Resistance Management: Mix or Rotate Between Insecticides?
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The answer to the question, "should you mix insecticides together in the same tank or rotate between insecticides to slow the development of resistance?," often has two different answers depending upon who you ask. In truth, the answer is controversial and the science behind the scene is incomplete. Therefore, to find the most logical answer, I like to start with a much simpler question, "what is the best possible resistant management program?" The answer to that is simple: don't use insecticides at all.

In fact, most of the standard resistant management methods involve methods that minimize insecticide use and/or pest population exposure, especially repeat exposure to the same type of product. If you can't give up insecticides all together, then the next best thing is to integrate chemical controls with effective cultural, biological, mechanical, physical or genetic controls to minimize insecticide use. In short, use IPM! That includes scouting, monitoring and using action thresholds to assure that applications are necessary before they are made. Other IPM methods like spot treatments, perimeter trap cropping and using a refuge planting help assure that some susceptible individuals survive to reproduce. Otherwise, repeat applications can remove all susceptible individuals from a farm leaving only those with special survival traits (or genes) to reproduce and produce resistant populations.

Now let's think about the theory behind mixing. By applying two or more insecticides at the same time you should be able to extend the useful life of products longer than if you used one until it became ineffective, and then the next (etc.), until they were all useless. The mixing theory is based on the fact that it is unlikely for individual pests to possess the genes that would allow them to survive multiple types of poison. The problem with the mixing theory is that it is unlikely to hold up in the field. Getting extended use from insecticides by mixing assumes that:

1. some susceptible individuals from the pest population are spared
2. that each pesticide in the mix has a different mode-of-action,
3. and the same length of effectiveness,
4. that resistant individuals are rare, and
5. that resistance is passed on to offspring by a single recessive gene.

The mixing theory should work well if two or more insecticides with different methods of killing the pests (modes-of-action) came on to the market at the same time and were always used together. In practice, however, we expect an expensive new insecticide to control the pest all by itself. In reality, few people would like to bear the expense of always using multiple products in their tank. So, we seldom start mixing products before we begin to have pest control failure problems with the first product. According to the theory, it is too late to start mixing at this point because resistant individuals would no longer be rare (assumption #4). This would accelerate the development of resistance rather than retard it because of the strong selection pressure for the survival of resistant individuals that could withstand the chemical barrage.
It is also unlikely that products with different modes-of-action would have a similar residual period of activity. For instance, there are several insecticides with different modes-of-action registered to control European corn borer on peppers and most have different residual periods: Javelin (3-4 days), Ambush (5-10 days), SpinTor (7 days), Intrepid (7-14 days), and Orthene (10-14 days). The only two that were registered at approximately the same time were Spintor and Intrepid, which have different lengths of effectiveness, so assumption # 3 will rarely if ever be met. That means there will be times when pests will be exposed to a single insecticide rather than a mix and the mixing theory breaks down again. Finally, if there is no immigration of susceptible individuals from outside of the field, or if multiple genes are involved in the inheritance of resistance, then mixing insecticides can actually hasten the development of resistance instead of delaying it. There are also many hidden costs and risks that such an intensive insecticide program might contain, such as environmental pollution problems, applicator safety, killing off beneficial organisms, secondary pest outbreaks, multiple re-entry intervals and different day-to-harvest restrictions.

On the other hand, rotating between insecticides with different modes-of-action, and only using one material at a time, fits right into the IPM and resistance management philosophy of trying to minimize pesticide use. Using one insecticide at a time, instead of two or more in each application, lowers the related expenses, costs and risks associated with chemical pest control. Rotation, especially with selective insecticides that only kill the pest species, also makes it more likely that you will spare beneficials that help prevent secondary pest problems and prevent additional pesticide use and expense.

**Rotation is the only logical choice in resistance management for farmers with an eye on a sustainable future.**

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