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Antixenosis resistance of one-year-old poplar seedlings of different clones to poplar clearwing moth, *Paranthrene tabaniformis* Rott. (Lep.: Sessiidae)

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ABSTRACT

Poplar clearwing moth *Paranthrene tabaniformis* Rott. (Lep.: Sessiidae) is considered as one of the major obstacles affecting the poplar seedlings in nurseries and poplar stands in Iran. In this study, the antixenosis resistance of 12 poplar clones have been studied at Fakhr-Abad Agricultural Research Station in Guilan Province, Iran. This resistance factor was based on the establishment and population density of poplar clearwing moth on the clones in natural conditions. For this purpose, 20 cm-cuttings of the examined species were planted in 9 m^2 area plots (three rows with a distance of 1.5 m from each other) at intervals of 20 cm from each other (15 cuttings in each planting row and 45 cuttings in the plot in total) in a randomized complete block design, with three replications. Manuring was performed only once with thrice weeding operations during the growing season (spring 2019). The percentage of infestations by poplar clearwing moth larvae on seedlings and the damage intensity (number of galls formed in each seedling) were recorded. The data were normalized using Kolmogorov-Smirnov test. The results showed a significant differences in the severity of infestation and the number of galls formed among various clones. The *Populus euramericana* Blanc du poitou and *P. x.* ITA.199 are reported as the most sensitive clones to the pest by 87.8% and 83.97% of infestation respectively. Also, *P. deltoides* 77/51 (known locally as Gildar) and *P. x. interamericana* by 44.7 % and 51.15% of infestation are considered as the most resistant clones to poplar clearwing moth pest. According to the present findings, the *P. x. interamericana* and *P. deltoides* 77/51 clones are suggested for propagation in northern Iran conditions as far as this insect pest is concerned.

Keywords: Antixenosis, Infestation, Poplar clearwing moth, *Paranthrene tabaniformis*, Poplar clones.

INTRODUCTION

The widespread decline of the world natural forests and the increasing human needs to woods and its various by-products have attracted wood farming with rapid growth species such as poplar (Niknejad *et al.* 2018; Taheri *al.* 2018). Poplar trees include fast-growing species with multiple varieties from which many hybrids can be obtained (naturally or artificially). These fast-growing species have been multiplied overtime and enjoyed a special economic status in different countries (Heidari *et al.* 2016; Feng *et al.* 2019). According to the latest survey in Turkey in 2008, there were 150,000 hectares of poplar plantations, of those, 80,000 hectares belonged to *P. euramericana* hybrids and *P. deltoides* clones. The rest (70,000 hectares ha) included *P. nigra* plantations. About four million cubic meters of wood harvested from these poplars annually (average production of 26.6 m^3 of wood per hectare in a year). The most important use of these woods is for industrial, traditional and rural purposes (Tunctaner & Ozel 2008). On the other hand, poplar trees are the hosts of various pests that cause severe damages to the cultivated poplars annually (Karliński *et al.* 2010; Dowkiw *et al.* 2010).

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Many studies have been done on biodiversity, macrofauna, growth and above-ground biomass of different poplar species in Iran (Heidari *et al*. 2015; Alizadeh & Mirarab-Razi 2016; Ghorbanzadeh *et al*. 2019). One of the most important pests invading poplar species is the poplar clearwing moth, *P. tabaniformis* Rott. (Lep., Sessiidae). This important pest of poplars and willows, is widely distributed in Asia, Europe and Africa. The damages of this pest is not limited to larval feeding only, since the feeding by this pest paves the entry fungi and pathogenic bacteria through the holes in the larval corridors that may cause even more severe damages than the pest itself. The pest has one generation per year, and the larvae overwinter inside the corridors made within the woods. Larvae begin their activities early in the spring and feed on wood.

The annual damages to Iran poplar plantations are reported as very severe by some authors (Salehi *et al.* 2002; Salehi & Sadeghi 2003). Therefore, it is necessary to effectively reduce the pest population using various safe and environmentally friendly methods in order to minimize damages (Hristovska 2009; Plath *et al.* 2012). In order to reduce the damages with maximal output and with lower hazards to the environment, an integrated pest management (IPM) is considered essential (Dowkiw *et al.* 2010; Ekesi *et al*. 2014; Muriithi *et al.* 2016). The first step in IPM is to identify the suitable poplar clones and a knowledge of their ecological needs (Billah *et al.* 2015). As a well-known fact, the use of pest-resistant species and clones, including resistance against pathogenic agents is considered as the most healthy, sustainable and cheap control method (Varela *et al.* 2006; Ekesi *et al*. 2014; Sanglestsawai *et al*. 2015). Antixenosisis is considered as one of the mechanisms employed by the plant to prevent the colonization of an insect in a particular host plant. Therefore, plants with high antixenosis mechanism are not welcomed by pests and therefore the host plant may remain safe (Kishore 2006; Qiu *et al.* 2013; Muriithi *et al.* 2016).

The study on resistance in poplar clones to various pests are limited. Amlashi & Salehi (2011) worked on 10 poplar clones in production nurseries in northern Iran reporting *P. eur. triplo*, *P. deltoides* 69/55 and *P. deltoides* 73/51 clones. Although these clones possess the same vegetative conditions, however, the degree of infestations by important pests of the nursery performed differently. According to Moharramipour *et al.* (2005) *P. deltoids* 72/51, *p. alba* 58/57 and *P. eur.* I-214 were reported as resistant to the aphid *Phloemyzus passerinii*, while *P. nigra* 56/72 was considered as the most sensitive one.

This study reported *P. deltoids* as the most resistant species to this pest. Nikdel & Dordaei (2011) reported antixenosis resistance against *Melasoma populi*, *Archips rosana* and *Pemphigus filaginis* by poplar clones in natural conditions. Their study indicated that *P. nigra* Shabestar, *P. alba* Marand and *P. nigra* 62/I54 were the most sensitive, while *P. alba* Bostanabad, *P. alba* Maragheh, *P. nigra* Maragheh and *P. euramericana* Bostanabad were the most resistant clones to *Melasoma populi*, respectively. *Archips rosana*, *P. alba* Mianeh exhibited the most sensitivity, while *P. alba* Maragheh, *P. nigra* Maragheh and *P. nigra* Miandoab displayed the highest resistance. Given the fact that Guilan Province has the highest poplar plantations in Iran (Limaei *et al.* 2011), hence we aimed to study antixenosis in 12 clones of two most commonly used poplar species including *P. deltoides*, *P. euramericana* and also hybrid poplars against the main pest of poplar clearwing moth, *P. tabaniformis* Rott. (Lep., Sessiidae). As per the current rules put forth by the respective organizations in Iran to prevent deforestations, the current study could help to substitute the process of deforestation and as well as benefiting the consumers at the same time.

MATERIALSAND METHODS

Study area

This study was conducted at Fakhr-Abad Agricultural Research Station located in northern part of Iran (Guilan Province) (East longitude of 49° 52′ 45.4″ and North latitude of 37° 23′ 4.4″) (Fig. 1). The region has a semi-humid and temperate climate with an average relative humidity of 87% and 9 m a.s.l. The annual rainfall, average annual temperature, and also the minimal and maximal absolute temperature of station are 1469 mm, 27 °C, -10 °C and 39 °C respectively. Soil texture of the station is loam with relatively deep horizon. The soil pH is 7.21 and the soil structure is fine granular (Lashkar bloki *et al.* 2014).

Methods

In this study, 12 new clones of *Populus euramericana*, *P. deltoides* and hybrid poplars were employed originated from Turkey, Germany, Italy, USA and two successful clones of *P. deltoides* 69/55 (Rahmati) and *P. deltoides* 77/51 (Gildar) comprising about 90% of poplar plantations of Guilan Province (Table 1).

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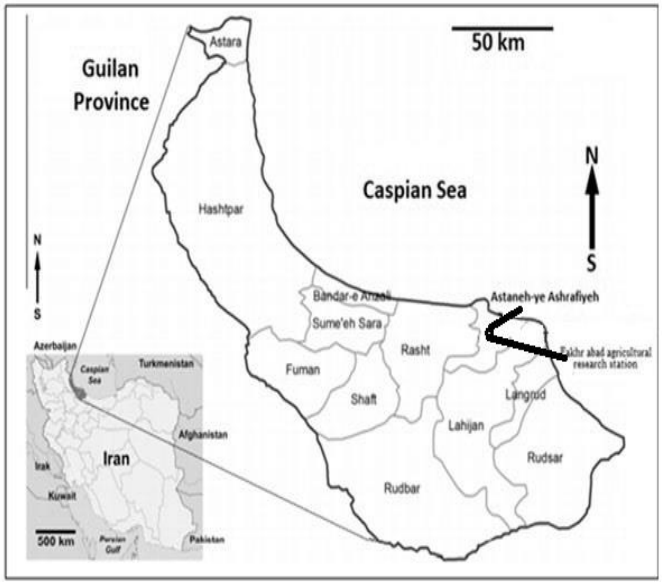

Fig. 1. Study area location on the map.

Table 1. List of studied poplar clones.

Poplar species and clones	Origin
Populus deltoides Marshall 92/258	America
P. deltoides Marshall 92/160	America
P. deltoides Marshall CV. Marquette	Germany
Populus x ITA.199	Turkey
P. x. euramericana (Dode) Guinier CV. Blanc du poitou	Germany
P. x. euramericana (Dode) Guinier CV. I-sieres	Turkey
Populus x 87m.119	Turkey
P. x. interamericana Brockh.	Germany
P. x. canadensis pacher	Turkey
P. x. euramericana (Dode) Guinier CV. BL.costanzo	Italy
P. deltoides Marshall 69/55	
P. deltoides Marshall 77/51	

At first, a plot with an approximate area of 0.2 hectares was selected. After preparing the soil surface (plowing and discs), necessary cuttings with 20 cm length and 3 active buds were taken from all selected poplar clones. Cuttings were planted in a 9 m^2-area plots (three rows with a distance of 1.5 m from each other) at intervals of 20 cm from each other (15 cuttings in each planting row, 45 cuttings in total) in Completely Randomized Block Design, with three replications. Then, one time of manuring and three times of weeding operations were performed in the plantation area during the growing season (spring 2019). The seedlings were transferred to the laboratory at the end of the growing season, followed by recording the percentage seedlings infestation and damage intensity (number of galls per seedling). The data were normalized using Kolmogorov-Smirnov test followed by performing analysis of variance (ANOVA) on the data set. The SAS 9.1 software was used for statistical analyses.

RESULTS

Analysis of variance of data obtained from infestation intensity of different poplar clones to *P. tabaniformis* Rott. indicated a significant difference between the clones at the 0.01 level (Table 2). The *P.eur.* Blanc de Poitou and *P.x.* ITA.199 are reported as the most sensitive clones to the pest by 87.8% and 83.97% of recorded infestation respectively. In addition, *P.x. interamericana* and *P. deltoides* 77/51 (Gildar) by 51.15% and 44.07% of infestation are considered as the resistant clones to poplar clearwing moth. In this study, *P.eur.* BL.costanzo, *P. deltoides* 92.258, *P.deltoides* 92.I60, *P.x. canadensis* pacher, *P.eur* I-sieres, *P. deltoides* 69/55, *P. deltoides* Marquette and *P. x.* 87m.119 were placed in middle groups respectively (Fig. 3). Analysis of variance for severity of infestation (number of galls made by pest on stem) of different clones exhibited a significant difference between the number of galls formed on the studied clones at 0.01 level of significance (Table 3).

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Table 2. Analysis of variance of the infestation intensity between the clones.

Source of variations	df	Sum of squares	Mean of squares	F value	Significance
Block	2	18	9	0.11	0.9^{ns}
Treatment (colon)	11	7234	658	7.64	0.0001^{**}
Error	22	1894	86		
Total	35	9146			
Coefficient of variation			14		

** Significance in level of 0.01 ns not significant.

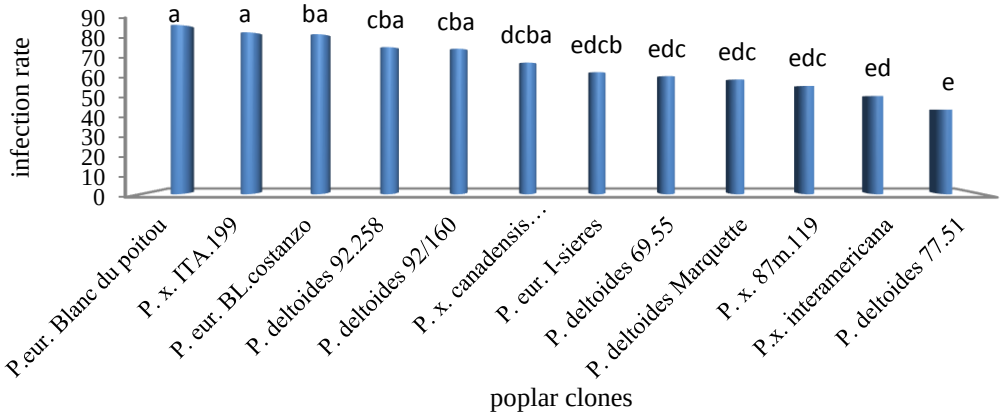

Fig. 3. Comparison the infestation percentage of different poplar treatments.

Table 3. Analysis of variance of the number of galls on the tested clones.

Source of variations	degree of freedom	sum of squares	average of squares	F value	significance level
Block	2	0.65	0.32	0.98	0.38^{ns}
Treatment (colon)	11	8.89	0.81	2.46	0.03^{*}
Error	22	7	0.3		
Total	35	16.8			
Coefficient of variation			28		

*Significance in the level of 0.05 ns not significant

There was a significant difference between treatments at 95% level as per the results where *P.eur.* Blanc de Poitou, *P.x.* ITA.199 and *P. eur.* BL.costanzo by an average of 3.61, 3.54 and 3.52 galls respectively exhibited the highest number of galls on the stems, while *P. deltoides* 77/51 and *P.x. interamericana* by 1.61 and 1.95 galls respectively, displayed the least number. Furthermore, *P. deltoides* 92/160, *P. deltoides* 92/258, *P. eur. I-sieres, P. x. canadensis pacher, P. deltoides Marquette, P. x. 87m.119 and P. deltoides 69/55, were classified at the next level of infestation severity respectively (Fig. 4).*

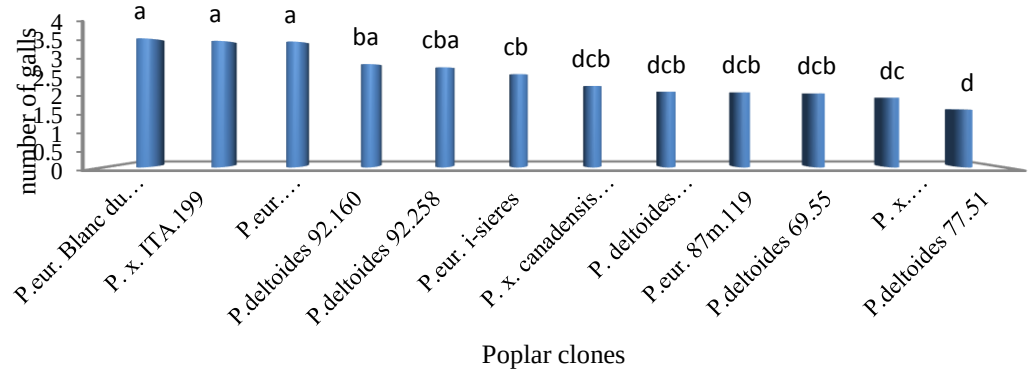

Fig. 4. Comparison the mean number of galls on poplar clones.

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DISCUSSION

The results of this study depicted that the sensitivity of the clones belonging to *P. euramericana* is more pronounced than the clones related to *P. deltoides* (i.e. severity of infestation and the number of galls). Significant resistance of *P. deltoides* to this pest is also reported in previous studies. Babaee *et al.* (2008) worked on the resistance of *P. deltoides* 69/55 to poplar clearwing moth in north of Iran and reported that as far as the growth rate is concerned, there was differences in average height in infested clones (i.e. being lower) in the first year. However, in the second year there was no significant differences between infested and non-infested seedlings as both grew well. In addition, there was no significant differences between the average diameter of the infested and healthy seedlings in the first and second years, indicating high resistance and low sensitivity of the *P. deltoides* to this pest. Amlashi & Salehi (2011) that *P.x. triplo*, *P. deltoides* 69/55 and *P. deltoides* 73/51 almost have similar vegetative features, although indicate different degrees of resistance to the important pests in the nursery. Based on our results, *P. euramericana* Blanc de Poitou and *P. eur.* ITA.199 were the most sensitive clones, while *P.x. interamericana* and *P. deltoides* 77/51 were the most resistant ones to the poplar clearwing moth. Therefore, the results indicate a higher sensitivity of *p. euramericana* to this pest. Yosefi *et al.* (2005) introduced *P. euramericana* hybrids as highly sensitive species to this particular pest by approximately 80% devastation in *Melanophilla* out breaks. In addition, there was a significant difference between *P. deltoides* and *P. euramericana* in terms of resistance to the pests. This difference was also significant between some of the clones of each species. Hemmati & Modir-Rahmati (2002) worked on poplar nursery and reported no significant differences between the seedlings of one-year-old clones of *P. deltoides* in terms of resistance to some of pests, in contrast to the present study. It can be related to some factors such as severity of pollution in Kermanshah Province (East Longitude of 47º 9' and North latitude of 34º 9') which is a very much polluted area compared to our location. Amlashi & Salehi (2011) examined the resistance of 10 different poplar clones to the poplar clearwing moth in a nursery in Guilan Province, Iran, reporting that there was a significant difference in the sensitivity of *P. euramericana* and *P. deltoides* to this pest. In another study, Salehi *et al*. (2005) examined the severity of infestation to poplar clearwing moth for a number of poplar clones in the field and laboratory conditions and found that there was a significant difference between the examined cultures, but with no difference between the results obtained in field and laboratory conditions in terms of resistance to various pests. The present results corresponds to the previous works, however, noteworthy, differences in the resistance or sensitivity of poplar species and clones in dealing with the causative factors are not always the same. Bozorgmehr (2004) in a study conducted at the Natural Resources Research Station of Bojnourd (northeast of Iran) on 36 native and non-indigenous clones of poplars reported that the clones were not sensitive to wood boring insects, which is not in line with our findings. The reason seems to be related to the population and outbreak situation of the pest, type of host in the region or even due to the differences in the climate in the two regions. On the other hand, the differences in infestation rate between two species can be related to the pest host preferences. Studies indicate that poplar pests, in addition to selecting different species, also attack different types of clones in various degrees. For example, examining the contamination rate (%) of two plantations of *P. deltoides* 77/51 and *P. deltoides* 69/55 to *Lymantria dispar* L. has shown that the *P. deltoides* 69/55 clone is more infested than *P. deltoides* 77/51 (Sadeghi et al. 2004). Of course, this host preference is not always the same for all types of pests. So that, in a study on the sensitivity and resistance of 12 different poplar clones to *Melanophila picta*, it was found that *P.eur. triplo*, *P. eur.* 56/41, *P.eur. costanzo* and *P. deltoides* 77/51 are the most resistant clones to that insect infestation (Haghighian *et al.* 2007). In addition, the selection of a plant species for the establishment and feeding of an insect or a pest depends on several factors, including the chemical composition of the plant. Barrios *et al*. (2014) investigated the effect of volatile substances and secondary compounds of poplar clones on their selection as host and feeding behavior of leaf aphids

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in two species of poplar hybrids and reported that volatiles and the presence of phenolic compounds in the plant as well as the thick leaf cuticle and the wax in the leaf play an effective role in the aphid feeding and antixenosis resistance in the different poplar species. Due to the greater resistance of the clones associated with the *P. deltoides* in the present study, the amount of these compounds in this species will be a reason to justify antixenosis resistance of this species to the poplar clearwing moth, *P. tabaniformis* Rott .

CONCLUSION

The results of this study showed that there is a significant differences between antixenosis resistance of one-year-old seedlings of different poplar clones in northern part of Iran compared to poplar clearwing moth, *P. tabaniformis* Rott. (Lep., Sessiidae). In general, the sensitivity of the *P. euramericana* to this pest was significantly higher than the clones related to the *P. deltoides*. Also, the highest infestation rat (%) to the pest and the highest number of galls were observed on the *P. euramericana* clones. According to the results of this study, cultivation and multiplication of *P. deltoides* clones in Guilan Province and other northern provinces with same climate are prioritized than other species (including *P. euramericana*). Among the examined clones, *P. x. interamericana* and *P. deltoides* 77/51 are introduced as superior clones in terms of resistance to poplar clearwing moth, *P. tabaniformis* Rott. (Lep., Sessiidae). Finally, noteworthy, paying attention to trees, including improved quality and richness of the soil, along with supporting the natural enemies of this pests, will play a key role in reducing the damages to Iran's poplar plantations.

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