NEWSLETTER

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Periodical information bulletin for the Prometeo project co-financed by the European Union in the framework of the ENI Cross-Border Cooperation (CBC) Programme "Italy-Tunisia" 2014-2020

The ENI CBC Programme "Italy-Tunisia" 2014-2020 is a bilateral cross-border cooperation programme, co-financed by the European Union under the European Neighbourhood Instrument (ENI). With a budget of EUR 33.3 million, the programme, which joint management has been assigned to the Sicilian Region's Programming Office, aims to promote fair, equitable and sustainable economic, social and territorial development in order to foster cross-border integration and enhance the territories and resources of the two participating countries. https://www.italietunisie.eu/

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SPECIAL EDITION: SCIENTIFIC ENTOMOLOGY PROTOCOLS OF THE PROMETEO PROJECT

This special issue of the Prometeo periodic Newsletter has a purely scientific character and is entirely dedicated to the publication of scientific protocols on Entomology, which are the result of research activities and discussions between scientific experts and stakeholders of the Prometeo project, with the objective of creating a cross-border network of collaboration between Italian and Tunisian researchers, companies and other actors to foster the development of innovative and sustainable technical solutions for the protection of Mediterranean tree crops against quarantine pathogens or emerging pests that threaten their profitability and survival.

These results will be useful to guide agricultural policies, strengthen phytosanitary services, increase production ef-

ficiency, competitiveness and sustainability of these sectors, and improve quality standards in food safety.

The next issue of the Newsletter, also with a purely scientific character, will instead be dedicated to the publication of the scientific Plant Pathology protocols of the Prometeo project.

Enjoy your reading!

California red scale - Pou rouge de Californie - Cocciniglia rossa della California *Aonidiella aurantii*

Citrus species are among the most extensively cultivated tree fruit in the world. Nowadays, the citrus industry in the Mediterranean area accounts for 20% of the world's citrus industry. Worldwide, there are 345 species (belonging to Diaspididae, Coccidae, *Pseudococcidae* and *Monophlebidae* families) associated directly or indirectly with citrus, and some of them can sometimes pose a serious problem for production (Morales et al., 2017). The scale insects are obligatory plant parasites. Many of them are polyphagous, cosmopolitan, and able to build large populations when environmental parameters are favourable (Miller and Davidson, 2005; Pellizzari and Germain, 2010). Faunistic studies are important for documenting new distributional data and notifying researchers of potential exotic pests. The establishment of new pests can be costly owing to increased crop damage, control programs, and quarantine restrictions on trade (Jendoubi, 2018). Hence, accurate documentation of exotic pest species is required for pest control and research programs that provide quarantine treatments or other mitigation approaches to reduce or eliminate pest load in traded agricultural commodities. Scale insects are successful invaders of new territories, frequently introduced and acclimatized in all terrestrial zoogeographical regions. Around 129 scales are established in Europe, representing hence one of the major groups of alien insects to Europe (Pellizzari and Germain, 2010). Most of them (overall *Diaspididae* and *Pseudococcidae*) originate from tropical regions of Asia. The trade of fruit and ornamental trees appears to be the usual pathway of their transfer. The damage caused by scale insects is the ingestion of plant sap. Moreover, except for *Diaspididae* and *Asterolecaniidae*, they excrete honeydew that becomes a growth medium for a black sooty mold fungus and photosynthesis is reduced up to 70%, leading to early senescence and loss of aesthetic value. They also inject toxic saliva and, are vectors of closteroviruses (Morales et al, 2017).

Red scale damage

California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: *Diaspididae*) is among the major pests of citrus crops worldwide. It attacks all aerial parts of the tree including twigs, leaves,

Dégâts du Pou Rouge sur agrumes

branches, and fruit by sucking on the plant tissues. Severe infestations cause leaf yellowing and drop, dieback of twigs and limbs, and occasionally death of the tree.
In Tunisia, few years ago, Jendoubi (2018) reported that despite A. aurantii is a serious pest for citrus crops, it has a localized distribution and was rare (1 to 3% of the number of scale insects recorded). However, recently, outbreaks of A. aurantii occurred, and could represent a real threat for citrus cultivations in Tunisia. Consequently, PROMETEO aims to monitor this pest, study its distribution, evaluate its damage, and develop control alternatives.

1. Pest survey and monitoring

Effective monitoring and trapping of *A. aurantii* can be achieved using California red scale sticky trap (yellow) and impact boards (white) baited with pheromone lures. Traps will help to minimize damage and assist growers in gaining control. Monitoring for pests should be at the forefront of all pest management programs, as early diagnosis will minimize crop destruction and increase the likelihood.
In the framework of PROMETEO project, a trapping network will be installed in various Tunisian citrus orchards in order to monitor *A. aurantii* and study its seasonal activities.

2. Pest distribution

The California red scale is widely distributed in many parts of the world, in particular the tropics and subtropics. In the Mediterranean basin, *A. aurantii* has been a serious pest for many years in eastern countries. In Italy, *A. aurantii* have been reported as citrus key pest (Elimem et al., 2022). In Tunisia, previous researches cited the limited distribution of this pest (Jendoubi, 2018; Limem et al., 2022).

3. Damage assessment

Aonidiella aurantii is one of the most important pests infesting citrus trees in different parts of the world (Claps et al. 2001; Abd-Rabou, 2009). It occurs on host plants belonging to at least 80 plant families (Moursi, 1991).
In the framework of PROMETEO project, the damage of *A. aurantii* will be assessed on different host plants in order to quantify losses.

4. Control

California red scale is one of the most dangerous pests on citrus around the Mediterranean basin. The damages by the California red scale are caused to all tree organs including fruit. Although there is no effective method available to eradicate the pest, scale control is mainly based on mineral oil and pesticide sprays in the field that are effective in reducing the incidence of the pest. Additionally, biological control using the natural enemies (parasitoids and predators) presented promising achievements. This method is now commonly used in citrus orchards in many countries. *Aphytis melinus* (Hymenoptera: *Aphelinidae*) is a specific parasitoid used with success against *A. aurantii* (Zappalà et al., 2012).
In the framework of PROMETEO project, treatments using some mineral oils and synthetic insecticides will be used. Additionnaly, the parasitoid *A. melinus* will be introduced from Italy. Biological trials using this parasitoid will be undertaken.

References

1. Abd-Rabou, S. (2009). Parasitoids attacking Aonidiella aurantii (Maskell) (Homoptera:Diaspididae) with emphasis on parasitoid fauna of this species in Baharia oasis. Egyptian Journal of Agricultural Research, 87(4): 939-946.
2. Pellizzari G, Germain JF. 2010. Scales (Hemiptera, Superfamily Coccoidea). BioRisk. 4(1):475-510.
3. Morales G., Denno BD, Miller DR, Miller GL, Ben-Dov Y, Hardy NB. 2017. Scale Net Database: A literature based model of scale insect biology and systematics, 2017.
4. Claps, L.E.; Wolff, V. R. S. and González, R. H. 2001. Catálogo de las Diaspididae (Hemiptera: Coccoidea) exóticas de la Argentina, Brasil y Chile. Revista de la Socieded Entomológica Argentina 60: 9-34.
5. Moursi, K. S. (1991). Preliminary studies on Mediterranean fig scale, Lepidosaphes ficus (Sign.) (Homoptera: Diaspididae) at Hammam area (Egyptian Western Desert). Mansoura University Journal of Agricultural Sciences, 16(9): 2174-2178.
6. Elimem, M., Jendoubi, H., Lahfef, C., LIMEM-Sellemid, E., Ben Belgacem, L., Kalboussia, M., Rouz, S. 2022. Further data on scale insect species in an organic citrus orchard in north-eastern tunisia: biodiversity, abundance and natural enemies. REDIA, 105, 59-69.
7. Jendoubi, H., 2018. The scale insect fauna of citrus in Tunisia: A critical overview – International Journal of Fauna and Biological Studies, 5 (3): 169-178.
8. Miller, D.R., Davidson, J.A., 2005. Armored scale insect pests of trees and shrubs (Hemiptera: Diaspididae). Cornell University Press, Ithaca, NY.
9. Zappal, L., Campolo, O., Grande, S.B., Saraceno, F., Biondi, A., Siscaro, G., Palmeri, V. 2012. Dispersal of Aphytis melinus (Hymenoptera: Aphelinidae) after augmentative releases in citrus orchards. European Journal of Entomology 109: 561–568.

The carob moth - La pyrale des caroubes - La falena del carrubo *Apomyelois (=Ectomyelois) ceratoniae.*

The moth *Apomyelois (=Ectomyelois) ceratoniae* Zeller (1839) (Lepidopteran *Pyralidae*), is commonly known as carob moth because of its infestation on pods of this plant. Other common names include “date moth”, “knot-horn moth”, “blunt-winged moth”, “locust bean moth” and “pomegranate neck worm” (Mirkarimi 2002; Botha and Hardie 2004; Massimino Cocuzza et al., 2016; 2021). As well as being a serious field pest of orchard crops, the carob moth is also known as a significant pest of stored products, including dried figs, dates, raisins, carobs, almonds and other nuts (Heinrich 1956; Higbee and Siegel 2009).

A. ceratoniae is a widespread pest of numerous commercial tree crops. In Tunisia, it attacks several hosts, such as citrus, pomegranate, date, and almond (Mediouni et al, 2004, 2012; Massimino Cocuzza et al., 2016; 2021). The carob moth can cause economic losses in the Mediterranean basin and Near East regions. Larvae feed on inner parts of the fruit and highly reduce its quality indices (Dhouibi, 1989).

Damage of *Ectomyelois ceratoniae* on stored almonds

Damage of *Ectomyelois ceratoniae* on orange Navel

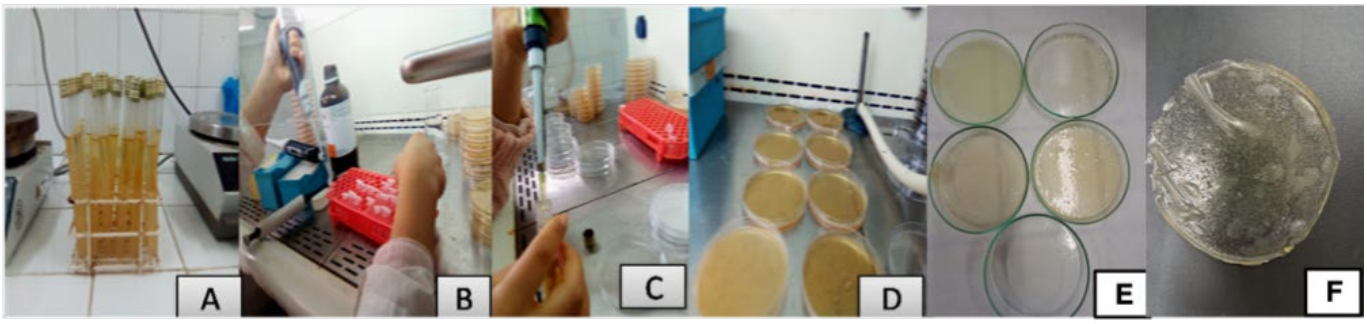
In fields, *A. ceratoniae* monitoring is mainly based on the use of sex pheromone traps (Mediouni, 2005). The control of the pest includes cultural practices like sanitation, removal and destruction of infested plant parts (including fruit) and fruit bagging (Dhouibi, 1989). In this regard, Gothilf (1970) cited that in carob plantations, unharvested pods have been noted to provide breeding sites and act as a population “reservoir” for carob moth. Indeed, in numerous crops, unharvested fruit remaining in orchards have been found to be a major breeding resource for the pest, and orchard hygiene has been recommended as a key pest management factor (Madge, 2015).

On the other hand, methods of protecting stored fruits essentially involve the use of fumigants and synthetic insecticides. However, the application of these chemicals is controversial due to concerns about human and environmental effects (Ben Abada et al, 2019). Thus, alternative control methods are required.

In the framework of PROMETEO project, our work aims to investigate innovative options for managing the carob moth in stored almonds through i) the development of natural packaging films based on bioactive compounds with insecticidal properties (Djebbi et al., 2023) and ii) industrial-scale applications of packaging films.

1. Development of natural packaging films

Films will be produced from different natural matrix (such as, pectin, chitosan) with essential oils and their constituents as active biomolecules with insecticidal activities (toxic, repellent, attractant).



Preparation of packaging films with insecticidal potential for the control of carob moth (Djebbiet al, 2023).

2.Industrial scale application of packaging films

Some trials to assess the efficacy of the packaging films will be undertaken on an industrial scale to test the potential of such material in reducing the damage of *A. ceratoniae*.

References

1. Ben Abada Maha, Soumaya Haouel Hamdi, Riham Gharib, Chokri Messaoud, Sophie Fourmentin, Hélène Greige-Gergesc and Jouda Mediouni Ben Jemâa. 2019. Post-harvest management control of Ectomyelois ceratoniae (Zeller) (Lepidoptera: Pyralidae): new insights through essential oil encapsulation in cyclodextrin. Pest Management Science, 75 (7): 2000-2008.
2. Botha, J. and J. Hardie (2004). Carob moth. W. A. Department of Agriculture. Gardennote 21.
3. Bouka, H., Chemseddine, M., Abbassi, M., Brun, J., 2000. La pyrale des dattes dans la région de Tafilalet au Sud-Est du Maroc. Fruits, 56 : 189-196.
4. Dhouibi M.H. 1989. Biologie et écologie d'Ectomyelois ceratoniae Zeller (Lepidoptera: Pyralidae) dans deux biotopes différents au sud de la Tunisie et recherche de méthodes alternatives de lutte. Thèse de Doctorat en Sciences naturelles, Université Pierre et Marie Curie Paris VI.
5. Djebbi Tasnim, Abir Soltani, Hadhami Chargui, Islam Yangui, Nesrine Teka, Emna Boushih, Hatem Majdoub, Chokri Messaoud, Jouda Mediouni Ben Jemâa. 2023. Encapsulated Bio-insecticide from Citrus aurantium (Rutaceae) Essential Oil and Pectin and Potential for the Control of the Lesser Grain Borer Rhyzopertha dominica (Bostrichidae). Waste and Biomass Valorization: 1-15.
6. Gothilf, S. 1970. The biology of the carob moth Ectomyelois ceratoniae (Zell.) in Israel. III Phenology on various hosts. Israel Journal of Entomology 5: 161-175.
7. Heinrich, C. (1956). American moths of the subfamily Phycitinae. Washington, D.C., Smithsonian Institution.
8. Higbee, B. S. and J. P. Siegel (2009). "New navel orangeworm sanitation standards could reduce almond damage" California Agriculture 64(1): 24-27.
9. Madge David. 2015. Managing Carob Moth in almonds, Final Report. Horticulture Innovation Australia Limited Level 8, 1 Chifley Square Sydney NSW 2000, 135pp.
10. Massimino Cocuzza G.E., Mazzeo G., Lo Giudice V., Russo A., Bella S., 2016 – Pomegranate Arthropod pests and their management in Mediterranean area. Phytoparasitica, 44 (3), 393-409.
11. Massimino Cocuzza G.E., Goldansaz S.H., Harsur M., 2020. Arthropod pests and their management. In: The pomegranate: botany, production and uses, Sarkosh A., Yavari A & Zamani Z. (eds.), CAB International, Wallingford, UK, 392-427 pp.
12. Mediouni Ben Jemâa J, S Haouel, M Bouaziz, ML Khouja. 2012. Seasonal variations in chemical composition and fumigant activity of five Eucalyptus essential oils against three moth pests of stored dates in Tunisia. Journal of Stored Products Research, 48, 61-67.
13. Mediouni Jouda, Iva Fuková, Radmila Frydrychová, Mohamed Habib Dhouibi, František Marec. 2004. Karyotype, sex chromatin and sex chromosome differentiation in the carob moth, Ectomyelois ceratoniae (Lepidoptera: Pyralidae). Caryologia, 57 (2): 184-194.
14. Mirkarimi, A. (2002). "The effect of stuffing Pomegranate neck (calyx) on reduction of Pomegranate neck worm Spectrobates ceratoniae Zell. (Lep. Pyralidae: Phycitinae) damage." Iranian Journal of Agricultural Sciences 33(3): 375-383.

The olive fly - La mouche des olives – La mosca dell'olivo *Bactrocera oleae*

Olive *(Olea europaea L.)* is one of the main crops and fruit trees in the Mediterranean region, where wild, feral and domesticated forms are widespread (Fanelli *et al*, 2022). Olive is the pillar of the Mediterranean agroecosystems, given its great economic, social and cultural importance (Besnard *et al*., 2018; Famiani *et al*., 2019). The crop is cultivated on more than 12 million hectares worldwide (Rugin *et al*., 2016), and displays a wide variability, witnessed by more than 2600 different varieties for oil and/or table fruits (FAO, 2010). The olive tree, an iconic symbol of the Mediterranean basin, is the object of growing international interest in the production of olive oil for the world food market. In Tunisia, which is the fourth-largest producer of olive oil in the world, the production of olives and olive oil is of great socio-economic importance. Cultivation is widespread from north to south of the country (Debbabi *et al*, 2022).

A major challenge has arisen in relation to the growing environmental impact of climate changes associated with abiotic stresses. They include cold, salinity and drought as well as new or resurgent pests and diseases, such as the new disease, the Olive Quick Decline Syndrome (OQDS), caused by the bacterium *Xylella fastidiosa* ((Montilon *et al*, 2022) and the olive fly *Bactrocera oleae* (Debbabi et al, 2022).

Bactrocera oleae (Rossi, 1790) (Diptera: *Tephritidae*), the olive fly, is monophagous and one of the primary threats to the olive tree causing serious economic losses (Ponti et al., 2009). In field, olive flies damage fruit by punctures resulting from oviposition, and these sites can serve as the entry point for microorganisms of rot, compromising the organoleptic quality of olive and olive oil. Larvae feed on the olive mesocarp, causing galleries in the pulp and fruit drop, which result in the reduction of the commercial value of table olives and make it impossible to commercialize the olive oil because of the high levels of acidity (Zygouridis et al., 2009, Daane and Johnson 2010). The estimation is that among the pest insects of the olive tree, *Bactrocera oleae* is responsible for up to 60% of the total damage (Gutierrez *et al*., 2010).

Damage caused by the olive fly *Bactrocera oleae*

In the framework of PROMETEO project, the team intend to:
- Monitor the insect in different olive groves in North of Tunisia
- Development of baits and attractants,
- Identification of associated parasitoids and predators,
- Implementation of control trials

References

1. Debbabi, O.S.; Amar, F.B.; Rahmani, S.M.; Taranto, F.; Montemurro, C.; Miazzi, M.M. The Status of Genetic Resources and Olive Breeding in Tunisia. Plants 2022, 11, 1759. https://doi.org/ 10.3390/plants11131759
2. Fanelli, V.; Mascio, I.; Falek, W.; Miazzi, M.M.; Montemurro, C. Current Status of Biodiversity Assessment and Conservation of Wild Olive (Olea europaea L. subsp. europaea var. sylvestris). Plants 2022, 11, 480.
3. Besnard, G.; Terral, J.F.; Cornille, A. On the origins and domestication of the olive: A review and perspectives. Ann. Bot. 2018, 121, 385–403.
4. Famiani, F.; Farinelli, D.; Gardi, T.; Rosati, A. The cost of flowering in olive (Olea europaea L.). Sci. Hortic. 2019, 252, 268–273.
5. Rugini, E.; Cristofori, V.; Silvestri, C. Biotechnology Advances. Genetic Improvement of Olive (Olea europaea L.) by Conventional and In Vitro Biotechnology Methods; Elsevier: Amsterdam, The Netherlands, 2016.
6. FAO. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture; FAO: Rome, Italy, 2010.
7. Montilon, V.; Susca, L.; Potere, O.; Roseti, V.; Campanale, A.; Saponari, A.; Montemurro, C.; Fanelli, V.; Venerito, P.; Bottalico, G.

Embryo Culture, in vitro Propagation, and Molecular Identification for Advanced Olive Breeding Programs. Horticulturae 2022, 8, 36.
8. Ponti, L., Cossu, Q.A., Gutierrez, A.P., 2009. Climate warming effects on the Olea europaea - Bactrocera oleae system in Mediterranean islands: sardinia as an example. Glob. Chang. Biol. 15, 2874–2884.
9. Zygouridis, N., Augustinos, A., Zalom, F. et al. 2009. Analysis of olive fly invasion in California based on microsatellite markers. Heredity 102, 402–412.
10. Daane, K.M., Johnson, M.W., 2010. Olive Fruit Fly: managing an ancient pest in modern times. Annual Review of Entomology 55, 151–169.
11. Gutierrez, A.P., Ponti, L., Gilioli, G., 2010. Climate change effects on plant-pest-natural enemy interactions. In: Hillel, D., Rosenzweig, C. (Eds.), Handbook of Climate Change and Agroecosystems: Impacts, Adaptation, and Mitigation. Imperial College Press, London, UK, pp. 209–237.

The Mediterranean fruit fly - La mosca mediterranea della frutta - La mouche Méditerranéenne des fruits *Ceratitis capitata*

Ceratitis capitata (Wiedemann) (Diptera: *Tephritidae*), communally called Mediterranean fruit fly or Medfly, is among the major destructive pests of fruits worldwide, particularly in the Mediterranean regions (Aluja and Mangan, 2008). In Tunisia, Medfly is a key economic pest on citrus and various crops (Jerraya, 2003). Current control program is mainly based on applications of organophosphate insecticides (Boussabbeh et al., 2016). However, their use is subject to much controversy, which resides in the destruction of auxiliary fauna, the increase in residue levels in fruits, the resurgence of secondary pests and the development of resistant strains (Mediouni-Ben Jemâa et al., 2010). Therefore, the development of techniques that would provide more effective control against *C. capitata* without serious environmental effects is necessary.

Damage caused by *Ceratitis capitata*

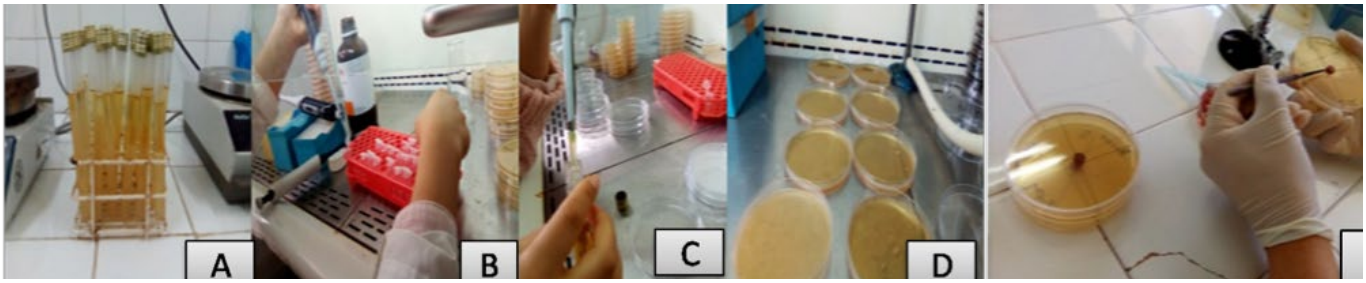
Numerous control approaches using attractants for the monitoring and the control of Medfly have been implemented (feeding and sexual attractants) (Figueroa Candia, 2018). On the other hand, Di-Ammonium Phosphate (DAP fertilizer) exhibited an attractive activity towards *C. capitata* adults. Indeed, traps baited with DAP solution were attractive to Medfly adults (Braham, 2013). Additionaly, our recent work revealed the attractant potential of bear yeast toward *Medfly adults.*

Trials to assess attractant potential of bear yeast under laboratory and field conditions.

In the framework of the PROMETEO project, we propose the following work plan and protocol:

1.Development of natural attractants

Our work will be focused on the development of natural attractant by adsorption onto DAP fertilizers of some plant extracts with attractant potential. Among the plant extracts, the use of



essential oil extracted from some plants (citrus fruit peels, Eucalyptus, ...) will be tested.

Different steps to prepare the attractant.

2. Field trials

The attractant developed and tested under controlled laboratory conditions will be tested and assessed under field conditions.

References

1. Aluja, M., Mangan, R.L., 2008. Fruit fly (Diptera: Tephritidae) host status determination: critical conceptual, methodological, and regulatory considerations. Annual Review of Entomology 53, 473–502.
2. Boussabbeh, M., Salem, I.B., Hamdi, M., Fradj, S.B., Abid-Essefi, S., Bacha, H., 2016. Diazinon, an organophosphate pesticide, induces oxidative stress and genotoxicity in cells deriving from large intestine. Environmental Science and Pollution Research 23, 2882–2889.
3. Braham, M., 2013. Trapping adults of the Medfly Ceratitis capitata and non-target insects: Comparison of low-cost traps and lures. Tunisian Journal of Plant Protection 8, 107–118.
4. Figueroa Candia, I., 2018. The invasive Mediterranean fruit fly Ceratitis capitata Wied. (Diptera; Tephritidae): Life history, ecology, behaviour and its implication in ethological management (Introductory paper at the Faculty of Landscape Architecture, Horticulture and Crop Production Sciences. 2018:2).
5. Jerraya, A., 2003. Principaux nuisibles des plantes cultivées et des denrées stockées en Afrique du Nord: leur biologie, leurs ennemis naturels, leurs dégâtsts et leur contrôle. Maghreb Editions, Tunisia, p. 415.
6. Mediouni-Ben Jemâa, J., Bachrouch, O., Allimi, E., Dhouibi, M., 2010. Field evaluatin of Mediterranean fruit fly mass trapping with Tripack as alternative to malathion bait-spraying in citrus orchards. Spanish Journal of Agricultural Research 2, 400–408.
7. Sadraoui-Ajmi, Nejib Benali, Abir Soltani, Samira Chaib, Essia Limem, Slim Jallouli, Emna Boushih, Abdallah Fajraoui, Jouda Mediouni-Ben Jemâa. 2022. Usage of agricultural DAP-fertilizer and Eucalyptus essential oils as potential attractants against the mediterranean fruit fly Ceratitis capitata (Tephritidae). Journal of Asia-Pacific Entomology, 25, 101857

Whitefly - L'aleurode des agrumes - La mosca bianca *Dialeurodes citri*

Whiteflies (Hemiptera: *Aleyrodidae*) are important insect pests (Hodges and Evans 2005) able to cause damage by sucking plant sap inducing the weakening of plants and, for some species, through the transmission of viruses. The citrus whitefly, *Dialeurodes citri* (Ashmead) (Hemiptera: *Aleyrodidae*) is considered one of the most important citrus pests. However, in some environments, other species can cause damage to crops, and among these, the most important in the Mediterranean basin are *Aleurothrixus floccosus* (Maskell, 1896), *Parabemisia myricae* Kuwana, 1927, *Paraleyrodes minei* Iaccarino, 1990 and *Aleurocanthus spiniferus* (Quaintance, 1903), the latter of which is spreading rapidly in several European countries (Italy, Greece, Montenegro, Bulgaria and Croatia).

The whitefly consum large quantities of sap and this feeding activity can weaken plants, especially young ones. Moreover, sooty mould fungi, belonging to the genera *Cladosporium*, *Capnodium* and *Alternaria*, grows over fruit and foliage due to copious amount of honeydew produced by the whitefly. It may cover the leaves and fruit and can interferes with the physiological activities of the plants. Heavily-infested trees become weak and produce small crops of insipid fruit. As mentioned above, fruit covered with sooty mould will be retarded in ripening and late in colouring, especially the upper part, which may remain green after the lower portion has assumed the colour of ripe fruit. In Tunisia, recently, *D. citri* was detected with very high population densities in some citrus orchards in the Cap-Bon) region (main area of citrus production in Tunisia). These observations confirmed its change of status and potential widespread in Tunisia (Boulahia-Kheder, 2021). Thus, in the framework of the PROMETEO project, we propose the following work plan and protocol:

1. Monitoring of *D. citri* using sticky trap (Surveillance moyennant les pièges englués)
2. Study of *D. citri* distribution in Tunisia (Etude de la distribution de l'insecte en Tunisie)
3. Damage assessmen
4. Establishment of an IPM program

Dialeurodes citri: Adults, larvae and damage (Photograph by University of Florida)

1. Monitoring

In recent years, yellow sticky traps have been widely used in pest control and monitoring (Tariq et al, 2016). Coloured sticky traps have been used for monitoring the population of whiteflies, leafminers, thrips and other insects in greenhouses and fields (Qiu and Ren, 2006).

2. Distribution

The citrus whitefly *Dialeurodes citri* has a wide range of distribution in different regions around the world (Bellows and Meisenbacher, 2007). *Dialeurodes citri* is one of the most widely distributed whitefly pests of citrus. It spreads rapidly throughout the citrus-growing area. In Tunisia, *D. citri* distribution was not studied.

In the framework of PROMETEO project, we intend to carry out the following activities:

- Surveys over citrus orchards,
- Study of *D. citri* distribution in Tunisia,
- Identification of the main infested areas (hot spots)

3. Management

Traditional chemical controls are the most used methods to manage citrus whiteflies. However, the heavy use of chemical pesticides has generated negative side-effects, especially insecticide resistance. Therefore, it is important to search for alternative methods for whitefly control (Kunimi, 2007).

3.1. Biological control

Biological control is the control of insect pests using predators and parasitoids and should be adapted at a large scale to avoid the unnecessary use of insecticides. There are various predators and parasitoids of *D. citri* in the citrus crop. The primary source of generalist predators is syrphid flies, ladybird beetles, lacewings, predatory mites, and ants (Yang et al, 2006). The first effective control method is to restore a biological balance in the agrosystem. This can allow the natural enemies of aleyrodids to develop and keep the whiteflies population below the economic threshold of damage.

In the framework of PROMETEO project, we intend to study:

-Sampling and identification of natural enemies associated to *D. citri*

-Assessment of control potential of natural enemies.

3.2. Cultural control

All the practices in citrus orchards that enhance the passage of airflow through the canopy of citrus trees come under cultural control, these practices include the following: maintaining a proper plant to plant and row to row distance, weed control, moderate pruning, and optimum application of irrigation and fertilizer. These cultural practices do not allow humidity among the trees to increase significantly and thus keep the population under check (Uygun and Satar, 2008).

In the framework of PROMETEO project, we intend to:

-Experiment with some cultural control methods

-Determine the impact of cultural control methods on *D. citri* infestations.

3.3. Chemical control

Chemical control using inorganic compounds, botanicals, and synthetic insecticides is an integral part of IPM for the control of citrus whiteflies; however, it should be used judiciously and only when required.

In the framework of PROMETEO project, we intend to:

- Application of summer oil or white oil emulsion,
- Application of some synthetic insecticides and plant extracts,
- Study the impact of chemical application on the natural enemies

References

1. Qiu, B.L. and S.X. Ren, 2006. Using yellow sticky traps to inspect population dynamics of Bemisia tabaci and its parasitoids. Chinese Bulletin of Entomology 43: 53-563.
2. Kaleem Tariq, Asad Ali, Gul Naz, Zeeshan Anwar, Arshad Ali Khan, Ibadullah Jan, Isma Khursheed, Jawad Ali Shah, Kawsar Ali, Muhammad Nadeem, Asim Gulzar and Zahid Ali Butt. 2016. Field Evaluation of Yellow Sticky Traps for the Control of Citrus Whitefly Dialeurodes citri (Ashmead) (Homoptera: Aleyrodidae) in Citrus Orchard of Pakistan. World Journal of Zoology 11 (2): 110-116.
3. Boulahia-Kheder, S. 2021. The whitefly Dialeurodes citri: a new pest on citrus in Tunisia? Tunisian Journal of Plant Protection 16 (1): 11-18.
4. Hodges, G.S., and Evans, G.A. 2005. An identification guide to the whiteflies (Hemiptera: Aleyrodidae) of the South-Eastern United States. Florida Entomologist 88 (4): 518-534.
5. Mound, L.A., and Halsey, S.H. 1978. Whitefly of the world. A systematic catalogue of the Aleyrodidae (Homoptera) with host plant and natural enemy data. British Museum (Natural History) and John Wiley and Sons, Chichester-New York - Brisbane-Toronto, USA, 340 pp.
6. Bellows TS, Meisenbacher C. 2007. Field population biology of citrus whitefly, Dialeurodes citri (Ashmead) (Heteroptera: Aleyrodidae), on oranges in California. Population Ecology. 49(2):127-134.
7. Kunimi Y. 2007. Current status and prospects on microbial control in Japan. Journal of Invertebrate Pathology. 95:181-186.
8. Yang Y, Huang M, Andrew G, Beattie C, Xia Y, Ouyang G, et al. 2006. Distribution, biology, ecology and control of D. citri, a major pest of citrus: A status report for China. International Journal of Pest Management (52):343-352.
9. Uygun N, Satar S. 2008. The current situation of citrus pests and their control methods in Turkey. IOBC-WPRS Bulletin, 38: 2-9.

General information on PROMETEO

Main beneficiary
Università degli Studi di Catania (UNICT)

Partners
P2: Université de Tunis El Manar (UTM)
P3: Centre Technique des Agrumes (CTA)
P4: Institut National de la Recherche Agronomique de Tunisie (INRAT)
P5: Agence Nationale de Promotion de la Recherche scientifique (ANPR)
P6: Comune di Palazzolo Acreide (PALAZZOLO)
P7: Centro di Ricerca per l'Innovazione e Diffusione della conoscenza (CERID)
P8: Expergreen S.R.L. (EXPERGREEN)

PROMETEO PROJECT IN NUMBERS	
Duration	**24 months**
Project start-up	**29/10/2021**
Date of completion	**28/10/2023**
N. of project Partners	**8**
Overall budget	**1.459.103,08 €**
EU Contribution	**1.291.659,13 €**

PROMETEO PROJECT ACTIVITIES	
Number of dissemination events and thematic meetings	**5**
Involved participants	**450+**
Project website	**1**
Social media channels	**4**

OUR CONTACTS

Project website: https://www.prometeo-italietunisie.eu

E-mail address: info@prometeo-italietunisie.eu

Facebook: https://www.facebook.com/Prometeo.ItalieTunisie

Instagram: https://www.instagram.com/prometeo_italietunisie/

Twitter: https://twitter.com/prometeo_ItaTun

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