Agriculture, Livestock and Supply-"Ministério da Agricultura, Pecuária e Abastecimento (MAPA)" (Souza 2005).

Soluble solids content (puree) was evaluated with a manual refractometer and the results were expressed in Brix. Fruits were classified by their transverse diam based on MAPA standards: large (> 60 mm), medium (50-60 mm) and small (40-50 mm) (Guimarães et al. 2007). Skin color was classified following Caliman et al. (2003).

Production costs of organic tomatoes were calculated per ha using 50 plants/block, but without considering bunch bagging. The cost of hand labor for bagging was obtained in a field trial with 3 farmers. A worker bagged an average of 600 tomato clusters/day. The production cost of organic tomatoes/treatment was estimated by calculating the gross and net revenue/ha.

Statistical analyses were performed with the statistical system R2.7.1 (R Development Core Team, 2008) and generalized linear models (GLM) were used to test the hypotheses. The data were subjected to Analysis of Deviance (Anodev) to calculate the significance (Nelder & Wedderbrun 1972). The model $y = block + treatments$ was tested per dependent variable (y).

The dependent variables related to the efficiency of bagging in reducing damage by insect borers and diseases of fruits were evaluated by counting lesions on the fruits (percent attacked by *T. absoluta*, *N. elegantalis* and/or *H. zea*), assessing the diseases (percentage of fruit with *Erwinia* spp. and *A. solani*), measuring flower abortion (percentage of aborted flowers) and by fruit classification, i.e., the percentage of small, medium, large, and "extra"-sized fruits.

The probability had a normal distribution for the dependent variable, weight of fruit, which was suitable for continuous data (Nelder & Wedderbrun 1972; Crawley 2007). Differences among treatments were evaluated by contrast analysis for model selection at 5% probability (Crawley 2007).

Results and Discussion

Only 0.3% of fruits bagged with organza fabric or TNT were damaged by the insect borers (*T. absoluta*, *N. elegantalis* and *H. zea*), while (showed 23% of fruit was damaged by them in non-bagged clusters (Fig. 1). Clusters bagged with paper had 7.1% fewer fruits injured by *H. zea*. Non-bagged fruits had a higher proportion of fruit damaged by insect borers: 7.5% by *T. absoluta*, 32.9% by *N. elegantalis* and 28.7% by *H. Zea* (Fig. 1). Serious damage by borers was reduced and higher fruit production with higher quality ("extra" type) was observed in clusters bagged with organza fabric and TNT. This finding agrees with the reduced damage inflicted by *N. elegantalis* on clusters of tomatoes bagged with paper glessine compared to insecticide treatment (Rodrigues Filho 2001). Efficient control resulted from greater protection by bags, which were completely sealed to prevent the penetration of these insects (i.e. oviposition on the fruits). Also, Jordão and Nakano (2002) observed that a protective paper cone open at the bottom reduced damage by *N. elegantalis* by 70%, and that by *H. zea* by 40%, but this type of protection was not effective against *T. absoluta*. The 4% damaged fruit on clusters bagged with paper that we observed was greater than the threshold level for fruit borers of 1% of the fruit being injured (Alvarenga 2004). This level of damage may be the result of the weakness of the paper, especially after rainfall, even when the bags were replaced periodically. Similar results were observed by Leite et al. (2012) with fruits of *A. crassiflora* bagged to protect them against fruit borers; and these authors found that paper bags were destroyed by rain thus allowing a high level of insect damage.

Bagging tomato clusters with TNT showed a greater disease reduction (93.3%) of fruit damage by *A. solani*, followed by tissue organza with 80.9% reduction. Fruit bagged with paper, microperforated plastic bags and non-bagged clusters had higher disease levels. The reduction of disease by *Erwinia* spp. was higher on fruit bagged with TNT and organza fabric, at 86.3% and 78.4% respectively, and lower (47.5%) with microperforated plastic bags (Fig. 1). TNT and organza fabric bags were more effective in preventing diseases by *A. solani* and *Erwinia* spp. because these coverings provided 1) greater protection against the spread of *A. solani* spores, which were mainly spread by wind as well as by splashing with rain and irrigation water (Zambolim et al. 2000); 2) higher gas exchange, avoiding the accumulation of moisture inside bagged clusters; and 3) increased protection against damage by insects, which also

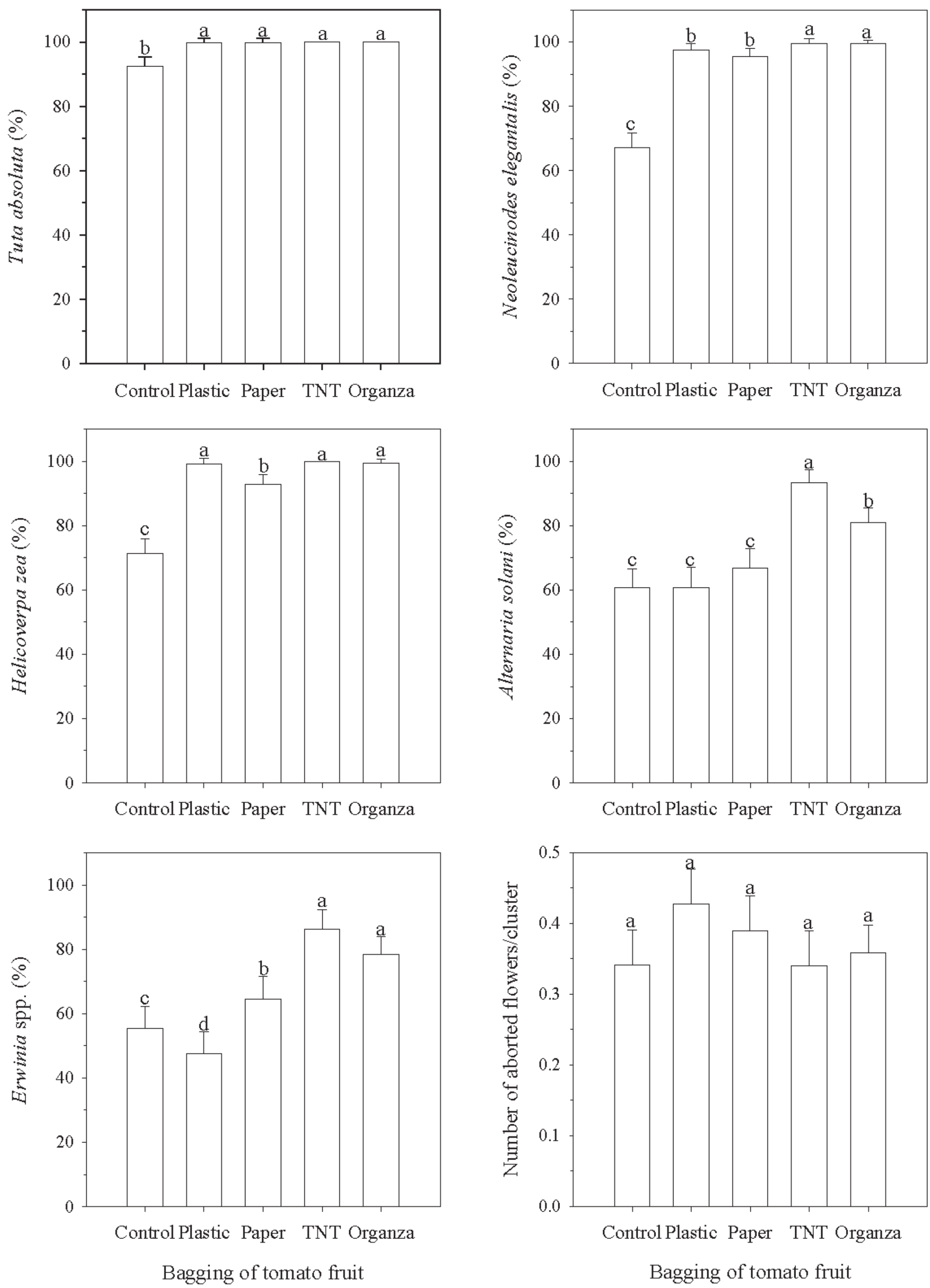

Fig. 1. Percentage of tomato fruit no damaged by *Tuta absoluta*, *Neoleucinodes elegantalis*, *Helicoverpa zea*, *Alternaria solani* and *Erwinia* spp. and number of aborted flowers/cluster in the control and in the treatments either with plastic, paper, TNT or organza bags. Values followed by same letter do not differ by contrast analysis at 5% probability. Bars symbolize upper limit. $N = 50$.

reduced the spread of *Erwinia* spp. (Bergamin Filho et al. 1995). Bagging of guava fruit with paper glessine reduced the incidence of postharvest diseases whose agents penetrate through wounds (Martins et al. 2007). Also, the lower effectiveness of bagging clusters with microperforated plastic against *Erwinia* spp. and *A. solani* shows that this material is inappropriate for organic tomato production. This may be a result of the reduced gas exchange and increased moisture accumulation, which favors the formation of a suitable environment for these pathogens.

The percentage of flowers aborted (average of 0.36%) (Fig. 1) and fresh fruit mass (average of 91.87 g) (Fig. 2) and were statistically similar among all of the treatments. Total number fruits of "extra" size/cluster/plant were similar for clusters bagged with organza fabric (0.97) or TNT (0.95), or 3.88 and 3.80 fruits in the 4 clusters/plant, respectively; while the control (0.45 fruits/bunch/plant) had less than 2 fruit of type "extra"/4 clusters/plant. Fruits bagged with TNT (0.04%) or organza fabric (0.02%) had fewer severe defects than the other treatments (0.12%), while the incidence of fruit with slight damage to fruits (0.04%) was similar among treatments (Fig. 2). Bagged and non-bagged fruit clusters had similar percentages of aborted flowers and similar formation of fresh mass, which suggest that the material of these bags did not affect the tomato fruit formation. Lebedenco (2006) measured similar production rate of fresh mass for bagged and non-bagged tomato fruit (Lebedenco 2006). The average fresh weight/fruit of 91.87 g resulted in a yield of 29.44 tons/ha. Open pollinated tomato lines of oblong type of organic tomato of the Santa Cruz group reached an average yield of 30-40 tons/ha (Souza 2003) with a fruit fresh mass of 80-250 g, suitable for marketing (Alvarenga 2004). The national average of conventional tomato production in the open field is 56 tons/ha. Average fruit weight is important for commercial production and it is an important factor in market competitiveness (Gualberto et al. 2002).

Fruit size differed only for those with medium diam, with the highest percentage (28.4%) for clusters bagged with microperforated plastic (Fig. 3). Clusters bagged with TNT or organza fabric had a higher percentage of "extra" fruit types with large (55.4% and 53.1%, respectively) and medium (19.8% and 17.7%, respectively) diam compared to non-bagged clusters. On the other hand, clusters bagged with microperforated plastic bags or clusters not bagged showed 22.9% and 17.7% large fruits and 11.1% and 6.3% medium fruits, respectively. The percentage of "extra" fruit types with small diam (4.14%) was similar among treatments (Fig. 3). Bagging with either organza or TNT provided more than twice the fruit yield of the control. Tomato fruit classified as "extra" have higher quality and market value (CEAGESP 2000).

Skin color did not differ among treatments (data not shown), with 92% of the fruit having the desired color pattern established by MAPA. The total soluble solids content (Brix) differed among treatments, with similar values for the organza fabric (3.52 °Brix), TNT (3.67 °Brix) and the control treatments (3.83 °Brix), which were higher the other treatments (2.77 °Brix) (Fig. 2). The development of fruit bagged either with TNT (41.03 days) or organza (40.72 days) to first harvest exhibited about a 3.86-day delay compared to the control (37.01 days) (Fig. 2). Similar skin color (= normal production of lycopene), similar Brix degrees and the roughly 3-day delay in starting the tomato harvest either with organza fabric or TNT bagging were important because of the need to maintain the quality (i.e., skin color and Brix degrees). The pattern of ripe tomato fruits and crude soluble solids present ranged from 3.5 to 6.0 °Brix, which showed that bagging fruit either with organza fabric or TNT maintains the proper temperature conditions for producing high quality fruits (Alvarenga 2004).

The economic gain for bagging with organza fabric and TNT was significantly greater than for the other treatments (Table 2). Bagging with TNT or organza yielded increases in profit over the control treatment of 373.7% and 331.4%, respectively. The reuse of organza fabric bags for up to 5 crops can provide an economic gain similar to bagging with TNT (Table 3).

The > 300% increase in production of tomatoes bagged either with organza fabric or with TNT compared to non-bagged clusters offset the higher production cost by lowering losses to insect borers and to diseases. The value of organic tomatoes ranged from US$2.54 to US$7.15/kg and averaged US$5.15/kg compared to an average of US$1.00/kg for conventionally grown tomatoes (Martins et al. 2006) in the consumer markets of São Paulo State, the largest producer of organic vegetables in Brazil (Valarini et al. 2007). The profitability of organic tomatoes in protected cultivation is 59.9% (summer) and 113.6% (winter) with a production cost 17.2% lower than conventional tomatoes (Luz et al. 2007). The lower yield of organic tomatoes (30 tonnes/ha) compared to conventional production (56 tonnes/ha) can be offset by the higher market value of organic fruit, which can be 304% higher than tomatoes grown using conventional techniques. Organic tomatoes bring prices 199% higher than conventionally tomatoes grown, which can more than compensate for the difficulties encountered when producing organic tomatoes and other organic vegetables (Martins et al. 2006). Growing a tomato crop is a high risk enterprise with fruit quality and the market determining the prices. The demand for foods with less risk to human health (Diniz et

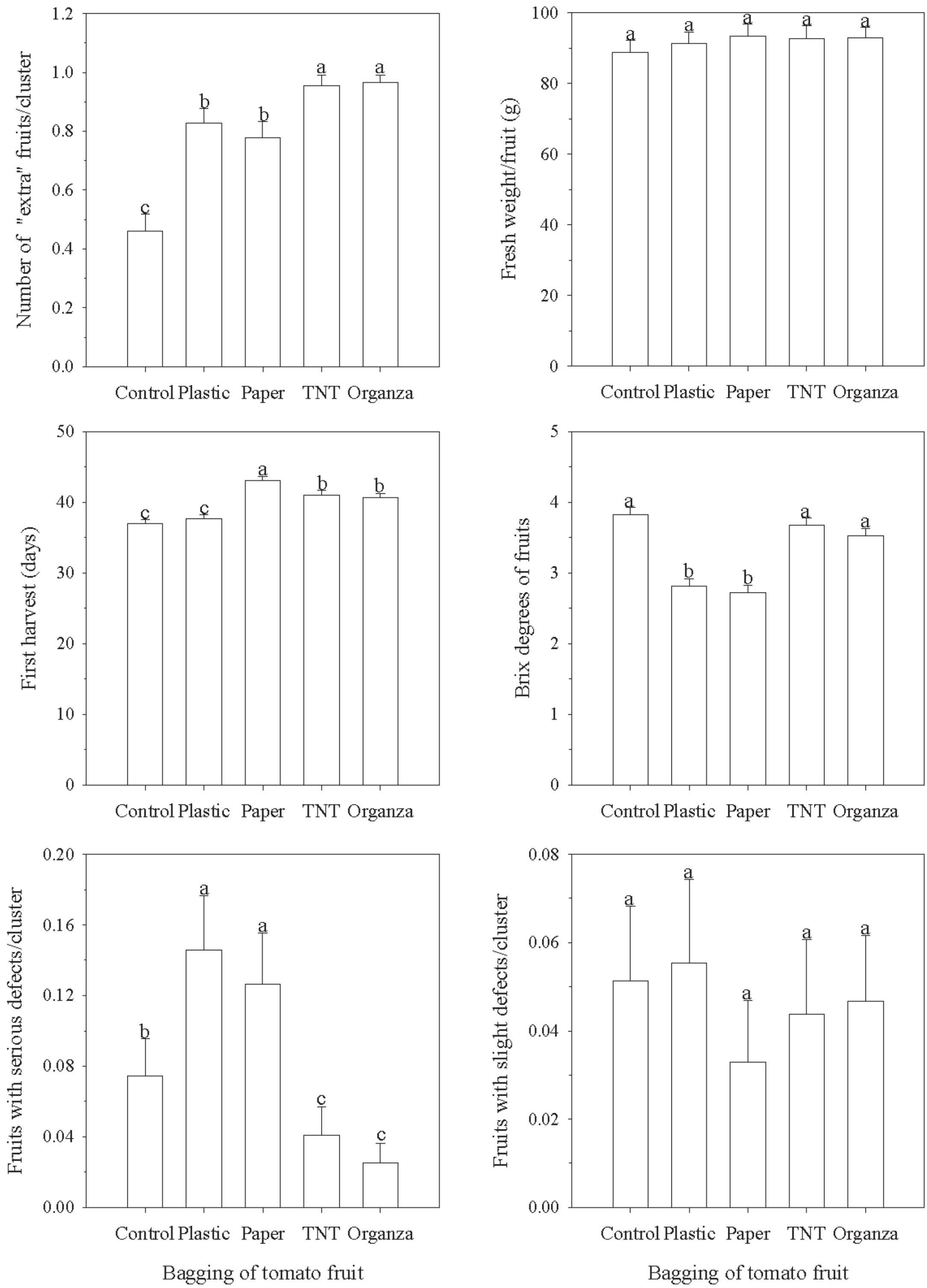

Fig. 2. Numbers of tomato fruit of type "extra"/cluster, average fresh weight of the fruits (g), time from transplanting to first harvest (days), brix degrees/fruit and numbers of severely fruit/cluster, and numbers of lightly damaged fruits/cluster in the control and the treatments with either perforated plastic, paper, TNT or organza bags. Values followed by the same letter do not differ by contrast analysis at 5% probability. Bars symbolize upper limit. $N = 50$.

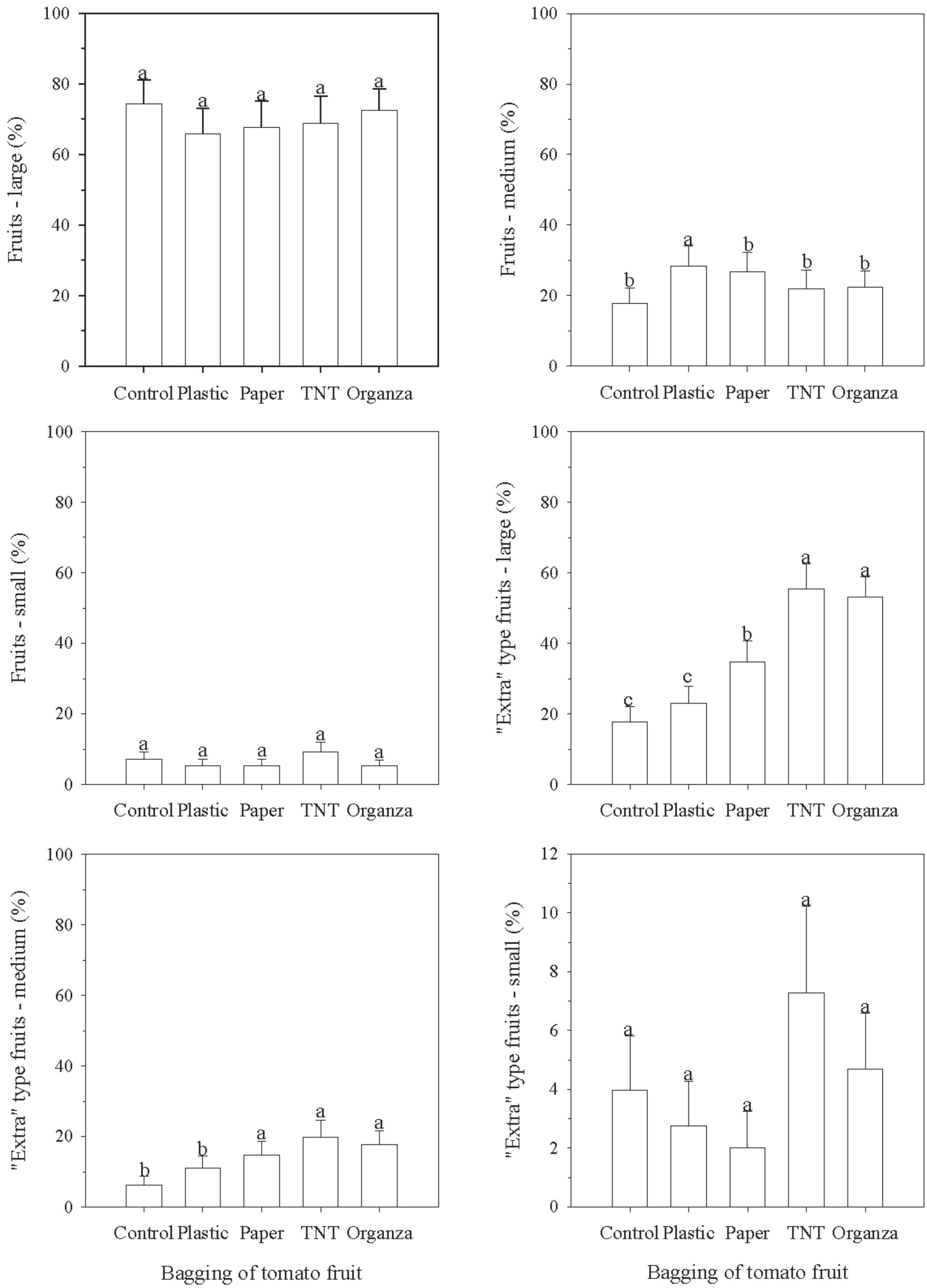

Fig. 3. Percentage of fruits classified as large, medium, small, type “extra” with large fruits, type “extra” with medium fruits and type “extra” with small fruits in the control and in the treatments with either perforated plastic, paper, TNT or organza bags. Values followed by same letter do not differ by contrast analysis at 5% probability. Bars symbolize upper limit. $N = 50$.

TABLE 2. TOTAL COST OF SUPPLIES AND SERVICES (TOTAL COST OF PRODUCTION) AND THE PROFIT FROM BAGGING (PROFIT) FOR THE PRODUCTION (US$) OF ONE HECTARE OF ORGANIC TOMATOES BY BAGGING 4 CLUSTERS OF FRUITS PER TOMATO PLANT.

	Units	US$/unit	Total US$
Total Cost of Production Excluding Bagging Costs			**$17,690**
Bagging: TNT	80,000	0.16	13,078
Operation of bagging	80,000	0.01	1,353
Total cost of production			32,121
Production kg/ha (type extra big)	16,307	7.10	116,556
Production kg/ha (type extra medium)	5,838	5.15	30,078
Production kg/ha (type extra small)	2,146	2.53	5,444
Profit (TNT)			**$119,958 a***
Bagging: organza	80,000	0.20	16,686
Operation of bagging	80,000	0.01	1,353
Total cost of production			35,728
Production kg/ha (type extra big)	15,636	7.10	111,758
Production kg/ha (type extra medium)	5,211	5.15	26,848
Production kg/ha (type extra small)	1,375	2.53	3,488
Profit (organza)			**$106,365 a***
Bagging: Paper	80,000	0.04	3,608
Operation of bagging	80,000	0.06	5,412
Total cost of production			26,709
Production kg/ha (type extra big)	10,210	7.10	72,976
Production kg/ha (type extra medium)	432.79	5.15	22,267
Production kg/ha (type extra small)	597.63	2.53	1,516
Profit (paper)			**$70,050 b***
Bagging: plastic	80,000	0.01	902
Operation of bagging	80,000	0.01	1,353
Total cost of production			19,945
Production kg/ha (type extra big)	6,730	7.10	48,104
Production kg/ha (type extra medium)	3,256	5.15	16,776
Production kg/ha (type extra small)	812.54	2.53	2,061
Profit (plastic)			**$46,996 b***
No bagging	80,000	0.00	0.00
Operation of bagging	80,000	0.00	0.00
Total cost of production			17,690
Production kg/ha (type extra big)	5,217	7.10	37,288
Production kg/ha (type extra medium)	1,852	5.15	9,541
Production kg/ha (type extra small)	1,166	2.53	2,957
Profit (no bagging)			**$32,096 c***

*Values followed by same letter do not differ by contrast analysis at 5% probability.

al. 2006) extends to organically grown tomatoes that may have higher concentrations of flavonoids with antioxidant properties, which can be effective against cardiovascular disease and some types of cancer (Mitchell et al. 2007).

The organza fabric can be reused numerous times, but should be cleaned in water with 1% sodium hypochlorite (Machado et al. 2001). Bagging of tomato fruits with the organza material reused for 5 consecutive seasons can provide an economic gain similar to those of bagging with TNT. In addition to economic profitability, bagging tomato fruits has major environmental benefits.

The bagging of tomato fruits clusters with TNT or organza fabric were more effective in reducing damage by insect borers and diseases than the other bagging treatments and the control. These 2 treatments produced higher number of "extra" grade of fruit, without negative effects on the color of the skin, fresh weight, Brix degrees and flower abortion, thus resulting in higher economic gains.

TABLE 3. TOTAL COST (US$) OF INPUTS AND SERVICES (TOTAL COST) AND PROFIT PER HECTARE FROM BAGGING WITH ORGANZA ESTIMATED ON THE BASIS OF RE-USING THE ORGANZA BAGS FOR 5 CROPPING SEASONS.

	Units	US$/unit	Total US$
Total Cost of Production Except Bagging			**$17,690**
Bagging: organza	80,000	0.10	8,343
Operation of bagging	80,000	0.01	1,353
Total cost of Production			**$27,386**
Production kg/ha (type extra big)	15,636	7.14	111,758
Production kg/ha (type extra medium)	5,211	5.15	26,848
Production kg/ha (type extra small)	1,375	2.53	3,488
Profit			**$114,708**

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