Adoption of proactive resistance management practices to control *Bemisia tabaci* in Arizona and California

Naomi Pier[1], Al Fournier[1], John Palumbo[2], Yves Carrière[3], Wayne Dixon[1], Lydia Brown[1], Steven J. Castle[4] and Nilima Prabhaker[5], Peter C. Ellsworth[1]
[1]University of Arizona, Maricopa, AZ, [2]University of Arizona, Yuma, AZ,[3]University of Arizona, Tucson, AZ, [4]USDA - ARS, Maricopa, AZ, [5]University of California, Riverside, CA

The Challenge

What if we could predict the probability of insecticide resistance before it occurred, based on spatial and temporal patterns of insecticide exposure of insects? We could help pest managers make spray decisions less likely to result in resistance, based on knowledge of previous insecticide use.

The goal of this project was to prepare pest managers to proactively manage whitefly resistance at the landscape level by providing them:

(1) Basic education on 1st principles of resistance management: limiting the use of chemistry, diversifying modes of action, and partitioning chemistry through space and time (supporting refuges) (Fig. 1); and

(2) Insecticide Use Maps as decision-support tools for partitioning chemistry through space and time regionally.

We evaluated changes in grower / pest manager knowledge and intentions to adopt with future work planned for measuring insecticide use behaviors regionally to determine the success of our project.

Educating Stakeholders

Our education program (described above) reached ~300 farmers & pest managers in Arizona & California over 2 years and included workshops where pest managers learned to access and interpret Insecticide Use Maps.

We measured changes in knowledge (Fig. 3), intention to use maps (Fig. 4–6), and changes in behavior (Fig. 7) using pre & post surveys at meetings and online, a post-season telephone survey of map users, and pesticide use data to evaluate outcomes. There were measureable gains in knowledge (Fig. 4).

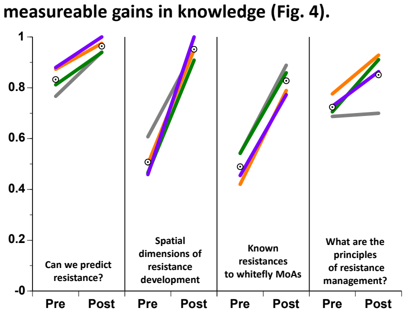

Figure 3. Participants were knowledgeable about resistance prediction and first principles prior to workshops. The largest gains in knowledge were measured for the spatial dimensions of resistance development and known local whitefly resistances.

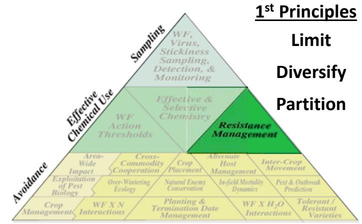

Figure 1. Resistance management is a small, yet important component of a complete whitefly IPM strategy. To help preserve existing whitefly chemistries, pest manager can do just 3 things, the first principles of resistance management. Pest managers must (1) limit insecticide use to the lowest practical levels, (2) diversify modes of action through time (i.e., rotation), and (3) partition usage of chemistries through space or time (i.e., create refuges).

Insecticide Use Maps

Maps depicting usage levels in 2014 and 2015 of the 6 whitefly modes of action at the section-level were provided to pest managers for use in making spray decisions (Fig. 2). Usage maps organize previously unavailable landscape level information and provide pest managers a tool that allows them to make educated decisions about insecticide use while following the principles of resistance management.

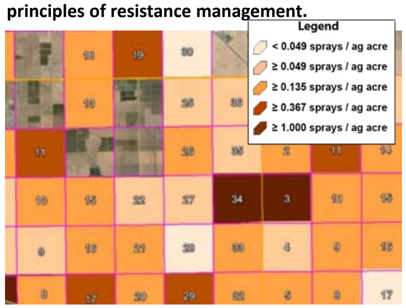

Figure 2. Insecticide Use Map showing 6 levels of use (unshaded = no use) for one mode of action. Maps for 6 insecticide modes of action were available to pest managers as a decision support tool for managing whitefly resistances.

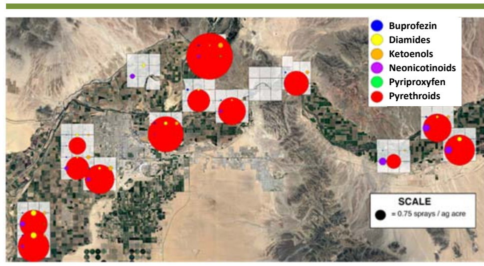

Figure 7. Insecticide usage in number of sprays per agricultural acre over 9-section areas (9 sq. miles) for each whitefly mode of action. A 1-mile diameter bubble represents 0.75 sprays per agricultural acre. Pyrethroids in red dominate the landscape due to the intensive cultivation of vegetables.

Intention to Adopt

We surveyed pest managers on their intention to adopt Insecticide Use Maps in making whitefly spray decisions. Factors measured included (1) participant influence on whitefly spray decisions; (2) current knowledge of previous year's sprays in Sections surrounding their fields, and (3) the extent to which knowledge of prior insecticide use influenced whitefly spray decisions. Outcomes indicate a relationship between decision-maker status, knowledge, and intention to adopt (Fig 4–6).

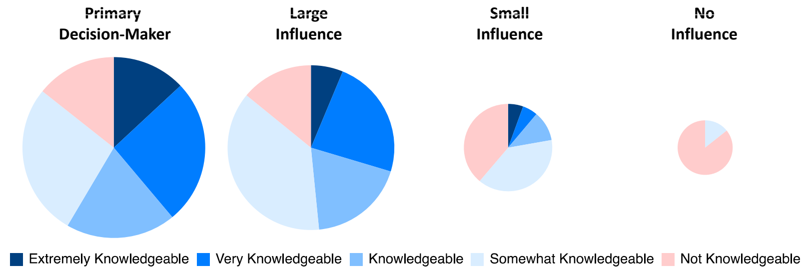

Figure 4. Level of respondent's influence on whitefly spray decisions and self-reported levels of knowledge of previous year's insecticide use. Respondents with a higher influence on whitefly sprays tended to have more knowledge of prior insecticide use.

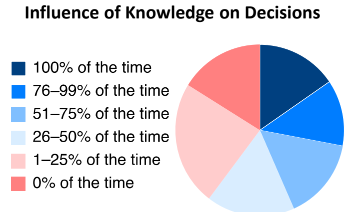

Figure 5. Survey participants quantified the degree to which their knowledge about the previous year's insecticide use influenced spray decisions for whitefly. Almost half of respondents indicated that this knowledge influenced their spray decisions more than 51% of the time, and 15% responded that all of their spray decisions were influenced by this knowledge.

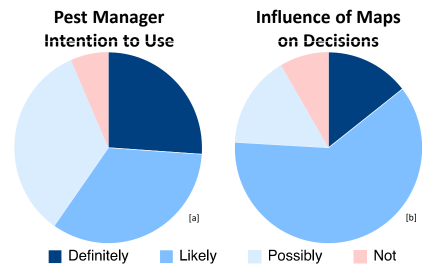

Figure 6. 60% of pest managers surveyed over 2 years indicated they would definitely (26%) or likely (34%) make use of Insecticide Use Maps [a]. An even larger percentage (75%) of respondents indicated that maps would definitely or likely influence their actual spray decisions [b].

Change in Behavior?

Pest managers learned the fundamentals of resistance management and have self-reported their intent to follow the 1st principles by using their knowledge of previous year's insecticide applications (i.e., the Insecticide Use Maps we developed).

Adoption can be measured using pesticide usage records. These records will show levels of adoption through changes in usage patterns over space and time (e.g., Fig. 7).

Importance

This project demonstrated that a knowledge of spatial and temporal insecticide use patterns can inform whitefly spray decisions and enable pest managers to proactively reduce specific selection pressures and thereby theoretically reduce the potential for resistance development.

These principles are most effective for preventing resistances when communities are empowered with decision tools and an understanding of resistance principles. Our Insecticide Use Maps and trainings provided pest managers the tools and skills necessary to combat resistance.

Acknowledgements: Thank you to all the growers and pest managers that cooperated with us during this project; without them it would have not been possible. Thank you to Joseph Cassano, Gilberto Castro, Isadora Bordini, Francisco Bojorquez, Goya Lizarraga, Paul Merten, Jose Partida, Tonya Thacker, and Julianne Trejo for their assistance. Thank you to James Hagler and Scott Machtley for the use of their vehicle. This research was supported by grants from USDA – National Institute of Food & Agriculture's Crop Protection / Pest Management, Applied Research & Development Program & Extension Implementation Program, Arizona Cotton Growers Association, ADA Specialty Crop Block Grant Program, Cotton Incorporated as well as from the Monsanto Insect Knowledge Management Program.

Thank you to the Center for Insect Science for providing funding for travel.

[1] Denholm, I., Cahill, M., Byrne, F.J., Devonshire, A.L., 1996. Progress with documenting and combating insecticide resistance in Bemisia. In: Gerling, D., Mayer, R.T. (Eds.), *Bemisia: 1995 Taxonomy, Biology, Damage, Control and Management*. Intercept Ltd., Andover, Hants, UK, pp. 577–603.
[2] Horowitz, A.R., Ishaaya, I., 1996. Chemical control of Bemisia - management and application. In: Gerling, D., Mayer, R.T. (Eds.), Bemisia: 1995 Taxonomy, Biology, Damage, Control and Management. Intercept Ltd., Andover, Hants, UK, pp. 537–556.
[3] Ellsworth, P.C., Martinez-Carrillo, J.L., 2001. IPM for Bemisia tabaci: a case study from North America. Crop Prot. 20, 853–869
[4] Li et al., unpubl. data

USDA United States Department of Agriculture National Institute of Food and Agriculture
Center for Insect Science
Arizona Pest Management Center