ORGANIC AND CONVENTIONAL TOMATO CROPPING SYSTEMS

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ABSTRACT: Among several alternative agricultural systems have been developed, organic agriculture has deserved increasing interest from. The objective of this paper was comparing both organic (OS) and conventional (CS) tomato cropping systems for varieties Débora and Santa Clara, through an interdisciplinary study. The experiment was set up in a randomized blocks design with six replicates, in a dystrophic Ultisol plots measuring 25 × 17 m. Cropping procedures followed by either local conventional or organic growers practices recommendations. Fertilization in the OS was done with organic compost, single superphosphate, dolomitic limes (5L, 60 g, and 60 g per pit), and sprayed twice a week with biofertilizer. Fertilization in the CS was done with 200 g 4-14-8 (NPK) per pit and, after planting, 30 g N, 33 g K and 10.5 g P per pit; from 52 days after planting forth, plants were sprayed once a week with foliar fertilizer. In the CS, a blend of insecticides, fungicides and miticides was sprayed twice a week, after planting. In the OS, extracts of black pepper, garlic, and *Eucalyptus*; Bordeaux mixture, and biofertilizer, were applied twice a week to control diseases and pests. Tomato spotted wilt was the most important disease in the OS, resulting in smaller plant development, number of flower clusters and yield. In the CS, the disease was kept under control, and the population of thrips, the virus vector, occurred at lower levels than in the OS. Variety Santa Clara presented greater incidence of the viral disease, and for this reason had a poorer performance than 'Débora', especially in the OS. Occurrence of *Liriomyza* spp. was significantly smaller in the OS, possibly because of the greater frequency of *Chrysoperla*. The CS had smaller incidence of leaf spots caused by *Septoria lycopersici* and *Xanthomonas vesicatoria*. However, early blight and fruit rot caused by *Alternaria solani* occurred in larger numbers. No differences were observed with regard to the communities of fungi and bacteria in the phylloplane, and to the occurrence of weeds.
Key words: *Lycopersicum esculentum*, alternative agriculture, biological control

SISTEMAS DE CULTIVO ORGÂNICO E CONVENCIONAL DE TOMATEIRO

RESUMO: Diversos sistemas agrícolas alternativos têm sido desenvolvidos e, dentre eles, a agricultura orgânica tem recebido destaque, despertando interesse por parte dos agricultores. Compararam-se o sistema orgânico (SO) e o convencional (SC) de tomates da variedade Débora e Santa Clara, por meio de um estudo interdisciplinar. O experimento foi conduzido em blocos casualizados com seis repetições, com parcelas medindo 25×17 m, em um Argissolo Vermelho-Amarelo distrófico. Todas as práticas culturais foram realizadas de acordo com as técnicas utilizadas pelos agricultores convencionais ou orgânicos da região. No SO a fertilização foi realizada aplicando, em cada cova, composto orgânico, superfosfato simples e calcário dolomítico (5 L, 60 g e 60 g) e pulverizando biofertilizante duas vezes por semana. No SC, foi utilizado 200 g 4-14-8 (NPK) por cova e, após o plantio, 30 g N, 33 g K and 10,5 g P por cova; a partir de 52 dias após o plantio, as plantas foram pulverizadas com adubo foliar uma vez por semana. No SC, para o controle dos problemas fitossanitários, foram realizadas aplicações de mistura de inseticidas, fungicidas e acaricidas duas vezes por semana. Para o SO o controle foi realizado pulverizando-se extratos de pimenta-do-reino, de alho e de eucalipto; calda bordaleza e biofertilizante duas vezes por semana. O vira-cabeça foi a principal doença do SO, resultando em menor desenvolvimento de plantas, número de inflorescência e produção. No SC, a doença foi mantida sob controle, sendo que a população de tripes, vetor do vírus, ocorreu em níveis inferiores que no SO. A variedade Santa Clara apresentou maior incidência da virose e, por esse motivo, teve desempenho inferior à Débora, especialmente no SO. A ocorrência de *Liriomysa* spp. foi significativamente menor no SO, possivelmente devido à maior freqüência de *Chrysoperla*. O SC apresentou menor incidência de manchas foliares causadas por *Septoria lycopersici* e *Xanthomonas vesicatoria*, entretanto a pinta preta e a podridão de frutos causados por *Alternaria solani* ocorreram em maiores proporções. Não foram observadas diferenças quanto às comunidades de fungos e bactérias do filoplano e quanto à ocorrência de plantas invasoras.
Palavras-chave: *Lycopersicum esculentum*, agricultura alternativa, controle biológico

INTRODUCTION

The society has been increasingly concerned about environmental damage caused by agricultural activities, especially with regard to health hazards resulting from the use of agrochemicals. On the other hand, growing phytosanitary problems and ever-increasingly depauperate soils lead to an all time high utilization of these products. Sustainability of conventional agriculture started being questioned, and the agricultural scene experienced changes (Van Bruggen, 1995). The emergence of market segments interested in differentiated products lead farmers to search for alternative cropping systems, enabling the production of food crops at lower environmental and economic costs.

Many alternative cropping systems have been developed and, among them, organic agriculture has been established and certified in many countries. Organic agriculture is characterized by the absence of synthetic fertilizers and pesticides, in addition to the frequent utilization of organic matter sources to maintain soil fertility (Stanhill, 1990; Van Bruggen, 1995).

The adoption of the new practices brought, however, the need for comparison between low-input against conventional systems. In addition, recovering the principles and mechanisms that operate in the nature to be utilized as replacement for the traditional input, will only be achieved if a broad base of knowledge of the complex relationships between organisms and their relationship with the environment is available (Edwards, 1989; Ghini & Bettiol, 2000). To that effect, interdisciplinary studies are needed to verify whether or not the sustainability of the agroecosystems can be achieved. Although the development of ecologically sound agriculture systems is rapidly emerging as a priority, few research papers have detailed the effects and interactions of the new proposed practices.

Tomato cropping is an excellent model for comparisons between the conventional and the organic systems for reasons like the intense use of agricultural input and the risk of contamination of consumers, farmers and ground water by agrochemicals (Drinkwater et al., 1995). In an interdisciplinary study, Drinkwater et al. (1995) evaluated several agronomical and ecological indicators in the organic and conventional tomato cropping systems in California (USA), and concluded that biotic agents are essential to make up for the absence of synthetic input. However, the involved mechanisms are much more complex than a mere replacement. For example, soil fertility management practices affected C and N dynamics and, as a consequence, also affected pathogen-host relationships and plant-herbivores interactions through community level mechanisms.

Creamer et al. (1996) compared in two locations the conventional, integrated, organic and no-input systems tomato cropping systems; the last three systems were associated to a cover crop. The number of fruits and flower clusters were higher in the conventional system during the initial assessments, becoming equivalent to the other systems later. No differences were observed with regard to the occurrence of pests and diseases among the treatments. In one of the regions, there was greater accumulation of plant dry matter and higher tomato yield in the conventional system than in other treatments, which represented greater economic gain. In the other region, however, no differences were observed among the systems. The differences between regions were associated with soil type and climate and, demonstrated the need for more studies to be carried out under different conditions.

The objective of this work was to compare organic and conventional tomato cropping systems, by evaluating plant development, occurrence of diseases and weeds, microorganisms and arthropods in the phyllosphere, and tomato yield.

MATERIAL AND METHODS

Trial setup

The experiment was carried out in Jaguariúna, SP, Brazil (22º 41' S, 47º W; altitude 570 m), on a dystrophic Ultisol, with the following chemical properties at the 0-20 cm topsoil layer, before liming: pH ($CaCl_2$ - 0.01 mol L^{-1}) 4.4; OM 6 g kg^{-1}; P (resin) 1 mg dm^{-3}; K 0.5; Ca 7; Mg 7; H + Al 28; CEC 43 and S 15 mmol dm^{-3} of soil; and V 35%.

The experiment was set up in a randomized blocks design, with six replicates, in plots measuring 25 x 17 m. Tomato planting pits were spaced 0.5 m with 1.20 m between rows. Each plot was split into two halves, the first half planted with variety Débora and the other planted with variety Santa Clara. Therefore, each of the twelve rows contained 17 planting pits per variety. The edging between plots was 10 m wide and planted with sorghum. Two tomato plants were transplanted per pit. The tomato crop was grown using the stake system, with one or two stems per plant. The number of stems was determined based on the successful establishment of seedlings. Furrow irrigation and plant pruning were performed as often as necessary.

The entire area received lime at 4.2 t ha^{-1} and 2 kg m^{-1}, 110 and 12 days before planting, respectively. Fertilization in the organic system was done with 2.5 L of organic compost (pH=6.4; C=29.6%; N=1.6%; P_2O_5=1.8; K_2O=0.17% and U=25.3%) plus 130 g of single superphosphate per pit; additionally, 2.5 L of organic compost, 60 g of single superphosphate, and 60 g of dolomitic lime per pit were applied as sidedressing; plants were sprayed twice a week with biofertilizer (Bettiol et al., 1997), at concentrations of 5 or 10%. In the conventional system, fertilization consisted of 200 g 4-14-8

(NPK) per pit and, after planting, a sidedressing application of 30 g N, 33 g K and 10.5 g P per pit from; 52 days after planting forth, plants were sprayed once a week with 3 mL L^{-1} foliar fertilizer [5-8-0.5 (NCaB)].

In the conventional system, 0.15 g of active ingredient of the insecticide carbofuram was applied per pit before planting. According to procedures utilized by conventional local farmers, a blend of insecticides, fungicides and miticides was sprayed twice a week, after planting. The following fungicides were applied at the rates recommended by the manufacturers: 1g L^{-1} metalaxyl + mancozeb at 2, 9, 41, and 78 days after planting (dap); 1 g L^{-1} of mancozeb at 4, 20, 27, 34, 44, 55, 66, 73, 83, 93, 103, and 120 dap; 2 g L^{-1} copper oxychloride at 6, 16, 24, 34, 41, 64, and 71 dap; 1 mL L^{-1} chlorothalonil at 13, 20, 30, 41, 52, 57, and 69 dap; 1 mL L^{-1} of kasugamicine 27, 36, 52, 57, 73, 80, 87, 93, 103, and 120 dap; 2 mL L^{-1} chlorothalonil + thiophanate-methyl at 38 dap; 2 mL L^{-1} thiophanate methyl at 44, 50, 60, and 66 dap; 0.7 g L^{-1} benomyl at 50, 64, 80, 91, and 106 dap; 1.5 g L^{-1} iprodione at 69, 78, 91, 104, and 120 dap; 2 g L^{-1} cuprous oxide at 36, 48, 57, 78, 87, 93, 103, and 120 dap; and 1.5 g L^{-1} cymoxanil + maneb + monohydrate zinc sulphate at 106 dap (Kimati et al., 1997). The following insecticides and miticides were applied at the rates recommended by the manufacturers: 1 g L^{-1} acephate at 4, 9, 30, 36, 48, 55, 64, 69, and 120 dap; 0.5 mL L^{-1} deltamethrin at 6, 22, and 38 dap; 1 mL L^{-1} methamidophos at 13, 24, 34, 41, 52, 60, and 66 dap; 1 mL L^{-1} permethrin at 17, 27, 34, 44, 52, 57, 73, 80, 91, and 98 dap; 1 g L^{-1} cartap at 22 and 38 dap; 0.5 mL L^{-1} lambdacyhalothrin at 78, 93, and 106 dap; 1 mL L^{-1} methomyl at 87, 93, and 104 dap; and 0.2 mL L^{-1} avermectin at 17, 24, 36, 44, 55, 60, and 73 dap (Compêndio de Defensivos Agrícolas, 1990).

Extracts of black pepper, garlic and *Eucalyptus*; Bordeaux mixture, and biofertilizer were applied twice a week (Bettiol et al., 1997; Abreu Jr., 1998) to control diseases and pests in the organic system, according to the program adopted by organic producers in the region. The biofertilizer was produced in a 200-L metal barrel, by mixing 40 L of cow manure, 80 L of water, 1 L of cow milk, and 1 L of molasses. The mixture was shaked and fermented by three days. After this period, one of the following salts was added each three days: $ZnSO_4$ (3 kg), $MgSO_4$ (1 kg), $MnSO_4$ (0.3 kg), $CuSO_4$ (0.3 kg), $CaSO_4$ (2 kg), and borax acid (l kg). At the end of the additions, the volume was completed to 180 L and fermented by another 30 days. After filtered, the biofertilizer was sprayed at 10% concentration. The Bordeaux mixture was produced with 1 kg of $CuSO_4$ and 1 kg of quicklime in 100 L of water. The Bordeaux mixture was prepared for each spray. The garlic and black pepper extracts were prepared by adding 100 g of either garlic to black pepper in 1 L of ethanol, followed by one week of rest. The extract of *Eucalyptus citriodora* was prepared by solving the essential oil obtained by destilation on ethanol. All extracts were applied twice a week in mixture with biofertilizer at a concentration of 1 L 20 L^{-1}.

Weed control was carried out by mechanical weeding and with the herbicide glyphosate (directed spray) on post-planting in the conventional system, and with mechanical weeding in the organic system.

Plant development

Plant height and number of flower clusters were assessed biweekly, in 20 plants of each variety per plot.

Plant diseases

Plants presenting spotted wilt (*Tospovirus*) symptoms were counted in each plot, and 80 days after planting the evaluation was carried out separately for each variety. The severities of leaf spot by *Septoria lycopersici* and bacterial spot caused by *Xanthomonas vesicatoria* were evaluated with the aid of a note scale, adapted from Moretto et al. (1993), where: 1 = 0%; 2 = 2.5%; 3 = 12%; 4 = 25%; and 5 = 50% of infected leaf area. Eight plants of each variety were evaluated per plot, and eight leaflets of each plant were evaluated per disease. The evaluation of early blight caused by *Alternaria solani* was performed by counting the number of lesions per leaflet, in the same sampling. The fruit rot caused by *A. solani* was evaluated by determining the percentage of infected fruits in 24 plants of each variety per plot. The incidence of *Verticillium* in the tomato plants was evaluated during the entire crop cycle by observations of the occurrence of wilt symptoms, and at 128 dap, by observing vascular discoloration through transversal and longitudinal cuts in 50 plants of each variety, per plot.

Phyllosphere microorganisms

The communities of filamentous fungi, yeasts and bacteria in the tomato plant phyllosphere were evaluated throughout the crop cycle. The leaflet area was determined and then extraction was performed through a sonication bath for 10 min, in sterilized buffer solution plus Tween 20 (0.1 mL L^{-1}). This suspension was serially diluted (1:10) and 0.1 mL aliquots were transferred to selective culture media. Martin's medium was utilized for the fungi, and the bacteria were grown on nutrient agar plus nystatin (42 mg L^{-1}).

Phyllosphere arthropods

The evaluation of mite, aphid (Hemiptera: Aphididae), thrips (Thysanoptera: Thripidae) and *Chrysoperla* (Neuroptera: Chrysopidae) communities in tomato plants was done by randomly collecting 25 leaves per plot, in a zigzag route. Frequencies of occurrence of individuals in the adult and immature stages were recorded.

The presence of *Liriomyza* spp. was also recorded during plants initial growth period. The evaluations included the type and severity of the lesions caused by the miner. With regard to type of lesion, leaves were considered as attacked or not attacked. Among the attacked, leaves were considered as perforated, perforated with mines, and leaves bearing pupae, so as to allow insect development, as well as the efficiency of control methods and the action of natural enemies, to be monitored along the crop cycle. After the evaluations, leaves were kept in observation for the emergence of natural enemies. With regard to the severity of lesions, a note scale was utilized, according to the intensity of attack by the insect, as follows: 1 = leaf without lesions (0% of leaf area attacked); 2 = leaf slightly attacked (less than 40%); 3 = considerable attack (40 to 60%); 4 = leaf very attacked (more than 60%); 5 = leaf completely attacked (100%). Incidence of small and large fruit borer was evaluated as refused, attacked fruits.

Weeds

The weed propagule bank was initially evaluated by collecting soil samples from the plots before the beginning of the experiment. Sampling was performed by randomly collecting ten, 0.5-L soil samples per plot, at a depth of 0-20 cm. The dry soil was crumbled and passed through sieves with different meshes. Weed seeds and bulbs were identified and counted.

To study the effects of the planting systems on the community structure and on the population dynamics of weeds, another evaluation was carried out at harvest. A sampling frame measuring 0.5×0.5 m was thrown on the four central rows of each plot, three times per row. Collected weeds were then identified, counted and evaluated with respect to dry weight.

Yield

Yield was evaluated through the harvesting of fruits from the eight central rows in the plots, with 10 pits harvested per variety. The tomatoes were classified as refuse or marketable, respectively, whether the fruits presented or not defects.

Statistical analyses

All statistical analyses were performed using SAS procedure (SAS Institute, Cary, NC) for analyses of variance. Means were compared by Tukey´s multiple range test.

RESULTS AND DISCUSSION

Both varieties had better development in the conventional system, and differences were significant ($P < 0.01$) after 80 days from planting (Table 1). Sixty six dap, variety Débora presented better development than ‘Santa Clara’ in both cropping systems, but the difference was more conspicuous in the organic system. A similar tendency was observed in the evaluation of the number of flower clusters (Table 1).

Spotted wilt was the most important disease occurring in the crop. The occurrence of disease was higher in the organic system along the crop cycle. In the conventional system, the virus disease was maintained under control with a maximum incidence of 52 diseased plants per plot, whereas in the organic system there were, on average, 500 diseased plants per plot (Figure 1). The small reduction in the occurrence of spotted wilt in the organic system, verified between 36 and 45 days after planting, resulted from the replanting of depauperate diseased seedlings. The intense dissemination of the disease in the organic system was due to the thrips population, larger than in the conventional system (Figure 2). Since no efficient alternative method could be utilized for control of thrips during the conduction of the experiment, the disease became a limiting factor in the organic system.

In the organic system, incidence of plants with spotted wilt was higher for variety Santa Clara (Figure 1). For this reason, smaller plant development was observed for variety Santa Clara 66 dap, especially in the organic system (Table 1).

The *S. lycopersici* leaf spot occurred in greater proportions in the organic system during the whole cycle,

Table 1 - Plant height and number of flower clusters of tomato plants of varieties Débora and Santa Clara, in the organic and conventional cropping systems.

Days after planting	Conventional		Organic	
	'Débora'	'Santa Clara'	'Débora'	'Santa Clara'
	Plant height			
	---------- cm ----------			
35	42.72 aA[1]	37.57 aA	38.90 aA	33.49 aA
51	75.67 aA	64.29 aA	68.40 aA	57.89 aA
66	125.19 aA	105.96 aB	115.18 aA	87.27 aB
80	164.59 aA	134.28 aB	142.73 bA	89.73 bB
94	184.37 aB	154.22 aB	157.73 bA	85.67 bB
113	196.20 aA	161.77 aB	160.22 bA	89.71 bB
	Number of flower clusters			
43	2.28 aA	2.34 aA	2.19 aA	2.18 aA
58	4.21 aA	3.83 aA	4.05 aA	3.61 aA
73	5.99 aA	5.50 aA	5.79 aA	4.93 aB
90	7.73 aA	6.38 aB	6.65 bA	4.13 bB
105	7.58 aA	6.63 aB	6.29 bA	3.82 bB

[1]Means of six replicates per plot, with 20 plants evaluated per replicate. Means followed by the same regular letter do not differ for comparison of cropping systems, within varieties and periods after planting by Tukey test at 1%. Means followed by the same capital letter do not differ for comparison of varieties, within cropping systems and periods after planting by Tukey test at 1%.

but no differences occurred between varieties (Table 2). The organic system also showed higher severity of leaf spot caused by *X. vesicatoria* (Table 2). On the other hand, early blight caused by *A. solani* ordinarily occurred

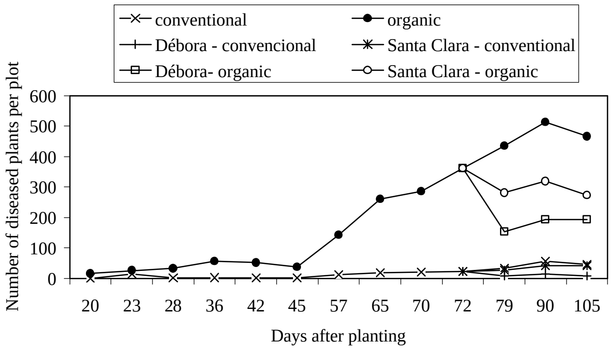

Figure 1 - Mean number of tomato plants with spotted wilt per plot. of varieties Débora and Santa Clara. in the organic and conventional cropping systems.

Table 2 - Severity of leaf spot caused by *Septoria lycopersici*, early blight and fruit rot caused by *Alternaria solani* and bacterial spot caused by *Xanthomonas vesicatoria* in tomato plants of varieties Débora and Santa Clara, in the organic and conventional cropping systems.

Days after planting	Conventional		Organic	
	'Débora'	'Santa Clara'	'Débora'	'Santa Clara'
	Leaf spot caused by *Septoria lycopersici* [1]			
86	1.14 b	1.11 b	2.69 a	2.72 a
93	1.26 b	1.16 b	3.06 a	2.64 a
107	2.12 b	1.93 b	3.25 a	-[2]
114	2.77 b	3.12 ab	3.70 a	-
	Early blight caused by *A. solani* [3]			
86	2.78 a	1.53 ab	0.19 b	0.10 b
93	3.63 a	2.35 ab	0.04 b	0.35 ab
107	5.37 a	5.17 a	0.16 b	-
	Fruit rot caused by *A. solani* [4]			
120	40.00 a	34.68 a	1.21 b	-
	Leaf spot caused by *X. vesicatoria* [1]			
120	1.90 b	1.86 b	3.15 a	-

[1]Severity evaluated by note scale (Moretto et al., 1993), where note 1 = 0%; note 2 = 2.5%; note 3 = 12%; note 4 = 25% and note 5 = 50% of infected leaf area; mean of six replicates consisting of eight leaflets from eight plants. Means followed by the same letter do not differ, within each evaluation period by Tukey test at 1%.
[2] - = Plants killed by spotted wilt.
[3]Mean number of lesions per leaflet, evaluated in six replicates consisting of 8 leaflets from 8 plants. Means followed by the same letter do not differ, within each evaluation period by Tukey test at 1%.
[4]Mean percentage of diseased fruits in six replicates, where each replicate consisted of 24 plants. Means followed by the same letter do not differ by Tukey test at 1%.

with lower intensity in the organic system, and no differences were observed among varieties. Fruit rot had greater incidence in the conventional system. This difference resulted from the fact that in the conventional system the amount of fruits was much greater, and the crop was at the end of the cycle, therefore with a higher incidence of diseases. For variety Santa Clara, in the organic system, the evaluation of those diseases was impaired because many plants died from spotted wilt. No occurrence of *Verticillium* wilt was observed along the crop cycle, and no plants showing vascular discoloration were observed by the end of the assay.

Abbasi et al. (2002) stated that composts incorporated to the soil in the organic system could induce suppression of foliar diseases, in addition to a proven effect upon soilborne pathogens, since it was verified a reduction in the severity of anthracnose fruit rot of tomatoes grown in the organic system, as occurred in this work with fruit rot caused by *A. solani*. However, the composts did not control other diseases. Still according to these authors, this effect can be temporary and insufficient for an adequate control, depending on the inoculum pressure and the presence of a favorable environment for occurrence of diseases. In a comparative study, Van Bruggen (1995) concluded that root diseases and pests are usually less or similarly severe in the organic system, while some leaf diseases are more and others are less severe. According to the author, the reason is a greater influence of climatic conditions than the interactions with antagonists in the phylloplane on leaf diseases, typical case of pathogens disseminated by the soil. In addition, it is harder to control leaf diseases through biological or cultural methods, than it is to control root diseases.

No differences were observed among fungi and bacteria communities in the phyllosphere of tomato plants (data not presented). Even though biofertilizer was used in the organic system, the microbiota was not stimulated, possibly because of the application of Bordeaux mixture, which has a broad-spectrum effect and could have eliminated a significant fraction of microorganisms. This result should be taken into consideration when microbial balance is sought in organic systems, via stimulation of natural, biological control of plant pathogens.

The aphid and thrips communities were higher in the organic system along the crop cycle (Figure 2). On the other hand, the occurrence of *Liriomyza* spp. was higher in the conventional system, in all evaluations, resulting in greater percentage of leaves with perforations, mines, and higher attack severity notes. The lower incidence of *Liriomyza* spp. in the organic system is possibly resulted from the higher frequency of *Chrysoperla* in the phyllosphere (Figure 2), which could have maintained the balance between populations. Drinkwater et al. (1995) also observed that the community of natural enemies, predators and parasitoids of pests was higher in organic

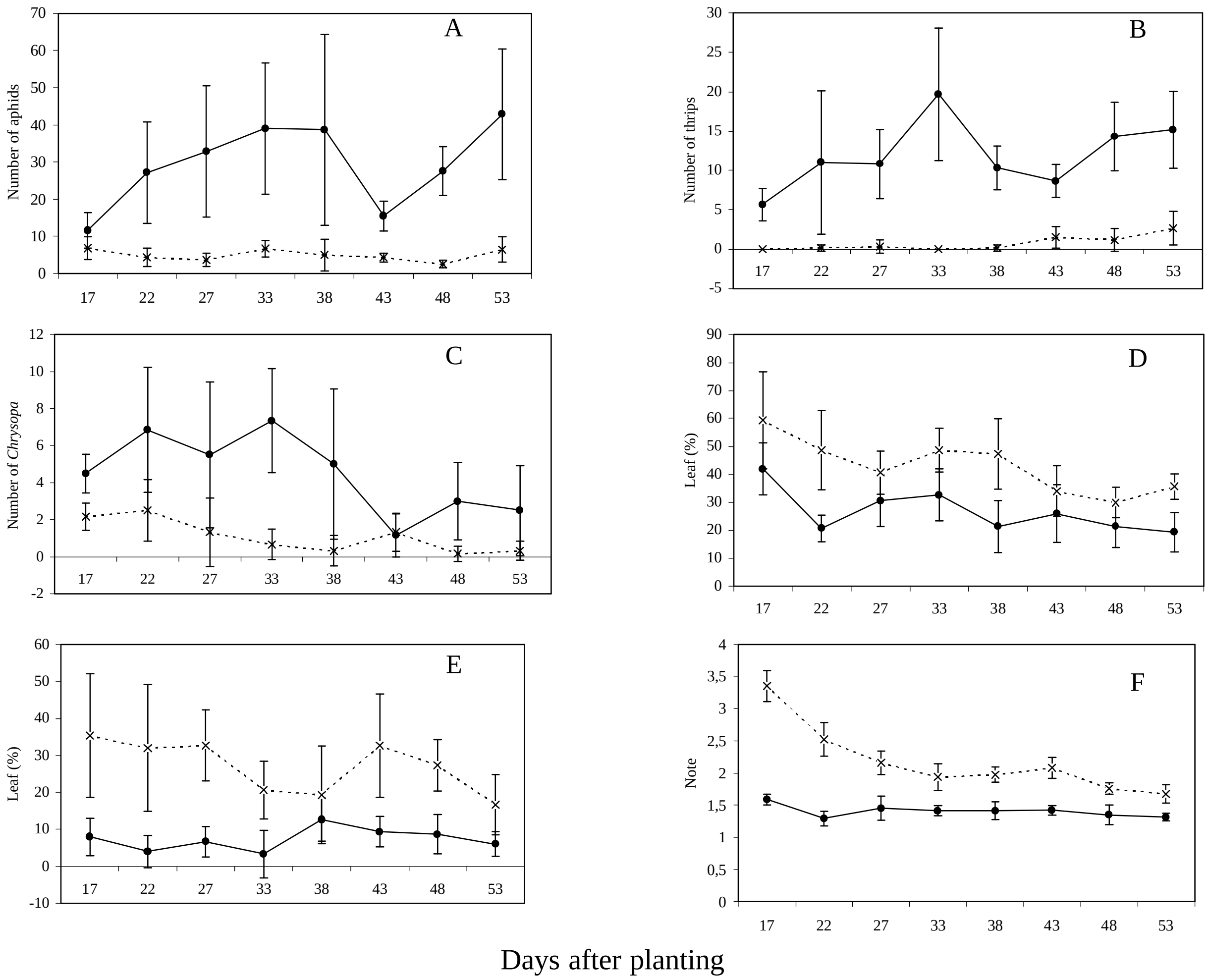

Figure 2 - Communities of (A) aphids. (B) thrips and (C) *Chrysoperla* in the phyllosphere of tomato plants, percentage of leaves with (D) perforations and (E) mines of *Liriomyza* spp.and (F) severity of lesions by *Liriomyza* spp. in the organic (—) and conventional (----) cropping systems. Bars represent the standard deviation of means.

tomato production system in California (USA), which ensured pest control; same is true for Lockeretz et al. (1984) regarding organically grown maize.

There were no problems with other pests as white fly, catterpilars, and *Tuta absoluta*. Catterpilars were controlled by pest management in both systems and white fly and *T. absoluta* did not occur in the region during the experiment.

Before the beginning of the experiment, seeds of *Digitaria horizontalis* were predominant in the propagule bank of soil weeds (Table 3). At harvest time, the separately-run statistical analyses for the grouped broad and narrow leaves, and for the total weed value, revealed no significant differences between cropping systems for the variables evaluated (Table 3).

On average total tomato yield in the organic system represented 36.5% of the yield in the conventional system, while the marketable fruit yield was 36.0% (Table 4). Lower yields were also obtained in other papers that compared organic with conventional system (Lockeretz et al., 1984; Gliessman et al., 1990; Creamer et al., 1996). However, Stanhill (1990) and Drinkwater et al. (1995), after detailed survey in properties that adopt both systems, concluded that this is not always the case, and that other factors have a greater effect on yield than the techniques that set the difference between the organic and the conventional system, such as soil type and fertility, water availability, cultivar, and climate.

Tomato spotted wilt was the most important disease in the organic system, resulting in smaller plant development, number of flower clusters and yield. In the conventional system, the disease was kept under control, and the population of thrips, the virus vector, occurred at lower levels than in the organic system (Table 1 and Figure 1). Variety Débora presented superior yield relatively to 'Santa Clara', in both cropping systems. However, in the organic system, the effect of varieties was more pronounced, since 'Santa Clara' yielded 23.5% of the conventional, while organic 'Débora' yielded 51.5% of the same variety in the conventional system. This is

Table 3 - Number of propagules, density and dry weight of weeds, in the organic and conventional tomato cropping systems.

Specie	Number of propagules[1]		Density[2]		Dry weight [2]	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
			---------- plants m^{-2} ----------		----------- g m^{-2} -----------	
Amaranthus deflexus	60.7[1]	60.3	7.3[2]	6.0	9.4[2]	26.0
Bidens pilosa	13.3	15.7	7.7	33.3	10.7	18.4
Brachiaria plantaginea	16.4	10.0	13.4	10.9	70.6	66.4
Cyperus rotundus	40.0	41.0	11.3	53.2	3.0	10.3
Digitaria horizontalis	421.7	529.0	75.0	59.3	58.7	71.1
Eleusine indica	2.7	0.3	3.3	0.8	0.9	0.9
Rhynchelytrum repens	0	0	0.3	0.8	1.4	19.7
Sida rhombifolia	5.3	2.7	12.9	7.4	4.2	3.0
Other species	17.7	30.0	15.2	11.3	3.1	20.1
Total			146.4 a[3]	183.0 a	162.0 a	235.9 a

[1]Total value from 60 soil samples (ten 0.5 L samples per plot), collected between 0-20 cm depth, before the beginning of the experiment.
[2]Mean of six replicates, where each replicate consisted of four 0.25 m^2 samplings per plot.
[3]Means followed by the same letter do not differ by Tukey test at 1%.

Table 4 - Fruit yield, marketable or refuse (with defects), of tomatoes of varieties Débora and Santa Clara, in the organic and conventional cropping systems.

Variety	Conventional	Organic
	Marketable yield	
	--------------------- kg --------------------	
Débora	278.68 aA[1]	133.62 aB
Santa Clara	228.63 bA	49.03 bB
	Refuse yield	
Débora	49.57 bA	35.43 aB
Santa Clara	57.82 aA	18.37 bB

[1]Mean of six replicates. with 80 tomato pits harvested per replicate. Means followed by the same regular letter do not differ among themselves for comparison of varieties. within cropping systems. Means followed by the same capital letter do not differ for comparison of cropping systems. within varieties (t test at <5%).

also a reflects of the occurrence of spotted wilt, since variety Santa Clara showed higher incidence of the disease (Figure 1) and demonstrates that variety choice is essential, given that genetic resistance to diseases might represent the only available control method.

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