THE CSIRO FUSARIUM BREEDING PROGRAM

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Background

Fusarium wilt was identified on the Darling Downs in the early 1990's and the disease has now been found in most cotton growing areas. The extreme levels of plant death and yield decreases from the disease, coupled with the rapid spread, have seen Fusarium emerge as a major threat to the future of the cotton industry in Australia.

Soon after the disease was recognised CSIRO began screening our locally bred lines and numerous introductions from all around the world. Unfortunately we found very little resistance to the disease. The best of our varieties was Sicot 189, but it could not cope with high levels of Fusarium. Some of our varieties such as Siokra 1-4 were extremely susceptible. There was some correspondence with Verticillium wilt resistance (Sicot 189 and Sicala V-2 have some resistance to both) but not in all cases (Siokra V-16 has some Verticillium resistance but is very susceptible to Fusarium). Amongst the introductions tested only MCU-5, a variety from India, showed significantly better survival. Using the results of the screening nurseries a large crossing and selection program was initiated to tackle Fusarium.

Challenges

The greatest problem confronting the Fusarium breeding effort is the lack of strong resistance in any of the lines screened so far. The poor agronomic characteristics of many of the better lines such as MCU-5 are also a major hindrance to breeding progress.

Variability of the disease in the field is a barrier to successful resistance screening as it is very difficult to properly rank lines. Environmental conditions have a very large effect on the expression of Fusarium. For instance if temperatures are not favourable the disease may not develop to sufficient levels to enable screening. Many replications and trials may be needed to properly discriminate between lines when differences are small.

The inability to take seed from Fusarium screening nurseries to other growing areas because of the danger of spreading the disease is a barrier to efficient breeding. If lines are selected in Fusarium nurseries they effectively have to go through a quarantine process to ensure the seed is disease free before they can be trialled in other areas or undergo seed increase.

Another major challenge has been to recover the Fusarium resistance of the various recurrent parents used in the development of transgenic varieties. In some cases the transgenic variety has

not had the resistance level of its parent. This has been the case with Sicot 189RR and Sicala V-2RR. There are probably a number of reasons for this including the susceptibility of the transgenic donor parents and the multiple genes involved in the resistance. If, as we suspect, Fusarium resistance involves a considerable number of minor genes it is very easy to lose some through the backcrossing process.

All of these points emphasise why breeding for Fusarium resistance is going to take extra time compared with simpler characteristics.

Progress

CSIRO has developed a very large Fusarium breeding effort with about one third of our total plots being in Fusarium nurseries. We are using a two pronged strategy involving crossing and single plant selection in Fusarium nurseries on the one hand and selecting plants at Narrabri and screening resultant progeny on the Downs on the other. This latter method enables disease free seed to be maintained while lines are screened.

In recent years the range of commercial CSIRO varieties with some Fusarium resistance has expanded significantly. Recent releases include Sicot 70, Sicot 71, Sicot 80, Sicot 289i and Sicot 289RRi. Thus farmers have a greater range of choice though there are still some gaps in desirable variety types for some areas and of course much higher levels of resistance are required. The apparent success (in data so far) with regaining the Fusarium resistance of Sicot 189 in the transgenic varieties Sicot 289i and Sicot 289RRi is pleasing and reflects the extra time taken with aggressive screening of numerous sister lines in Fusarium nurseries.

Two key gaps in the variety suite are early maturing and okra leaf Fusarium resistant varieties. These deficiencies are close to being corrected with an early maturing normal leaf line (Table 1) and a medium maturity okra leaf line (Table 2) likely to be released in 2003.

Table 1. Three year mean final plant survival % and yield in Fusarium nurseries for the early maturing line 6020 compared with Sicot 189 and Sicala 40.

Variety	Plant survival %	Seed cotton yield (kg/ha)
Line 6020	34	3071
Sicot 189	30	2230
Sicala 40	21	1545

Table 2. Three year mean final plant survival % and yield in Fusarium nurseries for the okra leaf line 2237 compared with Sicot 189 and Siokra V-17.

Variety	Plant survival %	Seed cotton yield (kg/ha)
Line 2237	27	2679
Sicot 189	29	2123
Siokra V-17	21	1618

A little further back in the program are numerous promising lines which have used some of the more exotic sources of resistance such as MCU-5 and exhibit greater plant survival ability. An example of these is line 7060 which has shown some promising results over the last two seasons (Table 3) and is in the CSD seed increase program. As previously mentioned however the use of the non-adapted parents means that the yield potential of lines such as 7060 are slightly down on varieties like Sicot 189 in disease free situations.

Table 3. Two year mean final plant survival % and yield in Fusarium nurseries for the full season, normal leaf line 7060 compared with Sicot 189.

Variety	Plant survival %	Seed cotton yield (kg/ha)
Line 7060	53	3168
Sicot 189	35	2305

In early stages of the screening program we have identified numerous lines with even better survival than line 7060. However they are some years from commercial release and even they are probably not able to cope with the highest Fusarium levels.

Future

To successfully combat Fusarium we desperately need new sources of resistance and there are some promising long-term prospects. We have screened large numbers of introductions over the years and amongst the interesting types are some race cottons and some *Gossypium barbadense* (Pima) lines. These will require extensive breeding to incorporate their resistance genes into productive backgrounds. Even more challenging are native Australian cottons such as *G. sturtianum* which have some promising characteristics but are extremely difficult to breed with because of different chromosome numbers and size. Curt Brubaker of CSIRO in Canberra is carrying out screening and breeding work with *G. sturtianum*.

Genetic engineering offers the possibility of gaining access to new sources of resistance from other species and perhaps enhancing the current resistance mechanisms by making them work at higher levels. For instance there are genes in tomato which have been identified as giving resistance to the Fusarium which attacks tomato. These genes have been isolated and might be incorporated into cotton. While the prospects of a major breakthrough this way may be small it is important that all avenues are pursued.

Conclusions

- CSIRO has a very large Fusarium breeding program with 30% of all plots being in Fusarium nurseries.
- Steady progress is being made with a number of new releases likely soon.

- New sources of resistance are needed and many different avenues are being explored.
- It is important that new better resistant varieties are also satisfactory for yield, fibre quality and other important characteristics.
- It is essential that farmers use an integrated disease management approach and total reliance is not placed on varieties to combat Fusarium.

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