Know-how for Horticulture™

Breeding advanced tomato varieties for Australian and export markets

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HRDC FINAL REPORT

Project Title:

Breeding Advanced Tomato Varieties for Australian and Export Markets.

General Objectives:

The project was undertaken with the following general objectives:-

a) To produce superior tomato varieties having resistance to Fusarium wilt (races 1,2 and 3).

b) To incorporate into the varieties high fruit quality, including fruit firmness and desirable sugar, acid and flavour components.

c) To assess the performance of new varieties under various cultural conditions to allow advice to growers on management procedures.

d) To carry out additional work using embryo culture techniques to access PVY resistance in a wild species and transfer it into conventional varieties.

Materials and Methods:

The diverse objectives of the project were approached in different ways. The production of Fusarium wilt resistant lines (objective (a) above) was pursued by conventional backcrossing, selfing and plant house screening procedures. Development of improved fruit quality was undertaken by selection among field grown genotypes for higher total soluble solids content and fruit firmness (objective b).

Additional work has been undertaken transferring bacterial and verticillium race 2 resistance through plant house and field evaluations of breeding populations.

New breeding lines with Fusarium resistance were evaluated in field trials grown on two different soil types which provided advice to growers on management procedures.

The *rin* gene was introduced to breeding populations using several donor parents. This gene is useful for extending the shelf life of fresh market tomatoes and is particularly appropriate for tomato varieties with export potential.

Results and Discussion:

a) **Fusarium Resistance - single gene resistance.**

Five advanced resistant lines were developed from a cross of a commercial hybrid cultivar by the resistant cultivar Tristar. Although resistant to Fusarium, Tristar has some agronomic defects and the cross to the commercial hybrid was designed to improve agronomic performance.

The inbred lines demonstrated improvements of 5-10% in marketable yield compared with the check cultivar Tristar. There were also significant improvements in fruit shape, size and appearance. One defect common to all lines was an unacceptable colour development during ripening which made them unsuitable for use as inbred lines. Further development of these lines will occur as they are incorporated in F_1 hybrid combinations and field tested. It is expected that these hybrids will overcome the marketing problem.

The practical significance of these new lines is that they will broaden the very limited range of resistant lines on which the industry in Bowen is now based. The resistant cultivars available are the open-pollinated cultivar Tristar or hybrid derivatives of Tristar which have been quickly generated by seed companies. The second cycle inbred lines developed in this project will improve the agronomic performance of F_1 hybrids derived from these lines.

It is anticipated that the performance of F_1 hybrids derived from these lines will be superior to presently available hybrids, despite their post-harvest colour problem. This is because all hybrids will have a non-resistant parent sourced from several programs in the United States which are of excellent quality. The new F_1 hybrids were made in 1991 and will be field tested in 1992.

Fusarium resistance - multigenic resistance

This material is now well developed and is semi-commercial. The resistance was obtained from an accession of *Lycopersicon pimpinellifolium* which gave rise to segregants with outstanding resistance. Subsequent genetic analysis clearly indicated a multigenic inheritance, distinct from the single gene operating in cultivar Tristar. True-breeding backcross 3 F_4 lines have now been developed with good agronomic attributes. Evaluation of these fixed lines in hybrid genotypes will be undertaken in 1992.

The practical significance of this alternative Fusarium program is that there are advanced lines available which may offer durable resistance to future virulent races of the Fusarium pathogen. The theory of host-pathogen interaction suggests that multigenic resistance is likely to offer durable resistance to future races of the pathogen. The history of single gene Fusarium resistances has been one of regular failures. Major genes have been effective for less then ten years on average. There is a high probability that current resistant cultivars will be susceptible to a newly evolved race within a few years, and a replacement cultivar from this material would be of immediate benefit to the industry.

Other Disease Resistance Breeding

1) Bacterial Wilt

Progress was made towards the development of bacterial wilt resistant cultivars adapted to the Bundaberg region. Field work was undertaken at a severely infested site so that breeding progenies could be screened for resistance.

Several hybrids involving resistant parents from AVRDC and the South African cultivar Rhodade were evaluated in the field through three generations with selfing and single

plant selection. Fourteen F_5 lines with good field resistance and acceptable agronomic performance were finally selected.

Glasshouse work to support field evaluation of bacterial wilt resistance began in the latter stages of the project. This was directed towards a suitable seedling screening technique where temperature, inoculum concentration and seedling age were carefully controlled to achieve reproducible symptoms. Initial results established best results for 5 week old seedlings root-dipped at an inoculum concentration of 10^8 colony forming units per ml.

Ultimately, it is hoped that good correlations between planthouse and field performance can be established so that most of the laborious screening work can be restricted to the planthouse. This offers an opportunity to reduce the cost of large field trials and improve the efficiency of the program. Initial observations suggest that this is feasible.

Bacterial wilt resistance is available in a limited number of commercial cultivars. A broader range is desirable, particularly for these areas where multiple disease resistance is necessary. The medium term development problem for the major fresh market industry in Bundaberg is the need for bacterial wilt and Fusarium 3 resistances. No cultivar carries both attributes and this objective was implemented.

2) Verticillium race 2.

Verticillium wilt race 2 continues to be a relatively minor pathogen of tomato in south-east Queensland. Because of its variable expression, and slow disease progress in inoculated seedlings, it has proved intractable in breeding work so far. Various sources of resistance have been incorporated into breeding populations. The most promising breeding lines appear to be derived from North Carolina State University, and these will be intercrossed with other lines from Heinz 22990. The best outcome may be a greater expression of tolerance from several cycles of recurrent selection. The same difficulty in transferring resistance has been experienced in North Carolina, where breeding work has been in progress for at least 12 years.

b) Improved Fruit Quality

The most significant improvement in fruit quality was the identification of very high levels of Total Soluble Solids (TSS) in an Asian cultivar. Although it is unadapted to Queensland cultural conditions and is unsuitable for our markets, it is the most reliable sources of high TSS, producing 6% to 7% Brix. By contrast, most commercial cultivars in Queensland achieve 3.5% to 4.5% Brix. The increase in solids content represents a large improvement as in sweetness and tomato-like flavour.

Inbreeding of the F_1 hybrid cultivar and selection within progenies has produced a series of F_4 lines with TSS content between 6% and 8% approximately. At present, this material is largely indeterminate, small fruited, soft-fruited and carrying a jointed pedicel, making it quite unsuitable for cultivation.

F_3 lines from this cultivar were hybridised with adapted genotypes, and the hybrids are now being evaluated. Some further crossing to adapted types will be necessary to

transfer disease resistances and good agronomic performance. High TSS in these breeding populations appears to be moderately heritable and the prospects for further improvement are good.

Long shelf-life is an important requirement for domestic and export fresh-market tomatoes where there is a delay between harvest and consumer purchase. The *rin* gene (ripening inhibitor) has been introduced into these high TSS lines to enhance consumer satisfaction and export potential. The gene is fully dominant and codes for an enzyme which blocks the normal rate of fruit wall softening which non-*rin* genotypes display. The gene must be present in the heterozygous condition to be useful. Since the distinction between homozygotes and heterozygotes in the field is marked and unequivocal, the joint development of genotypes incorporating *rin* and high TSS should be uncomplicated.

Genetically improved sources of high TSS are preferable to alternative means of increasing fruit quality in fresh market tomatoes. The alternatives proposed include the application of high fertiliser rates and saline irrigation water, both of which operate through osmotic effects within the plant. These can be questioned on the grounds of human health and environmental care. Genetic improvement is necessarily more uncertain, difficult, and long term, but the benefits are substantial. This program seeks to exploit both flavour improvement and post-harvest shelf-life, and the rapid, substantial progress so far achieved indicates very good prospects for a successful cultivar in the medium term.

c) Assessment of new varieties under different cultural conditions.

Approximately twenty true-breeding Fusarium resistant breeding lines were evaluated on two different soil types in the Bowen district. The purpose was to provide some experience with the growth and development of the lines under commercial conditions.

On black soil, it was found that fertiliser was best applied entirely pre-planting, whereas on lighter alluvial soil, some application of nitrogen to the crop was beneficial during fruit filling. Because ground crops in Bowen are not harvested repeatedly at short intervals, a strategic timing of harvests into a rather more concentrated period is necessary. Typically fruit is harvested three or four times. It was found that the new lines should be first harvested at a slightly later time than conventional varieties; this maximised marketable yield, although some mature fruit on the first hand was sacrificed. The experience of grower demonstration trials was instructive for further development of the lines into F_1 hybrid cultivars.

d) Potato virus Y resistance

The objective of transferring Potato Virus Y (PVY) resistance, as stated in the funding submission was not achieved. This work was seen as additional to the major goals in (a) to (c) above. Initial attempts to access PVY resistance in accessions of *L. peruvianum* and some accessions of *L. hirsutum* failed to produce viable embryos which could be developed by laboratory culture techniques. Repeated attempts using a range of wild genotypes were not successful and the work was subsequently abandoned.

Recommendations from Research, further development work:

It is anticipated that a cultivar release will be possible from this research program.
The cultivar will be an F_1 hybrid, resistant to Fusarium 3, with superior agronomic and post-harvest performance.

The fresh market tomato industry now appears to favour F_1 hybrid cultivars over open-pollinated types. This preference has been expressed, despite the higher cost of F_1 hybrid seed. F_1 hybrids are perceived as higher yielding, more robust under adverse conditions, and the cost of seed is only a minor proportion of total crop production costs.

In view of this emphasis by industry, it is clearly desirable to release F_1 hybrids from this research. The benefits from revenues from seed sales are much greater than with open-pollinated cultivars, and the hybrid can be protected by its owner.

Some careful assessment of F_1 hybrids produced from this research still needs to be made, however this work is close to completion and some decisions about marketing arrangements need to be made. Further, the supporting bodies (Queensland Department of Primary Industries, Queensland Fruit and Vegetable Growers, HRDC) need to discuss arrangements for the distribution of revenues from seed sales.