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Short Communication

The Relationship Between Infestation Rates of Carob Moth (Lepidoptera: Pyralidae) and Brown Spot Disease in Pomegranate Fruit under Field Conditions

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Authors' Contribution

MM designed the study, performed experimental work and analysed the data. MM and AB collected samples and wrote the article. AB edited and reviewed the manuscript linguistically.

Key words

Pomegranate, Carob moth, *Apomyelois ceratoniae, Alternaria alternate*, Infestation rate

ABSTRACT

The study was carried out in total of 10 pomegranate orchards in Central Şanlıurfa, Akçakale, Bozova, Harran, Hilvan, Siverek and Suruç counties of Şanlıurfa province in South-Eastern Region of Turkey in 2013 and 2014. Infestation rate of Carob Moth (CM) and Brown Spot Disease (BSD) were determined by controlling a total of 100 fruits from four different sides of randomly selected 25 trees from each orchard. In addition, 100 fruits infested with BSD were checked for damage, egg, larvae and pupae of CM during harvest. According to the results from the study, CM infestation rate was low in orchards where BSD infestation rate was high in pomegranate fruits. In terms of infestation rate in pomegranate fruits, a statistically strong negative relationship was determined between BSD and CM ($R_{(BSD, CM)}$ = -0,724; Y=46.312-0.467*X). In this study, BSD infestation rate explained the variance of CM infestation with 52.5% ratio (R^2= 0.525).

Pomegranate can grow in both temperate and sub-tropical climates. Pomegranate is widely used in the folk medicine of many cultures (Azeem *et al*., 2019) In Turkey, it is commonly grown in Şanlıurfa province having the highest number of trees and production area in the city after pistachio and olive (Turkstat, 2016). Pomegranate is widely grown in Aegean, Mediterranean and Southeast Anatolia regions. Turkey own 16,000,000 pomegranate trees and pomegranate production was 383,000 tons in 2013. Based on agricultural statistics in 2013, Şanlıurfa province had 1,325,000 pomegranate trees and the annual pomegranate production was 6,400 tons (Turkstat, 2016).

There are many pests and diseases that impede pomegranate production and reduce yield and yield quality. Insects, fungi, and bacteria can target different parts of the pomegranate tree. Carob Moth (CM), *Apomyelois ceratoniae* Zell. (Lepidoptera: Pyralidae) is the most significant harmful organism in pomegranate production area in Şanlıurfa in South-Eastern Region of Turkey. Also, brown spot disease (BSD) (*Alternaria alternata* (Fr.) Keissl.) has recently become one of the serious diseases of pomegranate in the province.

CM larvae firstly feed on crown of pomegranate (calyx) and later it does on fruit grains penetrating from calyx to fruit. As a result of that, browning starts on fruit's peel as spots and these spots grow over time leading to collapses in the peel, cracking and eventually decaying of fruits. During the final stage of disease, the interior part of the damaged fruits by CM completely become dark and covered by mold with the attack of some saprophyte fungi (PPTI, 2008; Mamay and Ünlü, 2013).

A. alternata is a ubiquitous necrotrophic fungus. There are many pathogenic variants of this fungus causing disease on different host plants (Kohmoto *et al*., 1991; Hatta *et al*., 2002; Ito *et al*., 2004). Nishimura and Kohmoto (1983) distinguished between the following path types of *A. alternata*: apple, citrus, Japanese pear, strawberry, tobacco and tomato, which cause Alternaria blotch of apple, brown spot of citrus, brown spot of pomegranate, black spot of Japanese pear, Alternaria black spot of strawberry, brown spot of tobacco, and stem canker of tomato, respectively. In Turkey, *A. alternata* causes lesions on leaves, flowers, and young fruits in pomegranate orchards (Pala *et al*., 2009). Also, *A. alternata* is an important pathogen of pomegranate in the eastern Mediterranean region (Ezra *et al*., 2010).

BSD can be seen in leaves, flower and small fruits of pomegranate. Under heavy infection conditions, leaves and small fruits fall off. Commonly the disease starts as brown spots at crown of fruits and forms brown symptoms on the peels. The peel takes in a dry and dark brown appearance. The growing of infected fruits delays. During later stages, the disease causes cracks on fruits due to desiccated peel.

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The disease is especially common on pomegranate fruits during spring season under favorable conditions (PPTI, 2008). BSD on fruit, the damage is restricted to the peel surface while the edible tissue remains unaffected. This is in contrast to black rot of pomegranate, in which the fruit rot is restricted to the internal area whereas the peel and leaves remains unaffected. Thus, *A. alternata* that causes brown or black spot of pomegranate is different from the one that causes internal rot of pomegranate (Ezra *et al*., 2010).

There have been many studies about *A. ceratoniae* in many parts of the world, as well as in Turkey. The studies have been conducted on its biology (Tokmakoğlu *et al*., 1967; Al-Izzi *et al*., 1985; Mart and Kılınçer, 1993; Nay and Perring, 2006), ecology (Kashkuli and Eghtedar, 1976; Alrubeai, 1987), population dynamics (Öztürk and Ulusoy, 2011; Uluç and Demirel, 2011; Mamay and Ünlü 2013), host plants (Mehrnejad, 1995; Mozaffarian *et al*., 2007; Mamay *et al*., 2014) and its management (Warner *et al*., 1990; Peyrovi *et al*., 2001; Vetter *et al*., 2006; Park *et al*., 2008; Mamay, 2013).

Although some studies have been carried out on *A. alternata* in pomegranate (Ezra *et al*., 2010; Gat *et al*., 2012; Tziros *et al*., 2008; Berbegal *et al*., 2014), but there is no sufficient information available on the pathogen dynamics in Turkey.

More importantly, there is no study showing the relationship between CM and BSD when both of them attack pomegranate. Previously conducted surveys indicated inverse relationship between CM and BSD which inspired this study. In the study we intended 1) to determine the interactions between CM and BSD, 2) if there is interaction then define the dynamics of the interaction in Turkey.

Materials and methods

The study has been conducted in total of 10 pomegranate orchards located in Şanlıurfa center, Akçakale, Bozova, Harran, Hilvan, Siverek and Suruç counties (Fig. 1). Detailed information about the orchards were given in Supplementary Table I. No pesticides have been applied in the orchards except the orchards in Siverek county which were treated with insecticides of Mospilan 20 SP and Eforia 247 SC alternating for aphids in May during both years of the study.

In order to determine the rates of infestation of CM and BSD, 100 fruits/orchard method have been followed (Mamay and Ünlü, 2013). For this purpose, during the harvest time (the end of September and the beginning of October) one fruit from each side of 25 trees totaling 100 fruits have been examined for eggs, larvae and damage symptoms of CM and BSD on the fruits. Contamination rate (%) for each orchard was determined by recording contaminated and uncontaminated fruits separately. In addition, to determine the relationship between CM and BSD infestation in pomegranate 100 fruits, uncracked but infested by the disease harvested from each orchard, were separately controlled to see whether they are also infested by CM.

The correlation and regression analyses between CM and BSD on collectively infested pomegranate fruits were performed. For the statistical analyses, SPSS package program has been used.

Results and discussion

The rates of the infestation with CM and BSD in the orchards were given in Figure 1. Generally, CM infestation rates were low in the orchards where BSD damage was high. As a two year average, the highest CM damage (61.5%) was observed in İncirli village located in Şanlıurfa center and the lowest CM damage (3%) was observed in Akçakale county. BSD infestation rate was highest in Çakmak Village of Bozova county and followed by Dağeteği village located in Şanlıurfa center (87.5% and 86%, respectively) while the lowest infestation was in Akçakale and Siverek counties (5.5%).

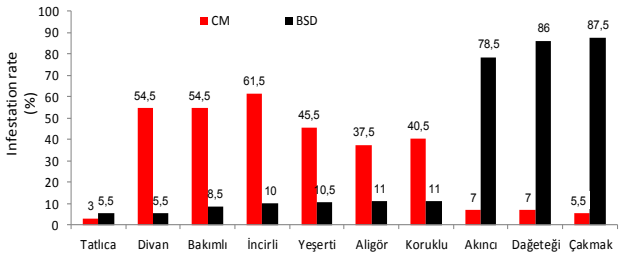

Fig. 1. Average infestation rates of carob moth (CM) and brown spot disease (BSD) in pomegranate orchards in Şanlıurfa.

In a study conducted in pomegranate orchards in Hatay province (in the Mediterranean Region of Turkey) the rate of pomegranate fruits contaminated with CM was found to be between 13 and 40% (Uluç and Demirel, 2011) while in this study the lowest infestation rate was 3%, and the highest was 63%. Mart and Altın (1992) stated that CM caused yield losses in Southeastern Anatolia region up to 70%. However, Öztürk and Ulusoy (2011) reported that CM damage in pomegranate orchards was insignificant and always less than 1%. Al-Izzi *et al*. (1985) reported that CM damage was higher in uncared orchards and the damage rate was between 20-80%. In addition, the damage rates caused by CM were 25-30% in pomegranate and 5-32% in citruses (Tokmakoğlu *et al*., 1967; PPTI, 2008).

In Greece, it has been reported that pomegranate heart rot, a different disease caused by *A. alternata,* could cause yield losses up to 40-50% (Tziros *et al*., 2008). In a study conducted in pomegranate orchards in Cyprus, in varieties of Acco, Herskovitz and Wonderful, fruit rots were 20.31, 14.91 and 9.82% respectively (Kahramanoğlu *et al*.,

2014). Gat *et al*. (2012) reported that the disease caused by *A. alternata* was different compared to the ones in Israeli's pomegranate orchards and symptoms of the disease appeared generally as black spots on leaves and fruits and damage was mostly observed on the outer skin rather than the edible part which mainly remained unspoiled. In a study performed in pomegranate orchards of Adana and its counties, *A. alternata* was isolated from pomegranate stem and fruits as 22.4% and 21.1%, respectively (Çetin, 2008). Wide spread of *A. alternata* around the world have been reported and it causes economically important infections in pomegranate orchards in Israel, India and Spain (Ezra *et al*., 2010; Berbegal *et al*., 2014).

Results of this study indicated a reverse interaction between CM and BSD infestation rates. If the orchard was highly invaded by one of these pest or pathogen, the rate of infestation of the other factor was lower (Fig. 1). In another word, CM infestation rate was low in orchards where BSD infestation rate was high in fruits. We believe that hardened pomegranate fruit skin by BSD makes it difficult for CM larvae to penetrate into fruits thus it reduces the infestation.

According to the regression and correlation analyses, In terms of infestation rate in pomegranate fruits, a statistically strong negative relationship was determined between BSD and CM ($R_{(BSD, CM)}$= -0,724; Y=46.312-0.467*X). In this study, BSD infestation rate explained the variance of CM infestation with 52,5% ratio (R^2= 0.525). As a result, CM infestation rate was low in orchards where BSD infestation rate was high in fruits. In other words, the coefficient of regression indicates that approximately 52.5% of CM infestation could vary as BSD infestation rate fluctuate.

In this study, to determine the relationship between CM and BSD infestation in pomegranate orchards, 100 fruits infested by the BSD disease harvested from each orchard, were separately controlled to see whether they are also infested by CM (Table I). The results indicate that when all fruits infested with BSD in general infestation with CM, at most 4% level of infestation, were low (Table I).

In both years of the study, except Akçakale town, infestation with CM was found to be over the economical injury level which is set as 5 % (PPTI, 2008). This situation showed that if CM is not controlled and managed well, it can cause significant yield losses. Results of this study are in agreement with other studies which showed that each week the removal of invaded fruits until harvesting time was effective in lowering the of the pest population (Tokmakoğlu *et al*., 1967; PPTI, 2008). It is extremely important to take measurements in order to prevent fruit cracks which lead to increase CM population and damages. In the region, CM population shows an increment after the end of July and the damage was low in August and thus chemical control program should be started at the beginning of August and based on residual effect of the pesticides it should be repeated in 2-3week intervals (Mamay and Ünlü, 2013).

Table I. The rate of CM infestations of the fruits invaded with BSD in pomegranate orchards in Şanlıurfa.

County	Village	Infestation rate (%)					
		2013		2014		Average	
		CM	BSD	CM	BSD	CM	BSD
Akçakale	Tatlıca	0	100	0	100	0,00	100
Bozova	Çakmak	0	100	1	100	0,50	100
Harran	Koruklu	0	100	0	100	0,00	100
Hilvan	Yeşerti	3	100	2	100	2,50	100
Central	Dağeteği	1	100	0	100	0,50	100
	Bakımlı	3	100	4	100	3,50	100
	İncirli	3	100	1	100	2,00	100
Siverek	Divan	2	100	1	100	1,50	100
Suruç	Aligör	2	100	2	100	2,00	100
	Akıncı	0	100	1	100	0,50	100

Results of our study show that there is a strong negative correlation between BSD and CM infestation therefore we could expect low infestation of CM to pomegranate fruits in the orchards where high level of BSD found (Table I). In general, in pomegranate fruits infested with BSD were not attacked by CM. We believe it is very likely that the reduced CM infestation in the presence of BSD is due to hardened fruit skin by the disease. Pomegranate fruits with hard skin can be attacked by CM only when cracks through fruit peel are present. Based on our observations during the study we found that CM larvae cannot make an entry into pomegranate fruits when crown parts of pomegranate fruits infested by BSD. However, our findings would need more detail investigation of the relation between CM infestation and pomegranate fruit's skin characteristics.

In summary, this study is the first reporting inverse relationship between BSD and CM infestation on pomegranate fruits. These results could be important guidelines for pomegranate breeders when developing resistant cultivars against CM damage. Although it was not a subject of this study we believe there are some pomegranate cultivars that have hard fruit skin which may impede the entrance of CM larvae and these kind of pomegranate cultivars could be improved for other desired qualities such as yield, taste etc. and recommended to growers for CM management.

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Supplementary material

There is supplementary material associated with this article. Access the material online at: https://dx.doi.org/10.17582/journal.pjz/20170823200843

Statement of conflict of interest

The authors declare there is no conflict of interest.

References

Alrubeai, H.F., 1987. *J. Stored Prod. Res.*, **23**: 133-135. https://doi.org/10.1016/0022-474X(87)90039-7

Al-Izzi, M.A.J., Al-Maliky, S.K., Younis, M.A. and Jabbo, N.F., 1985. *Environ. Ent.*, **14**: 149–153. https://doi.org/10.1093/ee/14.2.149

Azeem, A.A., El Shahat, A.N. and Mounir, A.M., 2019. *Pakistan J. Zool.,* **51**: 347-353. http://dx.doi.org/10.17582/journal.pjz/2019.51.1.347.353

Berbegal, M., Lopez-Cortes, I., Salazar, D., Gramaje, D., Perez-Sierra, A., Garcia-Jimenez, J. and Armengol, J., 2014. *Pl. Dis.*, **98**: 689-689.

Çetin, H., 2008. *Determination of phytopathological problems on the pomegranate plantations of çukurova and investigation of the effectivity of some fungicides applications against postharvest diseases* [master's thesis]. Adana (Turkey): Çukurova University.

Elsayed, G. and Bazaid, S.A., 2001. *Arch. Phytopath. Pl. Protec.*, **44**: 28 - 36. https://doi.org/10.1080/03235400902831075

Ezra, D., Gat, T., Skovorodnikova, Y., Vardi, Y. and Kosto, I., 2010. *Australas. Pl. Dis. Notes,* **5**: 1-2. https://doi.org/10.1071/DN10001

Gat, T., Liarzi, O., Skovorodnikova, Y. and Ezra, D., 2012. *Pl. Dis.*, **96**: 1513-1518. https://doi.org/10.1094/PDIS-12-11-1041-RE

Hatta, R., Ito, K., Hosaki, Y., Tanaka, T., Tanaka, A., Yamamoto, M., Akimitsu, K. and Tsuge, T., 2002. *Genetics*, **161**: 59-70.

Ito, K., Tanaka, T., Hatta, R., Tamamoto, M., Akimitsu, K. and Tsuge, T., 2004. *Mol. Microbiol.*, **52**: 399-411. https://doi.org/10.1111/j.1365-2958.2004.04004.x

Kahramanoğlu, İ., Usanmaz, S. and Nizam, İ., 2014. *Afr. J. Agric. Res.*, **9**: 905-907.

Kashkuli, A. and Eghtedar, E., 1976. *Ent. Pathol. Appl.*, **41**: 21-32.

Kohmoto, K., Akimitsu, K. and Otani, H., 1991. *Phytopathology*, **81**: 719-722. https://doi.org/10.1094/Phyto-81-719

Mamay, M., 2013. *Determination of population development and infestation ratio of carob moth Apomyelois ceratoniae Zell. (Lepidoptera: Pyralidae) in pomegranate orchards in Şanliurfa Province and using mating disruption technique for its control* [dissertation]. Şanlıurfa (Turkey): Harran University.

Mamay, M. and Ünlü, L., 2013. *Turkish Bull. Ent.*, **3**: 121-131.

Mamay, M., İkinci, A., Ünlü, L. and Doğan, E., 2014. *Turkish J. Ent.,* **38**: 101-110. https://doi.org/10.16970/ted.89680

Mart, C. and Altın, M., 1992. *Species of insects and mites determined in the Southeastern Anatolia Region*. Proceedings of Turkish II. Entomology Congress; Jan 28-31; Adana (Turkey). pp. 725-735.

Mart, C. and Kılınçer, N., 1993. *Turkish J. Ent.*, **17**: 77-86.

Mehrnejad, M.R., 1995. *Acta Horticul.*, **419**: 365-372. https://doi.org/10.17660/ActaHortic.1995.419.61

Mozaffarian, F., Sarafrazi, A. and Ganbalani, G.N., 2007. *J. Insect Sci.*, **7**: 11.

Nay, J.E. and Perring, T.M., 2006. *Environ. Ent.*, **35**: 237-244. https://doi.org/10.1603/0046-225X-35.2.237

Nishimura, S. and Kohmoto, K., 1983. *Annu. Rev. Phytopathol*., **21**: 87-116.

Öztürk, N. and Ulusoy, M.R., 2011. *Turkish Bull. Ent.*, **1**: 79-89.

Pala, H., Tatlı, A., Yılmaz, C. and Özgüven, A.I., 2009. *Acta Hortic*. (ISHS), **818**: 285-290. https://doi.org/10.17660/ActaHortic.2009.818.42

Park, J.J., Perring, T.M. and Mafra-Neto, A., 2008. *Pheromone application for mating disruption of carob moth*, *Ectomyelois ceratoniae*, *in commercial date gardens*. ESA Annual Meeting, Nov 16-19.

Peyrovi, M., Goldansaz, S.H. and Jahromi, K.T., 2001. *Afri. J. Biotechnol.,* **10**: 380-385.

[PPTI] *Plant Protection Technical Instructions (Turkey*). 2008. Volume: 5. Turkish Republic, Ministry of Agriculture and Rural Affairs General Directorate of Agricultural Research, Ankara, Turkey 301.

Tokmakoğlu, C., Soylu, O.Z. and Devecioğlu, H., 1967. *Pl. Protect. Bull.*, **7**: 91-106.

Turkstat, 2016. *Turkish Statistical Institute Database*. http://www.tuik.gov.tr/PreTablo.do?alt_id=1001 (November 2016).

Tziros, G.T., Lagopodi, A.L. and Tzavella-Klonari, K., 2008. *Pl. Pathol.*, **57**: 379. https://doi.org/10.1111/j.1365-3059.2007.01668.x

Uluç, F.T. and Demirel, N., 2011. *Detecting and monitoring the carob moth, Ectomyelois ceratoniae by using sex pheromone traps to determine its distribution, population density and damage level in pomegranate orchards in Hatay Province*. Proceedinds of Turkish VI. Entomology Congress; Jun 28-30; Kahramanmaraş (Turkey). pp. 202.

Vetter, R.S., Millar, J.G., Vickers, N.J. and Baker, T.C., 2006. *Southw. Entomol.*, **31**: 121-129.

Warner, R.L., Barnes, M.M. and Laird, E.F., 1990. *J. econ. Ent.*, **83**: 2357-2361.