WHITEFLY MANAGEMENT IN ARIZONA COTTON – STATUS AND NEEDS

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Status of Whitefly Management in Cotton

It has been less than 6 years since the devastation of the whitefly in Arizona and southern California. Numbers were so dense that windshields were clouded with the bodies of the adults, unprotected cotton fields were "biologically" defoliated, and fields stood in "permanent" wilt due to the excessive stress imposed by the immatures. Today our program has evolved from an effective, yet 2-dimensional system of chemical management to a multi-faceted, 3-dimensional and integrated management strategy (Ellsworth et al. 1996a; Ellsworth & Naranjo 1999). Early on the three "keys" to whitefly management were identified by us and others as 1) Sampling and detection, 2) Effective chemical use, and 3) Avoidance of the problem. Now, this matrix of factors can be represented in the form of a pyramid, an inherently stable structure (Fig. 1). "**Avoidance**" is the foundation block upon which "Effective **Chemical Use**" and "**Sampling**" rest. Confronted with a pest crisis, short term survival depends on the upper two levels of the pyramid. However, sustainable, long-term strategies ultimately must depend on the development of a solid foundation, "avoidance." At the same time, a pyramid-strategy developed for one pest must be compatible with like strategies in place for all pests of a system.

The building blocks of a successful pest management program can be further subdivided into component parts. **Sampling** in cotton involves multi-stage and binomial methods of classifying whitefly populations (Ellsworth et al. 1995, 1996c; Diehl et al. 1997a, b, c) and sits at the apex of the pyramid. This represents its overarching importance in the implementation of all insect control tactics. Further, sampling plays a central role in the refinement and understanding of our management strategies. Without well-designed sampling tools, progress in all areas of whitefly management would be hampered. These tools have been adapted for new chemistry as it was developed. **Effective chemical use** consists principally of the use of **action thresholds**, availability and understanding of **selective and effective chemistry**, and a proactive **resistance management** plan. Action thresholds have been developed that are effective at preventing yield and quality losses (Ellsworth & Meade 1994; Naranjo et al. 1998). These, too, are insect stage-specific and have been optimized for proper deployment of insect growth regulators (IGRs) (Ellsworth et al. 1996c, 1997a,b, 1998a; Ellsworth 1998). The IGRs, Knack® and Applaud®, became available for the first time in this country in 1996 and have had a sensational impact on the selective management of this pest. [However, one cannot understate the importance of concomitant use of Admire® (imidacloprid) in melons and vegetables to the overall, area-wide lowering of pest dynamics.] All chemistry has been organized into a 3-stage program of deployment for resistance management (Ellsworth et al. 1996a). The proactive nature of this program has led to the restriction of use of the new IGRs such that their modes of action may be preserved for as long as possible while providing relief for resistance risk to all products.

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Research and Implementation Needs

Adoption of IGRs and their proper use has been exceptional with over half to two thirds of all cotton acres being treated annually since 1996 (Table 1). The challenge remains, however, to further delve into the foundation block of our management program, avoidance. This level of management may be subdivided into three interrelated tiers of development, **Cross-Commodity Cooperation, Exploitation of Pest Biology, and Crop Management**. Key elements within these tiers are either in partial operation or development at this time. Dramatic successes so far — 6.6 sprays against whiteflies in 1995 down to just over 1 spray in 1998 (Table 2 & 3) — overshadow efforts to continue development of tactics of avoidance. Complacency in growers and the scientific community is a very real challenge to us now. Work should continue in all areas of avoidance; however, an opportunity has become available to make significant progress in cross-commodity cooperation with specific impacts on crop placement, alternate host management (source reduction), and inter-crop movement. As we build and strengthen our pyramid of whitefly management in cotton, we need to build similar structures of whitefly management for the other major crop hosts in Arizona (e.g., melons and vegetables). Only then can we fully realize an integrated, systemic, and sustainable solution to this highly mobile pest. Palumbo et al. (1999) reported on just such an effort to reconcile chemical use and whitefly management among the major crop host commodities in Arizona. Their initial efforts will be to interlock resistance management programs among four host crops, spring melons, cotton, fall melons, and vegetables.

Some other specific needs for our program include elements of refinement or discovery in each of the three keys to whitefly management. While huge gains have been made in the area of sampling whitefly populations (Naranjo, 1996; Naranjo & Flint 1994, 1995; Ellsworth et al., 1995, 1996a,b,c; Naranjo et al. 1997, 1998a), we need significantly more work and progress in the area of stickiness detection, sampling and monitoring (e.g., Henneberry & Naranjo, *this volume*; Etheridge & Hequet, *this volume*). With the marketplace poised to penalize growers or whole geographic regions for even the risk or perception of potential for sticky cotton, it is imperative that the industry develop measurement systems and practical plans for detecting sticky cotton. Furthermore, once detected, we need to identify the specific problems associated with that stickiness for the ginning, milling, and spinning industries.

The Section 18 for Emergency Exemption of the use of the two IGRs in Arizona was originally predicated on the demonstrated need for limited use of two compounds to mitigate our crisis situation with whiteflies (Ellsworth & Diehl 1996). Our gains in whitefly management have been so dramatic, that the vast majority of acres are sprayed with only one of the IGRs. If additional sprays are needed, growers often opt for alternatives to the IGRs such as non-pyrethroid and pyrethroid combinations. One reason for the relatively small use of both IGRs on the same acreages in sequence is the uncertainty factor for timing the second use. The IGRs on a per unit basis are more expensive than the conventional alternatives, where re-treatment timing is better understood (Ellsworth et al. 1995, 1996d) and practiced. Also, conventional insecticides carry the added advantage of being broader spectrum and capable of abating other pest problems later in the season. On the other hand, use of both IGRs provides for a powerful selective strategy for overcoming whiteflies while preserving natural enemies (Naranjo et al. 1998b,c; Ellsworth et al. 1998b; Naranjo & Ellsworth, 1999). Thus, further work is needed to identify the optimal conditions and timing for re-treatment with the second IGR (e.g., Ellsworth et al. 1997a,b, 1998; Ellsworth & Naranjo 1999). Furthermore, the use of IGRs needs to be integrated into whole systems of cotton pest management and production so that any inconsistencies or incompatibilities can be identified (Ellsworth 1998; Silvertooth et al. 1998; Ellsworth et al. 1998a,c; Dittmar et al. 1999; Ellsworth & Naranjo 1999).

Avoidance measures will likely always be the foundation practice to any pest management strategy in cotton. This is the area of greatest need presently. Significant efforts are underway already including in the broad area of cross commodity cooperation (Fig. 1; see above). **Exploitation of pest biology** and ecology is another fertile area in need of more investigation. For example, *Bemisia* is a polyphagous pest that depends on the year-round availability of host plants (Watson et al. 1992; Ellsworth et al. 1993). Without any definitive diapausing or overwintering stage, *Bemisia* would seem to be particularly vulnerable during the winter season. Little is known about the overwintering ecology of this pest or the impact of seasonal declines in temperature (Bivins et al. 1996, 1997). Yet environmental constraints to the expansion of this pest's geographic range clearly exist. With a better understanding of the low temperature dynamics and other overwintering features of this pest's ecology, we could potentially design better systems of avoidance through strategic plantings, oversprays, habitat management, or forecasting. Complementary studies of the mortality dynamics of this pest during the non-cotton seasons could broaden our understanding of the factors that regulate whitefly populations and prevent or lead to its outbreak status. Using the life table techniques implemented by Naranjo & Ellsworth (1999), we should be able to measure individual and population responses to natural biotic and abiotic mortality factors. Arizona with its season-long availability of both cultivated (cotton, melons and vegetables) and uncultivated hosts (weeds, desert, and landscape vegetation) is at a point where these types of studies are necessary to uncover the myriad of ecological factors which regulate whitefly populations. Only then will be we be able to significantly advance our current management system to a level of economic and environmental sustainability that is necessary for growers to survive in a global market. Thus, our challenge remains to preserve our successes while redoubling efforts to develop and integrate more tactics of avoidance for our whitefly management system.

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Disclaimer

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Table 1. Arizona statewide useage (in acres) of the insect growth regulators in cotton (1996–1998).

Year	Applaud	Knack	Planted Acres
1996	68,678	166,400	357,000
1997	67,425	101,310	347,000
1998	31,260	94,550	265,900

Table 2. Arizona statewide average number of sprays made for whitefly control and resulting lint quality (1990–1998).

Year	No. of SWF sprays	Lint Quality (est.)
1990	1.00	—
1991	1.80	some stickiness
1992	5.10	very sticky
1993	2.60	clean
1994	4.40	mostly clean
1995	6.60	compromised
1996	1.99	very clean
1997	1.81	clean
1998	1.05	very clean

Table 3. Arizona statewide average costs of control for whitefly and proportion of overall foliar insecticide budget (1990–1998).

Year	SWF Control($ / A)	% of Total Insect Control
1990	12.00	10.5
1991	25.20	24.0
1992	91.80	74.7
1993	52.00	74.4
1994	88.00	63.5
1995	145.20	67.5
1996	57.84	47.1
1997	52.72	49.0
1998	34.00	32.9

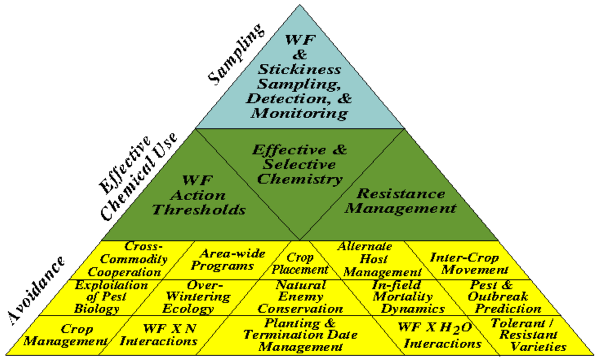

Figure 1. Conceptual diagram of integrated whitefly management in cotton. The pyramid structure is inherently stable and contains three levels or keys to whitefly management (left): Sampling, Effective Chemical Use, and Avoidance.