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EMERGING PESTS OF *ZIZIPHUS JUJUBA* CROP IN ROMANIA

Roxana CICEOI[1], Ionela DOBRIN[2], Elena Ştefania MARDARE[1], Elena Diana DICIANU[2], Florin STĂNICĂ[2]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Laboratory of Diagnosis and Plant Protection of Research Center for Studies of Food Quality and Agricultural Products, 59 Marasti Blvd, District 1, Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: roxana.ciceoi@gmail.com

Abstract

The jujube crop (Ziziphus jujuba Mill.) is one of the oldest crops in China and in the world. Written indications about its technology (grafting, pruning, pest control etc) are older than 1500 years, when the jujube was one of the top five most important fruits in China, together with peach, apricot, plum and chestnut. Their nutraceutical qualities were highly appreciated, but also the beauty of the tree and the flower perfume, which legends says, made people fall in love. Nowadays, the crop is expanding, both in China and on the other continents, due to the high content of bioactive compounds that can help in lowering the blood pressure, in liver diseases, anaemia and also inhibit the growth of tumor cells etc. In Romania, the species grows sub spontaneous since the antique times and until the present moment no important pests had been reported. Still, giving the climatic changes in the last years, many pests became invasive and enlarge their host plant spectrum. On the USAMV Bucharest experimental field, we monitor the pests incidence and we identify few species that might become a threat: Halyomorpha halys (Stal) (Heteroptera: Pentatomidae), Metcalfa pruinosa Say (Homoptera: Flatidae), Ceratitis capitata (Wiedemann) (Diptera, Tephritidae) and Nezara viridula (L.) (Heteroptera: Pentatomidae). The other potential polyphagous pests, like weevils, fruit borers and moths, made insignificant damages on the fruits, but they should still be under careful observation. Data about the pests' biology, damage and control are given.

Key words*: Zizipus jujuba, Halyomorpha halys, invasive alien species, polyphagous pests, quarantine pests.*

INTRODUCTION

The jujube fruits are nowadays worldwide appreciated as an outstanding source of biologically active compounds, with high nutraceutical value (Liu et al., 2014, Preeti et Tripathi, 2014). According to Gupta, 2004, jujube, along with date palms and grapes, start to be domesticated on the Indian subcontinent around the year 9000 BC, together with wheat and barley, which were cultivated from the very beginning of agriculture. In China, many written sources date back the jujube fruits 4000 years ago (Li et al., 2007, Liu et al., 2009) while in Romania it seems the tree was brought via the Silk road 2000 years ago, (Stănică, 2009). Jujube had been used both as crude and dried in the Chinese Traditional Medicine, for its antitussive, palliative, analeptic and nutraceutical properties, but also as a food and food flavourant for thousands of years (Li et al., 2007). It is cultivated also in Australia (Johnstone, 2014) and in Europe, research being done mainly in Romania, Itally and Macedonia (Cossio et Bassi, 2011, 2013; Markovski et Velkoska-Markovska, 2015; Stănică, 2002). Jujube leaves proved to have an insecticide action against one of the major pest in the world, *Helicoverpa armigera*, by inhibiting the digestive and mitochondrial enzymes which lead to growth retarding of the larvae (Varghese et Patil, 2005) and also against *Tribolium confusum* (Vasudha, 2012).

Around the world, except its native environment, the Chinese date seems to be very resistant to pests and no major damage had been registered until now outside the Asian continent borders (Yao, 2013).

In 2013, Balikai et al. mention almost 130 pest species recorded on *Ziziphus* crop in India and specify that 177 species of insect and non-insect jujube pests were recorded around the world. Only a few of them cause substantial economic damage (Balikai et al., 2013). In

India, in an IPM governmental meeting in 2015, 10 pests are cited as pests of national significance: the fruit flies *Carpomyia vesuviana* Costa, *B. zonata* Saunders, *B. dorsalis* (Diptera: *Tephritidae*), the fruit borers *Meridarchis scyrodes* Meyr (Lepidoptera: *Carposinidae*), the green slug caterpillars *Thosea sp*. (Lepidoptera: *Limacodidae*), the grey hairy caterpillars *Thiacidas postica* Walker (Lepidoptera: *Noctuidae*), the mites *Larvacarus transitans* Ewing (Tetranychoidea: *Tenuipalpidae*), the ber beetles *Adoretus pallens* Blanchard (Coleoptera: *Scarabaeoidea*), the grape mealybugs *Maconellicoccus hirsutus* (Green) (Hemiptera: *Pseudococcidae*), the ber mealybugs *Perissopneumon tamarindus* (Green) (Hemiptera: *Pseudococcidae*), the thrips *Scirtothrips dorsalis* Hood (Thysanoptera: *Thripidae*) and the termites *Odontotermes obesus* (Isoptera: *Termatidae*) (Satyagopal, 2015). Four of these ten categories were also cited by Azam-Ali et al. in 2006, as major pests for Asia: the fruitfly, the fruit borers, the ber beetles, the mites. The same authours included in their list the bark eating caterpillars *Indarbela quadrinotata*, *I. watsoni* and *I. tetraonis* (Coleoptera: *Cerambycidae*), the hairy caterpillars *Dasychira mendosa*, *Euproctis fraterna* (Lepidoptera: *Lamantriidae*), *Thiacidas postica* (Lepidoptera: *Noctuidae*) and the lac insect *Kerria lacca* and *K. sindica* (Hemiptera: *Keridae*). Acording to Balikai, 2013, in Europe, the following jujube pests were mentioned: *Carpomyia vesuviana* Costa (by Tominic, in 1954, in Yugoslavia), *Carpomyia incompleta* (Becker) (by Monastero, in 1970, in Italy), *Bactrocera zonata* (Saunders), (by Anonimus, in 2010, in the EPPO member countries, mentioned by Sarwar, 2006 as jujube pest), *Ceratitis capitata* (Wiedemann) (by Martinez et al., in 2006, in Amposta, Spain), *Hispa sp*. (by Jolivet, in 1989, in Turkey), *Grammadera clara* Brunner von Wattenwyl, (by Liebermann, in 1970, in Spain).

In Romania, Stănică, 1997, mentions that the most important pests of *Ziziphus jujube* are *Carpomya vesuviana* (Costa) and *C. incompleta* (Beck), dipterous that lay their eggs in July under the fruit epiderma and *Carposina sasakii* (Mats.), one Lepidopterous which in China destroys 15-20% of fruits, other minor pests being *Ceratitis capitata*, *Cydia molesta* and *Polycrosis botrana*.

No major research programs have been started until now regarding the resistance to pests, except some mentioned by Azam-Ali et al., 2006, against the fruitfly *Carpomyia vesuviana* and fruit borer *Meridarchis scyrodes*.

During the last 20 years, since we first introduced the jujube tree in the experimental fields of University of Agronomic Science and Veterinary Medicine Bucharest, no pests were observed in the field, except *Ceratitis capitata* fly, starting with 2013 and no chemical applications were needed. The year 2016 was totally exceptional from the point of view of climatic conditions and pests evolution, especially for the new invasive species. Four species were damaging the crop, namely *Metcalfa pruinosa* Say, *Ceratitis capitata* (Wiedemann), *Nezara viridula* (L.) and *Halyomorpha halys* (Stal), while another 2 species producing damages were not yet identified. Using online databases, we estimate the possible risk raised by other recorded pests of jujube crop in Romania.

MATERIALS AND METHODS

The present article includes a comprehensive literature review and also presents our own research results. The literature review is based on the online and offline bibliographical references that we found on the WEB and in the University library. We used the following international databases: Web of Science - Core Collection (Journal Citation Reports, Derwent Innovations Index, Thomson Reuters), SpringerLink Journals (Springer), Scopus (Elsevier), ScienceDirect Freedom Collection (Elsevier), PROQUEST Central, Oxford Journals, CAB Abstracts, Google Scholar, Agris Fao, simple google research.

Our observations were made in the experimental field of USAMV Bucharest, in the new fruit species testing field of the Faculty of Horticulture. Regular monitoring visits were done weekly, starting from August 2016. For the presence of *Ceratitis capitata* adults, Tephri traps were used by the researchers of Research and Development Institute for Plant Protection, Bucharest, Romania and the results will be

presented by them (Chireceanu et al., 2013). In laboratory, during the chinese dates morphometric determinations, we identified *C. capitata* larvae and apreciate the number of affected fruits, without precise counting. This prelimary observation will be follow-up in 2017.

To check the scientifically accepted name, spelling, alternative names and geographical distribution of pest species, we used the online Catalog of life databases, which holds essential information on the names, relationships and distributions of over 1.6 million species and the number is continuously rising. To verify the presence of a specific pest species or genus in Romania, we used the ARTHropod Ecology, Molecular Identification and Systematics database, belonging to INRA, France.

For the new non-native species *Halyomorpha halys*, as we consider it a serious threat, our laboratory launch its first citizen science action in July 2016. Warning leaflets were given directly or sent by mail to over 4000 citizens, including agricultural producers and also shared on social networks, as LinkedIn and Facebook.

RESULTS AND DISCUSSIONS

The pests of jujube crop could be grouped into four main categories, as illustrated in fig. 1.

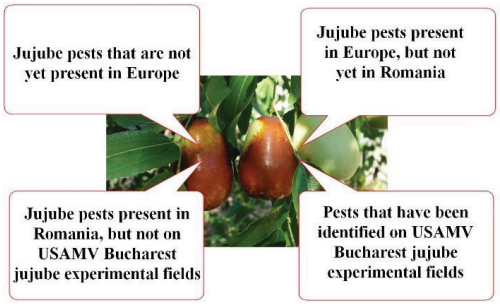

Figure 1. The four possible pests groups associated to *Ziziphus jujuba*

We present the four groups of pests in the order of their threat on jujube crop in Romania.

I. Pests that have been identified on USAMV Bucharest jujube experimental fields

The mediterranean fruit fly (MFF) - *Ceratitis capitata (Wiedemann) (*Diptera, *Tephritidae),* EPPO code CERTCA, A2 no. 105.

Ceratitis capitata is a highly invasive species, worldwide established, extremely polyphagous, having a high economic impact, affecting production, rising the pests control costs and limiting the international trade access (EPPO, 1997). According to EPPO, 2011, *C. capitata* is the most serious pest of some fruits, including citrus, especially in the countries with a warm, Mediterranean, tropical or subtropical climate, but the species is spreading to the north and the recent climate changes makes a larger area suitable for its establishment. Its presence, even as temporary population, leads to severe constraints regarding the export of fruits to uninfested areas and make *C. capitata* one of the most significant quarantine pests for the EPPO region. It originates in tropical Africa, from where it has spread to the Mediterranean area and the world. The larvae develop in fruits, in a very wide range of host plants, in the EPPO region the main hosts belonging to a large number of tree fruit crops, as apples, peaches, plums, cherry, avocados, *Citrus sp*., figs, kiwifruits, mangoes, pears etc. It has also been recorded on wild hosts. *Ceratitis capitata* is an EPPO A2 quarantine pest (EPPO, 1981), at no. 105 (EPPO, 2015) and is also of quarantine significance throughout the world. The spread to Europe, North and Eastern Africa, the Middle East, Australia and the Americas is the result of accidental transportation during the trade (CABI, 2016a).

The presence of the Mediterranean fruit fly in Romania was first time mentioned by Stanciu, 2007, on *Diospyros kaki* and described by Chireceanu et al. in 2013, following their research on 17 locations in Romania, on apricot, jujube and wild blackberry. The authors found *C. capitata* adults in five locations, on jujube in orchards and in private garden (Bucharest and Moara Domneasca, Ilfov County), on apricot in private garden (Agigea-Constanta County) and on wild blackberry bushes (Bucharest).

Regarding the attack on jujube, Chireceanu et al., 2013, states that in Bucharest the percentage of affected jujube fruits was under 10% and that the adults were collected from September to October, the first individuals being captured just when the jujube fruits start ripening.

During our observations, in 2016, in the laboratory, while weighting the jujube fruits which were previously held in plastic bags, we identified the *C. capitata* larvae, which flex and 'jump' repeatedly up to 2 cm when we pick the fruits from the bag. This behavior was previously described when the surrounding air temperature was warm and the larvae fully grown (EPPO, 2011). The degree of affected fruits was appreciated under 5%.

The morphological identification with a binocular microscope is the recommended diagnostic method and the description of the fly is provided by EPPO Diagnostics, 2011.

Biology

The eggs of *Ceratitis capitata* are laid below the skin of the fruit and hatch within 2-4 days in warm days and 16-18 days in cool weather and the larvae feed for others 6-11 days. The pupa forms in the soil, beneath the host plant and adults emerge after 6-11 warm days or longer in cooler days and adults live for up to 2 months (Christenson et Foote, 1960).

The adult flight and the transport of infested fruits are the major means of movement and dispersal to previously uninfested areas. Scientists suggest that *C. capitata* can fly at least 20 km (EPPO, 1990). Some fruits are only infested when ripe but precautions should be taken and the production should be carefully checked before transportation in another region.

Damage

The *Ceratitis capitata* larvae consume the heart of the fruit, making them inappropriate for consumption or processing. The attacked fruits have puncture marks made by the female's ovipositor and they often fall down before maturation.The fly can act also as a potential vector for *Erwinia amylovora* (Ordax et al., 2015), for other fungi, as *Rhizopus stolonifer* (Cayol et al., 1994), while Sela et al., in 2005 demonstrate that the fly is a potential vector of human pathogens as coliforms and *E. coli*.

Control

When detected, it is important to gather all fallen and infected host fruits and destroy them. The detection of *Ceratitis capitata* is done during monitoring with traps with trimedlure *(t-butyl-4(or5)-chloro-2-methyl-cyclohexane-carboxylate)* and terpinyl acetate, which attracts the males.

Malathion was long time used for chemical spraying and bait sprays (both male and female of *C. capitata* are attracted to a protein source which emanates ammonia). Bait sprays have minimal impact on natural enemies, as only the pests are attracted and killed by the chemical insecticide. Qazzaz et al. in 2015, demonstrate that extracts of entomopathogenic *Beauveria bassiana* significantly reduced the peach infestation.

Regarding the phytosanitary measures, the fruits imported from countries where *Ceratitis capitata* occurs, need to be carefully inspected and those suspected for symptoms of infestation should be cut and controlled for larvae. EPPO recommends treatments of the fruits belonging to the genus *Citrus* and *Prunus* by either cold treatment while in transit either by vapour heat, forced hot air or hot water treatment (EPPO, 1997). Fumigants as ethylene dibromide or methyl bromide are no longer recommended either because of the carcinogen effect, either because of the damaging effect on fruits or fruit shelf-life. Irradiation, a combination of methyl bromide fumigation and cold treatment and wrapping fruits in shrink-wrap film were investigated as possible methods of disinfesting procedures (Ohta et al., 1989, Jang, 1990).

The brown marmorated stink bug (BMSB) - *Halyomorpha halys (Stal) (*Heteroptera*: Pentatomidae)*. EPPO code HALYHA, deleted from the Alert list in 2013

Halyomorpha halys is a highly polyphagous pest, attacking mainly fruit trees and vegetables, but also field crops, some ornamentals and weeds. BMSB has become a major nuisance pest in the USA, in mid-Atlantic region and Pacific Northwest, due to its overwintering behavior which leads to unimaginable homes invasions (Inkley, 2012). In the mid-Atlantic region, serious crop losses have been reported for apples, peaches, sweet corn, peppers, tomatoes and row crops such as field maize and soybeans since 2010. Paula et al., 2016 consider this pest a devastating invasive species in the USA, as the direct losses produced only in the mid-Atlantic apples orchards alone, in the year 2010, were about $37 million. In Europe, the damages produced by *H. halys* in Italy, in 2016, were

approximated around 1 billion Euro (Fontana, 2016). For humans, allergic reactions and dermatitis have been mentioned (Anderson, 2012).

In Europe, the first specimen was captured in a light trap in 2004 in Liechtenstein at Balzers (EPPO, 2008), afterwards in 2007 in Switzerland (Wermelinger et al., 2008) and its evolution was silent until 2015, when it became invasive and major damages were reported, as in Italy, where despite all control measures applied, pest feeding caused severe damage to fruit crops, especially pear (EPPO, 2016). The pest was mentioned for the first time in 2011 in Germany (Heckmann, 2012) and Greece (Milonas et Partsinevelos, 2014) in 2012 in Italy (EPPO, 2013a) and France (EPPO, 2013b), in 2013 in Hungary (Vétek, 2014), in 2014 in Russia (EPPO 2016a), in 2015 in Austria (EPPO, 2016b) and Serbia (EPPO, 2016c).

In Romania, Macavei et al., 2015 first time described this species, found in Bucharest in September 2014, but they state that its presence could date back to at least 1-2 years ago, due to the fact that individuals were found at several kilometers away. Our observations confirm this theory and leads to the hypothesis that the cohabitation habit between *Nezara viridula* and *Halyomorpha halys* species is the misleading factor in the late identification of *H. halys* specimens in Romania. In 2016, in the USAMV Bucharest corn testing fields, goji testing fields and edible roses testing fields, the two species were always observed in cohabitation and they produced crop losses of 100% to goji crop, starting with the month of august (Ciceoi et al., 2016a,b). On the corn field, the estimated *H. halys* density/m^2 plant was 25.5 individuals on the field border area and 9.75 individuals in the field interior area, which indicates an exponential growth of the marmorated stink bug populations. On jujube experimental field, the adults of *H. halys* were observed since early September and we consider that the main two reasons for this late occurrence are the fact that the goji crop found in the vicinity was more "feeding" attractive and the population was fix until the complete fruit depreciation of the fruits and the fact that the fruits of jujube start to ripen in the first decade of September.

Biology

The biology of BMSB depends on its environment; it has up to five generations/year in southern China, one or two generations in USA and one generation had been reported until now in Europe (CABI, 2016c). Although the overwintering adults become active in April, due to the high demand of temperature, the oviposition peak in Europe starts at beginning of July (Haye et al., 2014) and then continue until the end of September. The eggs are laid in clusters of around 30 eggs (CABI, 2016c), on the inner leaves surfaces and a female may lay in average 79 eggs, maximum observed being 160 eggs (Haye et al., 2014). The species has 5 larval instars and the adults emerge in 60 to 131 days, depending on the temperature fluctuations. In controlled conditions, at 30°C, the cycle from egg to adult only lasted only 33.2 days and below 15 and above 35°C no development was observed (Nielsen et al., 2008, Haye et al., 2014). More than 300 host plants have been recorded, the most severely damaged being the tree fruits and small fruits, the vegetables, especially tomatoes, ornamentals and field crops (Nielsen et al., 2008).

Damage

The attacked fruits present feeding punctures, caused by the plant juices sucking, which lead to suberifications, the formation of necrotic areas and sometimes to deliquescent fruit pulp (Rice et al., 2014). The adults feed on fruits and the nymphs feed on leaves, stems and fruit. In 2016, in Bucharest some hobby tomatoes crops were completely destroyed by the BMSB, while at the USAMV Bucharest experimental field heavy infestations were observed on corn and goji crops, the goji fruits being severely distorted and quickly become blackish and juiceless, unmarketable. In Asia, *H. halys* cause significant damage to soybean, in Northern Japan to apple, in Italy to pear. In addition to plant damage, BMSB is a nuisance to humans because the overwintering adults aggregate in buildings and houses. *H. halys* has a strong flight capacity, including for long distances (more than 5 km/day), particularly in the summer generation, so the spreading capacity is very high.

Control

Monitoring and surveillance of the pest spreading in new areas are capital and should be followed by immediate eradication measures. The IPM programs for this pest are correlated with the number of generations per year and the peak of the last adult population, which is the most damaging stage (Nielsen et al., 2008). The black light traps and baited black pyramid traps (with methyl (2E,4E,6Z)-decatrienoate) have been successfully used to monitor *H. halys* (Leskey et al., 2012). The H. *halys* aggregation pheromone has been identified by Zhang et al., 2013. Leskey et al., 2012, tested the efficacy of 37 insecticide treatments and proved that dimethoate, malathion, bifenthrin, acephate, permethrin, methidathion, endosulfan, methomyl, chlorpyrifos and fenpropathrin have a greater potential for controlling BMSB.

Biological control methods are desirable, but as *H. halys* is a newly established invasive pest, the lack of knowledge combined with the lack of predators and parasites in the newly invaded areas makes the chemical control methods preferable. Some observations mention *Harmonia axyridis* and earwigs being efficient in eggs predation.

Citrus flatid plant-hopper - *Metcalfa pruinosa Say (*Homoptera*: Flatidae),* EPPO code: METFPR, no list

The citrus flatid plant-hopper is an extremely polyphagous pest, more than 300 hosts being mentioned until the present moment (Vlad et Grozea, 2016). It is a major nuisance pest in parks and gardens and produce qualitative depreciation of agricultural products, caused by the feeding with the sap of plants and by the massive productions of waxy secretions and honeydew, when in numerous populations (CABI, 2016d). The species originate from eastern North America and was first time mentioned in Italy in 1979 (Bărbuceanu, 2015, Strauss, 2010) and is now present in at least 15 European counties (Strauss, 2010, EPPO, 2016). Recently was discovered also in the eastern paleartic area, in Korea, where it imedialtely became a quarantine pest (Kim et al. 2011)

In Romania *M. pruinosa* was first time mentioned by Preda et Skolka, 2009, in the city of Constanta, in 2009, then in 2010 in Timisoara (Gogan et al. 2010, Grozea et al., 2011) and in 2011 in Bucharest, (Chireceanu et Gutue, 2011).

Our observation in the jujube experimental field showed low infestations and only on the lower leaves of the trees, having no influence on the fruit quality. Still, considering its evolution on other crops, we recomend a throughout monitoring of the *M. pruinosa* activity all year long.

Biology

According to Mead, 2014, *Metcalfa pruinosa* overwinters as eggs, hatching starting early in the spring. First adults emerge in around 70 days after the hatching and the species has only one generation per year. The species has five larval instars. In Romania, the larvae occur in the second half of May and the first adults can be seen in late July. An overlap of the stages usually happen (Bărbuceanu, 2015).

Damage

Although new and non-native pest for Europe, considering the low economic impact of the species in its area, *M. pruinosa* was not considered quarantine pest by EPPO. Although Mead, 2014 considers the pest does very little damage to plants, in Europe, Strauss, 2010 mentions serious qualitative damage of grapes and quantitative damage in soybean in Italy. For viticulture and fruit growing, the negative impact on quality is due to the *M. pruinosa*'s honeydew secretions, wich stimulate the black sooty mold development Strauss, 2010.

Control

Limiting the spreading of this pest is difficult, due to its very high mobility, very large host plants spectrum and waxy protection of the individuals. Bărbuceanu, 2015, conclude that the insecticide with the highest effectiveness is the mixture of imidacloprid 75 g/l, deltamethrin 10 g/l, lambda cyhalothrin 50 g/l, followed by a treatment with pirimiphos methyl 500 g/l, at 3-5 days after the first one. Still, the chemical treatments should be avoided, as the broad spectrum insecticides kills the natural beneficial species. The biological control with *Neodrynus typhlocybae* is assumed to be advantageous by Strauss, 2012.

Southern Green Stink Bug - *Nezara viridula (L.) (Heteroptera: Pentatomidae)* *EPPO code NEZAVI*

The southern green stink bug originates from Ethiopia and East Africa, although some authors believe it came from southern Asia (Grozea et al, 2012). It is spread now in the tropical and subtropical regions of Europe, Asia, Africa and the Americas (Squitier, 2013). The first reports of pest in Europe date from 1998, in Italy (CABI, 2016b). It is a highly polyphagous species, causing economic damage to legumes, soybean and beans (Portilla et al., 2015) but also fruits and vegetables.

In Romania, qualitative and quantitative depreciations of tomatoes were described by Grozea et al. in 2012, in Timisoara area while in Muntenia area the presence of the pest is stated in 2015 (Kurzeluk et al. 2015). The author mentions that in the Bucharest area *Nezara viridula* was identified on a goji experimental field since 2011.

The adults of *N. viridula* were observed on jujube experimental field since the beginning of September. The biology and ecology of *N. viridula* seem to be closely related to the *H. halys*'s one, as these two species cohabits. The vicinity of the depleted goji trial field and the jujube fruit maturity are considered the two main reasons for the late occurrence of the adults in the testing field. No major damages were noticed following the feeding on fruits, but further research is recommended, as the biology of the pest might change in the long and warm autumns, when the fruit start to ripe.

Biology

In the warm climates, the southern green stink bug may have four generations per year while in Europe just one generation had been mentioned. Overwinters as an adult under the bark of trees or leaf litter. In spring, after the feeding, the oviposition may start. In US, eggs have been found starting the second week of April till December. One female of *Nezara viridula* could maximum lay 260 eggs (Squitier, 2013). Its development includes five larval instars.

Damage

The damages include drop and malformation of the fruits (Panizzi, 2008) on the rostrum inserting points into the fruit or growing shoots tissues. The damages are even higher due to the digestive enzymes introduced while feeding (Grozea et al., 2015). Black spots or suberification may be observed on the mature fruits, while the younger fruits usually drop out of the plant.

Control

Although not considered a major pest, the economic thresholds for different crops were determined in the USA. For example, in soybeans, 36 stink bugs per 100 swings of a net, for cowpea 5000 southern green stink bugs per ha and 3 - 4 stink bugs per 100 swings for cotton are considered the upper limits before chemical interventions. Trap crops are considered having great potential. As biological control means, two parasites were introduced, a tachinid fly, *Trichopoda pennipes*, which parasitizes the adults and the wasp *Trissolcus basalis*, which parasitizes the eggs.

II. Jujube pests that are present in Romania, but have not been identified on USAMV Bucharest jujube experimental fields

Among the pests that have been mentioned in the literature as attacking jujube crop and that exist in Romania, but we did not identify it on the jujube crop yet, two are more important:

a. the leopard moth, *Zeuzera pyrina*, (Lepidoptera*, Cossidae*), EPPO code ZEUZPY, which is included in EPPO Alert list since 2001 and

b. the oriental fruit moth, *Grapholita molesta*, (Lepidoptera*, Tortricidae*), EPPO code LASPMO, formerly on A1/A2 list.

III. Jujube pests that are present in Europe, but not yet in Romania

Among the pests that have been mentioned in the literature as attacking jujube crop and that exist in Europe, but not yet in Romania, the ber fruit flies *Carpomya vesuviana* and *Carpomya incompleta (Diptera, Tephritidae)* EPPO code CARYVE, formerly on A1/A2, are the most dangerous. *C. vesuviana* was found in Bosnia-Herzegovina, Italy and Turkey, while *C. incompleta* was mentioned in South of Europe, Israel, France and Italy. (Vadivelu, 2014, Pollini, 2014, fera, 2016, catalogue of life.org, 2016)

The ber fruit fly, *Carpomya vesuviana* Costa, 1854 (Diptera: Tephritidae) is the most destructive pest of *Ziziphus* crop in its area of

distribution, that includes Bangladesh, China, Georgia, India, Indian Ocean Islands, Iran, Mauritius, Oman, Pakistan, Southern Europe, Turkmenistan, Turkey, and Uzbekistan (Amini et al., 2014, Vadivelu 2014).

The bug *Apolygus lucorum* (Meyer-Dur, 1843) (*Miridae: Hemiptera*), is another major pest of jujube crop in Asia. Overwintering *A. lucorum* eggs are primarily laid in the summer pruning wounds of Chinese date trees. It was reported in Europe in Britain, Denmark, Germany, Italy, Macedonia, Poland, Russia, Spain, Sweden, Switzerland, and Turkey, (catalogoflife.org, 2016, Pan et al., 2014). Another jujube pest is *Lygus pratensis* L. (*Miridae: Hemiptera*), which, according to the catalogue of life, was mentioned in Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Finland, France, Georgia, Germany, Greece, Iran, Italy, Hungary; Britain; Corsica, Macedonia, Siberia, Sweden and Turkey.

IV. Jujube pests that are not yet present in Europe

The most dangerous pest for jujube crop, but also for the entire fruit production in Europe is the Peach fruit moth - *Carposina sasakii (*Lepidoptera*: Carposinidae),* EPPO code CARSNI, A1 list: No. 163 (CABI, 2016e)

Also known as *Carposina niponensis,* the peach fruit moth can be easily mistaken as *Cydia pomonella* or *Cydia molesta*. Considered as one of the most important pests of pome fruits in the Far East, the quarantine pest can damage pears up to 100% in some cases, while apples are less heavily infested, in a degree of 40-100% (EPPO QP, 1988). Special phytosanitary measures are imposed for all *Chaenomeles*, *Crataegus*, *Cydonia*, *Eriobotrya*, *Malus*, *Prunus*, *Pyrus* and *Ziziphus* plants with roots imported from Asian country where this pest occurs. Additionally, the consignment should have been kept under conditions which prevent a reinfestation by the organism (EPPO, 1990). The growth of the larvae in the apple fruits was carefully examined by Koizumi, 2010.

CONCLUSIONS

Until the present moment, in Romania, *Ziziphus jujube* keeps its status of crop without major phytosanitary problems. All four identified pests produced a low to inexistent degree of damage.

Major attention should be given to the plants intended for planting imported from Asian countries. Although it might seem a good opportunity, importing plants with a questionable origin or doubtful phytosanitary certificate might have a severe economic impact on the fruit-growing areas of the EPPO region.

Considering that many alien invasive polyphagous pests start producing severe damages in Europe and USA and the recent climate changes, we recommend a thorough monitoring program and a detailed pest biology observation program.

REFERENCES

Amini A. Sadeghi H. Lotfalizadeh H. Notton D., 2014. Parasitoids Hymenoptera: Pteromalidae, Diapriidae) of *Carpomyia vesuviana* Costa (Diptera: Tephritidae) in South Khorasan province of Iran. Biharean Biologist 8(2):122-123.

Anderson B.E., Miller J.J., Adams D.R., 2012. Irritant contact dermatitis to the brown marmorated stink bug, *Halyomorpha Halys*. Dermatitis, 23(4):170-172.

Azam-Ali S., Bonkoungou E., Bowe C., deKock C., Godara A., Williams J.T., 2006. Ber and other jujubes. International Centre for Underutilised Crops, Southampton, UK.

ARTHropod Ecology, Molecular Identification and Systematics *database,* accessed on 09.10.2016.

Balikai R.A., Kotikal Y.K., Prasanna P.M., 2013. Global scenario of insect and non-insect pests of jujube and their management Options. Proc. 2nd International Jujube Symposium Acta Hort. 993:253 - 277.

Bărbuceanu D., Mihăescu C. F., 2015. New data about the control of the planthopper *Metcalfa pruinosa* (Say 1830) (Hemiptera: Flatidae) in the town of Piteşti (Argeş County). Annals of the University of Craiova - Agriculture, Montanology, Cadastre. XLV:26-31.

CABI, 2016a. *Ceratitits capitata* (Mediterranean fruit fly), http://www.cabi.org/isc/datasheet/12367

CABI, 2016b. *Nezara viridula* (green stink bug) http://www.cabi.org/isc/datasheet/36282#20163102287.

CABI, 2016c. *Halyomorpha halys* (Marmorated Stink bug), http://www.cabi.org/isc/datasheet/27377.

CABI, 2016d. *Metcalfa pruinosa* (frosted moth-bug), http://www.cabi.org/isc/datasheet/35054.

CABI, 2016e. *Carposina sasakii* (peach fruit moth), http://www.cabi.org/isc/datasheet/11401

Cayol J.P.; Causse R.; Louis C.; Barthes J., 1994. Medfly *Ceratitis capitata* as a rot vector in laboratory conditions. Journal of AppEnt 117, 338-343.

Ciceoi R., Mardare E. Ş., Teodorescu E., Dobrin I., 2016a. The status of brown marmorated stink bug,

Halyomorpha halys, in Bucharest area. JHFB, 20(4):18-25, DOI: 10.5281/zenodo.267978

Ciceoi R, Mardare E.S., 2016b The risks assessment of *Aceria kuko* (Kishida) and *Halyomorpha halys* (Stal) pests for the Romanian goji growers. Poster. DOI: 10.5281/zenodo.345966

Chireceanu C., Gutue C., 2011. *Metcalfa pruinosa (Say) (Hemiptera: Flatidae)* identified in a new south eastern area of Romania (Bucharest area), Romanian Journal of Plant Protection, 4:28-34.

Chireceanu C., Stănică F., Chiriloaie A. 2013. The Presence of the Mediterranean fruit fly *Ceratitis Capitata* (Wied.), (Diptera: Tephritidae) In Romania, Romanian Journal of Plant Protection. VI:92-97.

Christenson L.D., Foote R.H., 1960. Biology of fruit flies, Annual Review of Entomology 5:171-192.

Cossio F., Bassi G., 2011. Prospettive di diffusione in Italia di varietà cinesi di giuggiolo a frutto grosso, Frutticoltura. 11:58-61.

Cossio F., Bassi G., 2013. Field Performance of Six Chinese Jujube Cultivars Introduced and Tested In Northern Italy. Acta Hortic. 993:21-28.

EPPO, 1981. Data sheets on quarantine organisms No. 105, *Ceratitis capitata*. Bulletin EPPO Bulletin 11 (1).

EPPO, 1990. Specific quarantine requirements. EPPO Technical Documents No. 1008.

EPPO/CABI, 1997. *Ceratitis capitata*. Quarantine Pests for Europe, Wallingford (GB), 2nd edn, 146–152.

EPPO, 2011. Diagnostics. Ceratitis capitata PM 7/104(1). OEPP/EPPO Bulletin 41:340–346.

EPPO Services, EPPO A1 And A2 Lists Of Pests Recommended For Regulation As Quarantine Pests, 2015. EPPO.

EPPO, 2013a. First report of *Halyomorpha halys* in Italy (2013/108), EPPO Reporting Service, 05:10-11.

EPPO, 2013b. *Halyomorpha halys* continues to spread in the EPPO region: first reports in France and Germany (2013/109), EPPO Reporting Service, 05:11.

EPPO, 2016a. First report of *Halyomorpha halys* in Russia (2016/148), EPPO Reporting Service, 08:12.

EPPO, 2016b. First report of *Halyomorpha halys* in Austria (2016/150), EPPO Reporting Service, 08:13.

EPPO, 2016c. First report of *Halyomorpha halys* in Serbia (2016/151), EPPO Reporting Service, 08:14.

Fontana L., 2016. Question for written answer to the Commission. Subject: Damage to Italian agriculture: the case of the brown marmorated stink bug, Parliamentary questions.

Gogan A., Grozea I., Vîrteiu A. M., 2010. *Metcalfa pruinosa* Say (Insecta:Homoptera: Flatidae) –first occurrence in western part of Romania. Res. J. Agric. Sci., 42(4):63-67.

Golmohammadi F., 2013. Medicinal plant of Jujube (*Ziziphus jujuba*) and its indigenous knowledge and economic importance in desert regions in east of Iran: situation and problems, Tech J Engin & App Sci., 3 (6): 493-505.

Grozea I., Gogan A., Virteiu A.M., Grozea A., Stef R., Molnar L., Carabet L., Dinnesen S., 2011. *Metcalfa pruinosa* Say (Insecta: Homoptera: Flatidae): A new pest in Romania, African Journal of Agricultural Research Vol. 6(27), 5870-5877.

Grozea I., Ştef R., Virteiu A.M., Cărăbeţ A., Molnar L., 2012. Southern green stink bugs (*Nezara viridula* L.) a new pest of tomato crops in western Romania. R. Journal of Agricultural Science, 44(2):24-27.

Grozea I., Virteiu A.M., Ştef R., Cărăbeţ A., Molnar L., Florian T., Vlad M., 2015 Trophic Evolution of Southern Green Stink Bugs (*Nezara viridula l.*) in Western Part of Romania, Bulletin UASVM Horticulture 72(2), 371-375.

Gupta A.K., 2004. Origin of agriculture and domestication of plants and animals linked to early Holocene climate amelioration. Current Science. 87:54- 59.

Haye T., Abdallah S., Gariepy T., Wyniger D., 2014, Phenology, life table analysis and temperature requirements of the invasive brown marmorated stink bug, *Halyomorpha halys*, in Europe. J. Pest Sci. 87:407–418.

Heckmann R., 2012. Erster Nachweis von *Halyomorpha halys* (Stål, 1855) (Heteroptera: Pentatomidae) für Deutschland. Heteropteron 36:17-18.

Inkley DB, 2012. Characteristics of home invasion by the brown marmorated stink bug (Hemiptera: Pentatomidae). J. Entomol. Sci. 47:125-130.

Jang, E.B., 1990. Fruit fly disinfestation of tropical fruits using semipermeable shrink-wrap film. Acta Horticulturae No. 269, abstract.

Johnstone R., 2014, Development of the Chinese jujube industry in Australia, Rural Industries Research and Development Corporation, Publication No. 14/001.

Kim Y., Kim M., Hong K-J., Lee S., 2011. Outbreak of an exotic flatid, *Metcalfa pruinosa* (Say) (Hemiptera: Flatidae), in the capital region of Korea. Journal of Asia-Pacific Entomology, 14:473–478.

Koizumi M, Ihara F, Yaginuma K, Kano H, Haishi T., 2010. Observation of the peach fruit moth, *Carposina sasakii*, larvae in young apple fruit by dedicated micro-magnetic resonance imaging. Journal of Insect Science 10:145.

Kurzeluk D.K., Fătu Ac., Dinu Mm, 2015. Confirmation of the presence of the Southern Green Stink Bug, *Nezara viridula* (Linnaeus, 1758) (Hemiptera: Pentatomidae), in Romania, Romanian Journal for Plant Protection, Vol. VIII.

Leskey T.C., Hamilton G.C., Nielsen A.L., Polk D.F., Rodriguez-Saona C., Bergh J.C., Herbert D.A., Kuhar T.P., Pfeiffer D., Dively G.P., Hooks C.R.R., Raupp M.J., Shrewsbury P.M., Krawczyk G., Shearer P.W., Whalen J., Koplinka-Loehr C., Myers E., Inkley D., Hoelmer K.A., Lee D.-H., Wright S.E., 2012, Pest Status of the Brown Marmorated Stink Bug, *Halyomorpha Halys* in the USA. Outlooks Pest Manag. 23:218–226

Li J.W., Fan L. P., Ding S. D., Ding X. L., 2007. Nutritional composition of five cultivars of chinese jujube. Food Chemistry 103:454-460.

Liu M.J., Zhao Z.H., 2009, Germplasm resources and production of Jujube in China, Proc 1st Int`l jujube Symp, Acta Hort 840:25-31.

Liu M.J., Zhao J., Cai Q.L., Liu G.C., Wang J.R., Zhao Z.H., Liu P, Dai L., Yan G, Wang W.J., Li X.S., Chen Y., Sun Y.D., Liu Z.G., Lin M.J., Xiao J., Chen Y.Y., Li X.F., Wu B., Ma Y., Jian J.B., Yang W.,

Yuan Z., Sun X.C., Wei Y.L., Yu L.L., Zhang C., Liao S.G., He R.J., Guang X.M., Wang Z., Zhang Y.Y., Luo L.H., 2014. The complex jujube genome provides insights into fruit tree biology**.** Nature Comm., 5: 5315

Macavei L.I., Bâeţan R, Oltean I, Florian T, Varga M, Costi E, Maistrello L., 2015. First detection of *Halyomorpha halys* Stål, a new invasive species with a high potential of damage on agricultural crops in Romania. Lucrări Ştiinţifice seria Agronomie 58(1):105-108.

Markovski A., Velkoska-Markovska L., 2015. Investigation of the morphometric characteristics of Jujube types (*Zizyphus jujuba* Mill.) fruits in Republic of Macedonia. Genetika, Vol. 47(1):33-43.

Mead F.W., 2014. Citrus Flatid Planthopper*, Metcalfa pruinosa (Say) (Insecta: Hemiptera: Flatidae)*, Florida Department of Agriculture and Consumer Service-Division of Plant Industry: Gainesville FL.

Milonas P.G., Partsinevelos G.K. 2014. First report of brown marmorated stink bug *Halyomorpha halys* Stål (Hemiptera: Pentatomidae) in Greece. Bulletin OEPP/EPPO Bulletin 44(2):183-186.

Nielsen A.L., Hamilton G.C., Matadha D., 2008, Developmental Rate Estimation and Life Table Analysis for Halyomorpha halys (Hemiptera: Pentatomidae). Environ. Entomol. 37:348–355.

Ohta A.T.; Kaneshiro K.Y.; Kurihara J.S.; Kanegawa K.M.; Nagamine L.R., 1989. Gamma radiation and cold treatments for the disinfestation of the Mediterranean fruit fly in California-grown oranges and lemons. Pacific Science 43:17-26.

Ordax M., Piquer-Salcedo J.E., Santander R.D., Sabater-Muñoz B., Biosca E.G., López M.M., 2015. Medfly *Ceratitis capitata* as Potential Vector for Fire Blight Pathogen *Erwinia amylovora*: Survival and Transmission. PLoS ONE 10(5):e0127560.

Pan H, Liu B, Lu Y, Desneux N., 2014. Identification of the key weather factors affecting overwintering success of *Apolygus lucorum* eggs in dead host tree branches. PLoS ONE 9(4): e94190.

Panizzi A.R., 2008. Southern green stink bug*, Nezara viridula* (L.) (Hemiptera: Heteroptera: Pentatomidae). Encyclopedia of Entomology pp. 3471.

Paula D.P., Togawa R.C., Costa M.M.C., Grynberg P., Martins N.F., Andow D.A., 2016. Identification and expression profile of odorant-binding proteins in *Halyomorpha halys* (Hemiptera: Pentatomidae), Insect Molecular Biology 1-15.

Preda C., Skolka M., 2009. First record of a new alien invasive species in Constanta - *Metcalfa pruinosa* (Homoptera: Fulgoroidea). In: Paltineanu C. (Ed.) Lucrarile Simpozionului Mediul si Agricultura in regiunile aride: prima editie. Estfalia, 141-146.

Preeti S., Tripathi S., 2014. A phytopharmacological review on "*Ziziphus jujuba*", Int. J. Res. Dev. Pharm. L. Sci., 3(3):959- 966.

Pollini, A., Cravedi, P., 2014 *Carpomya vesuviana* A. Costa (Diptera: Tephritidae Trypetinae Carpomyini) from jujube tree in Emilia-Romagna (Northern Italy), Redia-Giornale Di Zoologia, 97:117-118.

Portilla M., Snodgrass G., Streett D. Luttrell R., 2015. Demographic Parameters of *Nezara viridula* (Heteroptera: Pentatomidae) Reared on Two Diets Developed for *Lygus spp*., J. Insect Sci. 15(1):165.

Rice K., Bergh C., Bergman E., Biddinger D., Dieckhoff C., Dively G., Fraser H., Gariepy T., Hamilton G., Haye T., Herbert A., Hoelmer K., Hooks C., Jones A., Krawczyk G., Kuhar T., Mitchell W., Nielsen A.L., Pfeiffer D., Raupp M., Rodriguez-Saona C., Shearer P., Shrewsbury P., Venugopal D., Whalen J., Wiman N., Leskey T., Tooker J., 2014. Biology, ecology and management of brown marmorated stink bug (*Halyomorpha halys*) J. Integr. PestManage. 5(3):1-13

Qazzaz F.O., Al-Masri, M.I., Barakat, R.M., 2015. Effectiveness of *Beauveria bassiana* native isolates in the biological control of the Mediterranean fruit fly (*Ceratitis capitata*). Advances in Entomology.3:44-55

Sarwar M., 2006. Incidence of Insect Pests on Ber *(Zizyphus jujube)* Tree. Pakistan J. Zool., vol. 38(4):261-263.

Sela S., Nestel D., Pinto R., Nemny-Lavy E., Bar-Joseph M., 2005. Mediterranean fruit fly as a potential vector of Bacterial Pathogens. Applied and Environmental Microbiology, Vol. 71 (7):4052–4056.

Stanciu I., 2007. Comportarea unor soiuri de kaki în condiţiile Câmpiei Române" Ph.D thesis. Faculty of Horticulture, University of Agronomic Sciences and Veterinary Medicine, Bucharest, Romania.

Stănică F., 1997. Curmalul chinezesc (*Ziziphus jujuba* Mill.), specie pomicolă pentru partea de sud a României (Chinese date (*Ziziphus jujuba* Mill.), fruit specie for the southern part of Romania). Hortinform.

Stănică F., 2002. Multiplication of Chinese date (*Ziziphus jujuba* Mill.) using conventional and *in vitro* techniques, XXVIth Congress ISHS, 11-17, Toronto, Canada, 303-304.

Stănică F., 2009. Characterization of Two Romanian Local Biotypes of *Ziziphus jujube,* ISHS Acta Horticulturae 840:259-262.

Strauss G., 2010. Pest risk analysis of *Metcalfa pruinosa* in Austria. Journal of Pest Science, 83:381-390.

Strauss G., 2012: Environmental risk assessment for *Neodryinus typhlocybae*, biological control agent against *Metcalfa pruinosa*, for Austria. European Journal of Environmental Sciences, 2(2):102-109.

Squitier J.M., 2013. Southern Green Stink Bug, *Nezara viridula* (Linnaeus) (Insecta: Hemiptera: Pentatomidae), UF/IFAS Extension Service, University of Florida, EENY-016 (IN142).

Varghese J., Patil M.B., 2005. Successive use of proteinase inhibitor of *Zizyphus Jujuba* leaves for effective inhibition of *Helicoverpa armigera* gut enzymes and larval growth, Biosciences Biotechnology Research Asia 3(2):367-370.

Lingampally V., Solanki V.R., Jayaram V., Kaur, A., Raja S.S., 2012. Betulinic acid: a potent insect growth regulator from *Ziziphus jujuba* against *Tribolium confusum*. Asian J. Plant Sci. Res. 2(2):198-206.

Vétek G., Papp V., Haltrich A., Rédi D., 2014. First record of the brown marmorated stink bug, *Halyomorpha halys* (Hemiptera: Heteroptera:

Pentatomidae), in Hungary, with description of the genitalia of both sexes. Zootaxa 3780(1):194-200.
Vadivelu K., 2014. Biology and management of ber fruit fly, *Carpomyia vesuviana* Costa (Diptera: Tephritidae): A review. African Journal of Agricultural Research 9(16):1310-1317.
Vlad M., Grozea I., 2016. Host Plant Species of the Cicada *Metcalfa Pruinosa* in Romania, Bulletin UASVM series Agriculture 73(1):131-137.
Yao, S. 2013. Past, present and future of jujubes-Chinese dates in the United States. HortScience, 48:672-680.
Wermelinger B, Wyniger D., Forster B., 2008. First records of an invasive bug in europe: *Halyomorpha halys* Stål (Heteroptera: Pentatomidae), a new pest on woody ornamentals and fruit trees? Bulletin De La Société Entomologique Suisse, 81:1–8
***species details: *apolygus lucorum* (meyer-dur, 1843), http://www.catalogueoflife.org/col/details/species/id/7fb6162f963b017e91741263c7764e20
***species details: *carpomya vesuviana* costa, 1854 http://www.catalogueoflife.org/col/details/species/id/ba931ddef181c172c517e6d6644301a5
***species details: lygus *pratensis* (linnaeus, 1758) http://www.catalogueoflife.org/col/details/species/id/1d6b9b22b095fa0df3d3c8e92e62a509
***https://gd.eppo.int/taxon/METFPR
***https://gd.eppo.int/taxon/NEZAVI
***https://gd.eppo.int/taxon/CERTCA


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