ACTA AGROBOTANICA
Vol. 58, z. 1 2005
s. 17 22

# Barley yellow dwarf disease as a target of breeding for resistance (short review)

**KATARZYNA GOLNIK**

Department of Plant Pathology, Warsaw Agricultural University,
Nowoursynowska 159, 02 776 Warszawa, Poland

(Received: 15.03.2005)

Summary

The aim of this work was to give a brief review of some points of wide knowledge of barley yellow dwarf (BYD) disease and its breeding for resistance program.*Yd2* gene has been shortly characterised. Current situation in Poland has been underlined.

Key words: Barley yellow dwarf virus (BYDV), Yd2 gene, resistance

## INTRODUCTION

Barley yellow dwarf disease is a serious treat to the cultivation of small grains. It was firstly recognized as being caused by a virus in 1951 by Oswald and Houston. Until recently *Barley yellow dwarf virus* (BYDV) was divided into two subgrups. Comparison of nucleotide sequences has led to definition of a new species named *Cereal yellow dwarf virus* (CYDV-RPV) from former serotype BYDV-RPV (D'Arcy et al., 2000). New virus was placed in genus *Polerovirus*. Serotypes PAV and MAV were defined as species of BYDV in genus *Luteovirus.* However, it is now known that genus *Luteovirus* shares many features with family *Tombusviridae* and there are some doubts about classification of that virus (Miller et al., 2002). Rest of the serotypes remain unassigned in the family *Luteoviridae.*

BYDV has isometric icosahedral (T=3) virions 25nm in diameter, single molecule of 5.6-5.8 kb positive sense ssRNA with six open reading frames (ORFs). Proteins are: RNA dependent RNA polymerase (RdRp) (ORF 1 and 2), protein for infection phloem tissue (ORF4), coat protein (ORF3) combined with readthrough domain (ORF5) responsible for aphid transmission. Viruses are not transmitted mechanically, but by many species of cereal aphids. Serotypes were firstly defined basing on dominant vector species eg. PAV usually transmitted by *Rhopalosiphum padi*, MAV usually transmitted by *Macrosiphum avenae*. (Brunt et al., 1996).

Main directions of research are virus replication and vector transmission.

## Economic importance

BYD is spread worldwide and is an economically most important viral disease of cereals. It affects barley, oat, wheat, maize, rice and many weeds. It causes substantial losses throughout the world e.g. in wheat (17%), barley (15%), and oats (25%) (Lister and Ranieri, 1995). Between 1988 and 1991 in European Russia the yields decreased by 90% because of viral epidemic which was supposed to be BYD (Mozhaeva and Kastalyeva, 2002). In England some special steps are taken every year to prevent losses (Knight et al., 1996) . In Poland monitoring was performed by Jeżewska and co-workers. In 1995 serotype PAV or mixed infections with MAV were common. Wheat and oat were affected most seriously. In 1999 MAV and PAV were detected in equal proportions, mixed infections prevailed. Prophylactical sprays were not recommended because of small number of infections observed in autumn (Jeżewska, 2001a). In 2001 an increase of infections was noted, especially in south-east Poland (Jeżewska, 2001b). In 2002 high degree of infections was noted in western Poland, on winter wheat and barley (Jeżewska, 2002).

*Yd2* gene

Shortly after first identification of BYD, in1959, Rasmusson and Schaller discovered in Ethiopia the first resistance gene named *Yd2*. It become soon, the most widely used gene in barley breeding for virus resistance. Unfortunately, the effect of this gene is satisfying only when plants are infected with PAV and MAV isolates. For RPV (now CYDV) such resistance was not detected (Herrera and Plumb, 1991).

*Yd2* gene is located on chromosome 3, on the long arm, 0.5 cM from the centromere and cosegregates with RFLP loci Xwg889 and XYlp (Collins et al., 1996). The Ylp gene was characterized by Ford and co-workers (1998). It was shown that it encodes for subunit of barley vacuolar proton-translocating ATPase. Basing on cDNA comparison, a single-base-pair polymorphism was found to be correlated with difference between BYDV susceptible and unsusceptible plants. An assay for resistance detection was proposed in the same work (Ford et al., 1998). In series of further investigations, the Ylp marker was found to be very useful, because it correlates perfectly with field resistance tests (Ovesna et al., 2000). Second marker, used in this tests, named YLM was found less related to *Yd2* gene, and it was less valuable for winter barley cultivars. For spring barley breeding program it was used with success (Ovesna et al., 1999). This phenomenon confirmed results of mapping experiments, where Ylp marker was placed closer to *Yd2* than YLM marker (Ford at al., 1998; Paltridge et al., 1998). Further approaches toward cloning and characterisation of *Yd2* gene are taken. One of the reasons for that studies is the interesting resistance mechanism of that gene. It appears to reduce the rate of replication of the virus in the phloem and on this basis it could be accounted to a new group of resistance genes (King et al., 2002).

*Yd2* is a semi-dominat gene. Its effect can be changed by genetic background (Makkouk and Ghulam, 1992). Unfortunately it is associated with excessive plant height, limited yield and poor seed quality (Comeau and Jedlinski, 1990).

It is big disadvantage for breeding programs, but many resistant lines and cultivars were generated. A lot of them are effects of CIMMYT (The International Maize and Wheat Improvement Center) and ICARDA (International Center for Agricultural Research in the Dry Areas) programs.

Some steps were taken to transfer Yd2 gene to wheat, but no success has been achieved up to now (Plumb, 2002).

## Other natural resistance genes

Many other genetic sources of resistance are considered. Some of them are mentioned below.

In barley other genes than *Yd2* usually give only moderate resistance. For example, in field tests in Czech Republic resistance in winter cultivars 'Pery and 'Sigra' was found on the level of 5 in 9 steps scale (0 = no disease symptoms). When *Yd2* cultivars were mostly found on the level of 3 (Ovesna et al., 2000). In Thailand some minor resistance gene in barley were mapped on chromosomes 1 (7H), 4(4H), and 5 (1H) without significant interactions (Toojinda et al., 2000).

In wheat genotype no resistance, but only some tolerance, was observed. Wheatgrass (*Thinopyrum intermedium*, sometimes other Latin names are used) was lately found to be a good source of resistance for wheat. Broad research programs has been developed including mapping projects. Main genes of resistance have been named *Bdv1* and *Bdv2* .Unfortunately, cultivar 'Frontana' with the gene *Bdv1* did not show even moderate resistance in field test in Czech Republic. Some Brazilian cultivars with *Rht* (reduced height) gene were promising (Vacke et al., 1996 a).

Although there was no broad genetic research program for BYDV resistance in oat, many cultivars characterised as resistant were generated and are available now. Mapping experiments were developed on University of Wisconsin (Zhu et al., 2003). Many combinations of resistance genes are available (Barbosa et al., 2000). *Avena sterilis* and its offspring lines are good source of resistance and are used from 70's (Frey, 1994).

The resistance to aphids can be also valuable for BYD control.

## Genetic modifications

Genetic modifications are a powerful tool in breeding for resistance. The pathogen derived resistance is mainly used in case of viruses, also in case of BYDV. Here are some examples of this type of research: oat transformed with the RNA-polymerase (Koev et al., 1998), oat and barley transformed with coat protein sequences (McGrath et al., 1997), wheat transformed with replicase, coat-protein, movement protein and a non-coding sequences (Dupre et al., 2002).

Barley was transformed with transgene designed to produce hairpin (hp) RNA containing BYDV-PAV sequences and extreme resistance was confirmed (Wang et al., 2000). This method could be used for other cereals.

European and Polish law forbids any practical use of these achievements.

## Conclusions

Although, barley yellow dwarf disease is not a serious economic problem in Poland, the increase of infections observed in 2001 can be significant. In England, the spread of disease was stimulated by tendency to earlier sowing. The degree of losses was highly correlated with time of inoculation, especially with winter cereals . One of the reasons, that caused earlier sowing, was the expansion of production of oilseed rape (Knight et al., 1996).

Polish cultivars have not been tested for resistance and there has been no breeding program for tolerance to BYDV (Jeżewska, 2001b). Results from Czech Republic can be taken into consideration. At the Research Institute for Crop Protection most of the registered barley cultivars from Central Europe were found susceptible or high susceptible (Ovesna et al., 2000). Resistance has not been found in tested varieties of spring wheat from Czech group (Vacke et al., 1996 a). 64 Czech oat varieties have been tested and only 2 new lines have shown high resistance on the average of control cultivar 'Ogle' (Vacke et al., 1996 b).

The conclusion is, that problem of breeding for resistance to *Barley yellow dwarf virus* has not been solved yet. More concern should be taken when cereal cultivars will be estimated and registered to prevent possibility of increase of importance of this disease.

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## Streszczenie

Celem tej pracy było zapoznanie czytelnika z pewnymi punktami rozległej wiedzy na temat choroby żółtej karłowatości jęczmienia. Najpopularniejszy gen odporności, *Yd2,* został krótko opisany. Największy nacisk został położony na obecny stan rozpoznania tej choroby w Polsce.