

## RESISTANCE FACTORS - WHAT DO THEY MEAN?

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### Introduction

Insecticide resistance continues to be a major problem for the cotton grower. It also is the focus of much of the research into the use and management of transgenic plants. At times, the jargon associated with resistance can be vague or misleading, not only to the cotton grower or consultant but also to specialists in pest management. Terms such as resistance factors, resistance levels and resistance frequencies are all used to connote the seriousness of resistance. The distinction among the three terms is not always clear and they are sometimes used interchangeably.

### Definitions

The term **resistance factor** (R.F.) is a measure of the increase in concentration of insecticide (or biopesticide or toxin) needed to kill resistant versus susceptible insects. **Resistance frequency** is a measure of how common resistant individuals are in the population. For example if the frequency is 50%, then 1 in 2 individuals in the population are resistant; 33% means that 1 in 3 individuals are resistant. **Resistance level** is used to mean either of these, so it can refer to the potency of resistance in individuals or to the frequency of resistant individuals in populations. It is a term that leads to confusion and woolly thinking and is best avoided.

Neither resistance frequency nor resistance factors can by themselves be used to predict if and when resistance will lead to problems in field control of insects. There are many reasons for this but the one that we wish to illustrate is that resistance factors at best indicate a qualitative difference in response of susceptible and resistant insects, rather than providing a quantitative measure of the difference. This is because estimates of resistance factors vary according to the test technique used and to the life-stage tested.

### Resistance Factors & Endosulfan Resistance

Traditionally, resistance factors (R.F.) are calculated at the doses that cause 50%, and 99% mortality. These doses are called the LD<sub>50</sub> and LD<sub>99</sub>, respectively. It is most common to calculate R.F.s at the LD<sub>50</sub>. R.F.s are the ratio of the LD<sub>50</sub> of the resistant insects divided by the LD<sub>50</sub> of the susceptible insects. This point can be illustrated with endosulfan resistance in *H. armigera*. The response of 4th instar larvae, susceptible and resistant to, endosulfan is illustrated in Figure 1. The doses required to kill 50% of susceptible and resistant insects are 0.9 µg/larvae and 54 µg/larvae, respectively. Thus,

$$\begin{aligned} \text{R.F.} &= 54/0.9 \\ &= 62 \end{aligned}$$

So the resistance factor is 62-fold. These data were collected in 4th instar larvae (medium-sized larvae) that were bioassayed using the standard topical dose test. In this test, larvae 30-40 mg in body weight have a small drop of insecticide placed on their back. The larvae are assessed as dead or alive after 4-6 days on artificial diet.

The topical dose bioassay is the standard procedure for estimating resistance factors in *H. armigera*. An alternative technique is to expose larvae to leaves treated with applications of endosulfan applied in a spray tower. The larvae walk over the surface and eat the leaf. Again, this is a laboratory test, but it is more similar to field exposure. Figure 2 illustrates resistance factors determined for larvae from hatchlings to 10-day old larvae. Estimates ranged from 14-fold in hatchlings to 2-fold in large larvae. This comparison was for fully resistant compared with susceptible insects. Resistance factors for a comparison of heterozygotes compared with susceptible insects would be even lower. Clearly, there was poorer discrimination observed between resistant and susceptible insects using this technique than was obtained in the topical dose bioassay.

We also calculated resistance factors in adults. In this life-stage, adults were exposed to the endosulfan as they walked across a treated glass surface inside a vial. It mimics exposure in the field as the insect lands or rests on a leaf. Resistance factors were 22-fold in females, 30-fold in males.

These results indicate that there is no set value for the resistance factors of endosulfan resistance in *H. armigera*. At the same age-class of larvae, 7-day olds, the estimate using the leaf technique (4.4-fold) was greatly different from that observed with the topical dose test (62-fold). Even using the same technique estimates differed between the age-classes. Estimates of resistance factors are subject to other problems, not observed in our experiments with endosulfan resistance. Some techniques used to monitor resistance can produce artifacts, particularly if it is not possible to apply a dose of insecticide that will kill 99% of insects. In such situations, resistance factors of 1000s or 10,000s could be observed but they would be no more than statistical aberrations.

Results such as those we obtained for *H. armigera* can help us to understand why resistance does not always cause major problems with field control of insects. The leaf bioassay with *H. armigera* larvae and the vial tests with adults resembles field exposure. From these tests we would predict that in cotton, field application rates should not readily distinguish between larvae but may do so in adults. Data we have collected from field trials indicates that these predictions are correct. We observed little difference in the mortality of resistant and susceptible larvae (Daly 1992) under most conditions. Figure 3 illustrates the mortality of adults directly exposed to field application rates. Discrimination was very good in adults. Most susceptible insects were killed while resistant adults survived. We conclude that

changes in frequency of endosulfan resistance are driven by strong selection in adults.

### Conclusion

Estimates of resistance factors are not constant for a particular case of resistance but vary with the life-stage and size of insect tested and with the technique used. Thus, we urge caution in the uncritical use of resistance factors to predict field efficacy of an insecticide.

### Reference

Daly, J.C. (1992). Endosulfan resistance in *Helicoverpa armigera*, pp 353-358. Proceedings of Sixth Australian Cotton Conference, Broadbeach, Queensland, Australian Cotton Growers Research Association, August 1992.

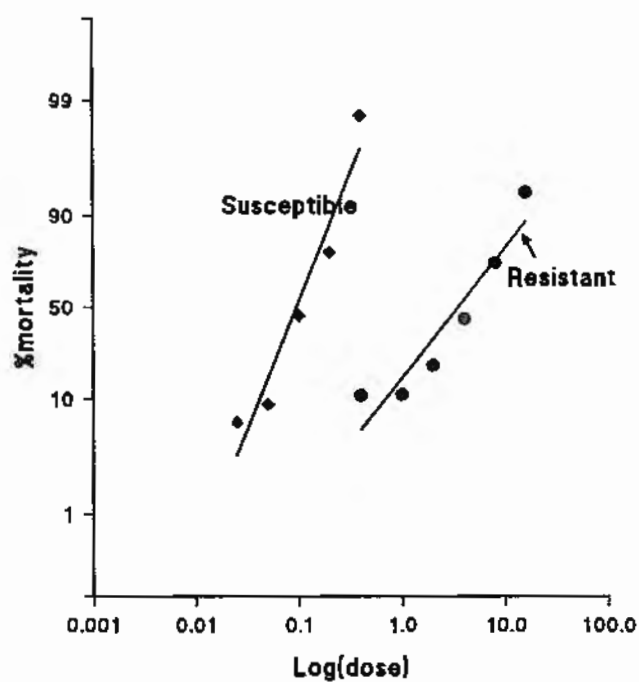


Figure 1. Dose-response of 4th instar larvae

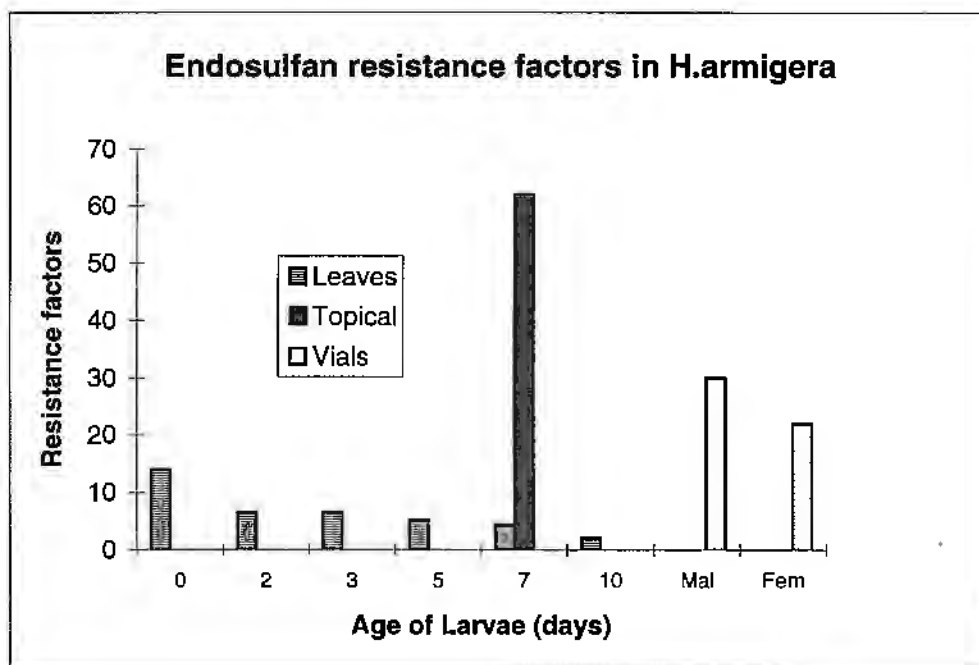


Figure 2. Resistance factors in *H.armigera* in different aged larvae and in adults. Bioassays were done by exposing larvae to leaves treated with endosulfan (leaves) or with the standard topical application of endosulfan.

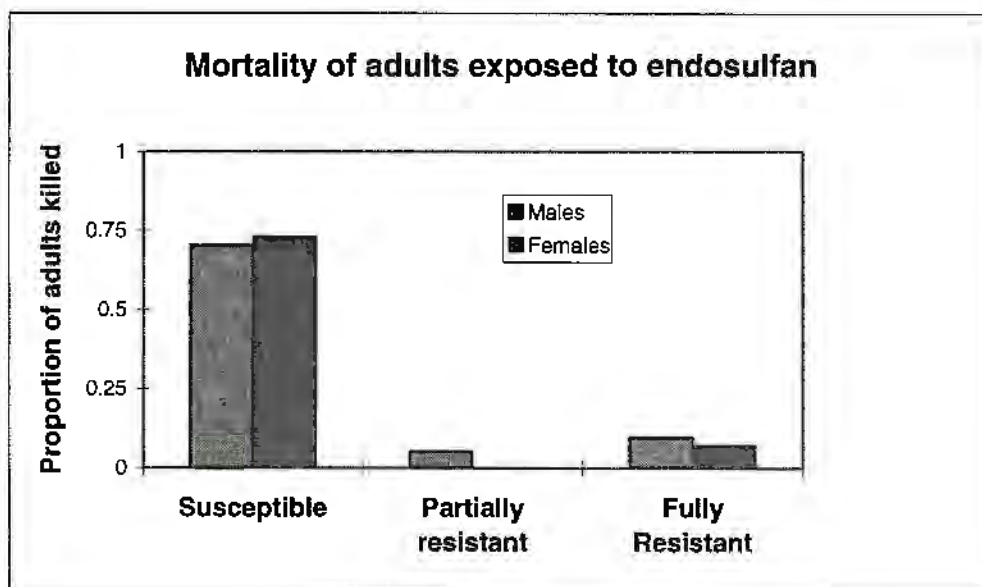


Figure 3. The proportion of adults killed after exposure to field application rates of endosulfan in a cotton field.