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Disease management of organic tomato under greenhouse conditions in the Jordan Valley

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ABSTRACT

Production of organic tomato under greenhouse conditions has significantly increased in the last few years. Although greenhouse systems provide the option of off-season production and expansion of markets over traditional outdoor field systems, such systems also pose unique challenges with regard to pest management. An experiment was conducted in the Jordan Valley during the fall of 2011/2012 to evaluate the effects of integrated pest management that combines different preventive and control measures, on diseases and pests of tomato grown under greenhouse conditions. The experiment consisted of three treatments (organic farming, conventional farming and integrated pest management (IPM) farming) with four replicates arranged in a randomized complete block design (RCBD). The plant diseases and pests were monitored in all treatments. Powdery mildew disease was recorded at 6 weeks after transplanting in all treatments and at 22 weeks after transplanting, the disease incidence was 74%, 68% and 57% in the IPM, conventional and organic treatments, respectively. However, the disease severity did not exceed 1.5 in any of the treatments. Early blight disease appeared at 16 weeks after transplanting and at 22 weeks after transplanting, the disease incidence was 62%, 54% and 47% in the IPM, conventional and organic treatments, respectively. Neither bacterial symptoms nor nematode symptoms were observed in any of the treatments. Enzyme-linked immunosorbent assay (ELISA) tests revealed the presence of *Tomato ring spot virus* (ToRSV) and *Tomato bushy stunt virus* (TBSV). Overall, the study showed that there were no significant differences between the three treatments with regard to tomato plant height, width, circumference, number of flowers/cluster, number of clusters/plant, fruit yield, shoot dry weight and root dry weight. Furthermore, several quality parameters of tomato fruits were studied; dry weight, lycopene content and pH were found to be significantly higher in the organic tomatoes.

1. Introduction

The protected cultivation of herbaceous crops in mild-winter climate locations can be an effective tool used by growers to enhance their off-season production and to improve the quality and quantity of the products (Hanafi and Papasolomontos, 1999). Indeed, protected cultivation is of great significance in Jordan, where the total area covered by greenhouses estimated to be approximately 4117 ha in 2009 (Anonymous, 2009). Greenhouse production is predominant in the Jordan Valley where the climate is characterized by a warm winter. The main crops grown under greenhouse conditions in the Jordan Valley are tomato, cucumber and pepper, with most of the production being exported to Europe and Gulf states. However, the intensive agricultural practices in the Jordan Valley have created a favorable condition for the development of soil-borne and air-borne diseases, and plant disease remains the leading drawback for greenhouse production in the Jordan Valley. Therefore, chemical control is intensively used despite the hazardous effects and high cost of these chemicals. Furthermore, the application of chemicals has decreased the opportunity of Jordanian farmers to compete with their neighboring countries in exportation of vegetables to European countries. As consumer demand for high-quality, fresh produce has increased over the last few years; Jordanian growers must effectively develop new cultural technologies, such as organic farming systems, to compete in the global market. Disease management in organic agriculture is highly complicated because the application of chemicals is prohibited (Berlinger et al., 1999), and organic farming technology in Jordan has proceeded slowly, with no work having been performed to date on disease management in organic farming

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under protected conditions. Therefore, the overall aim of this study was to encourage farmers to implement this highly valued technique through the development of programs for the management of significant diseases of protected tomato without the use of chemicals.

2. Materials and methods

The experiment was performed at the Institute of Agriculture, Research, Training, Extension and Education in the Jordan Valley during the fall growing season of 2011/2012. The following three treatments were applied: conventional (all agricultural practices as typically performed by farmers), integrated pest management (IPM, minimum use of synthetic pesticides and synthetic fertilizers) and organic farming (no use of any synthetic pesticide or fertilizer). All treatments were performed in one site as explained below.

2.1. Site selection and preparation

The selected site was mostly isolated and relatively far from cultivated areas. The land was nearly flat, with a slight slope, well drained, free of trees and previously planted with a forage legume (*Medicago sativa*) for 7 years. After deep plowing, the soil was cleared of the previous plant residues and then heavily irrigated for two days using a sprinkler irrigation system. The land was plowed and leveled when the soil moisture level was approximately 40% of the total field capacity. A metal frame structure of 6 greenhouses (hoop types) was installed, and each greenhouse was arranged to have 5 raised beds of soil (planting beds; 60 cm width, 40 m length and 10 cm height). For the organic farming treatment, the soil of the rows at the depth of 15–20 cm was mixed thoroughly with heat treated organic fertilizer (sheep manure; 1:16, N:C) at the rate of 5 kg/m^2. A drip irrigation system was installed, and then black mulch was used to cover the rows. The rows were routinely irrigated for 2 h/week. A soil solarization process was applied in stripes for all treatments. It was allowed for 11 weeks (mid August to late November). One week after soil solarization, the metal structure of greenhouses was covered with heat-resistant plastic sheets, and heat treated sheep manure was added to the rows of the IPM treatment. A randomized complete block design (RCBD) with three treatments and 4 replicates per treatment was used. Thus each greenhouse was divided to two blocks and a total of 12 blocks for the 6 greenhouses.

2.2. Tomato transplanting

The Newton commercial tomato cultivar (high resistance to *Fusarium oxysporum* f. sp. *Lycopersici* (*Fol*) race 1 and race 2, *Tomato Mosaic Virus* strains 0, 1, 1.2 and 2, *Stemphylium* spp., *Fulvia fulva* and gray leaf spot caused by *Stemphylium solani*), commonly used by farmers in the Jordan Valley, was selected for this study. The one month old tomato seedlings, seeded in polystyrene seedling trays, were obtained from a trusted nursery to ensure that the seedlings did not carry any diseases, mites or insects (at various stages), and no pesticides or fertilizers were added. Around 800 tomato seedlings were transplanted for each treatment. Lateral branch removal began at 4 weeks after transplanting. Pollination was enhanced by shaking plants daily.

2.3. Pest management

The following measures were implemented in all treatments: (i) weed eradication inside the greenhouses was performed manually when needed, whereas the weeds around the greenhouses were removed by plowing and (ii) spraying with organically acceptable compounds was performed once in the IPM and organic farming treatments and twice in the conventional treatment.

The organically acceptable compounds included (i) Thiovit (active ingredient: sulfur, Syngenta Crop Protection Pty Limited Company, Greensboro, NC, USA) at the rate of 1 kg a.i./1000 L (against powdery mildew and mites), (ii) Vertimec (active ingredient: abamectin, Syngenta Crop Protection Pty Limited Company, Greensboro, NC, USA) at the rate of 100 ml a.i./250 L (against mites and thrips) and (iii) Kocide (active ingredient: *copper hydroxide*, DuPont de Nemours & Co, Wilmington, DE, USA) at the rate of 1 kg a.i./800 L (against late blight, early blight and bacterial spots).

2.4. Special measures for each treatment

2.4.1. Organic treatment

The workers washed their hands with soap prior to entering the greenhouses, and all materials and equipment used in the organic replicates were cleaned with soap. A double muslin sheeting system was used to cover the sides of the structure, and the space between two muslin sheets was 1.5 m. Four ventilation fans covered with muslin were installed in each plot, and seven sticky yellow traps were placed in each plot. Sticky-roll pheromone traps and water pheromone traps specific for *Tuta absoluta* (Russell IPM, UK) were also used. The plots were irrigated using a regular schedule. Organically acceptable compounds were used once, as follows: liquid soap at the concentration of 0.5 ml a.i./L (against mites), Spintor (active ingredient: spinosad, DOW AGROSCIENCES LLC Company, Indianapolis, IN, USA) at the rate 250 ml a.i./1000 L (against mites and white flies), Fytoclean (active ingredient: benzalkonium chloride, Russell IPM, UK) at the rate of 6 L a.i./400 L (against mites) and Neem (active ingredient: azadirachtin, e-nema GmbH Company, Schwentinental, Germany) at the rate of 50 ml a.i./20 L (against *T. absoluta*). Thiovit was used twice at the rate of 1 kg a.i./1000 L to control mites and powdery mildew whereas and Kocide was used once at the rate of 1 kg a.i./800 L to control blights and bacterial spots.

2.4.2. Integrated pest management treatment

The same measures applied in the organic treatment were used in IPM, in addition to the single application of the fungicide Blin exa (active ingredient: hexaconazole, Químicas del Vallés [IQV], Barcelona, Spain) at the rate of 200 ml a.i./500 L against powdery mildew. Additional two applications of thiovit at the rate of 1 kg a.i./1000 L were added. While the two insecticides, Emamectin Benzoate 5% (IPROCHEM, China) at the rate of 300 g/1000 L and ENGEO (active ingredients: thiamethoxam and lambda-cyhalothrin, Syngenta Crop Protection Pty Limited Company, Greensboro, NC, USA) at the rate of 300 ml/1000 L were used once each to suppress *T. absoluta* and thrips, respectively.

2.4.3. Conventional treatment

Single muslin sheet, sticky yellow traps and ventilation slots were used. Several applications of pesticides were added during the growing season taking into consideration the application intervals as indicated by the manufacturers; Thiovit was applied 5 times at the rate of 1 kg a.i./1000 L to control mites and powdery mildew; Blin exa to suppress powdery mildew were added 3 times during the growing season at the rate of 200 ml a.i./500 L; Systhane (active ingredient: myclobutanil, DOW AGROSCIENCES LLC Company, Indianapolis, IN, USA) was added twice at the rate of 200 ml a.i./1000 L to control powdery mildew; Kocide was used once at the rate of 1 kg a.i./800 L to control blights and bacterial spots. Emamectin Benzoate 5% at the rate of 300 g/1000 L and was used once each to suppress *T. absoluta*. ENGEO at the rate of 300 ml/1000 L was applied once to control thrips. Alpha cypermethrin (Agrochina,