THE AUSTRALIAN SYSTEM FOR RANKING VARIETY RESISTANCE TO FUSARIUM WILT

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Abstract

Australian cotton growers requested a quantitative system to rank commercial varieties for their resistance to Fusarium wilt. The use of vague terms such as 'some', 'fair' or 'good' resistance was not considered to be satisfactory. A ranking system was developed that compares the resistance of a variety to the resistance of a standard variety based on plant survival in field experiments that are conducted according to an established protocol. The standard variety is given a F.rank of '100'. Varieties that are more susceptible than the standard have an F.rank < 100 with an F.rank of '0' indicating completely susceptible. Varieties that are more resistant than the standard have an F.rank > 100 with an F.rank of '200' indicating complete immunity. The number of field experiments where the resistance of a variety has been compared to that of the standard is included in brackets after the average F.rank.

When resistance ranking was instigated in Australia all commercial varieties were more susceptible than the standard. Over the last nine years the situation has been completely reversed with almost all current varieties more resistant than the standard. The most resistant cotton variety grown in Australia is Sicot F-1B which has an F.rank of 154(19). The cotton variety that is most widely grown in Australia is Sicot 71 BRF which has an F.rank of 118(8).

Introduction

Through the Australian Cotton Cooperative Research Center, a committee of cotton pathologists and industry representatives developed protocols for describing cotton variety resistance to *Fusarium oxysporum* f.sp. *vasinfectum* (Fusarium wilt) and *Verticillium dahliae* (Verticillium wilt). The purpose of this system was to provide cotton growers and other industry members with a quantitative measure of the relative wilt resistance or susceptibility of new or existing cotton varieties. Recommended modifications arising from reviews in 2004, 2006 and 2008 have been incorporated into this current version of the protocol.

Fusarium Resistance Ranking for cotton varieties – 'F.rank'

1.1 A standard for describing cotton variety resistance to *Fusarium* wilt

- Sicot 189 is nominated as the standard variety for Fusarium wilt resistance ranking to Australian strains of the Fusarium wilt pathogen.
- The resistance of all other varieties will be expressed relative to the resistance of the standard, which is given the value of 100
- All varieties will be ranked on a scale limited to between '0' and '200'
- Varieties more resistant than the standard will be ranked between '100' and '200'
- An F.rank of '200' indicates completely resistant or immune (all plants survive unaffected)
- The F.rank for varieties that are more susceptible than the standard will be between '0' and '100'
- An F.rank of '0' indicates completely susceptible (all plants affected substantially)
- The number of comparisons (field experiments/variety trials) must be indicated in brackets after the resistance ranking value.

1.2 Criteria for applying the *Fusarium* Resistance Ranking protocol

Field trials must:

- be registered with the Cotton Research and Development Corporation;
- have confirmed the strain of *Fov* present at the site by submitting samples for testing;
- be laid out in a statistically valid design eg. appropriate number of replicated plots or repeated check design;
- have plots of no less than 10 meters in length;
- be planted to achieve a commercially acceptable stand;
- include the standard for *Fov* resistance ie. Sicot 189;
- have a 'Proportion of Plants Rating '0' or '1' (ie. survival) of no more than 70% in the standard variety;

- be sprayed with insecticides as required to minimize differences in fruit load between conventional and transgenic varieties.

1.3 Assessments and calculations to determine the 'F.rank'
The following values are determined for each variety:

A. Initial Plant Stand
This is the total number of seedlings in the row or plot (a minimum of 10m) assessed as soon as possible after emergence (and no later than 3 weeks).

B. Number of Plants Rating '0' or '1' at Harvest
This value describes the number of plants in a plot that have a Vascular Browning Index rating of '0' or '1' (see below) when the stems of plants are cut at or near ground level immediately following harvest.

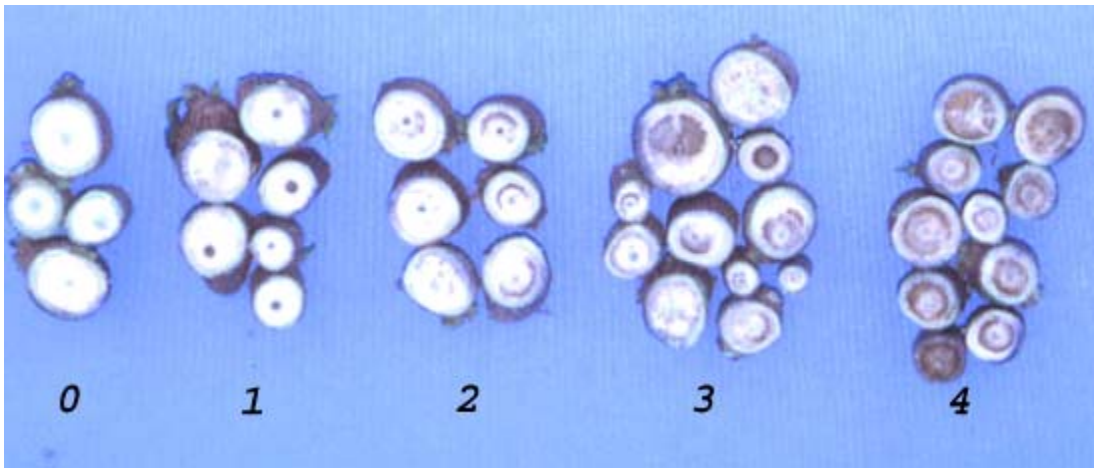

Figure 1. The Vascular Browning Index used to assess disease incidence, or plant survival, when plants are cut at ground level immediately following harvest. Plants assessed as either a "0" or a "1" at maturity are counted as 'survivors'.

C. Survival (Proportion of Plants Rating '0' or '1')
The survival is the number of plants rating '0' or '1' at harvest as a percentage of the initial plant stand. This value is calculated by dividing the value of B by the value of A and converting to a percentage.

D. 'F.rank'
The calculation of the F.rank differs depending on whether the survival in the test variety (T) is lower or higher than the survival in the standard variety (S).
The calculation is easily done in MS Excel using an 'IF' statement:

=IF(T<S, 100*T/S,100+((T-S)/(100-S)*100))

This statement says that if survival in the test variety (T) is lower than survival in the standard variety (S) use the equation 100*T/S, but if T is higher than S, use the equation 100+((T-S)/(100-S)*100).

1.4 Extension of Results
The F.ranks for current commercial varieties are updated annually and presented to growers in graph (Figure 2) and Table format and circulated either in print form or via the Internet (www.csd.net.au). If the ranking is accessed via the Internet it is possible to view a summary of all trials contributing to the F.rank of each variety(Table 1).

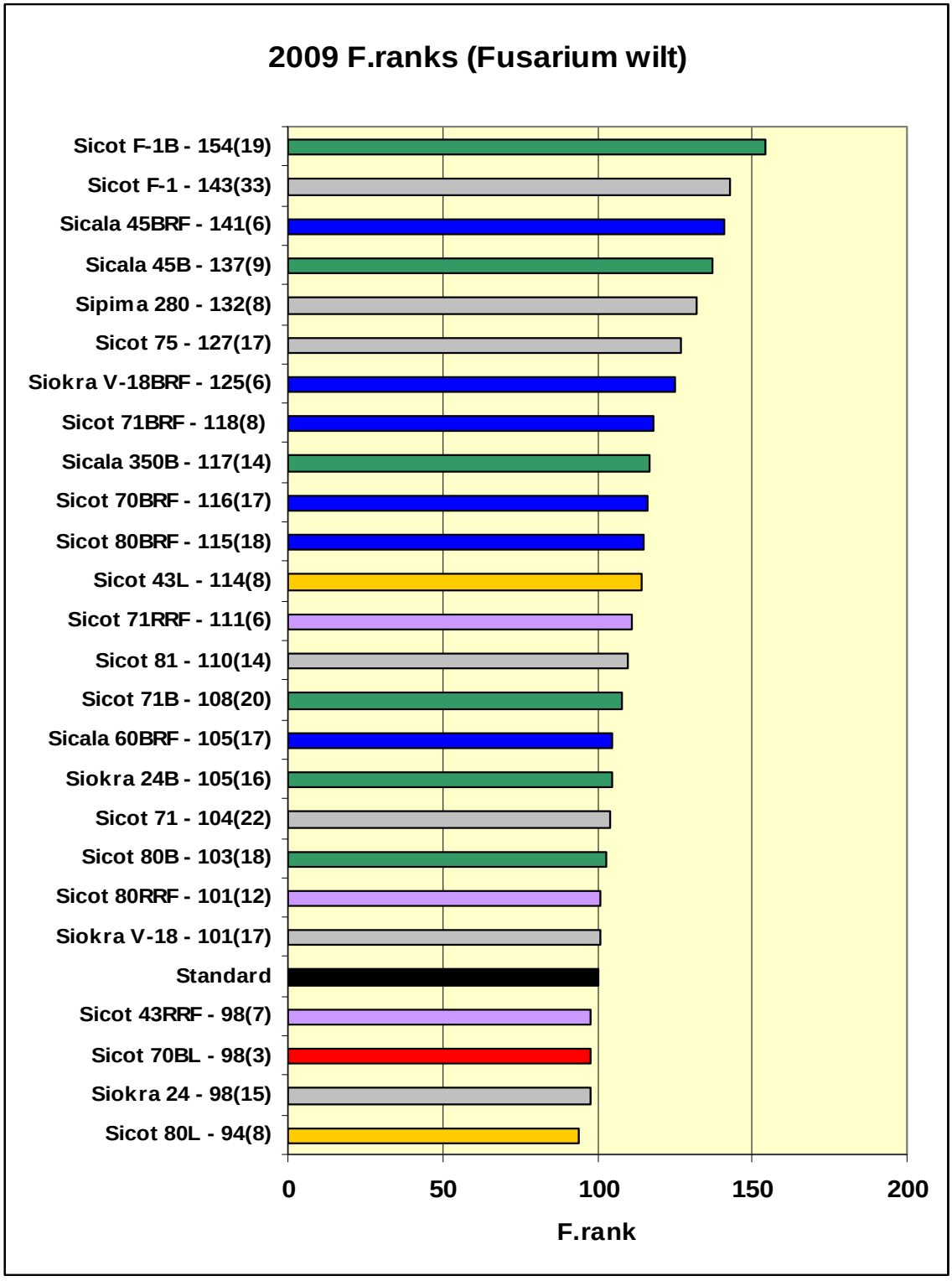

Figure 2. Established F.ranks for commercial cotton varieties available in Australia. The colour of each bar coincides with the color of the seed (eg. varieties with the Bollgard II Roundup Ready Flex technology are sold to growers with a blue seed color.) By visiting the CSD website and double clicking on the F.rank for a variety it is possible to view a summary of all field experiments contributing to that F.rank (see Table 1).

Table 1. A summary of the 33 field experiments where the resistance of the variety Sicot F-1 to *F. oxysporum* f.sp. *vasinfectum*, was compared to the resistance of the standard variety Sicot 189. Field experiments highlighted in yellow were performed by independent state government research staff. The standard error provides an indication of the variability of the results.

Sicot F-1 **F.rank = 143(33)**

Season	Location	Trial type/Rego No.	VCG	Survival in Std (%)	Survival in Test (%)	**Frank**
00/01	Norwin	CSIRO small plot	11	10.3	34.9	**127**
01/02	Norwin	CSIRO small plot	11	36.6	65.1	**145**
02/03	Pampas	CSD small plot	11	49.0	67.1	**136**
02/03	Pampas	CSD box trial	11	33.5	66.7	**150**
02/03	Pampas	CSIRO small plot	11	42.0	71.0	**150**
02/03	Brookstead	CSD box trial	11	33.6	74.9	**162**
02/03	Norwin	QDPI small plot	11	24.1	33.0	**112**
02/03	Pampas	CSIRO small plot	11	39.0	72.2	**154**
02/03	Norwin	CSIRO small plot	11	19.0	49.6	**138**
02/03	Brookstead	CSD small plot	11	37.1	67.5	**148**
02/03	Boggabilla	CSD box trial	11	23.6	76.9	**170**
03/04	Norwin	CSD strip trial	11	31.5	77.5	**167**
03/04	Melrose	CSD strip trial	11	56.2	61.8	**113**
03/04	Pampas	CSD small plot	11	18.9	57.6	**148**
03/04	Brookstead	CSD small plot	11	66.1	80.6	**143**
04/05	Pampas	CSIRO small plot-Q506	11	27.9	57.5	**141**
04/05	Brookstead	CSD small plot - Q504	11	10.5	23.8	**115**
04/05	Pampas	CSD small plot - Q503	11	27.4	55.6	**139**
05/06	Pampas	CSIRO small plot-Q063	11	7.8	49.2	**145**
05/06	Pampas	CSIRO small plot-Q063	11	10.7	48.7	**143**
05/06	Norwin	CSIRO small plot-Q064	11	8.4	44.4	**139**
05/06	Pampas	CSD small plot - Q062	11	16.8	70.2	**164**
06/07	Pampas	CSD small plot - Q0701	11	67.15	86.6	**159**
06/07	Norwin	QDPI&Fsmall plot	11	29.77	47.79	**126**
06/07	Pampas	CSIRO small plot - Q0705	11	64.8	81.0	**146**
06/07	Norwin	CSIRO small plot - Q0704	11	43.4	60.0	**129**
06/07	Brookstead	CSD small plot - Q0702	11	46.97	68.9	**141**
07/08	Pampas	CSD small plot - Q0801	11	9.8	66.6	**163**
07/08	Brookstead	CSD small plot - Q0804	11	26.5	63.4	**150**
07/08	Norwin	CSD small plot - Q0802	11	1.8	43.8	**143**
08/09	Brookstead	CSD small plot - Q0901	11	40.1	65.4	**142**
08/09	Norwin	QPI small plot	11	11.1	54.3	**149**
08/09	Pampas	CSD small plot - Q0902	11	36.5	48.5	**119**
	QPI planted, stem cut and counted				mean	**143**
					s.e.	**15**

Discussion

The use of a system for ranking variety resistance to Fusarium wilt has been practiced in Australia for the last nine years. Australian cotton growers, with Fusarium wilt present on their farm, consider the 'F.rank' to be an important factor when selecting a variety to plant in the coming season. Quantifying the level of resistance in a variety also enables emphasis of the importance of applying other disease management strategies. The use of a resistant variety is just one component of an Integrated Disease Management strategy for Fusarium wilt that may also include delayed sowing, crop rotation, crop residue management, seed treatments and irrigation practices.

Selection of a standard variety was critical to the development of the ranking system. The standard variety provides a 'ruler' against which all other varieties are measured. The standard variety needed to be widely adapted and commonly grown. 'Sicot 189' was chosen as the Australian standard because it met these criteria and displayed the highest level of resistance available in a commercial variety at that time. Though 'Sicot 189' was frequently devastated by Fusarium wilt, there were many other commercial varieties that appeared to be much more susceptible.

Sicot 189 is a conventional variety. In recent years it has become increasingly difficult to identify trial sites that allow conventional varieties to be grown. Most growers prefer to grow transgenic cotton varieties. A transgenic standard variety, with a level of resistance equivalent to that of Sicot 189 (confirmed by numerous comparisons, at several sites and over several seasons) can be substituted as required.

The implementation of a ranking system has also illustrated the progress made by plant breeders screening and selecting for improved host resistance to Fusarium wilt. Initially all commercial varieties were more susceptible than the standard variety, Sicot 189. Now, almost all commercial varieties are more resistant than Sicot 189. The most resistant cotton variety grown in Australia is Sicot F-1B which has an F.rank of 154(19). The cotton variety that is most widely grown in Australia is Sicot 71 BRF which has an F.rank of 118(8).

Acknowledgments

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