Combining ability of resistance to Fusarium crown rot of bread wheat

Herde DJ [1], McNamara RB [1], Wildermuth GB [2]

[1] Queensland Department of Primary Industries & Fisheries, Leslie Research Centre, Toowoomba, 4350, QLD. [2] Retired from Queensland Department of Primary Industries & Fisheries, Leslie Research Centre, Toowoomba, 4350, QLD.

ABSTRACT

Crown rot is a major soilborne disease problem in the wheat and barley industries of many countries, including Australia. Genetic resistance is a vital tool for combating crown rot. Breeding for crown rot resistance has proven difficult in the past, so the combining ability of nine bread wheat parent lines of varying crown rot resistance was determined.

Three half-diallel glasshouse experiments were conducted (2003, 2004, 2005). All experiments found highly significant general combining ability (GCA), as well as highly significant specific combining ability (SCA). Narrow sense heritability estimates were: 2003 – 0.58; 2004 – 0.71; 2005 – 0.59, however the significant specific combining ability makes this figure less valuable.

Across the three experiments, IRN497 and CPI133814 (when present) were the parents with the best GCA for improving resistance. The SCA results were variable between experiments. The three experiments were re-analysed using only the seven parents available in all years. The mean rank across all experiments showed that five of the six better F1 crosses had IRN497 as a parent.

The significance of GCA effects, and the different patterns of SCA effects suggests that there are many different genes or gene complexes present in these parental lines for crown rot resistance. There is potential for targeting specific high performing crosses, rather than crossing potentially high performing parents and overlooking the optimal gains available.

INTRODUCTION

Crown rot, caused predominantly by *Fusarium pseudograminearum* (teleomorph *Gibberella coronicola*), is a major soilborne disease problem in the wheat and barley industries. The disease is widespread and causes losses in yield and quality in Queensland, New South Wales, Victoria, and South Australia. Brennan and Murray (1998) estimated that the disease was causing losses of up to $56M p.a. in bread wheat throughout Australia. In Queensland, losses have been estimated at up to 50% in some areas and losses of 20 to 30% occur regularly, while the disease can inflict yield loss of up to 89% (Klein *et al*. 1991).

MATERIALS AND METHODS

A diallel quantitative genetics experiment was conducted in the glasshouse over three years (2003, 2004, 2005). The diallel enables a combining ability analysis to be conducted. We used a nine parent half-diallel (so 36 F1 hybrids tested) with a number of different resistance sources.

A combining ability analysis was conducted on the F1 hybrids, following Griffing's (1956) method 4, fixed effects model. In this design no distinction is made between the direction of the crosses, meaning that reciprocal effects cannot be tested for.

Of the bread wheat genotypes studied, two of these (Puseas and Kennedy) are susceptible; the remaining seven (2-49, CPI133814, IRN497, Lang, QT10162, Sunco, and W21MMT70) have a level of partial resistance. The parent 2-49 is considered one of the best sources of resistance to crown rot currently available (Wildermuth *et al*. 2001).

One of the three experiments (2004) had germination problems with 2-49 and CPI133814 progeny, so these crosses were removed from analysis.

The seedlings were phenotyped for crown rot resistance in a glasshouse test, following a modification of the Wildermuth and McNamara (1994) method, as described below. This method closely mimics field infection, and is highly correlated with field results.

In summary of this method, this seedling phenotyping is a three week duration experiment where seeds are planted in steam-sterilised soil below a banded layer of inoculum (consisting of a mixture of five *F. pseudograminearum* isolates grown on colonised wheat and barley grain, and milled through a 2 mm sieve). Through control of moisture, the seedlings grow for a week without fungal activation, then the remaining two weeks with the actively growing fungus. After three weeks the seedlings are washed free of soil and the percentage of lesioning on the first three leaf sheaths visually assessed.

The standard glasshouse procedures have evolved since the 1994 paper, with modifications in the ratio of soil in the three pot layers, and a changed weight of inoculum per pot. The category rating system has been replaced by the actual percentage of lesioning for this genetics work, however the original system is still used for routine screening.

RESULTS

All experiments found highly significant general combining ability (indicating that a parent generally passes on its performance to its progeny). All experiments also found highly significant specific combining ability (indicating that many F1 hybrid combinations performed in an unexpected manner). An overall narrow sense heritability estimate is available for each experiment (2003 – 0.58; 2004 – 0.71; 2005 – 0.59), however the significant specific combining ability makes this figure less valuable, because you cannot rely solely on the parental phenotype to indicate the progeny performance.

Across the three experiments, IRN497 and CPI133814 (when present) were the parents with the best GCA for improving resistance. The SCA results were variable between experiments. The three experiments were re-analysed using only the seven parents available in all years. The mean rank across all experiments showed that five of the six better F1 crosses had IRN497 as a parent.

DISCUSSION

The higher narrow sense heritability estimate in 2004 is potentially due to the absence of 2-49 and CPI133814 progeny, and shows the reduced heritability associated with these highly resistant parent lines.

The parent 2-49 is in itself highly resistant, yet it was not the line able to produce the most resistant progeny, which partly explains the difficulty of breeding for crown rot resistance with 2-49. Instead, IRN497 and CPI133814 were the parents with the best GCA for improving resistance.

The results of these experiments indicate the potential of targeting specific high performing crosses, rather than crossing potentially high performing parents and missing the optimal gains available.

Further work is underway, based on the results of this experimentation.

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