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INTEGRATED PEST MANAGEMENT METHODS USED IN PEPPER (*CAPSICUM ANNUUM*) CROP IN EUROPEAN UNION

Lorena-Roxana Gurau, Ioan Radu

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INTRODUCTION

By 2050 the Earth will have to feed about 9,000 million people which determines a regular and major challenge in terms of agricultural pest management (Ash et al., 2010; Thomas, 1999; Godfray et al., 2010). Even if pesticides have started to be used after 1960, the yield losses because of pests, diseases and weeds are high or even increasing in some cases (Oerke, 2006). These losses tend to be higher in developing countries, averaging 40–50%, compared with 25–30% in high-income countries (Thacker, 2002). The definitions of IPM are various, but all connect the coordinated integration of different complementary methods to overcome pests in a safe, economic and environmentally friendly way (Ehler, 2006; Kogan, 1998). The aim is not to eradicate pest populations but rather to manage them below levels that cause economic damage. The main IPM tactics include: i) synthetic chemical pesticides that have high levels of selectivity and are classed by regulators as lowrisk compounds, such as synthetic insect growth regulators, ii) crop cultivars bred with total or partial pest resistance, iii) cultivation practices such as crop rotation, intercropping or undersowing, iv) physical methods, such as mechanical weeders, v) natural products, such as semiochemicals or biocidal plant extracts, vi) biological control with natural enemies, including predatory insects and mites, parasitoids, parasites and microbial pathogens used against invertebrate pests; microbial antagonists of plant pathogens and microbial pathogens of weeds, vii) decision support tools to inform farmers when it is conomically beneficial to apply pesticides and other controls. These include the calculation of economic action thresholds, phenological models that forecast the timing of pest activity and basic pest scouting. These tools can be used to remove pesticide from routine calendar spraying to a supervised or targeted programme. (Chandler 2011).

The pesticides active substances list available for UE area confer important data as Status under Reg. (EC) No 1107/2009, date of approval, expiration of appproval and a review report (EU Pesticides Database, 2019).

DISEASES CONTROL

Stolbur disease in pepper

Management measures against the transmission of stolbur disease should include: the reduction of infection resources, weeds in this case. The management of vectors by means of insecticides and a proper use of agriculture engineering methods (i.e. distribution/rotation of susceptible and less susceptible and/or non-host crops) (Navratil et al., 2009).

***Cucumber mosaic virus in pepper* (CMV)**

Control measures against this virus include i) pepper varieties resistant to some strains of CMV, ii) the use of virus-free seeds (Choi et al., 2018), iii) eradication of virus reservoirs such as volunteer plants and nearby weeds, iv) aphids control by planting either very early or very late in the season to avoid exposing young plants to high or migratory populations, by covering the planted area with fine 32-mesh nylon net, planting barrier crops that are not susceptible to CMV such as corn, applying sticky traps and growing trap crops nearby that attract aphids, v) seedlings or mature plants eradication that show virus symptoms, vi) tools, stakes, and equipment desinfectation before moving from diseased areas to healthy areas (AVRDC 1). Using crops barrier contributed to a significant reduction of CMV spread when sorghum was considered (Avilla et al., 1996) and also when maize and vetch were cultivated (Ferres, 2000).

***Tomato spotted wilt virus in pepper* (TSWV)**

The presence of thrips which are vectors in pepper fields can be monitored using yellow sticky cards. Infected plants should be removed and destroyed. Elimination of infected plants is not always as effective as a control for secondary infections because TSWV has been often spread before symptoms have developed. Host plants include tomato, pepper, pea, lettuce, potato, tobacco and other members of the same family, as well as other broadleaf and grassy plants, including numerous weeds and ornamentals. Remove volunteer and host plants as well as weeds from the production by maintaining a 10-m plant-free border is effective.

Thrips emerge from crop debris and disperse from the field if infected field areas are fallowed for 3-4 weeks. During the first stage of plant production, the use of a nethouse structure or seedbed covered with a netting of 40-mesh or higher to exclude thrips from seedlings prior to transplanting also proved effective. Attention should be paid to virusfree transplants. Ideally, insecticides for thrips should be applied with equipment that produces very small spray particles (AVRDC 2; http://ipm.ucanr.edu/PMG/r604100911.html#MANAGEMENT). Using TSWV-resistant pepper cultivars is a way to stop the occurence of this virus (Bese et al., 2012); for instance the incorporation of the Tsw resistance gene from *C. chinense* (Salamon 2016).

Xanthomonas campestris* pv. *vesicatoria

The spread of this virus can be managed by using copper products (Marco et Stall, 1983). Control also relies on the production of plants from healthy seed and on care in handling young transplants to prevent spread at an early stage (Goode et Sasser, 1980). The plants are susceptible at high relative humidity and warm temperature (Jones et al., 1991; Abolmaaty & Abd El-Ghafar, 2010). Other control measures include: i) removing pepper debris, burn, or chop and bury immediately after harvest, incorporate into the soil to assist in rapid decomposition of diseased pepper debris, ii) cleaning the tools after working in infested areas, iii) maintaining a good supply with N and K, iv) use flood or furrow irrigation if possible and if is necessary overhead irrigation (begin early in the day so that the foliage can dry before the evening), v) rain shelters to reduce water splash may reduce disease severity during periods of high rainfall, vi) use crop rotations of 2 to 3 years, excluding eggplant, tomatoes and tobacco, vii) incorporate all crop residues into the soil promptly after harvest to encourage more rapid decomposition of tissue infected with bacteria and plow cover crops very early in the spring to minimize carry-over (AVRDC 3).

Leveillula taurica

IPM for powdery mildew include to: i) avoid useless visitors access to the greenhouse, ii) control outdoor weeds emerged in the greenhouse, iii) maintain a low relative humidity level and increase air circulation, iv) early detect disease, v) use resistant varieties (Sabaratnam, 2018; AVRDC 4).

Alternaria solani

The fungal pathogen can be controlled cultivating resistant cultivars. If this option is not available, it is not advised to use irrigation with overhead sprinklers; crop rotation should be introduced (Tsitsigiannis et al., 2008).

Botrytis cinerea

On the market there are biofungicides based on *Streptomyces lydicus* and *Bacillus subtilis* whose action can supress gray mold. Plants should be supplied adequately with calcium by liming acidic soils and maintain uniform soil moisture (Stall et al., 1965). Ideally, all diseased plants and plant parts should be removed and destroyed. *Botrytis* spores are always present, but they do not germinate until exposed to specific abiotic conditions (especially high umidity). For this disease IPM also includes: i) to avoid overhead watering and irrigation, ii) watering to be performed in the morning, iii) allowing enough space for good air circulation, iv) do not over-feed plants, especially with nitrogen as young growth is susceptible to fungus, v) use biological fungicide based on bacteria *Streptomyces griseoviridis* or Neem oil, vi) use resistant cultivars (https://organicgardeningnewsandinfo.wordpress.com/tag/organic-control-of-botrytis-blight/).

PESTS CONTROL

Trialeurodes vaporariorum

A great attention has been directed to sustainable alternative control methods, such as biological control, using four species of parasitoids wasps (family *Aphelinidae*) and 15 predatory species (families *Miridae, Nabidae, Anthocoridae, Coccinellidae* and *Chrysopidae*) in several different parts of Serbia. The registered species of chalcidid wasps from the genus *Encarsia* were: *Encarsia formosa* Gahan, *Encarsia tricolor* Foerster, *Encarsia partenopea* Masi and *Encarsia lutea* Masi. The most important predatory species were: *Clitostethus arcuatus* Rossi, *Synharmonia conglobata* Linnaeus, *Adalia bipunctata* L., *Propylea quatuordecimpunctata* L., *Tytthaspis sedecimpunctata* L., *Hippodamia tredecimpunctata* L., *Adonia variegata* Goeze, *Chrysopa carnea* Stephen, *Crhysopa phyllochroma* Wesmael, *Nabis ferus* Linnaeus, *Nabis pseudoferus* Remane, *Nabis brevis* Scholtz, *Dicyphus errans* Wolf and resistance breeding (Mutwiwa et al., 2005; Peric et al. 2009). Crop management includes to maximize the distance and time interval between host crops. Adults of whiteflies are repelled by silver- or aluminum-colored mulches.
(http://ipm.ucanr.edu/PMG/r604300811.html)

Aphis spp.

Reflective silver mulch, low dose of nitogen and use of extracts based on *Allium schoenoprasum* have shown good results (Ben-Issa, 2017). Mechanical control like water jet removed apfids from the leaves or from the branches. Biological control is encouraged: green lacewing larvae (*Chrysoperia rufilabris*) as a natural enemy or parasitic wasps (*Aphidius species*). For home gardeners, it is best to use plants in the garden and landscape that will attract these beneficial insects, such as sunflowers, clovers, liatris, and coreopsis. Similar to a traditional insecticide, any product containing *Beauvaria bassiana* can be applied under the umbrella of biological control. This entomopathogenic fungus is usually applied as a foliar spray and is parasitic to many soft body insects (Jeffers, 2019)

SURVEY OF THE LITERATURE IN DATABASES

A survey of the literature was performed to show the differences regarding the number of articles between three common vegetables and their control of diseases and pest. The vegetables considered were tomato, pepper and onion. The databases used were CAB Direct and Scopus. The was performed for the abstract with simple and combined keywords (*i.e.* “tomato”, “tomato pest”, “tomato disease”, “tomato integrated pest management” etc.). Transformation to $\log_{10}$ was performed to reduce the skewness and facilitate interpretation of the columns (Cosoveanu et al., 2018). Columns are proportional to the number of publications. When the name of the vegetables was searched for individually, results indicate that ”tomato” in both databases, had the highest number – 4,75 and 3,78, respectively while ”onion” had the lowest number of results 4,23 and 3,26

”Pepper” and ”integrated pest control” entries in CAB Direct represent 0,004% compared to ”pepper” alone. The tendency for low hits is given by tomato (0,03%) and onion (0,05%) too.

Comparing vegetables keywords, the number of publications containing “tomato” represents 39,22%, compared with “onion” and “pepper” in CAB Direct database (Figure 1).

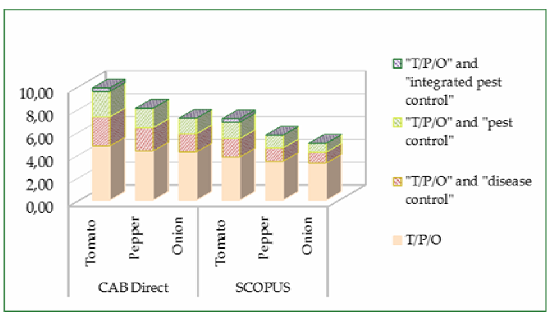

Fig. 1. Survey of the literature in Scopus and CAB Direct databases (T/P/O – Tomato/Pepper/Onion)

These values reflect the great interest in tomatoes, which is the most mportant vegetable used worldwide (Kimura et Sinha, 2008).

CONCLUSIONS

Although an alarm signal for introducing IPM in agriculture was given many years back, this system seems to be less studied than one may consider. It needs a continuous research to improve and update methods used in IPM.

Some approaches are similar among pest like avoiding contact with plants or eliminating infected plants. Even if some results were obtained in countries that are not in EU, those IPM principles can be applied without any legislative rules or can be studied in EU area. These are methods used in the crop management for pest control.

ABSTRACT

Integrated Pest Management (IPM) principles started from pest identification and pursues assessing the effect of pest management. Approaches for managing pest are organized in: biological control, crop management, mechanical and physical controls as well as chemical control. Several of them can be used only by taking into account the regulatory framework of an area. Biological control for pepper crop pest mainly includes the use of biopesticides. Nowadays, the scientific paradigm is focused on establishing and introducing innovative biocontrol solutions. Thus, the scientific research results are disseminated in dedicated events within European Union. The aim of this study is to present IPM methods available for Europeans eager to eradicate the use of chemical products in pepper crop.

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AUTHORS' ADDRESS

GURAU LORENA-ROXANA, RADU IOAN - Research and Development Institute for Plant Protection, 8 Ion Ionescu de la Brad Blvd., District 1, Bucharest, Romania, e-mail: raduioan1999@gmail.com