

Studies on barley yellow dwarf virus (BYDV) in wheat

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Abstract

BYDV has been one of the major production issues in wheat in high rainfall areas of the southern region including Tasmania, Victoria, and Western Australia. Yellow dwarf virus (YDV) are caused by a range of related luteoviruses but in wheat BYDV-PAV vectored mainly by the oat aphid (*R. padi*), has been considered the most damaging species worldwide including Australia. Sources of tolerance are thought to be available amongst existing wheat cultivars, but this has not been experimentally validated, nor has the yield advantage been quantified. In our recently GRDC funded project, we will establish one or two sites where infection can be consistent; test current varieties adapted to high rainfall wheat production zones and breeding lines supplied by breeders for BYDV resistance/tolerance; test the impact of the current source of resistance gene *Bdv2* derived from intermediate wheatgrass (*Thinopyrum intermedium*) on yield and grain quality; and provide breeders with useful BYDV tolerance or resistance in a minimum of four grower preferred varieties adapted to high rainfall zones (HRZ). This project will also screen more germplasm for alternative YDV resistance genes. Preliminary yield trials showed a significant reduction in yield due to virus infection. Screening trials in both Australia and China identified a few resistant germplasm. If new genes are found, molecular markers linked to the gene will be identified for use in breeding programs.

Key words

BYDV resistance, wheat, germplasm

Introduction

BYDV are the most widespread and damaging viruses of cereals. They infect wheat, barley, oats and grasses and are transmitted by several aphid species. The effect of the disease on yield depends on viral species or strain, time of infection and rate of spread. Yield reductions of 10% may occur even without visible symptoms of infection. Most severe losses are from early infections and can be as high as 80% (Edwards et al, 2001; McKirdy et al, 2002). The most effective approach to overcome the problem is to breed varieties with tolerance/resistance. To effectively breed varieties for BYDV tolerance/resistance, useful sources of resistance must be identified and accurate phenotyping is crucial.

The transmission of plant viruses can depend on a range of abiotic and biotic factors affecting the virus, the insect vector and the plant host. The role of these factors varies across space and time, leading to regional variation in disease incidence and impact on crops. Thus, reliable screening conditions are important to ensure accurate results. The difficulties in maintaining bioassay infrastructure, rearing aphids, and controlling virus types have meant that the CSIRO wheat breeding program is the only one to have bred and released YDV partial resistance (dual purpose winter wheats Mackellar and Manning). This is closely associated with the development of the *Bdv2* source of partial resistance. The development of testing sites in this project will assist breeders to incorporate resistance into new breeding lines.

Several YDV species reportedly infect wheat in Australia. In general, BYDV-PAV is dominant. However, mixed infections of BYDV-PAV with other YDV species are common. In oats and barley, YDVs include CYDV-RPV, BYDV-RMV, and three or more subgroup 1 YDVs (genus *Luteovirus*) related serologically to BYDV-MAV and BYDV-PAV. There are two main aphid species that colonise wheat in Australia: the oat aphid (*Rhopalosiphum padi*) and the rose-grain aphid (*Metopolophium dirhodum*) (Milne and Delves, 1999; Thackray et al., 2005). Both are reported to be efficient vectors of BYDV-PAV, but their relative importance in YDV epidemiology in wheat is uncertain.

Source of tolerance is another major issue for breeders. The only available resistance gene in wheat is Bdv2 from intermediate wheatgrass, *Thinopyrum intermedium* (Banks et al., 1995). This gene does not provide immunity and can be overcome by high inoculation pressure and early infection. Alternative tolerance or resistance genes are needed.

Recently a new project was set up to: 1) evaluate the effect of BYDV on yield and quality of wheat; 2) set up a reliable greenhouse and field based phenotyping method for the screening of YDV resistance/tolerance; 3) add the known tolerance gene to four to six grower preferred varieties; 4) screen for new tolerance genes from a large collection of wheat germplasm; and 5) map the new tolerance genes.

Materials and Methods

Development of phenotyping method

Vector efficiency for a Tasmanian isolate of BYDV-PAV was tested in an aphid culture room in Launceston. *R. padi* and *M. dirhodum*, being the two most commonly encountered species on barley in Tasmania, were reared under controlled conditions in the culture room, given access to infected barley leaves for 48 h and then transferred to healthy barley plants at the 3-leaf stage for 48 h (one aphid per plant). Plants were then sprayed with insecticide to remove the aphids and allowed to grow for 4 weeks before being tested for BYDV infection by ELISA test.

Field trials

Thirty two wheat varieties and/or breeding lines (including two barley controls and one oat control) were sown in 2014-15 growing season at Cressy Research Station in Tasmania, Manjimup Horticultural Research Station in Western Australia, and UNE, Armidale NSW, with two treatments: high BYDV (natural BYDV spread (no insecticides used)) and low BYDV (using seed dressing) for WA; high BYDV (BYDV viruliferous aphid spreading) and low BYDV (imidacloprid application on seed and 2 aphicides in-crop) for NSW; and high BYDV (natural BYDV spread with no insecticides used) and low BYDV (continuous spraying for aphids) for TAS. Spreader rows of YDV susceptible oat cv. Eurabbie sown at 100 kg/ha between each replicate block was used to assist uniform inoculum across trial sites. BYDV symptoms and plot yields were assessed.

Screening trials in China

More than 250 Chinese wheat core collections were screened for BYDV tolerance in both Yangzhou University and Chinese Academy of Science where a screening facility has been established. Among these collections, 150 were winter type and 100 were spring type. In Chinese Academy of Science, all the accessions were sown in hill plots with 4 replications. Various reared aphids (*Schizaphis graminum*, *Rhopalosiphum padi*, *Sitobion avenae*) carrying BYDV-PAV were used to inoculate the plants. In Yangzhou University, each collection was sown in a hill plot with two replications. BYDV virus infected aphids were inoculated to individual plants. BYDV tolerance was scored according to visual symptoms.

Screening trials in Tasmania

Over 100 germplasm lines sourced from the Cereal Collection Centre of Australia were screened in single rows in the field, and in tanks with controlled water supply at Mt Pleasant Lab, in the 2014-15 growing season. Natural BYDV spread occurred, and no insecticides were applied. BYDV tolerance was scored according to visual symptoms.

Results and Discussion

R. padi is more effective in transmitting the virus

60% of plants exposed to *R. padi* became infected with BYDV, while only 2% of plants exposed to *M. dirhodum* became infected. 12% and 6% of plants showed borderline results for *R. padi* and *M. dirhodum* respectively. This experiment will be replicated to confirm results and *R. maidis* will be reared and added to future trials.

BYDV caused significant yield reduction of wheat varieties

Good infections of the virus were observed in the non-sprayed plots of sensitive varieties. Figure 1 shows the average scores and yield loss due to the virus infection from the trial in Cressy Research Station of Tasmania.

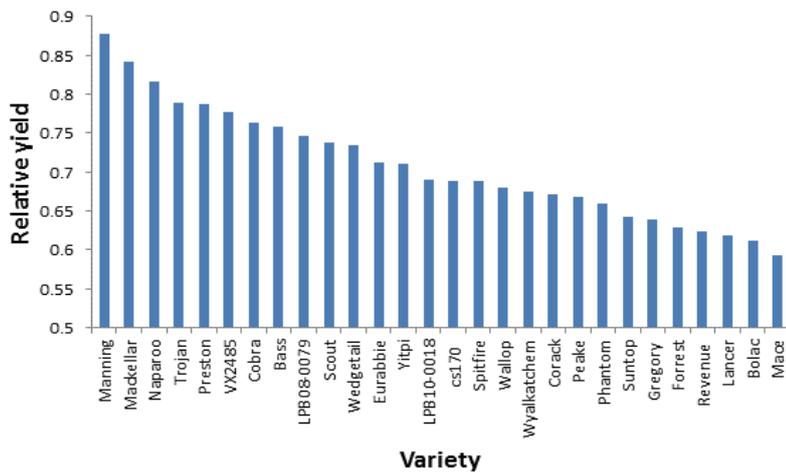


Figure 1: Relative yields of selected wheat varieties/breeding lines under BYDV disease stress. Results are from the field trial in Cressy Research Station of Tasmania.

Most of the varieties showed severe symptoms of virus infection with only Manning and Mackellar showing good resistance to BYDV. The yield data also showed a consistent result with the symptom scores. However, some varieties, i.e. Gregory and Forrest, showed less symptoms but had greater yield loss (>36%). The yield loss due to virus infection ranged from 41 to 12% with the two tolerant varieties, showing only 12% and 15%, respectively.

Conditions were unusually dry during trial growth in the NSW trial, with half average rainfall during the growing season. Consequently, aphids were virtually absent due to the lack of green vegetation and little natural infection occurred, thus the effect of BYDV on yield was not scored.

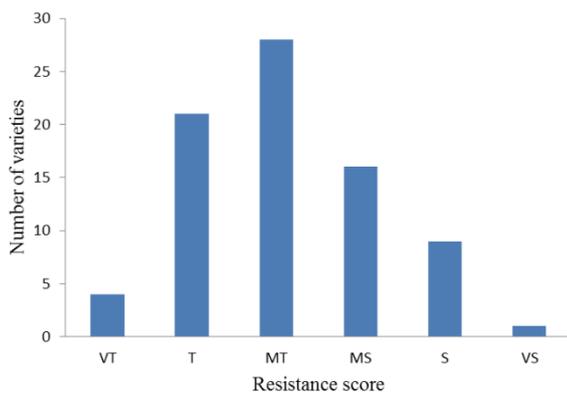


Figure 2 Distribution of BYDV resistance of 100 germplasm lines from Cereal Collection Centre of Australia, based on symptom resistance

In WA trial, virus spread was extensive throughout the entire trial with little difference in symptoms between the ‘high’ and ‘low’ virus blocks. Seed dressing only provided protection for 4-6 weeks. Of the lines tested only Mackellar rated as moderately resistant, all other lines tested ranged from very susceptible to moderately susceptible with symptoms of leaf streaking being the most predominant. From ELISA testing, BYDV-PAV was the predominant virus present, with CYDV being detected occasionally. Yields were not included in this paper since little difference was observed between the ‘high’ and ‘low (control)’ virus blocks.

YDV resistance/tolerance of germplasm from Cereal Collection Centre of Australia and China Preliminary results from screening in single rows and in tanks showed some resistance in some lines, based on symptom tolerance (Figure 2). Further testing of bread wheat and durum wheat will be conducted this year in combination with Chinese introductions.

Based on the symptom, the first year’s results showed that most of the germplasm was very susceptible to BYDV with only a few of them showing tolerance (Figure 3). One of the landrace has shown much

better tolerance than known tolerant varieties (Zhong 4, Zhong 5) which possess the tolerance gene from intermediate wheatgrass. Further mapping study will be conducted by crossing this germplasm with sensitive varieties and the variety (Mackellar) with Bdv2 from intermediate wheatgrass.

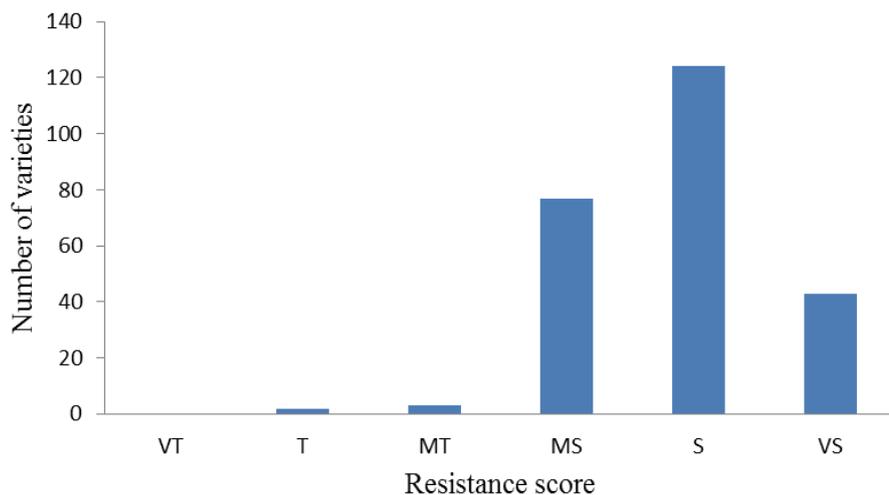


Figure 3: Distribution of BYDV resistance of 250 Chinese core collections

Conclusions

In conclusion, BYDV showed significant effect on wheat grain yield, causing up to 40% yield reduction in susceptible varieties. A new source of tolerance has been identified from Chinese wheat core collection, which can be used in breeding program.

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