Crop Protection 62 (2014) 79–85

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Screening of the susceptibility of newly released genotypes of potato to thrips infestation under field conditions in northwest Iran

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ARTICLE INFO

Article history:
Received 12 December 2013
Received in revised form
30 March 2014
Accepted 4 April 2014

Keywords:
Damage index
Population density
Relative growth rate
Solanum tuberosum
Thripidae

ABSTRACT

Use of host plant resistance is an essential component of integrated management of *Thrips tabaci* Lindeman. The present research was designed to screen five commercial cultivars of potato, namely Agria, Kondor, Morene, Diamant and Savalan, and two breeding lines 397082-2 and Khavaran for their susceptibility to thrips infestation and for their mean relative plant growth rate (MRGR) and crop yield in an experimental field (not frected with insecticides) and a control field (chlorpyrifos frected) in the Ardabil region of Iran in 2011 and 2012. Thrips populations were assessed by visual inspection on potato leaves. At harvest time, the percentage of leaf area damaged by thrips infestation was assessed on leaves of the tested genotypes. All adults of phytophagous thrips collected in the experimental field were *T. tabaci*. In both years the mean numbers of thrips adults and larvae were lowest on Savalan cultivar among the tested genotypes. The mean damage index was also lowest on Savalan in both years and the MRGR and the mean yield were greatest in Savalan in the control field. Moreover, in thrips-infested plants, the lowest percentage of MRGR loss and the lowest percentage of yield reduction were observed in Savalan (3.7% and 5.8%, respectively). Of the genotypes tested, Savalan is the most resistant host and has potential for use in the sustainable management of *T. tabaci* on potato.

1. Introduction

In many parts of the world the onion thrips, *Thrips tabaci* Lindeman, is a highly polyphagous species and a serious pest of a wide range of economically important crops (Lewis, 1997; Larentzaki et al., 2007). In Iran, damage due to *T. tabaci* has been reported on different agricultural crops including: potato, onion, cucumber and tobacco (Pourrahim et al., 2001; Fekrat et al., 2009; Sedaratian et al., 2010). Thrips have rasping-sucking mouthparts and feed by piercing the surface of the tissues (leaves and leaf buds) and sucking up the exuded cellular contents. On attacked leaves, the empty cells create silvery-white spots, silver damage, which causes quantitative yield losses (Lewis, 1997; Koschier et al., 2002). The damage index of *T. tabaci* on a crop depends on various factors, such as the population density of thrips, the duration of thrips infestations, the suitability of environmental conditions, the different cultivars within the same crop, and plant growth stages (Lewis, 1997; Shelton et al., 2008). Even if potato plants compensate well for the thrips damage (Lewis, 1997; Richter et al., 1999), heavy thrips infestations can lead to quantitative yield losses from intense reductions in plant MRGR (mean relative growth rate) (Hommes et al., 1994; Koschier et al., 2002).

T. tabaci is also an important vector of several plant viruses such as tomato spotted wilt virus (TSWV) in potato and some vegetable crops (Pourrahim et al., 2001; Jenser et al., 2003; Riley et al., 2011). In 1998, TSWV infections in potato plants were observed for the first time in Iran coinciding with high populations of *T. tabaci* which causes yield reduction (Pourrahim et al., 2001). There is no direct method for determining the initial attack of virus, so it is necessary to aim control at its vectors (Pourrahim et al., 2001). Use of resistant genotypes to *T. tabaci* or TSWV infections in vegetable crops is an appropriate approach to reducing yield losses (Gibson, 1979; Lorenzen et al., 2001; Rovenská and Zemek, 2006; Grafius and Douches, 2008; Wilson et al., 2010; Westmore, 2012; Shrestha et al., 2013). However, no adequate knowledge is available on how thrips-resistant genotypes influence TSWV infections (Wilson et al., 2010; Westmore, 2012; Shrestha et al., 2013). Westmore (2012) suggested that potato cultivar resistance to thrips is unlikely to provide a reliable method for reducing TSWV infection levels in commercial potato crops under field experiments. Furthermore, Shrestha et al. (2013) reported that thrips-mediated transmission resulted in TSWV infection in both TSWV-resistant

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http://dx.doi.org/10.1016/j.cropro.2014.04.006
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and susceptible genotypes of peanut and they exhibited typical TSWV symptoms. However, they concluded that some resistant genotypes had reduced viral loads (fewer TSWV N-gene copies) compared to susceptible genotypes.

In Iran, potato *Solanum tuberosum* L. is an important crop, the cultivation of which extends over more than 160,000 ha annually (Anonymous, 2009). *T. tabaci* is one of the major insect pests of potato in Iran (Fathi and Nouri-Ganbalani, 2010). Chlorpyrifos is a chlorinated organophosphate insecticide and widely used to control of thrips on a wide range of crops (Yarahmadi et al., 2009; Watts, 2013). Prolonged use of Chlorpyrifos has resulted in the incidence of resistance in 65 species in at least 47 countries (Ouyang et al., 2010; Watts, 2013). Moreover, use of insecticides for controlling *T. tabaci* has low efficacy because females lay eggs within leaf tissues, larvae hide in leaf domatia and between the inner leaves of plants, and pupae rest in the soil (Theunissen and Legutowska, 1991). Adverse side effects of insecticide application for control of *T. tabaci* necessitate use of alternative pest management approaches, such as host plant resistance (Shelton et al., 2008). Insect resistant plants may have a direct effect on the pest by reducing its developmental rate, fecundity and survival rate (Fekrat et al., 2009), or they may have an indirect effect on natural enemies by increasing generation time of the pest and, as a result, increasing exposure time of the pest to its natural enemies (Price et al., 1980).

Five potato cultivars, including Agria (originated from Germany), Savalan (originating from Iran and newly released), Kondor, Morene and Diamant (originating from Netherlands) and two breeding lines 397082-2 and Khavaran (originating from Iran) have recently been introduced in the Ardabil region. The ancestor of these cultivars was *S. tuberosum*. All seven potato genotypes that were investigated in this research have good horticultural characteristics e.g. good shape, marketability and higher yield (Anonymous, 2009, 2013). Furthermore, in previous study it was found that Savalan is the least suitable cultivar, Diamant and Morene are the moderate suitable cultivars, and Agria and Kondor are the most susceptible cultivars for *Leptinotarsa decemlineata* (Say) (Fathi et al., 2013). Moreover, Mansouri et al. (2013) demonstrated that tubers of Morene, Khavaran and 397082-2 are the least suitable cultivars, Agria and Kondor are the moderate cultivars, and Savalan is the most susceptible cultivar for *Phthorimaea operculella* (Zeller). Some studies have been carried out focusing on resistance of some potato genotypes to *T. tabaci* (Gibson, 1979; Rovenská and Zemek, 2006; Westmore, 2012). However, most studies should be focused on testing different cultivars or accessions of potato as potential sources of resistance to *T. tabaci*. Therefore, the present research was designed to screen the mentioned genotypes of potato with respect to thrips infestation, MRGR and crop yield under field conditions.

2. Materials and methods

2.1. Source of plants

Tubers of five potato cultivars including Agria, Kondor, Morene, Diamant and Savalan, and two breeding lines 397082-2 and Khavaran were selected for the screening studies with respect to thrips infestation, MRGR per plant, and crop yield per plant. The tubers were obtained from the Seed and Plant Improvement Institute of Karaj, Iran. Tubers of seven tested genotypes of potato were planted in the Ardabil region, Iran (elevation: 1332 m; longitude: 48° 17′ E; latitude: 38° 15′ N) in May 2011 and 2012 in an experimental field and a control field, each of 0.1 ha. In both fields, a randomized complete block experimental design with four blocks was used. A distance of 2 m between blocks was left unplanted in order to facilitate access and easily insect sampling. The plants were spaced 20 cm apart within each row and 75 cm between rows. The fields were managed according to the local practice with weekly flood irrigation and hand weeding. In the experimental field, only the fungicide Mancozeb (750 WG, 4 Farmers Pty Ltd Co.) was used at a prescribed rate of 150 g/100 L to prevent foliar disease during the early stem elongation stage and no insecticides were applied in this field. Whereas, in the control field, chlorpyrifos (Lorsban 500 EC, Dow AgroSciences Co.) was applied at a prescribed rate of 75 mL/100 L) every 20 days to control of thrips, in addition to the use of fungicide. Nitrogenous fertilizer (100 kg ha^{-1}) was applied in both fields during the early stem elongation stage of potato plants.

2.2. Population density of thrips

In both experimental and control fields, thrips populations were monitored on the seven genotypes during the six growth stages of potato (including late stem elongation, early inflorescence visible, early flowering, full flowering, late flowering and petal fall stages) by examining sub-samples of five middle leaves (one leaf from each plant) from each genotype chosen randomly from each of four blocks (20 leaves per genotype). The numbers of thrips larvae and adults per leaf were counted using a 20× hand lens, collected with a mouth aspirator, and transferred to the laboratory. In the laboratory, thrips adults were identified to species by morphological characteristics under a stereomicroscope at 40× magnification according to Palmer et al. (1989). In these experiments, at each of the six growth stages of potato, the average numbers of thrips larvae or adults densities in five sub-samples from each genotype at each of four blocks was considered a replicate, so these experiments were analyzed with four replicates.

2.3. Damage index

In the control and experimental field at harvest time (in September), thrips feeding symptoms were assessed on the seven tested genotypes of potato by checking sub-samples of five middle leaves (one leaf from each plant) from each genotype chosen randomly from each of four blocks (20 leaves per each genotype) in 2011 and 2012. The level of thrips damage was classified to one of five classes including: 0 = 0%; 1 = <10%; 2 = 10–25%; 3 = 25–50%; 4 = >50%, depending on the percentage of leaf area damaged for the whole leaf. Intensity of the damage was expressed by $R = \sum(nb)/N$, where n = number of leaves damaged at the same level, b = level of damage (0–4), and N = number of leaves in the sample (Duchovskiene, 2006). The same procedure was used in both years. In these experiments, an average damage indexes in five sub-samples from each genotype at each of four blocks was considered a replicate, so these experiments were analyzed with four replicates.

2.4. Relative growth rate of control and infested plants

In both experimental and control fields, the mean relative growth rate (MRGR) per control and thrips-infested potato plant were calculated for each genotype from 11 June (observation of thrips larvae infestation at late stem elongation stage) until 2 August (at petal fall stage) (for 52 days). For this purpose, on 11 June sub-samples of five plants from each genotype were chosen randomly at each of four blocks (20 plants per each genotype), cut from stem just above soil, and transferred to the laboratory. The same work was also performed on 2 August at the petal fall stage. In the laboratory, sampled plants were dried at 50 °C for 24 h inside an oven. Dried plants were weighed using a Sartorius scale (Sartorius Inc., Edgewood, NY, USA). These data were used to calculate the