Integrated pest management programs

Session VII

Implementing integrated pest management programs for *Bemisia argentifolii* in North America; an overview

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Bemisia argentifolii became a problem in North America in the early 1980's, infesting first greenhouse crops and then commercial crops and ornamental plantings out of doors. It quickly spread throughout greenhouse production areas of North America. In the open field, it became a pest in warm desert and subtropical areas of California, Arizona, Texas, Florida and some areas of Mexico. In all areas where *B. argentifolii* was introduced, damaging outbreaks occurred which caused substantial losses to crops that necessitated widespread use of broad spectrum pesticides for control. While still an important problem and a continuous threat to crop production, strategies became implemented which reduced its damage to tolerable levels. IPM programs for *B. argentifolii* are not uniform in all areas, but they include several essential elements such as use of new pesticide products like insect growth regulators, resistance management, biological control and cultural controls often implemented using areawide or regional management approaches. Because implementation of many of the cultural controls required changes to existing management practices such as host free periods, elimination of preferred hosts during specific periods and changes to planting dates of certain crops on a regional basis, consultation with and involvement of stakeholders was an essential factor in success of the areawide or regional programs.

Whitefly management in Latin America and the Caribbean

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Since the mid-1980's, some 18 crops in Latin America have been affected by *Bemisia tabaci*. There have been cases of direct damage in cotton, melons and soybean, but the bulk of these situations refer to transmission of viruses, especially in beans, tomato, bell peppers and melons. In 1992, an *Action Plan for Whitefly and Geminivirus Management* was launched, aimed at validating and transferring integrated pest management (IPM) technologies to growers. This Plan is led by National Committees, with the support of many people and 3 diagnosis and training activities. So far, its main achievements are: a) Both agronomists and growers are now better aware of the implications of the whitefly-geminivirus problem in economic, agricultural and environmental terms; b) In addition to improving their perceptions, which makes them more prone to adopt and implement IPM programs, they are now familiar with available tactics and their combinations to deal with the problem; c) There have been original contributions in conceptual and methodological issues related to farmer participatory research, for favoring IPM adoption; d) Area-wide plant protection campaigns, involving quarantine regulations and host-free periods, have been successful in several countries; and e) Some novel contributions on plant breeding for tomato and beans, as well as promising cultural practices (seedlings produced under fine netting, and living ground covers), are now under field testing or validation. Nonetheless, accomplishments between countries have been rather uneven, and there is still a pressing need to increase coverage of successful IPM programs.

Managing cassava mosaic geminiviruses and their *Bemisia tabaci* vector in Africa: current practice and future opportunities

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For the more than 80 years that there has been active research on the *Bemisia tabaci*-vectored cassava mosaic geminiviruses (CMGs) that cause cassava mosaic disease (CMD), the primary focus has been on management of the virus(es) rather than the vector. This approach has delivered results, and both multigenic resistance derived from interspecific crosses, and more recently a single dominant gene (CMD2) based resistance identified in local landraces from Nigeria, have been incorporated into cassava germplasm resulting in high levels of field resistance to CMD. As a consequence of these successes, virus-resistant germplasm comprises the primary weapon in the current battle against the still expanding African CMD pandemic. Unusually abundant *B. tabaci* populations in pandemic affected zones, and an increasing realisation of the importance of this abundance as a factor driving the pandemic, however, have encouraged scientists to look for potential whitefly control strategies that may complement virus management. Detailed studies have been initiated to identify the principal species of natural enemy that attack *B. tabaci* in East Africa, examine their efficiency, and determine if their activity can be enhanced through habitat management. The possibility of improving natural control still further with exotic introductions will also be explored. Whitefly resistant cassava varieties obtained from Latin America, also show some resistance to African *B. tabaci*, as do some African landraces, and potential may therefore exist for the development and deployment of whitefly resistant germplasm. Current efforts, being co-ordinated through the Tropical Whitefly IPM Project, aim at integrating these possible *Bemisia* control components with virus resistance, phytosanitation and other novel techniques such as mild strain protection into an IPM basket. This should provide a flexible, yet sustainable and effective approach to the management of CMD in Africa.

The European Whitefly Studies Network

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The European Whitefly Studies Network (EWSN) began in 1999 as a two-year EC-funded concerted action. Its aim was to network European scientists and industrialists in addressing various aspects of whitefly research and control within European agriculture. Over this two year period, EWSN attracted additional financial support from a number of commercial associates. This enabled a growth in membership, an expansion of activities and the development of quality outputs and deliverables. EWSN also provided a unique forum for members from a number of different disciplines to focus and enhance their activities, whilst interacting with research programmes outside of their normal areas. Through a number of workshops, members were able to discuss and standardise important working procedures, which are now being published within EWSN's Resource Pack. The pack also contains other important documents that have been submitted by members such as whitefly and virus identification guides and information on crop protection products. Besides addressing the important issues of studying and controlling whiteflies, EWSN brought together many people from many different countries and instigated an invaluable web of friendship. When the EC grant ended in March 2001, EWSN was not only able to expand its final workshop into an international whitefly symposium (hosted by the University of Catania, in Ragusa, Sicily), but has continued to secure enough financial support from its industrial associates to continue operating. Global links are now being established and a second international whitefly symposium planned for 2004 in Croatia. The future activities of EWSN are to be discussed in more detail.

Integrated control of *Bemisia tabaci* in the Mediterranean basin

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Bemisia tabaci is widely distributed across the Mediterraean basin although, probably because it is very susceptible to winter low temperatures, its populations are less abundant in the North and interior parts of the Mediterranean Basin. In a variably large area, *B. tabaci* may coexist with *Trialeurodes vaporariorum* (Westwood). The high capacity of *B. tabaci* to transmit plant viruses –leading to low economic thresholds- as its polyphagy -that enables it to cyclically exploit protected and outdoor crops the year round- makes control of the whitefly difficult. Chemical control has been practically the only used in many areas leading to the rapid build-up of insecticide resistance. In the recent years, greenhouse screening has been preconised to exclude immigrating viruliferous whitefly adults although this practice is largely antagonistic to other control tactics as biological control by conservation and augmentation of native natural enemies. Instead of this last approach, first steps in developing biological control for *B. tabaci* have preferred to use exotic parasitoids in spite of the native *Eretmocerus mundus* easily establishes in greenhouses where hard chemical spraying programs are avoided. An area wide management program of *B. tabaci* and virus hosts, including cultural practices, would allow perhaps to reduce pest and virus inocculum pressure on protected crops. Availability of varieties resistant to *B. tabaci*- transmitted viruses would also contribute to more integrable and sustainable methods for whitefly control than just trying to seal geenhouses and fill it with released natural enemies.

The silverleaf whitefly in Mexico

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The silverleaf whitefly *Bemisia argentifolii* Bellows and Perring also known as B biotype of *Bemisia tabaci* (Gennadius) became a serious pest of several crops in northwestern Mexico in 1991. In 1995 it had became a serious pest of many crops in Mexico. This year, it was officially established a national campaign against the silverleaf whitefly that also included other species such as *B. tabaci, Trialeurodes vaporariorum*, *T. abutilonea*, *Tetraleurodes ursorum*, and *Aleurothrixus floccosus*. Actions involved pest management strategies which were mandatory and officially supported by a national legislation, known as NOM-020-FITO-1995. Information was generated by INIFAP and applied as it became available; also experiences from other countries mainly the U.S.A. were validated and implemented. Eight scientific memories compiled abstracts of research. International, national, regional and local meetings, conferences and workshops helped to interchange experiences educate and capacitate people in whitefly management tactics and strategies. The integrated work of different institutions, authorities and producers, achieved a successful management of the whitefly situation by 1997. The availability of new insecticides with different mode of action helped to suppress the problem and producers returned to the traditional way of crop management. Producers are confident that with these "new" insecticides they are solving the problem. However, this year huge populations were observed in different agricultural areas of Mexico, which were not controlled with insecticides even at high rate dosages or reduced application frequency, indicating that whiteflies either are becoming resistant or are coming back.

Whiteflies in Arizona: an IPM success story

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Whiteflies (*Bemisia tabaci* [biotype B]) invaded Arizona in the early 1990's causing catastrophic losses to agriculture. Honeydew excretions contaminated cotton lint, giving rise to market penalties. Foliar insecticide intensity reached an historic 25-yr high in 1995 mainly because of this pest. However, in 1996 key technologies and a major new IPM plan were introduced and disseminated to over 700 pest control advisors and growers through multilateral educational meetings. The AZ IPM plan depends on three central keys: "Sampling" & "Effective Chemical Use" built on a foundation of "Avoidance." Avoidance may be thought of as all practices that serve to prevent or maintain pests below economic levels. Effective Chemical Use optimizes all remedial inputs, and Sampling sits atop the pyramid and serves all other layers of management. With the adoption of the AZ IPM Plan, whitefly sprays have been reduced by 71% to around 1 spray per season, and growers have saved over $100 million in control costs and yield savings in the last 5 years. Foliar insecticide use reached a 25-yr low in 1999. Six years of success have led to historic lows in insecticide use in cotton and have been based on: 1) research-based guidelines for sampling & thresholds, 2) access to powerful & selective IGRs with proven guidelines for their use, 3) the extended suppressive interval, known as "bioresidual", which maximizes natural mortality factors of the whitefly and creates area-wide benefits, and 4) an organized & comprehensive educational campaign.

Farmer field school: an IPM training and extension model for pests management

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Whitefly is a major constraint to common bean production in northern Sudan. A number of resistant varieties and cultural practices were developed by Agricultural Research Corporation as major components of IPM strategy. Adoption of these technologies was very slow and none in some areas, due to a number of constraints of which knowledge and awareness of the technologies were the most important. Farmer Field Schools (FFSs) were established in two major bean producing areas as IPM training and extension models. In on-farm demonstrations, out of eight varieties tested, five (Giza3, Basabeer, Sarag, RO/2/1 and Red Mexican) were resistant varieties to whitefly, and three (Khafif, Tagil and Super) were local farmer varieties. Results showed that Giza3, RO/2/1 and Basabeer were superior to farmer varieties in both resisting whitefly infestation and in improving yield. In controlling whitefly with insecticides and cultural practices, intercropping beans with coriander significantly reduced whitefly infestation and improved bean yield. Sumicidin, a chemical insecticide, gave better results than coriander. However, non-significant differences could be detected among them. Neem seed extract occupies an intermediate position. The farmers method of dusting beans with ash in order to control whitefly did not differ from the untreated control. The performance of FFSs as a method of disseminating IPM approach was satisfactory with strong farmers appreciation and participation.

Last minute abstracts

Commercial-scale trials of *Eretmocerous* spp. Mercet (Hymenoptera: Aphelinidae) for control of *Bemisia tabaci* in tomato and sweet pepper in southeastern Spain

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Eretmocerous mundus, is native to the Mediterranean region where it occurs spontaneously parasitizing *Bemisia tabaci* in fruiting vegetables, although only the American species *E. eremicus* was commercially available prior to 2001. Surveys conducted in commercial greenhouses during the 1998/99 and 1999/2000 seasons demonstrated that, despite initial establishment, the exotic parasitoid was steadily replaced by the native one immigrating from outside, providing impetus for commercial production of *E. mundus*. Incidence of whiteflies and other pests were compared in 7 conventionally managed greenhouses and 12 IPM greenhouses using biological control in four growing regions of Spain: Águilas/Mazarrón (Murcia), Almería, Motril (Granada), and the Canary Islands. *Eretmocerous eremicus* was released in half of each IPM greenhouse and *E. mundus* in the other half using a Latin square design. IPM greenhouses were more likely to use tolerant cultivars, and fewer and more selective insecticides. Little partism (3%) was seen in conventional greenhouses compared to IPM greenhoses (50%) where *E. mundus* was dominant. Whitefly control was similar in both. For the pepper trials, each of 12 greenhouses in Campo Cartagena (Murcia, Spain) received *E. mundus* alone, *E. eremicus* alone or a 1:1 mixture of the two in an RCB design with 4 replications. Insecticidal control of whitefly was not required in any of the test greenhouses. Significantly fewer whiteflies were observed in greenhouses were *E. mundus* or the mixture was released compared to those receiving only *E. eremicus. E. mundus* rapidly displaced *E. eremicus* where both were released and eventually where only *E.eremicus* was released, attesting to a significant immigrant component of the *E. mundus* population.

Life history of *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae) on *Bemisia tabaci* biotype "Q" (Homoptera: Aleyrodidae) using sweet pepper and tomato

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Eretmocerous mundus is native to the Mediterranean region where it spontaneously parasitizes *Bemicia tabaci* in greenhouse-grown fruiting vegetables. Fecundity on tomato and pepper was evaluated by placing newly emerged couples (n = 15) of *E. mundus* on leaf disks infested with second instar *B. tabaci* the preferredstage maintained at 25ºC and changed daily until the female died. All whitefly nymphs were observed for host feeding and inverted to count parasitoid eggs. Adult longevity was estimated at 10.1±1.0 d (mean ± SEM) in pepper and 7.3 ± 0.81 d in tomato. Fecundity (number of hosts) was estimated 171.1 ± 22.8 per female in pepper and 147.8 ± 13.5 in tomato. Host feeding incidence was 15.6 ± 0.98 nymphs per female in pepper and 10.7 ± 1.3 in tomato. No significant differences were detected in the duration of life stages between tomato and sweet pepper. Preimaginal survivorship estimated in clip cages starting with 66 eggs in pepper and 59 in tomato was 81.0% and 64.4% respectively. Most of the difference was due to 17% mortality during the pupal stage in tomato possibly dueto leaf degradation and not seen in pepper. R_o in pepper was estimated at 67.50± 8.71 (mean ± SD) which was significantly greater than 47.00 ± 4.02 in pepper. However, generation time (T) was also significantly greater in pepper (19.40 ± 0.46) than in tomato (18.10 ± 0.36). As a consequence of these two opposing factors, the estimate of intrinsic rate of increase (rm) was not statistically different in pepper 0.218 ± 0.005 than in tomato (0.214 ± 0.004). These values are well above those reported for *B. tabaci* on any crop indicating the potential of *E. mundus* to control this pest.

Calibration of release rates for *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae) for control of *Bemisia tabaci* in sweet pepper and tomato

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The efficacy of *Eretmocerus mundus* was evaluated in an air conditioned plastic greenhouse in Águilas (Murcia, Spain) divided with fine screen into 24 compartments 8 m^2, each containing 10 plants. Two experiments were conducted, one in fall andthe other in spring, the two main horticultural cropping seasons in southern Spain. Two factors wereevaluated: host plant (tomato and sweet pepper) and release rate of *E. mundus* (0,1.5 and 6 ind./m^2) using a split plot design with 4 replicates. In fall, female whitefly adults were released only once at 4.8 ind./m^2 two weeks after transplanting, whereas 3 weekly whitefly releases were made in spring to simulate typical immigration. Parasitoid releases were initiated 2 weeks after whitefly entry and continued weekly for 6 weeks in sweet pepper and 11 and 9 weeks in the fall and spring tomato trials respectively. Control infestations were highest in fall, reaching more than 700 nymphs/leaf in tomato and 150 nymphs/leaf in pepper. Nevertheless, upwards of 95% whitefly control was achieved in sweet pepper with the low release rate, although the high rate was required to obtain this result in tomato. The low rate was adequate in both crops during spring. These experiments suggested that an intermediate release rate of 3 ind./m^2 for approximately 6 weeks should be adequate for most situations if initiated early, although higher rates could be necessary in fall tomato when temperatures are high and immigration often intense.