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Views and Ideas

# Early-season populations of *Aphis gossypii* on cotton: 'to spray or not to spray? is not the only question

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The use of broad-spectrum insecticides in agriculture frequently generates a conflict between individual growers and the society at large. While the primary putative benefits of insecticide use (suppressed herbivore populations, increased crop yields) are reaped by the grower, many costs of insecticide use (pesticide resistance evolution, farm worker exposure, pesticide residues in food, water contamination, and general environmental degradation) are born by various segments of society (Zilberman et al., 1991). Nevertheless, some immediate costs of insecticide use may be felt locally, by the individual grower, including target pest resurgence and secondary arthropod pest outbreaks (Luck et al., 1977). If these effects are severe enough, the use of insecticides may be disadvantageous from both the perspectives of the grower and society. Thus, the demonstration that established insecticide use practices are unfavorable to the individual grower is particularly important.

Zhang and Chen (1991; see also Chen et al., 1991) have recently identified one such example of insecticide use that is disadvantageous even from the perspective of the individual grower. Cotton growers in the coastal areas of eastern China rely on insecticides to control early-season populations of the cotton aphid, *Aphis gossypii* Glover. Casual observations of commercial fields during 1976–1981 suggested, however, that unsprayed cotton fields produced greater yields than sprayed fields. To investigate this observation, replicated field studies were conducted contrasting cotton growth, maturation, and yield in plots sprayed every 1–2 weeks through June with carbofuran and parathion with plots left unsprayed. These studies demonstrated that sprayed and un-

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sprayed plots were not significantly different in terms of plant growth (number of lateral buds, nodes, bolls, and summer bolls per plant), the timing of crop maturation (pre-frost bloom rate), or yield. Although not statistically analyzed, Chen et al. (1991) also report trends of increased populations of non-aphid late-season herbivores and their associated damage, as well as apparent suppression of natural enemy populations in sprayed plots. They conclude that it does not pay to spray during the early season, and ascribe this result to two causes: (1) the ability of cotton plants to compensate for early-season damage; (2) the role of cotton aphids in supporting the growth of generalist natural enemy populations that regulate populations of other late-season pests. Zhang and Chen (1991) suggest, therefore, that early-season cotton aphids are not pests, but rather should be viewed as a beneficial component of the agroecosystem.

We feel that the interpretation of early-season cotton aphids as beneficial insects over-extends the experimental results in important ways. It is critical to distinguish two related, but fundamentally distinct, questions. First, is the early-season use of insecticides by cotton growers in eastern China cost effective? (This question focuses on contrasting the costs and benefits of two specific control strategies: (1) spraying carbofuran and parathion every 1–2 weeks; (2) spraying nothing.) Second, are early-season aphid populations in fact decreasing cotton productivity, such that some other control practice (cultural, biological, or chemical) might still be warranted even if current insecticide applications are ineffective? Zhang and Chen (1991) address the first question, but not the second. They demonstrate that early-season insecticide applications are not cost effective, but do not address whether these pesticide applications reduce the cumulative aphid populations and aphid-generated damage experienced by plants over the course of the growing season (i.e. insecticide efficacy). It should be noted that only by demonstrating different levels of aphid-generated damage can there be an inference that plant compensation is involved in final yield responses. The aphids studied by Zhang and Chen (1991) may have caused yield losses that were not experimentally detected for several reasons: (1) the insecticides were ineffective; (2) the insecticides killed both aphids and their natural enemies, so that the net long-term effect on the aphid population was the same as if no insecticides had been applied; (3) the insecticides killed both aphids and their natural enemies, and the reduced natural enemy population resulted in later secondary pest outbreaks that reduced cotton yield. Indeed, in the introduction to their paper, Zhang and Chen (1991) report casual observations of commercial fields suggesting that insecticide applications are ineffective and that even sprayed fields suffer substantial aphid damage.

The answers to these questions are critical to the management of cotton aphids in cotton grown in China and many other areas of the world where early-season populations attacking seedlings are severe (e.g. the San Joaquin Valley of California, parts of Texas, Israel, and Brazil). In many of these areas, a variety of control measures that are quite effective in controlling aphid populations are available and are widely used. Because the ecological and environmental costs of these control measures (e.g. the use of side-dress applications of aldicarb before plant emergence) may be severe, it is critical to know whether there is any reason for their use. Are early-season cotton aphids pests?

We have recently reported the initial results of field experiments that evaluate the pest status of early-season *A. gossypii* on cotton (Wilhoit et al., 1992). Cotton aphid populations in replicated field plots were experimentally manipulated by inoculating plants with greenhouse-reared aphids, by manually removing aphid predators, and by applying a selective aphicide. A large range of aphid densities was produced, including some that were extremely high. Cotton seedlings bearing heavy early-season aphid populations were severely affected: leaves did not expand normally and plants were stunted when compared with plants supporting few aphids. Many commercial growers responded to these crop damage symptoms with applications of broad-spectrum insecticides. Nevertheless, unsprayed cotton plants were able to compensate completely for the early-season damage after predators and parasitoids exerted control of aphid populations. There was no effect of early-season aphid populations on final plant size, the timing of crop maturation, yield, and a large number of parameters that define cotton lint quality (Wilhoit et al., 1992; Rosenheim and Wilhoit, unpublished data, 1991). None of the plots bore significant populations of other herbivores at any time during the growing season, and the experimental plots were small enough ($3 \text{ m} \times 7 \text{ m}$) that between-plot movement of adult predators was rapid. Thus, any enhancement of natural enemies in plots with heavy early-season aphid populations could not maintain long-term differences in predation pressure across plots.

If confirmed by our ongoing studies, these results suggest not only that the insecticide use strategies of cotton growers studied by Zhang and Chen (1991) should be discontinued, but also that early-season aphid populations are not pests. Therefore, there may be no need to seek additional, more effective means of suppressing early-season aphids. Furthermore, the widespread use of early-season insecticides for cotton aphid control in areas like the San Joaquin Valley, although effective in suppressing aphid populations, should be abandoned. Like Zhang and Chen (1991), we have observed substantial generalist natural enemy populations developing on early-season aphids and then suppressing other potentially key pests, such as *Tetranychus* spp. spider mites and a variety of lepidopteran caterpillars. Thus, early-season aphids may be more than simply 'non-pests', but indeed beneficial components of the cotton agroecosystem.

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