APPLICATION ASPECTS OF INTEGRATED PEST MANAGEMENT

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SUMMARY

Three major objectives characterize the current trend in intensive agriculture: pest control, environmentally safe measures and consumer demand for, among other things, pesticide-free products. Therefore, the main goal in pest-management research is to improve pesticide application technology for its effective action and rapid dissipation from crop tissues. Air-assisted spraying technology that makes use of fine droplet size and low volumes is an effective way of depositing the spray on both the upper and under sides of leaves. Application of pesticides with aerosol generators (foggers) and other sprayers has shown practical and effective control of insects, mites and foliar pathogens in various field and tree crops. Moreover, effective control is achieved even when pesticide rates are significantly reduced. Soil disinfestation is the most effective tool for knocking out inoculum in soil, but it has to be accompanied by additional measures in the framework of integrated pest management. Research into exploiting soil solarization by combining it with reduced doses of permitted fumigants, or other tools, is expected to produce the most promising approaches. Furthermore, a sublethal dosage of fumigant in combination with solarization, or other pest-management methods, can provide a reasonable solution to many of today’s problems. Combining fumigation or solarization with biocontrol agents could also improve the control of target pests, maintain the microbial balance in soils and maintain suppressiveness against pathogen buildup in those soils. Improvement of application methods for soil disinfestation is another issue which warrants special attention.

Key words: soil disinfestation, soil solarization, pesticide application, pesticide residues, spray techniques.

INTRODUCTION

Intensive production systems in modern agriculture are characterized by an increasing demand for the constant supply of a wide spectrum of high-quality fresh products. The significant expansion of production systems aimed at maintaining a continuous supply has resulted in an inevitable increase in infestation and damage by various pests. Effective management of crop pests should include the use of appropriate measures (e.g. pesticide, physical means), an effective and practical application method, and the implementation of these within a practical technology. A combination of methods and tools can extend the spectrum of controlled pests with minimal risk to the environment, and can provide additional benefits which further contribute to those of a cost-effective application technology. An effective application technology should also consider how to avoid negative effects on the environment. The issues of optimal implementation of pest-control measures and adapting (or developing) the appropriate technology for achieving those maximal effects require special attention for any crop production system in today’s agriculture. Moreover, the ultimate success or failure of any pest-management combination depends upon the application technology and its effective implementation for optimal use and treatment success.

APPLICATION AND PESTICIDE RESIDUES IN PRODUCTS

Chemical pest management in crops is becoming a challenging task, since avoiding or minimizing the use of pesticides is a strong requirement, due to restrictions on pesticide residues on marketable produce. Furthermore, the pesticide constraints coincide with an increase in pest infestation and the need to maintain a healthy crop and steady supply of pesticide-free products. Hence, the developments in pesticide application are being directed to improved application while minimizing pesticide rates, and to a shift to environmentally safe measures, without reducing the efficacy of pest control.
Effective application of pesticides. Effective spraying technology must focus on pest control with reduced pesticide rates and rapid dissipation of the pesticide on the marketed products. The use of fine droplet size together with air assistance, which can effectively deliver the spray to all target surfaces, has been extensively studied (Matthews, 2000). The use of aerosols in a closed greenhouse was shown to be effective at controlling a wide spectrum of pests (Austerweil and Grinstein, 1997). Spraying aerosols (fogging) consists of ultra low-volume application of a very fine droplet size spectrum of a concentrated spray solution. Such application results in a high and uniform spray deposit on both the upper and under sides of the leaves. Spraying pesticides with aerosol generators yields effective control of various pests and usually results in rapid dissipation of the pesticide in plant tissues compared with high-volume or air-assisted techniques (Gamliel et al., 2000). These results were further validated in semi-open structures with various herb crops using a specially designed sprayer (Gamliel et al., 2004a).

Effective delivery, distribution and deposition of pesticides were extensively studied in various fruit trees. Specially designed sprayers were developed for effective pesticide distribution and pest control in grapes and date fruits (Gamliel et al., 2004b, 2008). Application of pesticides with such sprayers resulted in minute amounts of pesticide residue on the marketed fruits. Obviously, achieving effective pest control without overlooking the environmental constraints requires understanding the need for spray coverage and adjustment of the appropriate equipment.

Improved application of biopesticides. Biopesticides encompass many aspects of pest control, including active biocontrol microorganisms or their metabolites, plant extracts and insect pheromones, among others. The use of biopesticides has emerged in recent years, but they have not yet become major players in the pesticide market. At present, conventionally applied biopesticides are successfully utilized in specialty and niche agricultural and horticultural situations. Effective application of biopesticides should consist of the same principles governing the application of chemicals. Furthermore, unlike certain pesticides with systemic capacity, biopesticides have limited mobility. Hence, optimal coverage is needed for their effective performance. These aspects have been reviewed by Sundaram (1995) and Gan-Mor and Matthews (2003).

APPLICATION OF INTEGRATED SOIL DISINFESTATION

Management of soilborne diseases has to deal with all sources of inoculum, throughout the entire disease cycle, including measures such as soil disinfestation, sanitation and additional actions. Soil disinfestation is a major approach for achieving a healthy crop. Soil fumigation (i.e. applying volatile and nonselective biocides) has provided great benefits to agricultural production for many years. However, public concern over the environmental hazards of using fumigants is providing a strong impetus for the search for nonchemical methods, as well as their use in combinations.

Soil solarization is a nonchemical method that can be incorporated as a part of integrated pest management (IPM) programs for the control of soilborne pests (Katan, 1981). This approach consists of exploiting solar energy to heat the upper soil layer under a transparent plastic film for several weeks. The mechanisms of soil solarization involve thermal killing of pests, as well as other chemical and biological mechanisms which play an important role in the lethal process (Gamliel and Katan, 2009).

The management of soilborne diseases should not be based on a single measure, even if it is a highly effective one. Hence, combinations of disinfestation methods and their effective implementation constitute an important tool. Since methods of disease management differ with respect to application method and technology, the appropriate technology for the combined application is crucial for the success of the process.

Improved combined application of solarization and fumigants. Combining solarization with soil fumigants appears to be a practical and powerful approach to improving the control of soilborne pests and broadening the spectrum of affected pests (Gamliel and Katan, 2009). Such combinations may enable reducing the dose of the needed pesticide while extending the effectiveness of the treatments. Indeed, exposure of organisms to solarization, at a lethal or sublethal dosage, e.g. reducing pesticide dosage in combination with pesticides should be considered from two points of view: as a way of improving solarization, i.e. by shortening length of application and improving pest control, or as a way of improving the other methods with which solarization is combined. Furthermore, the combination of solarization with a low rate of the appropriate pesticide may provide the benefit of a more predictable treatment, which is a requirement for commercial users, as it provides a wider safety margin for the treatment’s long-term success.

Eshel et al. (2000) established an important and practical rationale for the sequence of application of solarization and fumigants. They showed that control efficacy of a reduced dose of methyl bromide (MB) or metham sodium is strongly increased when applied after a short solarization period of 8 days, i.e., after mulching. Thus, it was recommended to apply solarization for a short period and then introduce the desired fumigant.
(or other control agent) via the drip-irrigation system or other means. Chellemi and Mirusso (2006) extended this concept by applying soil solarization for a short period of 7 days followed by injection of a mixture of 1,3-dichloropropene+chloropicrin under the plastic film. That study also demonstrated an important application challenge of this sequence. Chellemi and Mirusso (2006) designed a machine for injecting soil fumigants underneath raised planting beds covered by plastic mulch without disturbing the integrity of the beds or tearing the plastic tarp, which produced satisfactory pest control results.

**Application of solarization and biological control.**

Combining beneficial organisms and soil solarization has become a component of IPM. Changes in the soil following solarization may create a platform for the effective introduction of beneficial microorganisms and biocontrol agents. Such a combination could improve the control of certain soilborne pathogens and provide a wider spectrum of controlled pests, which is especially pertinent when various pests exist and solarization alone controls only some of them. In addition, a frequent criticism of the use of beneficial organisms refers to the inconsistency of the results under different conditions. However, modifying soil conditions by solarization can improve reproducibility of results and the organisms’ biocontrol performance. Furthermore, combining beneficial microorganisms with solarization may also enable shortening the solarization process, as well as allowing its use under marginal conditions. The success of combining beneficial microorganisms with solarization depends upon a consideration of the characteristics of these organisms and their mode of action. Application of beneficial organisms following solarization means that the microbial balance in the soil has already been partially or fully established, and the introduced organisms need to successfully compete in this new environment. It is possible, however, to introduce beneficial thermotolerant organisms before or during solarization, e.g. via the drip-irrigation system. Endospore-forming bacteria appear to be suitable for application during or at the termination of solarization, as shown with Bacillus firmus for the control of root-knot nematodes (Anastasiadis et al., 2008; Giannakou et al., 2007). In contrast, a heat-sensitive organism such as the bacterium Pasteuria penetrans (a Gram-positive bacterium which is antagonistic to Meloidogyne spp.) can be applied as a biocontrol agent only upon termination of the solarization process (Freitas et al., 1997).

**CONCLUDING REMARKS**

Reductions in pesticide use can be implemented by an effective IPM approach that combines effective monitoring and effective pesticide application, when needed. Optimization of the application technology, in combination with other chemical, biological or cultural practices, could further improve pest control and might enable further reduction in the frequency and volume of pesticides used. The increasing demand for pesticide-free products and the phase out of many pesticides are expected to lead to the following developments:

1. Application technologies for rapidly dissipating pesticide. These can be based on pesticides with high vapor pressure, but such chemicals can only be applied in closed systems, such as closed structures for foliar pesticides or under impermeable films for soil fumigants. Application methods which will enhance pesticide dissipation can only be performed with special application technologies.

2. Development of soft pesticides and their optimal application. Several compounds of natural and synthetic origin are being tested for pest control. Among these, plant extracts, mineral oils, natural pesticides and many others are showing promising results under controlled conditions. In some studies, it was found that the mode of application is important for successful control of the target pest. The commercial use of such chemicals will also depend on the development of effective application methods.

Further research and, more importantly, field studies and on-farm validation are needed to advance these approaches for a pest-free crop, pesticide-free product, and safe environment.

**REFERENCES**


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