RESISTANCE : CAN WE SURVIVE?

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Well to satisfy everyones's curiosity, I will answer the question straight away. Yes, we can survive resistance! However, in answering it, I shall put another, perhaps even more thought provoking than the first. Yes, but for how long? We not only need a strategy which seems to be working now, but one that will continue to work well into the future. The ultimate goal is a sustainable pest management system for cotton in which insecticides and resistance management are only a part.

In their invitation to address this gathering, the ACGRA asked me to review how well we have done in the past, to give an update on the current resistance status and to give my vision of the future. This seems as good a framework as any, on which to structure this talk.

What have we achieved since Emerald 1983? I specifically chose this starting point as the systematic response to the pyrethroid resistance crisis has been in stark contrast to the confused response to previous resistance episodes eg. the DDT resistance crisis of the early 70's.

This time the problem was diagnosed early, the right questions were asked and answered quickly by relevant research. This was followed by the formulation, ratification and implementation of an Insecticide Resistance Management Strategy within 6 months of the first field failures. The structure of this

Strategy has changed little since its inception and it stands as the world's first attempt at nationwide curative resistance management. The original Strategy had 5 supplementary recommendations but ongoing research has since resulted in the adoption of a further five. These encapsulate a lot of the knowledge gained since those early days.

1. To help prevent resistance developing to other insecticides, use no less than 3 of the 5 available chemical groups throughout the season.

2. Use mixtures of ovicides and larvicides when egg pressures warrant.

3. Avoid repetitive spraying with endosulfan where reasonably cost-effective alternatives exist.

4. Adopt an early crop setting strategy to avoid the need for spraying in autumn, when *Heliothis armigera* is most abundant.

5. Do not respray a suspected pyrethroid failure with a pyrethroid.

6. Target pyrethroids to egg hatch. Applications to established resistant larvae will be ineffective and will increase levels of pyrethroid resistance. Regular and thorough scouting is essential to achieve this objective.

7. Avoid pyrethroids when there is high *Heliothis armigera* pressure.

8. Sample overwintering pupae under cotton stubble and cultivate if there are more than 1 per metre of row.

9. Don't grow December flowering crops attractive to *Heliothis armigera* (eg.maize, sunflowers) in predominantly cotton areas. These simply act as nursery crops producing large numbers of *armigera* for the Stage 2 pyrethroid period.

10. Avoid consecutive sprays of pyrethroids where *Heliothis armigera* are emerging from neighbouring maize, sorghum or sunflower fields,as resistance levels will be exacerbated by selection of moth before mating.

These 10 recommendations combine chemical, cultural and agronomic approaches to managing insecticide resistance. I believe this integrated approach is the only viable long term solution to the management of insecticide resistance.

Each season's research and experience has allowed us to broaden our knowledge of this problem. For example, this year saw the lowest end of season resistance level for some time. It is becoming increasingly clear now, that this end of season level varies as a result of the interaction of three main factors:-

1. WEATHER; - Wet summers result in large numbers of susceptibles breeding in unsprayed dryland alternate host crops such as sorghum, sunflowers and maize. These can then migrate into the cotton area and significantly dilute resistance. In dry years, production of susceptibles in the unsprayed refugia is negligible and dilution is not a significant factor. Resistance levels reflect closely insecticide use in the

irrigated cotton crop.

2. PYRETHROID USE; - High pest pressure results in higher insecticide use and therefore greater selection pressure for resistance.

3. EARLY SEASON STARTING POINT; - High Stage i resistance levels are obviously a cause for concern, as experience has shown that moth selection results in an immediate 1.5 to 2.0 fold increase in resistance during the critical Stage 2 pyrethroid use period. The Stage 1 resistance level itself, is strongly dependent on the survival rate of the highly resistant overwintering armigera pupae under cotton stubble.

We have no control over the weather or pest pressure but we do over the third factor. This leads me to our current recommendations for managing resistance in *Heliothis armigera*. Without wishing to depreciate the importance of the 10 supplementary recommendations already mentioned, we have, what I consider, 3 key guidelines for managing resistance.

1. Don't use pyrethroids outside of the 42 day window.

2. Don't use endosulfan on cotton in Stage 3.

3. Cultivate overwintering pupae, if present.

Please note that I rate the third guideline as of equal importance as the first two, which I suspect, may not be the case for some growers here. Gary Fitt will talk in a moment on the importance of the overwintering stage in the ecology of *Heliothis*

armigera. Suffice it to say, that given increased vigilance to this problem, I believe that it may be possible to reduce Stage 1 resistance levels further, perhaps even approaching those recorded in the early years of the Strategy.

Now what of the future

The current Strategy is a delicate balance between pyrethroid resistance on the one hand, and endosulfan resistance on the other. We are running our cotton industry principally on two insecticide groups (endosulfan and pyrethroids), both at risk to resistance. We need to strike a fine balance if we are to maintain satisfactory insect control. The current strategy is basically buying time until we can incorporate new ideas and technology into a hopefully sustainable pest management programme for cotton. I believe these will come, and indeed, some are not far off.
eg.

1. New Insecticide Groups - These will come slowly onto the market eg. the chitin inhibitors, avermectins etc. However, these new products will be substantially more expensive. I would suggest $45-50/ha as a starting point for most new insecticides. Many will also have disadvantages such as slow kill, lack of contact action, narrow spectrum of pests controlled etc. which will limit them to specific use areas only. eg. The slow acting stomach poison chitin inhibitors can only be used successfully against Heliothis on cotton when crop growth slows down at the end of the season. Even then, they have poor activity against other late season pests such as mites and aphids. In addition to new groups, I also believe it may even be possible to design specific molecules from

already discovered groups, to overcome certain resistance mechanisms eg. mixed function oxidases imparting pyrethroid resistance.

2. Synergists - Our recent research has shown that piperonyl butoxide (pbo) may be useful to suppress the main pyrethroid resistant gene involved in our resistance situation. Up to two thirds suppression could be expected. However the draw- backs will be:

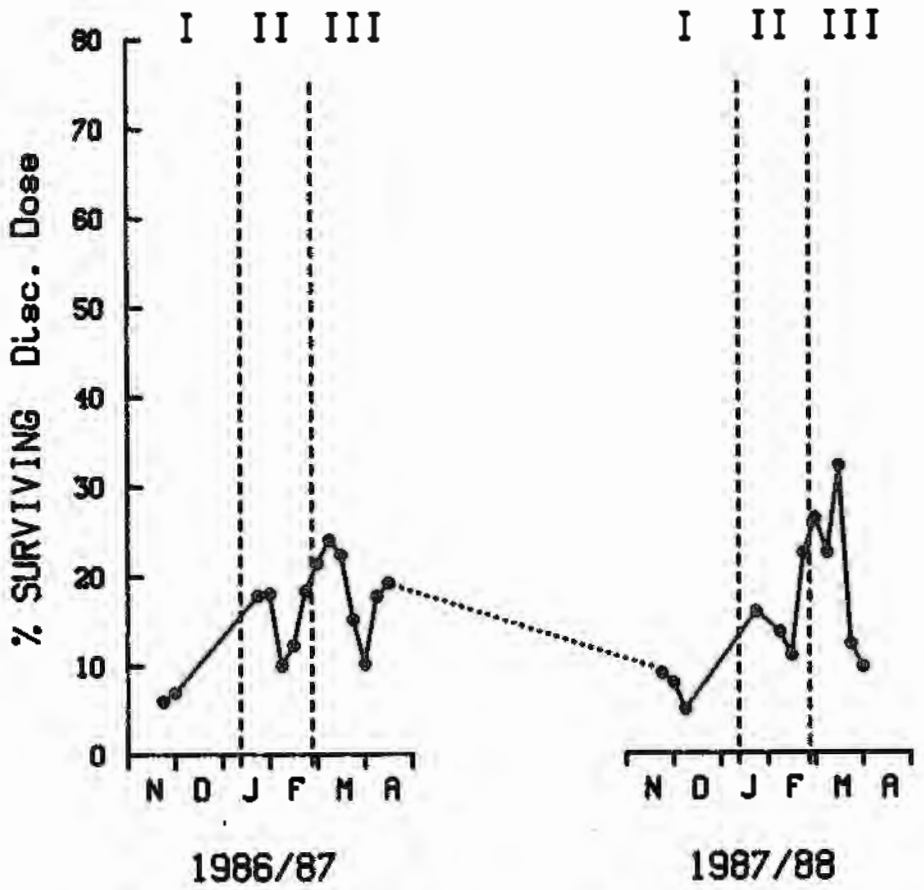
   - extra cost
   - piperonyl butoxide will work only on resistant *H. armigera* (no increased kill of susceptible *H. armigera* or *H. punctigera*). Therefore the extra cost will only be warranted in moderate to high pyrethroid resistance situations.
   - overuse could lead to resistance to piperonyl butoxide/ pyrethroid mixes.

   Nevertheless, I believe there is room for one piperonyl butoxide spray preferably mixed with the third Stage 2 pyrethroid, increasing its reliability and thus relieving increasing selection pressure on endosulfan in Stage 2.

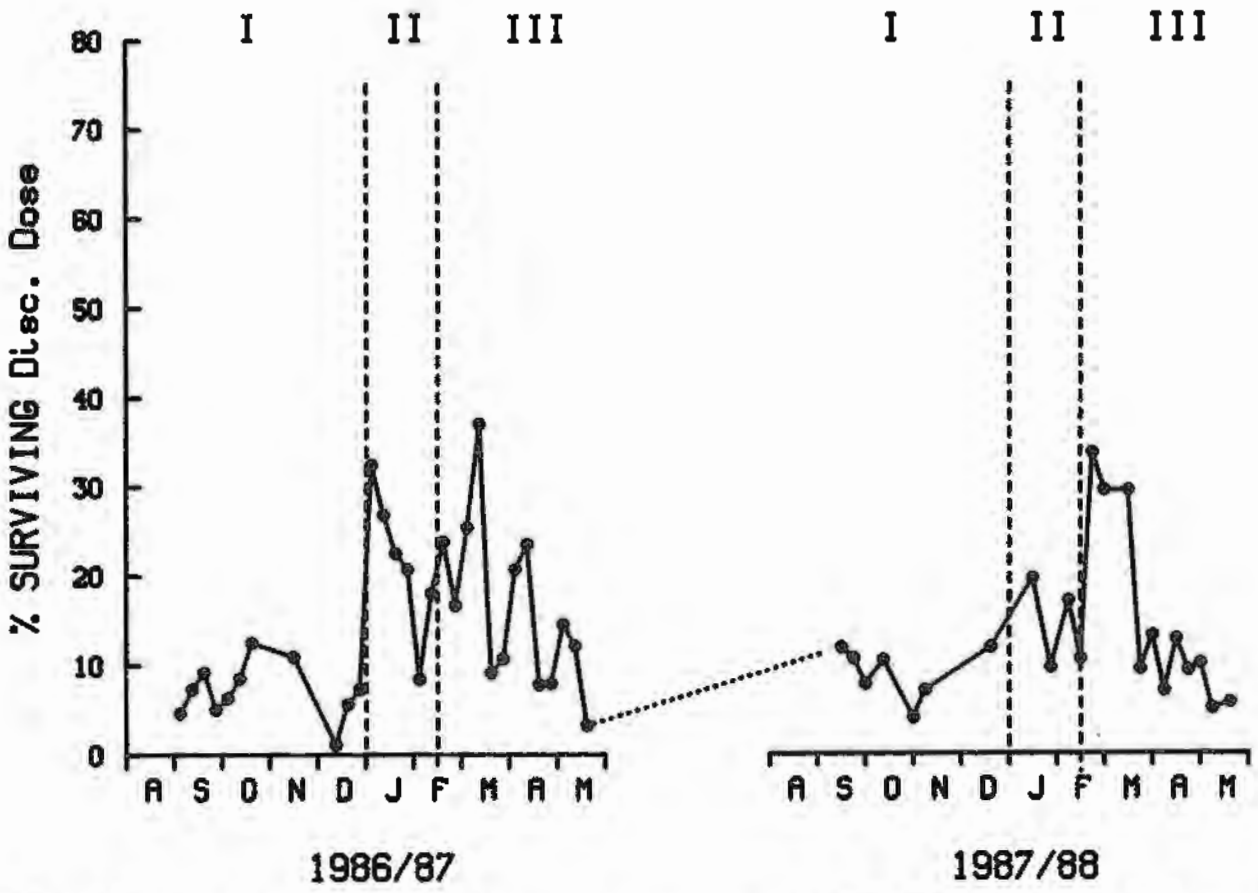
3. Resistant Varieties - While yield and quality will always remain the highest priorities for cotton breeders, I believe some advances will be made in the field of host plant resistance. Even small gains will be useful, particularly those against intractable pests such as mites and whitefly, which can severely disrupt any pest management programme.

4. Genetic engineering - We have only just begun to scratch the surface in this area which I believe has tremendous potential if managed correctly. At present, most of these programmes eg. the incorporation of the *Bacillus thuringiensis* toxin producing gene into cotton, have been driven by technological challenge. We need to have input from field ecologists in these programmes, even right back at the design stage, to ensure we develop a useful and durable product. For example, we should be asking:- How long will it take for Heliothis to develop resistance to *B.t.* if the expression of the gene cannot be easily regulated? What cues can be used to turn the gene on/off? When do we want it expressed? etc. etc.

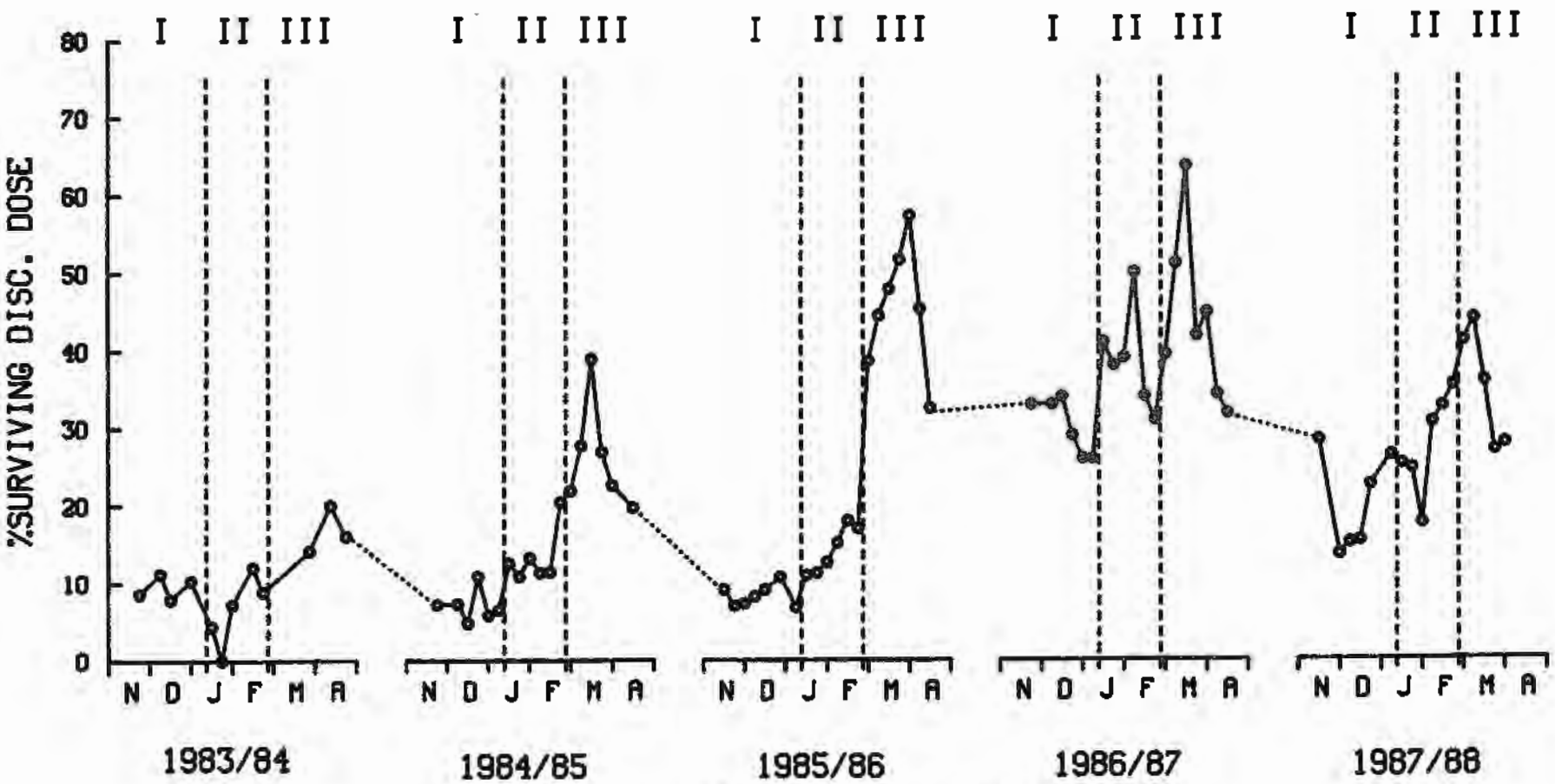
In conclusion, Yes, I do believe we can survive resistance. In the short term, we will rely on the current Strategy to give us breathing space. However this will not be easy. It will require continued close co-operation and compliance, with complacency the biggest threat to continued success. In the long term, I believe the current Strategy will probably ultimately fail. The only question is when? We need to be planning for that time. We need to research synergists and new molecules and the best way to use these. We need to research the pest more, to determine its vulnerabilities and to exploit them. We need to utilise new and old technology to seek cotton varieties with at least some measure of resistance to our major pests. We need to integrate all these new ideas with those that we have reliably used in the past, to achieve a truly sustainable pest management system for cotton.



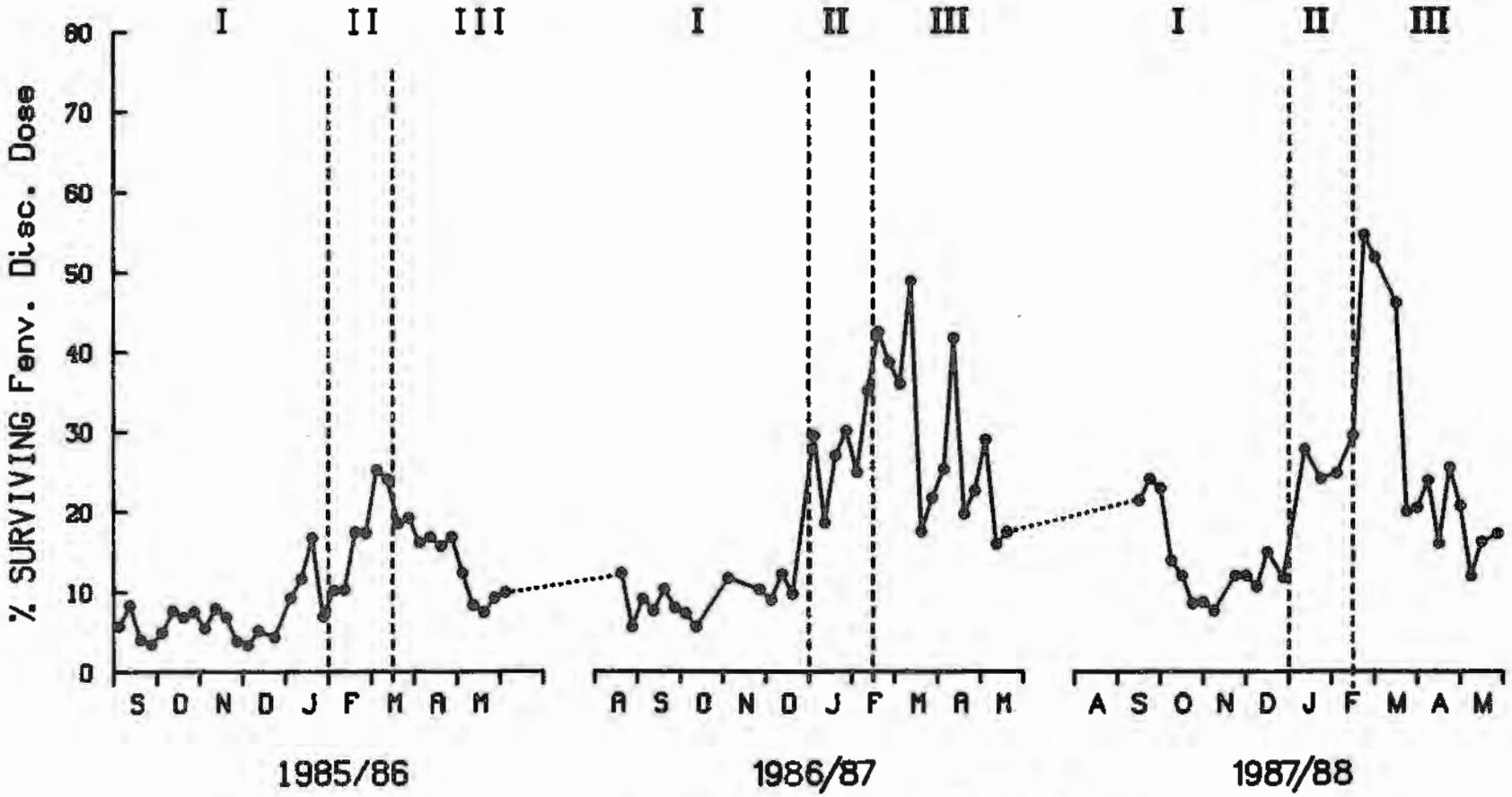
Endosulfan resistance for the past 2 seasons in the NAMOI/GWYDIR area of Northern N.S.W.



Endosulfan resistance for the past 2 seasons at EMERALD, Central Queensland.



Pyrethroid resistance for the 5 seasons since the introduction of the strategy in the NAMOI/GWYDIR area of Northern N.S.W.



Pyrethroid resistance for the past 3 seasons at EMERALD, Central Queensland.