Conference Summary
Crop Protection

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In total eighty five papers were presented in the crop protection sessions of the meeting, covering disease resistance, weed control, nematology, insect control and IPM. Further presentations were made in the allied areas of biotechnology for crop protection and in the transfer of pest management technology.

What follows is a brief position statement on the various components of cotton crop protection as reflected in the various papers in these proceedings.

Diseases

Soil borne diseases remain the major problem in most areas with problems increasing in some areas increasing in some areas, eg. Fusarium wilt in Australia. Verticillium wilt is the major problem in S. and E. African. Although there are effective fumigation and seed treatments available, for cost reasons, overwhelming reliance for control remains on the use of crop rotations. New fungicide seed treatments, described here in the form of 3-way mixtures, raise issues and hopes. Biocontrol with antagonistic micro-organisms continues to shows promise and the mode of operation of these organisms is now on a firmer scientific footing. Insect vectored diseases are a rapidly growing issue. In particular, whitefly as a virus vector is increasing in importance. In Pakistan in 2002 whitefly-vectored *Cotton Leaf Curl Virus* overcame all the established and novel resistant cultivars, including those recently developed by genetic engineering. *Cotton Leaf Crumple Virus* is now a growing problem, while aphid transmitted blue disease remains intractable in South America.

Weeds

In Africa, weeds are more important than insects. Labour problems globally are moving farmers towards minimum tillage and increased herbicide use. On herbicide use, concern was expressed at the over-reliance on glyphosate, even in areas where a monocot post-emergence herbicide would be more appropriate. There is certainly a perceived need for improved integrated weed management, particularly in minimum tillage systems. An interesting possible role was presented for cotton as a trap crop for *Striga* in subsequent maize crops.

Nematodes

Root knot nematode, especially when complexed with microbial disease, is worsening in severity. South African work with nematocides is technically interesting, but cost remains a barrier. Important advances have been made in resistance to reniform nematode in *G. hirsutum* through inter-specific breeding with wild species.

Insect non-chemical control

As shown by the much reduced number of research papers on the subject compared with earlier conferences, pheromones have not lived up to early promise as control agents through mating disruption. Technical success is again reported with pink bollworm slow-release formulations but even Egypt, in which the technique had proved so successful in the 1990s, has moved away from wide-scale use. Entomopathogenic viruses are still performing poorly on cotton, as opposed to other crops, with poor persistency and slow activity remaining the major stumbling blocks to more wide-scale application. Much work continues to be put into trap crops for diverting the attention of ovipositing females of the major pest insect species, but benefits remain limited, especially during the cotton flowering season when cotton competes very efficiently with the other crops proposed. More success has been recorded with the use of companion crops for the development and maintenance of beneficial predators and parasitiods of pest species.

Insect chemical control

Insecticide use declining in cotton. This may in part be due to relatively poor recent cotton prices but various integrated pest management initiatives are coming to fruition now, and the deployment of transgenic Bt cotton in some 20% of the world cotton area is playing a role. There are major and worsening insecticide resistance problems in most areas not deploying Bt transgenics, including in W. Africa now. There are some promising 'new' materials with different modes of action. Neonicotinyls for sucking pest control are receiving universal acclaim, but newer materials are not immune to resistance development. Spinosad, for example, is significantly resisted after only two years of very restrained use on cotton in Australia. Work in Asia is showing that the use of insecticide mixtures selects multiple resistance mechanisms, which develop faster than with the same chemicals applied in rotations. Patterns of resistance and its mechanisms are beginning to be understood across Asia giving us the first opportunity to rationally place new and existing chemistries in pest management packages. The area of spray application technology remains very under-researched. Welcome work on minimum spray application equipment specifications for bollworm control is Asia was presented at the meeting.

Bt cotton

Impressive benefits in insecticide use reduction, bollworm control and farmer profitability, were reported for Bt cotton in USA, China, Australia and South Africa. India, which first commercialized Bt cotton in 2002, has seen only minimal benefit as yet, in part because 2002 was a year of very low pest pressure nationally. Bt cotton is generally over-sprayed with conventional insecticides. Some species which were secondary pests earlier, notably aphids and mirids, are increasing problems in some areas. Poor Bt expression in plant tissues later in the growing season and interference with its biological activity by secondary plant chemical are genuine problems, but insecticide use on top of Bt cotton is excessive in many regions, including China. New IPM programs for Bt cotton need to be developed and dis-

seminated urgently. No field resistance to Bt cotton has yet been demonstrated anywhere, even in China which has no formal refugia requirement. However genes for resistance to BT are present at surprisingly high levels (as much as one insect in a thousand) in India and China. As far as has been determined using laboratory generated resistant populations of *Helicoverpa armigera*, resistance is not inherited recessively. This throws doubt on the usefulness of refuge strategy. The validity of the dual gene or stacked gene concept (essentially mixtures), for delaying the development of resistance, rests on untested assumptions. South Africa has quantified the number and importance of natural plant refugia for bollworms. This is an important step towards developing effective resistance-delaying refugia for small-farmer situations.

Farmer participatory processes

Farmer participatory involvement in the development and support for pest management programs is gaining in importance and acceptance. It is now operating on different scales in many countries, including high-input Australia as well as the six countries of the EU/FAO Asia Cotton IPM Program. The message may perhaps be summed-up as 'facilitating, not teaching'. Evidence of financial and other benefits to participators and their farming communities is strong. There are, however, tensions between the costs of such programs and the scale of operations required. A lower input, Indian government, pesticide rationalization program is also impacting very favorably on crop production economics. Further debate is required on optimal knowledge generation and dissemination processes for large-scale, small-farmer, production systems.

Suggestions for WCRC-4

The World Cotton Conference-4 organising committee may like to consider raising the level of topicality of the meeting by reducing the number of symposia and calling for papers on specific pre-defined key topics. Potential topics from the crop protection area include:

- Pest control in organic cotton
- IPM in Bt cotton
- Effective resistance management strategies in Bt cotton for small-farmers
- Novel in-the-seed solutions for insect, weed and disease control

It is suggested that WCRC-4 could incorporate discussion sessions on pre-circulated papers, covering topics such as:

- Extension delivery models
- Benefits of minimum tillage
- Pest control in organic cotton