



## Ολοκληρωμένη διαχείριση των θρεπτικών στοιχείων στο σύστημα έδαφος-φυτό για την επίτευξη της αειφορικής γεωργίας

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### ΒΙΒΛΙΟΓΡΑΦΙΑ

1. Blum WEH, Eswaran H (2004) Soils for sustaining global food production. *J Food Sci* 69:R37–R42.
2. Cherlet M, Hutchinson C, Reynolds J, Hill J, Sommer S, von Maltitz G. (Eds.), (2018) World Atlas of Desertification, Publication Office of the European Union, Luxembourg.
3. ECA (2018) Special Report Combating desertification in the EU: a growing threat in need of more action. 1-65.
4. Ehaliotis K, Giannakopoulou F (2019) Ecosystem-based plant growth promotion strategies. Proceedings of Conference Phytobiomes and plant health: from basics to application. 23-25 Jan, Thessaloniki, Greece.
5. Gasparatos D (2018) Soil, food security and human health. Proceedings of 8th Conference Fertilizers and sustainable management of soil: Quantity- quality and safety of agricultural products, 3 Feb. Thessaloniki, Greece. 18-29.
6. Janzen HH, Fixen P, Franzluebbers AJ, Hattey J, Izaurralde RC, Kettner QM, Lobb DA, Schlesinger WH (2011) Global prospects rooted in soil science. *Soil Sci Soc Am J* 75:1–8.
7. Kopittke MP, Punshon T, Paterson JD, Tappero VR, Wang P, Blamey FPC, Van der Ent A, Lombi E (2018) Synchrotron-Based X-Ray Fluorescence Microscopy as Technique for Imaging of Elements in Plants. *Plant Physiol.* 178:507–523.
8. McBratney A, Field DJ, Koch A (2014) The dimension of soil security. *Geoderma* 213:203–213.
9. Sepuru KT, Dube T (2018) An appraisal on the progress of remote sensing applications in soil erosion mapping and monitoring. *RSASE*. 9:1-9
10. Stavi I, Bel G, Zaady E (2016) Soil functions and ecosystem services in conventional, conservation, and integrated agricultural systems. A review. *Agron. Sustain. Dev.* 36:1-12.

# Η εξέλιξη της ανθεκτικότητας ελληνικών πληθυσμών της πράσινης αφίδας της ροδακινιάς σε εντομοκτόνα

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## ΒΙΒΛΙΟΓΡΑΦΙΑ

- Sparks TC and Nauen R, IRAC: Mode of action classification and insecticide resistance management, *Pestic Biochem Physiol* 121:122–128 (2015).
- Sparks TC, Insecticide discovery: An evaluation and analysis, *Pestic Biochem Physiol* 107:8–17 (2013).
- Blackman RL and Eastop VF, Taxonomic issues, in *Aphids as crop pests*, ed. by van Emden HF and Harrington R. CAB International, Wallingford, pp. 1–29 (2007).
- Eastop VF and Blackman RL, Some new synonyms in Aphididae (Hemiptera: Sternorrhyncha), *Zootaxa*: 1089:1–36 (2005).
- Bass C, Puinean AM, Zimmer CT, Denholm I, Field LM, Foster SP, Gutbrod O, Nauen R, Slater R and Williamson MS, The evolution of insecticide resistance in the peach potato aphid, *Myzus persicae*, *Insect Biochem Mol Biol* 51:41–51 (2014).
- Bass C, Denholm I, Williamson MS and Nauen R, The global status of insect resistance to neonicotinoid insecticides, *Pestic Biochem Physiol* 121:78–87 (2015).
- Anthon EW, Evidence for green peach aphid resistance to organo-phosphorous insecticides, *J Econ Entomol* 48:56–57 (1955).
- Blackman RL, Malarkey G, Margaritopoulos JT and Tsitsipis JA, Distribution of common genotypes of *Myzus persicae* (Hemiptera: Aphididae) in Greece, in relation to life cycle and host plant, *Bull Entomol Res* 97:253–263 (2007).
- Margaritopoulos JT, Malarkey G, Tsitsipis JA and Blackman RL, Microsatellite DNA and behavioural studies provide evidence of host-mediated speciation in *Myzus persicae* (Hemiptera: Aphididae), *Biol J Linn Soc* 91:687–702 (2007).
- Cox D, Denholm I and Devonshire A, Monitoring of insecticide resistance in *Myzus persicae* from Greece, in *Aphids in a new millennium*, ed. by Simon J-C, Dedyryer CA, Rispe C and Hullé M. INRA Editions, Paris, pp. 275–280 (2004).
- Margaritopoulos JT, Skouras PJ, Nikolaidou P, Manolikaki J, Maritsa K, Tsamandani K, Kanavaki OM, Bacandritsos N, Zarpas KD and Tsitsipis JA, Insecticide resistance status of *Myzus persicae* (Hemiptera: Aphididae) populations from peach and tobacco in mainland Greece, *Pest Manag Sci* 63:821–829 (2007).
- Anstead JA, Mallet J and Denholm I, Temporal and spatial incidence of alleles conferring knockdown resistance to pyrethroids in the peach-potato aphid, *Myzus persicae* (Hemiptera: Aphididae), and their association with other insecticide resistance mechanisms, *Bull Entomol Res* 97:243–252 (2007).
- Margaritopoulos JT, Tsamandani K, Kanavaki OM, Katis NI and Tsitsipis JA, Efficacy of pymetrozine against *Myzus persicae* and in reducing potato virus Y transmission on tobacco plants, *J Appl Entomol* 134:323–332 (2010).
- Voudouris CC, Kati AN, Sadikoglou E, Williamson M, Skouras PJ, Dimotsiou O, Georgiou S, Fenton B, Skavdis G and Margaritopoulos JT, Insecticide resistance status of *Myzus persicae* in Greece: long-term surveys and new diagnostics for resistance mechanisms, *Pest Manag Sci* 72:671–683 (2016).
- Voudouris CC, Williamson MS, Skouras PJ, Kati AN, Sahinoglou AJ and Margaritopoulos JT, Evolution of imidacloprid resistance in *Myzus persicae* in Greece and susceptibility data for spirotetramat, *Pest Manag Sci* 73:1804–1812 (2017).
- Margaritopoulos JT, Tsitsipis JA, Goudoudaki S and Blackman RL, Life cycle variation of *Myzus persicae* (Hemiptera: Aphididae) in Greece, *Bull Entomol Res* 92:309–319 (2002).
- Puinean AM, Foster SP, Oliphant L, Denholm I, Field LM, Millar NS, Williamson MS and Bass C, Amplification of a cytochrome P450 gene is associated with resistance to neonicotinoid insecticides in the aphid *Myzus persicae*, *PLoS Genet* 6:e1000999 (2010).
- Bass C, Puinean AM, Andrews M, Cutler P, Daniels M, Elias J, Paul VL, Crossthwaite AJ, Denholm I, Field LM, Foster SP, Lind R, Williamson MS and Slater R, Mutation of a nicotinic acetylcholine receptor β sub-unit is associated with resistance to neonicotinoid insecticides in the aphid *Myzus persicae*, *BMC Neurosci* 12:51 (2011).
- Philippou D, Field L and Moores G, Metabolic enzyme(s) confer imidacloprid resistance in a clone of *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) from Greece, *Pest Manag Sci* 66:390–395 (2010).
- Slater R, Paul VL, Andrews M, Garbay M and Camblin P, Identifying the presence of neonicotinoid resistant peach-potato aphid (*Myzus persicae*) in the peach-growing regions of southern France and northern Spain, *Pest Manag Sci* 68:634–638 (2012).
- Mottet C, Fontaine S, Caddoux L, Brazier C, Mahéo F, Simon J-C, Micoud A and Roy L, Assessment of the dominance level of the R81T target resistance to two neonicotinoid insecticides in *Myzus persicae* (Hemiptera: Aphididae), *J Econ Entomol* 109:2182–2189 (2016).
- Cutller P, Slater R, Edmunds AJF, Maienfisch P, Hall RG, Earley FGP, Pittnera T, Pal S, Paul V L, Goodchild J, Blacker M, Hagmann L, Crossthwaite AJ, Investigating the mode of action of sulfoxaflor: a fourth-generation neonicotinoid, *Pest Manag Sci* 69:607–619 (2013).
- Panini M, Dradi D, Marani G, Butturini A and Mazzoni E, Detecting the presence of target-site resistance to neonicotinoids and pyrethroids in Italian populations of *Myzus persicae*, *Pest Manag Sci* 70:931–938 (2014).
- Martinez-Torres D, Foster SP, Field LM, Devonshire AL and Williamson MS, A sodium channel point mutation is associated with resistance to DDT and pyrethroid insecticides in the peach-potato aphid, *Myzus persicae* (Sulzer) (Hemiptera: Aphididae), *Insect Mol Biol* 8:339–346 (1999).
- Devonshire AL, Field LM, Foster SP, Moores GD, Williamson MS and Blackman RL, The evolution of insecticide resistance in the peach-potato aphid, *Myzus persicae*, *Philos Trans R Soc B Biol Sci* 353:1677–1684 (1998).
- Eleftherianos I, Foster SP., Williamson MS. and Denholm I, Characterization of the M918T sodium channel gene mutation associated with strong resistance to pyrethroid insecticides in the peach-potato aphid, *Myzus persicae* (Sulzer), *Bull Entomol Res* 98:183–191 (2008).
- Vais H, Williamson MS, Goodson SJ, Devonshire AL, Warmke JW, Usherwood PNR, and Cohen CJ, Activation of *Drosophila* sodium channels promotes modification by deltamethrin: reductions in affinity caused by knock-down resistance mutations, *J Gen Physiol* 115:305–318 (2000).
- Anstead JA, Williamson MS and Denholm I, Evidence for multiple origins of identical insecticide resistance mutations in the aphid *Myzus persicae*, *Insect Biochem Mol Biol* 35:249–256 (2005).

30. Fontaine S, Caddoux L, Brazier C, Bertho C, Bertolla P, Micoud A and Roy L, Uncommon associations in target resistance among French populations of *Myzus persicae* from oilseed rape crops, *Pest Manag Sci* 67:881–885 (2011).
31. Davies TGE, Field LM, Usherwood PNR and Williamson MS, DDT, pyrethrins, pyrethroids and insect sodium channels, *IUBMB Life* 59:151–162 (2007).
32. Powell W, Dean GJ and Bardner R, Effects of pirimicarb, dimethoate and benomyl on natural enemies of cereal aphids in winter wheat, *Ann Appl Biol* 106:235–242 (1985).
33. Unal G and Jepson PC, The toxicity of aphicide residues to beneficial invertebrates in cereal crops, *Ann Appl Biol* 118:493–502 (1991).
34. Cabral S, Garcia P and Soares AO, Effects of pirimicarb, buprofezin and pymetrozine on survival, development and reproduction of *Coccinella undecimpunctata* (Coleoptera: Coccinellidae), *Biocontrol Sci Technol* 18:307–318 (2008).
35. Foster SP, Denholm I and Devonshire AL, Field-simulator studies of insecticide resistance to dimethylcarbamates and pyrethroids conferred by metabolic- and target site-based mechanisms in peach-potato aphids, *Myzus persicae* (Hemiptera: Aphididae), *Pest Manag Sci* 58:811–816 (2002).
36. Moores GD, Devine GJ and Devonshire AL, Insecticide-insensitive acetylcholinesterase can enhance esterase-based resistance in *Myzus persicae* and *Myzus nicotianae*, *Pestic Biochem Physiol* 49:114–120 (1994).
37. Nabeshima T, Kozaki T, Tomita T and Kono Y, An amino acid substitution on the second acetylcholinesterase in the pirimicarb-resistant strains of the peach potato aphid, *Myzus persicae*, *Biochem Biophys Res Commun* 307:15–22 (2003).
38. Foster SP, Denholm I, Harling ZK, Moores GD and Devonshire AL, Intensification of insecticide resistance in UK field populations of the peach-potato aphid, *Myzus persicae* (Hemiptera: Aphididae) in 1996, *Bull Entomol Res* 88:127–130 (1998).
39. Foster SP, Harrington R, Dewar AM, Denholm I and Devonshire AL, Temporal and spatial dynamics of insecticide resistance in *Myzus persicae* Hemiptera: Aphididae), *Pest Manag Sci* 58:895–907 (2002).
40. Needham PH and Sawicki RM, Diagnosis of resistance to organophosphorus insecticides in *Myzus persicae* (Sulz.), *Nature* 230:125–126 (1971).
41. Mazzoni E and Cravedi P, Analysis of insecticide-resistant *Myzus persicae* (Sulzer) populations collected in Italian peach orchards, *Pest Manag Sci* 58:975–980 (2002).
42. Harrewijn P and Kayser H, Pymetrozine, a fast-acting and selective inhibitor of aphid feeding. In-situ studies with electronic monitoring of feeding behaviour, *Pestic Sci* 49:130–140 (1997).
43. Kaufmann L, Schümann F, Yiallouros M, Harrewijn P and Kayser H, The serotonergic system is involved in feeding inhibition by pymetrozine. Comparative studies on a locust (*Locusta migratoria*) and an aphid (*Myzus persicae*), *Comp Biochem Physiol Toxicol Pharmacol CBP* 138:469–483 (2004).
44. Harrewijn P and Piron P, Pymetrozine, a novel agent for reducing virus transmission by *Myzus persicae*, in *Proceedings Brighton Crop Protection Conference – Pest and Diseases*, BCPC, Farnham, Surrey, UK, pp. 923–928 (1994).
45. Cloyd RA, Indirect effects of pesticides on natural enemies, in *Pesticides. Advances in chemical and botanical pesticides*, ed. by Soundararajan RP. IntechOpen Limited, London, pp. 127–150 (2012).
46. Jansen JP, Defrance T and Warnier AM, Side effects of flonicamide and pymetrozine on five aphid natural enemy species, *BioControl* 56:759–770 (2011).
47. Foster SP, Denholm I and Thompson R, Bioassay and field-simulator studies of the efficacy of pymetrozine against peach-potato aphids, *Myzus persicae* (Hemiptera: Aphididae), possessing different mechanisms of insecticide resistance, *Pest Manag Sci* 58:805–810 (2002).
48. Nauen R, Reckmann U, Thomzik J and Thielert W, Biological profile of spirotetramat (Movento®) – a new two-way systemic (ambimobile) insecticide against sucking pest species, *Bayer Crop J* 61:245–278 (2008).
49. Brück E, Elbert A, Fischer R, Krueger S, Kühnhold J, Klueken AM, Nauen R, Niebes J-F, Reckmann U, Schnorbach H-J, Steffens R and van Waetermeulen X, Movento®, an innovative ambimobile insecticide for sucking insect pest control in agriculture: Biological profile and field performance, *Crop Prot* 28:838–844 (2009).
50. Wang Z-H, Gong Y-J, Jin G-H, Zhu L and Wei S-J, Effects of spirotetramat on development and reproduction of *Myzus persicae* (Hemiptera: Aphididae), *Austral Entomol* 55:235–241 (2016).
51. Elbert A, Nauen R and Salmon E, Resistance management guidelines for the new ketoenol insecticide Movento®, *Bayer Crop J* 61:403–416 (2008).
52. Van Pottelberge S, Van Leeuwen T, Khajehali J and Tirry L, Genetic and biochemical analysis of a laboratory-selected spirodiclofen-resistant strain of *Tetranychus urticae* Koch (Acar: Tetranychidae), *Pest Manag Sci* 65:358–366 (2009).
53. Hu J, Wang C, Wang J, You Y, and Chen F, Monitoring of resistance to spirodiclofen and five other acaricides in *Panonychus citri* collected from Chinese citrus orchards, *Pest Manag Sci* 66:1025–1030 (2010).
54. Kramer T and Nauen R, Monitoring of spirodiclofen susceptibility in field populations of European red mites, *Panonychus ulmi* (Koch) (Acar: Tetranychidae), and the cross-resistance pattern of a laboratory-selected strain, *Pest Manag Sci* 67:1285–1293 (2011).
55. Karatolos N, Williamson MS, Denholm I, Gorman K, ffrench-Constant R and Nauen R, Resistance to spiromesifen in *Trialeurodes vaporariorum* is associated with a single amino acid replacement in its target enzyme acetyl-coenzyme A carboxylase: Spiromesifen resistance in the greenhouse whitefly, *Insect Mol Biol* 21:327–334 (2012).
56. Pan Y, Yang C, Gao X, Peng T, Bi R, Xi J, Xuecheng X, Zhu E, Wu Y and Shang Q, Spirotetramat resistance adaption analysis of *Aphis gossypii* Glover by transcriptomic survey, *Pestic Biochem Physiol* 124:73–80 (2015).
57. Peng T, Pan Y, Yang C, Gao X, Xi J, Wu Y, Huang X, Zhu E, Xin X, Zhan C, Shang Q, Over-expression of CYP6A2 is associated with spirotetramat resistance and cross-resistance in the resistant strain of *Aphis gossypii* Glover, *Pestic Biochem Physiol* 126:64–69 (2016).
58. Bass C, Zimmer CT, Riveron JM, Wilding CS, Wondji CS, Kaussmann M, Field LM, Williamson MS and Nauen R, Gene amplification and microsatellite polymorphism underlie a recent insect host shift, *Proc Natl Acad Sci* 110:19460–19465 (2013).
59. Fenton B, Margaritopoulos JT, Malloch GL and Foster SP, Micro-evolutionary change in relation to insecticide resistance in the peach-potato aphid, *Myzus persicae*, *Ecol Entomol* 35:131–146 (2010).
60. Morita M, Ueda T, Yoneda T, Koyanagi T and Haga T, Flonicamid, a novel insecticide with a rapid inhibitory effect on aphid feeding, *Pest Manag Sci* 63:969–973 (2007).
61. Foster SP, Denholm I and Devonshire AL, The ups and downs of insecticide resistance in peach-potato aphids (*Myzus persicae*) in the UK, *Crop Prot* 19:873–879 (2000).
62. Fenton B, Kaspruwicz L, Malloch G and Pickup J, Reproductive performance of asexual clones of the peach-potato aphid, (*Myzus persicae*, Homoptera: Aphididae), colonising Scotland in relation to host plant and field ecology, *Bull Entomol Res* 100:451–460 (2010).
63. Vorburger C, Lancaster M and Sunnucks P, Environmentally related patterns of reproductive modes in the aphid *Myzus persicae* and the predominance of two “superclones” in Victoria, Australia, *Mol Ecol* 12:3493–3504 (2003).
64. Nauen R, Jeschke P, Velten R, Beck ME, Ebbinghaus-Kintzsch U, Thielert W, Wölfel K, Haas M, Kunz K and Raupach G, Flupyradiflurene: a brief profile of a new butenolide insecticide, *Pest Manag Sci* 71: 850–862 (2015).
65. Scott JG and Wen Z, Cytochromes P450 of insects: the tip of the iceberg, *Pest Manag Sci* 57:958–967 (2001).
66. Sauphanor B and Bouvier JC, Cross resistance between benzoylureas and benzoylhydrazines in the codling moth, *Cydia pomonella* L., *Pestic Sci* 45:369–375 (1995).
67. Nauen R, Vontas J, Kaussmann M and Wölfel K, Pymetrozine is hydroxylated by CYP6CM1, a cytochrome P450 conferring neonicotinoid resistance in *Bemisia tabaci*, *Pest Manag Sci* 69:457–461 (2013).
68. Μαρούντας Ι, Τοπάλης Π, Διαλυνάς Ε, Μαργαριτόπουλος ΙΤ, Ελευθεροχωρινός Η, Μαλανδράκης Α, Καραογλανίδης Γ, Κατής Ν, Βουδούρης ΚΧ, Ροδιτάκης Ε, Τζωρτζακάκης Ε, Φλουρή Φ, Τσαγκαράκου Α, Βόντας Ι και Λούνη Χ, Καινοτόμος δράση για τη φυτοπροστασία στην Ελληνική γεωργία, *Γεωργία – Κτηνοτροφία* 4:36–41 (2014).
69. Βόντας Ι, Ροδιτάκης Ε και Μαργαριτόπουλος ΙΤ, Τελευταίες εξελίξεις & νέες τάσεις στα εντομοκτόνα & ακαρεοκτόνα, *Γεωργία – Κτηνοτροφία* 6:72–77 (2015).