Paper 39

N.Z. Agronomy Society
Special Publication No. 5

BREEDING APPLE SCAB RESISTANT DESSERT APPLES FOR QUEENSLAND

L.B. Baxter and J.B. Heaton
Department of Primary Industries,
Granite Belt Horticultural Research Station,
Applethorpe, Queensland,
Australia

ABSTRACT

Breeding a range of high quality dessert apple varieties with scab resistance has commenced at the Granite Belt Horticultural Research Station. Initially, single gene resistance from high quality American varieties from the Purdue-Rutgers-Illinois and New York State Experiment Station Breeding programmes is being utilised in combination with high quality commercial varieties (Granny Smith, Delicious, and Lady Williams) and breeding selections from an early red apple breeding programme. Progeny seedlings are screened for resistance to apple scab both in the glasshouse and field. Field screening is carried out using a special disease nursery and natural field infection to ensure adequate exposure to scab ascospores. To date, 1300 seedlings have been field planted and 530 show a high level of glasshouse resistance to scab.

KEYWORDS

Single gene resistance, *Venturia inaequalis*, Delicious, Granny Smith.

INTRODUCTION

The Granite Belt region of Queensland is a warm temperate area which, although considered marginal for apple growing, produces the earliest apples in Australia. Apple production in this region is based mainly on the two varieties Delicious (and its red strains) and Granny Smith, which each account for 40% of total production.

Granny Smith, in particular, and Delicious are both susceptible to the disease apple scab (*Venturia inaequalis*) (Heaton, 1974). Control of this disease currently relies upon expensive chemical measures. Effective control of apple scab has become complicated by resistance to some recommended fungicides. Since 1979, resistance to the benzimidazole fungicides benomyl, carbendazim, and thiophanate methyl have been reported on the Granite Belt (Penrose, *et al.*, 1981; Colbran, 1981).

The increasing costs of chemical control, the appearance of pesticide resistance, and the unavailability of suitable disease resistant varieties from a similar climate prompted an apple scab resistance breeding programme at the Granite Belt Horticultural Research Station in spring 1984. The aim of this programme is to produce a range of scab-resistant high quality dessert apple varieties specifically adapted to Queensland conditions. While scope exists for new early and late red cultivars, emphasis is being placed on the production of scab-resistant red Delicious and scab-resistant Granny Smith types. These two varieties are now firmly entrenched in the Australian apple market and new disease resistant varieties must be very similar if they are to become replacements (Tomlin, 1985).

MATERIALS AND METHODS

Breeding

Initially, single gene resistance (V_f gene) from high quality American varieties from the Purdue-Rutgers-Illinois and New York State Experiment Station breeding programmes is being used. Varieties such as CO-OP 13, CO-OP 18, and Prima are being crossed with high quality commercial varieties (Granny Smith, Delicious, and Lady Williams) and breeding selections from the Granite Belt Early Red Apple Breeding Programme using standard cross pollination techniques. Eventually polygenic resistance of Antonovka origin will be incorporated into advanced lines. Planned major crosses in the initial programme are shown in Figure 1.

Germplasm is obtained as pollen, seed, and scion material. Australia is currently free from fireblight (*Erwinia amylovora*) and where pollen is used as a source of the V_f gene special precautions are necessary because of strict Australian quarantine requirements and the danger of fireblight infection from overseas. All introduced pollen is first tested for freedom from *E. amylovora*. Crossing using this pollen is carried out in isolation in a high humidity quarantine glasshouse 275 km from the Granite Belt. Progeny seedlings subsequently produced are screened for freedom from fireblight before scab resistance screening at Applethorpe. Under this system the number of seedlings produced is severely restricted. Where scion material is introduced a five-year quarantine period for fireblight and virus indexing is necessary, and so further crosses must be anticipated well in advance.

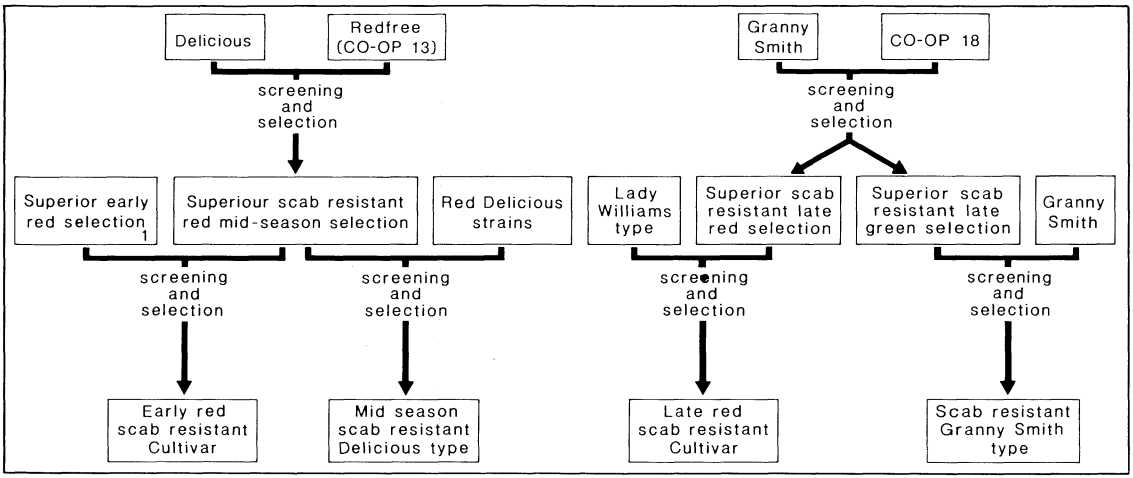

Figure 1. Planned major crosses in the initial breeding programme on high quality dessert apples for scab resistance. [1] Early Red Parents from the Granite Belt Early Red Apple Breeding Programme (1945-1985).

Seed containing the V_f gene is the easiest means of importing desirable germplasm and requires only surface sterilisation before stratification.

Seed from all crosses is germinated in May and June and maintained in a glasshouse for about five months. After scab-resistance screening, progeny seedlings are planted in the field with alternate rows of infected seedlings and Granny Smith trees. Scions from the major crosses are grafted onto precocious M9 and M27 rootstocks and treated with Alar and Ethrel to reduce the time to flowering.

Scab-resistance screening

Scab-resistance screening on progeny seedlings is carried out in two stages.

Glasshouse screening

Glasshouse screening is carried out using a modification of the Purdue-Rutgers-Illinois system (Shay and Hough, 1952; Williams, 1976; Hough, pers. comm.). Apple seedlings at the 4-6 true leaf stage are spray inoculated with conidial suspensions of $2.5 \times 10^5 - 2.5 \times 10^6$ spores/ml made from a mixture of cultures grown from six Queensland apple scab isolates. These cultures originate from isolates grown on water agar and later transferred to wick cultures in 4% malt agar.

Seedlings are sprayed with inoculum and held at 20°C with high humidity for two to three days. Inoculated plants are subsequently transferred to conditions of constant leaf wetness where they remain for 10 to 14 days. After this time assessment for reaction to scab is carried out using a 0 to 4 scale: rating 1 (pitting — no sporulation), 2 (necrotic or chlorotic lesions — no sporulation), 3 (necrotic lesions with restricted sporulation) are considered resistant and are retained; rating 4 (extensive lesions with abundant sporulation) is considered susceptible and seedlings are discarded. Seedlings rated 0 (no macrosporic infection) are reinoculated.

Field screening

One to two weeks before field planting, potted resistant seedlings are placed in rows in a special scab nursery where heavily infected scab leaf litter has accumulated around mature trees. These plants are then subjected to at least one release of ascospores. If it does not rain for one or two days during this stage artificial release of primary inoculum is triggered by overhead irrigation and seedling leaves are kept wet for at least 12 hours. In the field, alternate rows of susceptible and infected seedlings are included in the planting and trays of infected leaves are placed throughout the progeny. Individual plants are assessed several times each season for evidence of field infection to scab.

CURRENT PROGRESS

The isolation, culture, and screening techniques employed so far have been successful and seedlings have exhibited the complete range of infection classes. A ratio of 60 to 40 resistant to susceptible seedlings has been consistent throughout screening.

To date 1300 seedlings have been field planted with 530 showing a high level of resistance (ratings 0, 1, and 2) to apple scab in the glasshouse. These plants will be grown on and assessed for field resistance to scab and a range of fruiting characteristics. A further 4000 seeds from introductions andd crossing carried out at the Granite Belt Horticultural Research Station will be available for germination and screening and May and June, 1986.

REFERENCES

Colbran, R.C. 1979. Report on overseas study tour (Queensland D.P.I., Indooroopilly).

Heaton, J.B. 1974. Apple scab control *Queensland Agricultural Journal, August, 1974:* 361-364

Penrose, L.J., Heaton, J.B., Washington, W.S. 1981. Diseases of deciduous fruits and vines — final report of working party — recommendations for research (SCA Plant Pathology Committee Fifth Meeting, April, 1985).

Shay, J.R., Hough, L.F. 1952. Evaluation of apple scab resistance in selections of Malus. *American Journal Botany 39:* 288-297.

Tomlin, E.R. 1985. *In:* Proceedings of Stanthorpe Apple Seminar. S. Tancred (ed). Queensland Department Primary Industry, Brisbane. 142-155.

Williams, E.B. 1976. *In:* Proceedings Apple and Pear Scab Workshop. A.L. Jones, and J.E. Gilpatrick (eds). Kansas City, Missouri pp. 16-17.

SYMPOSIUM DISCUSSION

Dr H.C. Smith, Consultant, N.Z.

Did you do any economic evaluation of the likely success of this programme before you went into it? It sounds a very expensive programme, and to my knowledge there is no breeding programme for resistance that has yet released very successful, commercially desirable varieties. Would it not be better to aim for a reasonable level of partial resistance.

Baxter

No, we did not do a commercial evaluation as such — a cost benefit analysis. The problem with a lot of American varieties has been that while some reasonable material comes out of the programme, they have to compete with existing varieties. We are looking to producing material very similar to Delicious or Granny Smith. The industry does not want another variety — they want a Delicious or Granny Smith type.

As regards polygenic resistance, with scale you only need one lesion on fruit, and one of those fruit in a box, and that's the end of the box. So for polygenic resistance you can probably use only 20% of your population to look at. Whereas with the single gene resistance we look at 50%. It's very long term, true, but it took us 20 years to breed an earlier apple.

Smith

I doubt you realise the economic value of a limited degree of resistance. Growers in Hawkes Bay in New Zealand spend a considerable amount to try to control scab in Gala, which is a very susceptible variety. It may not need a very marked level of tolerance to cut down the cost of the spray programme by half.

Baxter

Delicious already appears to have some polygenic resistance anyway and only under the worst conditions does the resistance fully break down. The second point is that with the amount of backcrossing we will have to do to get close to the varieties, polygenic resistance as opposed to single gene resistance, is an extra complication. We realise the dangers of the approach we have taken with the V_f gene — in some places in the world it has been overcome by scab. But weighing up all the factors involved we still believe that initially it is the best approach. We intend to put other genes in as we go along, if possible.

Dr R.D. Burdon, Forest Research Institute

You mentioned the introduction of the V_f gene, which is thought to be a single gene. Could you explain the occurrence of a range of infection classes in the light of the introduction of a supposedly single gene?

Baxter

There seem to be a few reasons for it. Firstly, scab has a number of races and some work has used single conidial isolates, and so has just worked with one race. With one race on one *Malus* species, you can get one symptom class, with the second race on the same species there is a different symptom class. We are dealing with a range of *Malus* material, and we hope there is a range of races in our isolates. We hope that within the mixture of isolates there is more than one class. Hopefully all the races we have in Queensland are represented, although we would be naive to expect that they were. We are also using different *Malus* material, so there is a complicated interaction involved.

Dr M.D. Wilcox, Forest Research Institute

How well correlated are the resistance of the juvenile leaves and the fruit resistance?

Baxter

There seems to be good agreement between seedling resistance in the glasshouse on the leaves, and resistance in the field. Even the rating of 3 in the glasshouse, which is limited sporulation, seems to maintain resistance in the field.

Dr F.H. Alston, East Malling Research Station

Isn't it a bit misleading to leave the concept that resistance conferred by the V_f gene means you're dealing with immunity. From the large amount of work that has been done with this gene, it would seem very much more likely that the V_f gene alone would probably confer only partial resistance and in fact what you're seeing in your grading system is an effect of the V_f gene plus modifiers — the lower scores (Os and 1s) are probably representative of plants which are a combination of the V_f gene, a basic gene for scab resistance, but modified.

Baxter

Yes, I agree. I do not think the work is as cut and dried as it appears to be in the literature.

Mr H.K. Hall

How do you define Delicious and Granny Smith types?

Baxter

On the basis of shape and internal characteristics —

for Delicious sweet, juicy and crunchy; and an improvement in colour to a cherry red colour.

Mr L. Decourtye, INRA

From your geographic situation I would have expected chilling requirement to be important.

Baxter

We get 1000-1200 hours below 7 °C and we believe that is not really low chilling, because most of the temperate varieties that we grow will fruit and produce, and not show any of the classical symptoms of low chilling. So we do not select for low chilling. We believe that our important problem is the temperature after fruit set — the reaction of the fruit to high temperatures during development and fruit maturity. For example, Delicious in Queensland does not store very well. We think that is an effect of the high temperature during fruit development. We also have colour problems and our fruit are much later than the traditional Delicious from Europe.

Dr M.J. Carson, Forest Research Institute

I am interested in your indirect selection approach — mass selection. In other words you are selecting individual seedlings in the glasshouse before planting them out in the field to verify resistance. Is there a possibility of getting cross information out of indirect selection? Could you check whether your single gene is present from the ratios of resistant to susceptible seedlings?

Baxter

There are a few complications. One of them is that one of the parents we are using is Delicious, which seems to have some polygenic control; the feeling now with the V_f gene is that there are modifiers attached to it. Really, some further study is needed.

Carson

What about the possibility of improving the cross itself rather than selecting individuals? Could you remake the most promising cross and then do your backcrossing for further selection?

Baxter

I guess we could. The problem with the initial cross is that we are doing that cross in the glasshouse, and the number of seedlings we can produce is limited to a couple of hundred. We hope to make up the numbers in the backcross.

Mr T.P. Palmer, private breeder, N.Z.

With your back-crossing programme you are really breeding for the past instead of the future. By the time you get a resistant Granny Smith out Granny Smith will no longer be in demand, and similarly for Delicious.