Western Australian *Botrytis* fungicide resistance study

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Botrytis cinerea (grey mould) has a broad host range, impacting over 1400 plant species worldwide. It is prone to fungicide resistance because of its genetic diversity and ability to produce high volumes of spores over its short life cycle. Its prevalence and ongoing control in major fruit and vegetable crops increase its susceptibility to fungicide resistance.

In 2021 and 2022, researchers at the Curtin University Centre for Crop and Disease Management in Western Australia characterised fungicide resistance in *Botrytis* isolated from berries collected from Perth retailers and strawberry runners sourced from Victoria and Queensland.

A total of 307 *Botrytis* isolates were extracted from the samples collected. Among these isolates, forty-five (45) different phenotypes were identified, a reflection of the high genetic diversity of the pathogen.

Botrytis isolates were tested for resistance to the fungicides listed in Table 1.

Phenotype: In genetics, a phenotype is an organism's set of observable characteristics or traits. The term covers the organism's morphology (physical form and structure), developmental processes, biochemical and physiological properties, behaviour, and the products of behaviour. An organism's phenotype results from two basic factors: the expression of its genetic code (its genotype) and the influence of environmental factors.

Table 1. *Botrytis* isolates were tested for resistance to these fungicides

Active	Fungicide group	Crops Registered/Permitted
Carbendazim	Group 1	Not registered in berries – previously permitted/registered in Strawberries and Rubus
Iprodione	Group 2	Raspberries, Blueberries, Strawberries
Tebuconazole	Group 3	Strawberries
Boscalid	Group 7	Raspberries, Blackberries, Blueberries
Pyrimethanil	Group 9	Raspberries, Blackberries, Blueberries, Strawberries
Azoxystrobin	Group 11	Raspberries, Blackberries, Blueberries
Fludioxonil	Group 12	Raspberries, Blackberries, Blueberries, Strawberries
Fenhexamid	Group 17	Raspberries, Blackberries, Blueberries, Strawberries

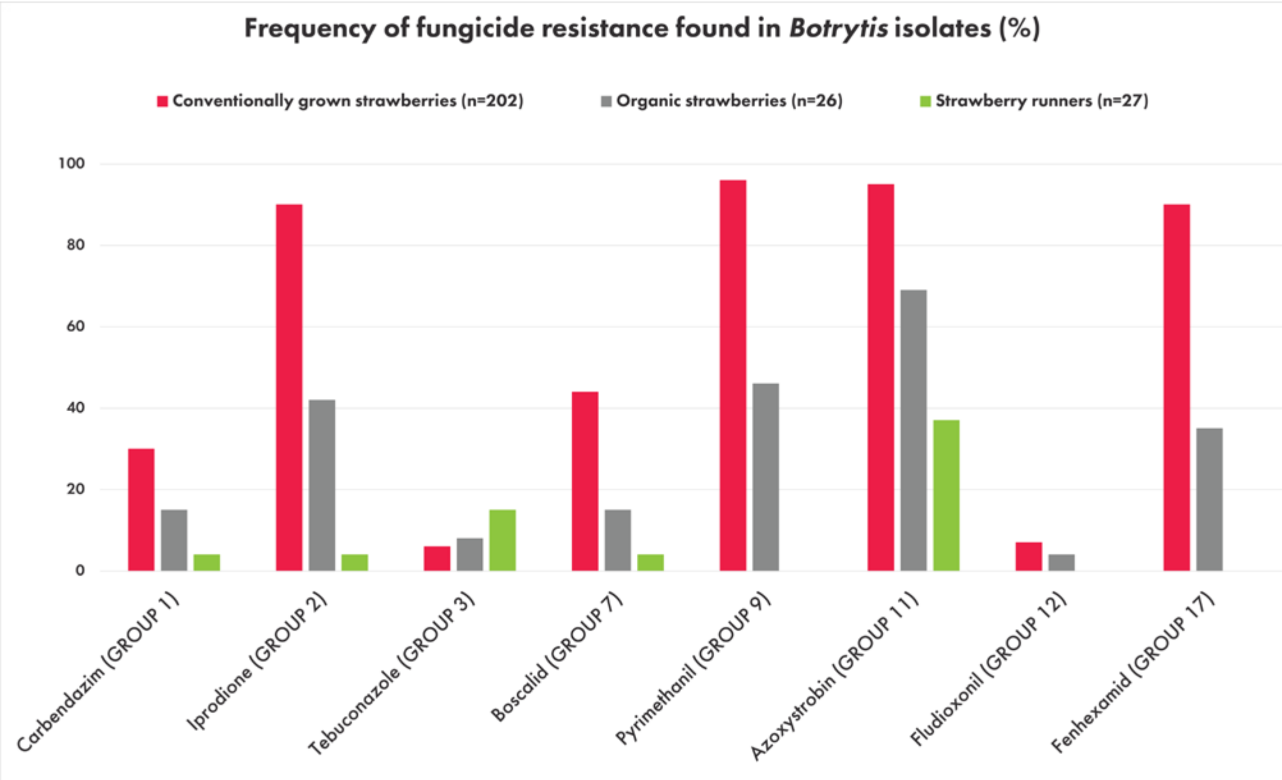
Isolates found to have resistance to the active tested are expected to have resistance to other actives in the same Group.

Table 2 shows the number of *Botrytis* isolates collected across the berry categories and runners during the two-year study. The frequency of fungicide resistance found in isolates in each berry category is also shown. A frequency of 100% means that resistance to at least one of the fungicides tested was found in all (100%) isolates.

Over 200 samples of *Botrytis* on conventionally grown strawberries were collected as part of this study, so data from this category is more reliable. Fewer samples were collected in the other categories, so this article focuses on results from the strawberry component of the trial.

Table 2. Fungicide resistance frequency for *Botrytis* isolates characterised in this study for each host sampled

	Blueberry		Strawberry		Blackberry	Raspberry	Runners
	Conventional	Organic	Conventional	Organic			
Number of isolates tested	18	14	202	26	9	11	27
Resistance frequency in isolates (%)	75%	10%	93%	75%	100%	100%	40%



Conventionally grown strawberries had very high levels of resistance to pyrimethanil (Group 9), azoxystrobin (Group 11), iprodione (Group 2), and fenhexamid (Group 17); and high levels of resistance to boscalid (Group 7) and carbendazim (Group 1). Resistance to tebuconazole (Group 3) and fludioxonil (Group 12) was low. Ninety-nine percent (99%) of the resistant isolates tested had resistance to more than one fungicide; 88% were resistant to 5 to 7 of the fungicides tested.

Organic strawberries had high to moderate levels of resistance to azoxystrobin, pyrimethanil, iprodione, and fenhexamid; and moderate to low resistance to carbendazim, boscalid, fludioxonil and tebuconazole. Seventy percent (70%) of the resistant isolates tested had resistance to more than one fungicide; Sixty-six percent (66%) were resistant to 2 to 6 of the fungicides tested.

Strawberry runners had high to moderate levels of resistance to azoxystrobin and tebuconazole; and low levels of resistance to boscalid, carbendazim, and iprodione. No resistance was recorded for pyrimethanil, fludioxonil, and fenhexamid. Thirty-eight percent (38%) of the resistant isolates tested had resistance to more than one fungicide.

In this research, fludioxonil (Group 12) resistance was low, as reported in other studies. Fitness costs associated with fludioxonil resistance may contribute to the low frequencies of resistance to this fungicide. Highly resistant isolates found in this study had very poor sporulation, which would likely limit their ability to proliferate in the field when competing with normal highly sporulating fludioxonil-sensitive or less resistant isolates.

Resistant frequencies observed for boscalid (Group 7) fall within the range of other studies. It is unclear if fitness costs associated with resistance could suppress Group 7 resistance frequencies.

Resistance frequencies were very high for iprodione (Group 2), pyrimethanil (Group 9), azoxystrobin (Group 11), and fenhexamid (Group 17). High selection pressures appear to have overcome potential fitness costs associated with resistance to these fungicides.

Resistant isolates found on organic fruit or in crops where the chemical or Group is not registered can be the result of:

- wind dispersal of resistant isolates from other *botrytis*-susceptible crops (e.g. grapes and vegetable crops)
- physical transfer of resistant spores during harvest or post-harvest operations (poor hygiene)
- persistence of resistant isolates from past conventional management practices or to chemistries previously registered/permitted
- resistance caused by other (potentially registered) chemicals in the same Group

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