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# Resistance of two potato cultivars with different morphological characteristics to potato tuberworm, *Phthorimea operculella* (Lepidoptera: Gelechiidae) in field condition

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ABSTRACT

Potato tuberworm, *Phthorimea operculella* Zeller, is one of the most important pests of potato in many regions of the world. Resistance of two potato cultivars, Sante and Arinda, with different morphological characteristics to leaf and tuber infestations by the pest were investigated in two research fields. Samplings were performed weekly during two agricultural seasons (2013/2014 and 2014/2015). Results showed that although population density of the pest eggs on the Sante cultivar, with non dense leaf trichome density, was significantly higher than the Arinda cultivar, with dense leaf trichome, but larval density in the Sante cultivar significantly was lower than Arinda. The obtained data showed that damaged tuber yield in the Sante cultivar, with high tuber tissue density, were significantly higher than Arinda cultivar, with low tuber tissue density. No significant difference was observed in the total potato tuber yield (Damaged + no damaged yields). Use of the cultivars with dense leaf trichomes in combination with higher inundative release rate of the parasitoid wasp or other natural enemies of the pest are recommended in integrated pest management program of *P. operculella* in potato fields.

**Key words:** Antixenosis, IPM, Lepidpteran pest, Pest density, Potato damage

The potato (*Solanum tuberosum* L.), is the third most important food crop in the world after rice and wheat in terms of human consumption. More than a billion people worldwide eat potato, and global total crop production exceeds 300 million metric tonnes (Faulkner 2011). Potato tuberworm, *Phthorimea operculella* Zeller (Lepidoptera: Gelechiidae), is one of the most damaging pests of potatoes (Haines 1977). The pest attacks potato plants in two ways: by mining the foliage and feeding on tubers. Larvae penetrate the plant leaves and weaken or break its stem and, in tubers, deposit eggs near the eye buds, causing irregular galleries deep inside the tubers (Trivedit and Rajgopal 1992). It is reported that the pest is responsible for about 1 to 65% infestation in potato fields and storage in Middle East (Rondon 2010). Host plant resistance to insect pest is considered an effective, economical, and environment friendly method of integrated pest control (Pedigo 2002). Host plant resistance is defined as the sum of the constitutive, genetically inherited qualities that result in one cultivar or species being less damaged than a susceptible plant lacking these qualities (Smith 2005). Painter divided the phenomena of resistance into three mechanisms: antixenosis (non-preference), antibiosis, and tolerance. Host plant's morphological characteristics, such as leaf trichomes, can significantly affect insect behaviour and their population (War *et al.* 2012). Plant trichomes are the first structure with which arthropods come in contact after making the decision to alight or walk on the plant structure. Therefore, the trichomes are one of the main reasons of feeding or oviposition antixenosis resistance. The trichome-based antixenosis resistance is a very broad based defense, apparent in crop plant representative from major taxa such as solanaceous plants (Smith 2005). In previous studies, the roles of plant trichomes in feeding or oviposition antixenosis resistance of some *Solanum* spp. to *P. operculella* (Musemeci *et al.* 1997, Arnone *et al.* 1998), some potato aphids such as *Myzus persicae* Sulzer (Saljouqi *et al.* 2003, Le Roux *et al.* 2008, Mottaghinia *et al.* 2011 ) and *Macrosiphum euphorbiae* Thomas (Le Roux *et al.* 2008), potato psyllid, *Bactericera cockerelli* Sulc (Hemiptera: Triozidae), *Empoasca fabae* Harris (Homoptera: Cicadellidae (Lamp *et al.* 1994) and *Leptinotarsa decemlineata* Say (Coleoptera: Chrysomelidae) (Pelletier and Tai 2001). Orietz *et al.* (1990) reported that antibiosis and antixenosis are the two mechanisms of potato tuberworm resistance in this population.

There has not been any effort to determine effect of plant characteristics on resistance of potato cultivar to *P. operculella*. Therefore, the objective of this study was to study effect of plant characteristics, such as leaf trichomes

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and tuber skin, on population and damage of the pest on potato fields.

## MATERIALS AND METHODS

All trials were done in two separate experimental potato fields, at Lour region, Andimeshk, Khouzestan province, south of Iran (48°19′53″N and 32°30′177″E) during November to April of 2013/2014 and 2014/2015 agricultural years. Seeds of two commercial potato cultivars, Sante and Arinda, were separately cultivated (≈ 83,000–85,000 plants per hectare) in each experimental field. Morphological characteristics of the cultivars are presented in Table 1.

Cultural practices were performed according to practical recommended of Khouzestan agricultural organization. The experimental fields were not treated by any pesticides.

Sampling was usually done at weekly intervals during the two potato phonological periods: 1- aerial development starting at the end of sprouting and emergence till the filling stage of tubers (≈ 15–85 days after planting) 2-tuber development (≈85-120 days after planting).

In each plot of the two experimental fields, ten wooden quadrats (0.5 m × 0.5 m) were placed on the ground at 10 m intervals and X-shaped movement pattern in each experimental plot. After that, the potato plants in each quadrat were checked for the number of immature life stages of pests (eggs and larvae) and leaf mines from the top, middle, and bottom of three leaves of potato plants. Larvae of *P. operculella* pupate on soil or in debris under the plant (Rondon 2010). The pupa was omitted for sampling because it is very difficult to detect by visual inspection. During tuber development period, in addition of the pest density estimation on potato leaves, a tuber was randomly chosen from each selected plant and the number of the larvae and excavate tunnels through it were recorded.

Cumulative insect days ($CID_s$) of egg or larvae of *P. operculella* in each replication of the tested cultivars were calculated by following equation (Ruppel 1983):

$$CID=\sum_{n=1}^{\infty}\left(\frac{x_{i-1}-x_i}{2}\right)\times t$$

where $x$ is the mean number of the pest eggs or larvae on sample day $i$, $x_{i-1}$ is the mean number of the pest larvae or eggs on the previous sample day, and $t$ is the number of days between samples $i$ - 1 and $i$.

Finally and after tuber maturity, damaged and undamaged tuber yields were separately weighted. In damaged tuber group, one or more larval tunnels were observed in the tuber. There was not any larval tunnel in the tubers of undamaged yield group.

Experiments were performed in completely randomized plot design with four replications. Data were compared by analysis of variance (ANOVA) using SPSS 16.0 (SPSS Inc. Chicago, USA). When data were not normally distributed, the data were log (x+1) transformed to meet the assumptions of normality logarithm transformation data were used in the analysis.

## RESULTS AND DISCUSSION

The CID means of eggs and larvae of *P. operculella* and on the Sante and Arinda leaves during aerial development period were shown in Table 2. The CID of *P. operculella* eggs in the Sante cultivar was significantly more than the Arinda cultivar. Same result was obtained for the larvae density on tubers of the cultivars during tuber development period. Non-glandular trichomes mainly function as a structural defense against small herbivores (Dalin *et al.* 2008). They interfere with the movement of insects and other small arthropods over the plant surface and make it more difficult for insects to access the leaf epidermis underneath for feeding or oviposition (Southwood 1986, Dalin *et al.* 2008). In numerous species, a negative correlation has been established between trichome density in the plant surface and insect feeding or oviposition (Mihm 1997). The oviposition deterrence of leaf trichomes of tomato to *Bemisia tabaci* Gennadius (Heinz and Zalom 1995, Srinvasan and Uthamasamy 2005), *Helicoverpa armigera* Hubner (Srinvasan and Uthamasamy 2005) and *T. absoluta* (Khediri *et al.* 2014) *Arabidopsis lyrata* L. to *Plutella xylostella* (Lepidoptera: Gelechidae) (Puentes and Agren 2013), *Atherigona soccata* Rondani to sorghum (*Gomashe et al.* 2010), strawberry to *Tetranychus urticae* Koch. (Steinite and Ievinsh 2003) were reported. Malaker and Tingey (2000) showd that glandular trichomes on foliage of the wild potato species, *Solanum berthaultii* Hawkes, deter oviposition of the potato tuber moth, *Phthorimaea operculella* Zeller and negatively affect other important performance parameters.

The population density (CID) of the pest larvae in the Sante cultivar leaves was significantly lower than Arinda cultivar leaves during aerial development period. It is implicated that despite of oviposition preference of potato tuberworm moth on leaves of Sante, with lower trichome

Table 1 Morphological characteristics of Sante® and Arinda® cultivars

| Cultivar | Maturity | Trichome density | Leaf extension | Tuber tissue density | Plant canopy |
|---|---|---|---|---|---|
| Sante® | Early | Low (43.4 ± 1.8 per $cm^2$) | Moderate | High | Moderate extended |
| Arinda® | Moderate | High (95.3 ± 2.1 per $cm^2$) | High | Low | High extended |

Table 2 Means±SE of potato tuberworm $CID_s$ on leaves and tubers of the tested cultivars during aerial and tuber developmental periods, respectively.

| Potato phonological period | *P. operculella* life stage | Sante | Arinda | t | P-value |
|---|---|---|---|---|---|
| Aerial development | Egg | 0.67±0.03 | 0.41±0.06 | 3.28 | 0.017 |
| Aerial development | Larvae | 5.38±0.11 | 6.31±0.13 | -5.18 | 0.002 |
| Tuber development | Larvae | 7.1±0.36 | 8.3±0.2 | -2.84 | 0.029 |

density, larvae density of *P. operculella* on the cultivar wa significantly lower than the Arinda cultivar, with dense leaf trichome. The difference in results may be related to higher activity of the pest natural enemies on the Arinda. Shahbi and Rajabpour (2015) showed that larval parasitism of *P. operculella* by *Bracon hebetor* Say (Hymenoptera: Braconidae) on the Arinda cultivar is significantly higher than Sante cultivar. In their study, the negative correlation between larval parasitism of *P. operculella* and potato leaf trichome density was demonstrated. Larval parasitoids interact with their host and the food plant of their host in a variety of ways depending on their specific biological attributes and host-finding behaviors. The details of the interactions between parasitoids and plant defensive traits are important determinants of the type and magnitude of potential tritrophic effects (Kennedy 2003). Antagonistic effects of leaf trichome on parasitism activity of *Haeckeliania seprata* Pinto against *Diaprepes abbreviatus* (Coleoptera: Curculionidae) eggs (Carrilo *et al*. 2008), *Anagrus nigriventris* Girault against *Empoasca fabae* Harris eggs on alfalfa (Lovinger *et al.* 2000), *Trichogramma pretiosum* Riley and *Telenomus sphingis* Ashmead on lepidopteran eggs on tomato (Kashyap *et al.* 1991) were previously reported. Also, Horgan *et al.* (2007) proved that neonate establishment on *S. berthaultii* is generally positively related to trichome densities, indicating that trichomes may be a poor defense against *P. operculella* when the moth oviposits in soil and neonate larvae select the host plant.

The undamaged and total potato tuber yields in the Sante and Arinda cultivars are presented in Table 3. Result indicated that *P. operculella* qualitative damage on potato tubers was significantly different in the Sante and Arinda cultivars. The damaged tuber yield in the Sante cultivar, with high tuber tissue density, were significantly higher than Arinda cultivar, with low tuber tissue density. But no significant difference was observed in the total potato tuber yield (Damaged + undamaged yields). Our finding agreed with the results of Golizadeh *et al.* (2014) who reported that intrinsic rate of *Phthorimea operculella* in Arinda tubers is significantly higher than other tested cultivars, including Agria, Agata, Almera, Baneba, Fiana, Marfona, Ramus, Satina, and Volvox.

The present study indicated that the potato cultivars with different morphological characteristics have significant effect on population densities of *P. operculella*. The female moths significantly preferred the cultivars with lower leaf trichomes. But, the cultivars with dense leaf trichomes interfere with activity of *B. hebetor* as major biological control agent of the pest in potato fields of Khouzestan province, Iran. Therefore, using the cultivars with dense leaf trichomes in combination with higher inundative release rate of the parasitoid wasp or other natural enemies of the pest are recommended in integrated pest management programe of *P. operculella* in potato fields.

Table 3 Weight means±SE of No damaged and total potato yields in the Sante® and Arinda® cultivars

| | Sante® | Arinda® | t | Df | P-value |
|---|---|---|---|---|---|
| Damaged yield | 162.2±5.3 | 132.38±5.58 | -3.86 | 14 | 0.002 |
| No damaged yield | 197.7±5.39 | 227.5.51 | 3.8 | 14 | 0.002 |
| Total yield | 359.6±0.26 | 360±0.26 | -1 | 14 | 0.334 |

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