Effects of Barley Yellow Dwarf Virus on Yield and Yield Components in Different Winter Wheat Genotypes

Ionuț RACZ^{1,2*}, Rozalia KADAR², Laura ȘOPTERIAN², Adina VARADY^{1,2}, Diana HIRIȘCĂU^{1,2}, Loredana SUCIU^{1,2}

¹University of Agricultural Science and Veterinary Medicine of Cluj-Napoca, Calea Mănăștur 3-5, 400372 Cluj-Napoca, Romania

²Agricultural Research and Development Station, Agriculturii Street 27, Turda, Romania

*corresponding author: ionut.racz@usamvcluj.ro

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Abstract

Barley Yellow Dwarf Virus is a *Luteovirus* disease that affects small grain yields. The climatic conditions of the agricultural year favoured the development of vectors, so that the virus attack caused significant damage on different genotypes. The first visible symptom includes plant stunting and yellowing and purpling, so that plant height was the first traits affected reducing with 24.58 to 44.33 % compared to the unaffected plants. Regarding the main yield components their performance or reduced with 37.89 % to 74.35 % for weight of spike, 33.66 to 87.70% for number of grains per spike and from 50.90 to 88.03 % in case of weight of grains per spike. Grain yield as a complex and most important feature that characterizes a genotype was affected between 49.05 to 87.76 % which suggest that the infection can have a different intensity depending on certain morpho-physiological traits.

Keywords: grain yield, yellow dwarf, winter wheat

INTRODUCTION

Yellow dwarf is considered the most economically devastating virus disease of small grains worldwide (Wegulo and Hein, 2013) causing between 11% and 33% yield loss in wheat fields and sometimes up to 80% (Walls III *et al.*, 2019). The disease Barley Yellow Dwarf Virus (BYDV) was first recognized by Oswald and Houston (1951) as a viral pathogen transmissible by aphids. The viruses that cause BYD infect over 150 species of cultivated, lawn, weed, pasture and range grasses. Some infected hosts display no obvious symptoms. However, in many hosts the most common symptom is stunting due to reduced internode length (D'Arcy and Domier, 2000). The viruses that cause BYD are transmitted from plant to plant by at least 25 different species of cicades and aphids as:

Psammotettix alienus, *Macrostelus laevis*, *Javesella pellucida*, *Rhopalosiphum padi*, *Rhopalosiphum maidis*, *Sitobion avenae* and *Schizaphis graminum* (Ingwell *et al.*, 2014; Kaddachi *et al.*, 2014). BYDV is caused by a group of phloem-limited luteoviruses transmitted by aphids in a circulative non-propagative manner. The disease is often unrecognized because even experienced cereal agronomists have difficulty in distinguishing its symptoms from those associated with frost, wet weather, waterlogging, nutritional deficiencies and several other non-infectious agents (Banks *et al.*, 1995). The most conspicuous symptom on infected hosts, loss of green color in leaves, is often more prominent on older leaves. Discoloration typically begins 1 to 3 weeks after infection and may be preceded by the development of water-soaked

areas on the leaves. Symptoms may be affected by the genotype, age and physiological condition of the host plant, as well as by the strain of the virus and the environmental conditions (D'Arcy and Domier, 2000). Other symptoms of infection may include upright and stiff leaves, and serrated leaf borders, reduced tillering and flowering, sterility and failure to fill kernels, which results in fewer and smaller kernels and corresponding yield losses. Common effects of the virus on agronomic characteristics include reductions in yield, yield components, height, aboveground dry weight, and root growth (Baltenberger *et al.*, 1987; Burnet *et al.*, 1976; Carrigan *et al.*, 1981; Hoffman and Kolb, 1997). The host plant is sessile within such a plant pathosystem, however, the plant characteristics (e.g. growth, reproduction, emitted volatiles and plant nutrients) can be altered substantially by pathogen infection (Liu *et al.*, 2014).

The mechanisms of tolerance to BYDV in wheat are not well understood. A cultivar that appears to be tolerant in one environment may be less tolerant in another environment, thus complicating selection for tolerance (Hoffman and Kolb, 1998).

The aim of this study was to establish the influence of yellow dwarf disease on some winter wheat genotypes regarding the main yield components and finally on grain yield.

MATERIALS AND METHODS

Twelve winter wheat genotypes affected by Barley Yellow Dwarf Virus in normal field condition at Agricultural Research and Development Station (ARDS) Turda were studied regarding the agromorphological trait such as plant height, spike weight, number of grains per spike, weight of grain per spike and grain yield. The biologic material was composed from 4 Romanian varieties - Glosa, Miranda, Dumitra, Codru and two perspective lines: T. 11-15 and T. 19-16; and other 6 foreign varieties. Field trials were carried out in the experimental field of the ARDS Turda, in 2018-2019 year; sowed at optimum sowing date (~20 october) in a dryness and heat conditions, which favoured the development of aphids and cicades population. Atypical climatic conditions during the autumn may be considered as less favourable for wheat crop, which influenced the winter wheat plant development. The plant infection was caused through the natural sting of insects this makes

it difficult to distinguish the symptomatology of BYDV, thus the presence of the virus was visual observed in the spring. At the physiological maturity sample plants/genotype were analyzed for: plant height; spike weight; number of grains per spike; weight of grains per spike; grain yield.

The data matrix was prepared and processed in Excel program (Microsoft, USA).

RESULTS AND DISCUSSIONS

Barley Yellow Dwarf virus causes important damage with significant yield losses. All studied genotypes were affected by BYDV in a different level (Figure 1). Plant height is the first visible character affected by BYDV. This quantitative character is specific to genotype, but the virus infection of plants determines a reduction of this character with 24.58 to 44.33% (Table 1). Generally, plants had the same reaction for plants height, but in terms of characters more closely correlated with production as number of grains per spike (Figure 1-B), weight of grains per spike (Figure 1- C) and weight of spike (Figure 1-D), the presence of a specific reaction can be observed (Miranda, Glosa).

Plants wheat performances are severely affected by BYDV, their reaction being specific to each genotype (Table 1). Caused to premature installation its effect has a major influence on all analysed traits, thus spike weight was reduced with 37.89 % in case of Miranda variety to 74.35 % at foreign variety Exotic, with an average spike weight value by 58.44%.

Regarding the number of grains per spike, Josef variety was the most affected genotype with a reducing rate by 87.70 % almost the same value for the weight of grains/spike traits (87.38 %) and grain yield (87.05 %) reducing rates. Weight of grains/spike are the most affected character between morpho-productive studied traits with an average rate of reduction by 64.47 %; Exotic variety had the highest value of the reduction rate of this character (88.03 %) in opposite with Miranda variety (50.90 %).

Plant height was significantly lower on virus infected plants, with an average reducing rate of 35.07 % for all group of varieties, most affected genotype being Exotic variety (44.32 %) compared to Josef variety whose height has been reduced by 24.58 %.

Figure 1. Effect of barley yellow dwarf virus on winter wheat: plant height (A); number of grains/spike (B); weight of grains per spike (C) and weight of spike (D)

Table 1. Relative decrease of agronomic traits in wheat plants affected by BYDV

Traits/ Genotype	Plant height (%)	Spike weight (%)	Number of grain/spike (%)	Weight of grains/Spike (%)	Grain yield (%)
Altigo	33.45	61.47	60.64	72.65	70.33
Apache	38.46	59.34	48.52	69.22	66.80
Arlequin	36.23	57.24	43.79	69.88	67.64
Capo	31.12	42.86	33.66	51.74	49.05
Exotic	44.33	74.35	74.77	88.03	87.76
Josef	24.58	67.18	87.70	87.38	87.05
Glosa	36.37	54.48	44.38	63.21	63.21
Miranda	36.42	37.89	35.12	50.90	53.60
Codru	31.63	60.77	48.22	68.42	68.78
Dumitra	30.76	66.40	76.25	83.88	58.92
T. 11-15	37.68	59.20	62.21	70.52	71.20
T. 19-16	39.78	60.15	58.14	71.26	73.16
Mean	35.07	58.44	56.12	64.67	69.79

Table 2. Relationship between analysed morpho-productive traits in different infection level

Uninfected plants				
	Spike weight	Number of grains/spike	Weight of grains/spike	Grain yield
Plant height	0.23	0.27	0.36	0.42
Spike weight		0.87**	0.96***	0.98***
Number of grains/spike			0.87**	0.70*
Weight of grains/spike				1.00***
Infected plants				
	Spike weight	Number of grains/spike	Weight of grains/spike	Grain yield
Plant height	0.57	0.35	0.48	0.36
Spike weight		0.83**	0.96***	0.95***
Number of grains/spike			0.44	0.86**
Weight of grains/spike				1.00***

Note: Pearson's correlation between plant traits; $p < 0.05$ (*), $p < 0.01$ (**), $p < 0.001$ (***)

Grain yield, as the main trait which include all morpho-productive characters, it was affected in 69.79 % by BYDV, with a high grain yield reduction rate of 87.76 % at Exotic variety to 49.05 % to Josef genotype.

Regarding the relationship between analyzed traits, the BYDV infection strengthens the relationship between some morpho-productive traits (Table 2). Several correlation coefficients had higher values in infected plants, such as: correlation between number of grains/spike and plant height but statistically insignificant, and relationship between grain yield and number of grains/spike which becomes distinctly significant. On the other side, BYDV reduce the intensity of normal strengthens between number of grains/spike and weight of grains/spike (0.87** at uninfected plant to 0.44^{ns} at infected plants).

Regarding the relationship between weight of grains/spike and grain yield this are not affected by the presence or absence of BYDV, final grain yield being dependent of weight of grain/spike.

CONCLUSION

Barley yellow dwarf virus infection have a major impact on morpho-productive traits reducing the performance of those, and finally grain yield. BYDV infection had a variable effect on studied genotypes, effect which can be not

attribute to susceptibility of genotypes but rather to their capacity to maintain its productivity elements under infection.

Yield is the product of three components: number of spikes per unit area, number of grains per spike, and grains weight per spike. Two of these components were evaluated to determine which were most severely affected by BYDV infection. Both kernels per spike and kernel weight were reduced by infection with 56.12%, respectively 64.67%.

Breeding for improved tolerance to BYDV is difficult because simple effective selection strategies are not available. Following an intensive program of breeding and selection for BYDV tolerance, some studies indicated disappointment with the yield loss levels of a number of elite lines.

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