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EFFECT OF SOWING DATE ON OCCURRENCE AND SEVERITY OF BARLEY YELLOW DWARF VIRUS (BYDV) IN DIFFERENT WHEAT CULTIVARS

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Abstract

Barley yellow dwarf virus (BYDV) is considered as the most important viral disease of cereal crops in several Asian countries including Iran. Field studies were conducted to determine the effect of planting date on naturally occurring barley yellow dwarf virus (BYDV) incidence in different wheat genotypes. The experimental design was a split-plot arrangement in a randomized complete block with three replications. Eight seeding dates (SD) at one month intervals were assigned to main plots. Fourteen cultivars (Twelve bread wheat, one durum wheat and one triticale cultivar) were subplots that randomized within each main plot. The effect of sowing date, cultivar and the interaction between sowing date and cultivar grain yield and KTW was statistically significant. Our results indicated that wheat genotypes showed different level of BYDV infection in different sowing dates. There was a high correlation between the growth habit and the level of BYDV severity. In general, the spring wheat cultivars, except the durum cultivar, Behrang, showed more BYDV infection than the winter cultivars. Most of the susceptible cultivars showed their highest level of infection in the first sowing date. Our results demonstrated the role of planting date in the level of BYDV infection and can be used to recommend modifying the sowing dates as a means to escape the disease in the BYDV hot spot regions.

Key words: *BYDV, disease incidence, disease severity, sowing date, wheat genotypes.*

INTRODUCTION

Barley yellow dwarf virus (BYDV; genus *Luteovirus*, family *Luteoviridae*) is the most destructive and the most widespread viral disease of the grass family (*Poaceae*), including the commercially most important cereal crops, wheat, barley, rice and maize. BYDV also infect many perennial weeds and forage grasses. Early infection of BYDV in wheat usually result in stunting and reddening or yellowing at the tip of the flag leaves. As the virus infection progresses, entire leaves are discolored and may die prematurely. Yield loss caused by BYDV infection is reported to be varied depending on the used cultivar, virus strain, time of infection, and environmental conditions. In wheat, yield losses due to BYDV infection have been reported to be as high as 40-50% (Herbert et al., 1999; Riedell et al., 1999). Herbert et al. (1999) reported that fall infection of winter wheat and winter barley significantly reduce tiller height, spike number, number of seed per spike, 1000 kernel weight (TKW), and yield but spring infection significantly reduce number of seed per spike and TKW, but not the other yield components. BYDV is a disease complex that results from the interaction between many cereal-feeding aphid species, different strains of the pathogen, many vector and virus hosts, different reaction of cultivars and environmental conditions. Recently, the taxonomy of Yellow Dwarf viruses of cereals is revised based on the variations in genomic organization. BYDV - PAV and BYDV - MAV are grouped in the genus *Luteovirus* while Cereal yellow dwarf virus strain RPV (previously known as BYDV-RPV) is grouped in the genus *Polerovirus* (van Regenmortel et al., 2000). BYDV is not transmitted mechanically but exclusively transmitted by several aphid species in a persistent circulative manner. BYDV is over season in perennial grasses and volunteer plants which are deserve as the main sources of the pathogen and the aphid vectors and their spread to the host crops (Jones et al., 1990; McKirdy and Jones, 1993).

The virus is often spread in the fall but the spring infection can also occur. The incidence of barley yellow dwarf virus is reported be related to a range of crop and field characteristics including sowing date (e.g. Foster et al., 2004; Cowger et al., 2010; Chapin et al., 2010). In cereal crops, planting date and variety selection is considered important tasks for wheat producers. The choice of planting date and variety might reduce the risk of frost damage at anthesis, meet requirements of exposure to low temperatures (vernalization), and favor the accumulation of temperature and precipitation by the plant throughout the growing season (Tapley et al., 2013). Early sowing dates in fall might increase the risk of BYDV epidemic, some other important viral pathogens including wheat streak mosaic virus and Soil-borne wheat mosaic virus, the take-all disease caused by the fungal pathogen, *Gaeumannomyces graminis* var. *tritici* and hessian fly pest (*Mayetiola destructor*) (Ortiz, 2012; Gibb, 2014). On the other hand delayed planting in wheat could cause yield losses (Chen et al., 2003).

BYDV is considered as the most important viral disease of cereal crops in Iran. The disease have been reported from the major wheat and barley cultivation areas across the country including Khorasan, Fars, Mazandaran, Alborz, Chaharmahal va Bakhtiari and Zanjan and is tough to be present in other parts of the country (Sahragard et al., 2010). The Khorasan Razavi province is one of the main cereal production regions in Iran. PAV and MAV serotypes of BYDV are identified to be present in the region using serological and molecular methods (Nazari et al., 2008).

Our objectives in the present study were to evaluate the level of BYDV resistance in major wheat cultivars under the natural epidemic of disease and to investigate the effect of planting date on incidence of BYDV in the Mashhad area to determine the optimum seeding dates to avoid BYDV infection.

MATERIALS AND METHODS

This study was part of a three-year field experiment to determine the photo-thermo periodic reaction and phonological plasticity of different wheat cultivars to environmental changes in different sowing dates. Field trials were conducted at the Torogh Agricultural Research Station (36°13' N, 59°40' E), located near Mashhad in three consecutive growing seasons (2012-2015). The experimental design was a split-plot arrangement in a randomized complete block with three replications. Eight seeding dates (SD) at one month intervals were assigned to main plots. In the 2012-2013 cropping season, the first sowing date was on 5 September 2012 and the 8th sowing date was on 5 April 2013 (Table 2). Fourteen cultivars (Twelve bread wheat, one durum wheat and one triticale cultivar, table 1) were subplots that randomized within each main plot. Each subplot was 1.2 meter wide by 2 meter long. The area of each subplot was 2.4 m^2 (1.2 × 2) and sown at a rate of 450 seeds m^2. Standard agronomic practices were followed throughout the studies. Each Plot received a basal application of nitrogen, phosphorus and potassium based on the recommendations of the stations' soil analysis laboratory. 2-4-D and Granstar herbicides were used at dose of 1.5 litter and 20 gram per hectare respectively at the late tillering stage. Statistical analysis of variance performed by using computer program (MSTATC). Duncan multiple range tests applied to separate the differences between means.

Table 1. Description of the cultivars used in this study

Cultivar Name	Species*	Growth habit	Year of release	Reference
Pishgam	BW	W	2009	Mahfoozi et al., 2009
Gascogne	BW	W	1991*	http://wheatpedigree.net
Falat	BW	S	1990	Wheat Atlas: http://wheatatlas.org/varieties
Chamran	BW	S	1998	Esmaeilzadeh Moghaddam et al., 2014
Rooshan	BW	S	1958	Esmaeilzadeh Moghaddam et al., 2014
Parsi	BW	S	2009	Amin et al., 2010
Pishtaz	BW	S	2003	Esmaeilzadeh Moghaddam et al., 2014
Sirvan	BW	S	2011	Najafian et al. 2012
Mihan	BW	W	2010	Seed and Plant Improvement Institute: http://www.spii.ir
Oroom	BW	W	2011	Yazdansepas et al., 2011
Bezostaya	BW	W	1969	Wheat Atlas: http://wheatatlas.org/varieties
Behrang	DW	S	2010	Seed and Plant Improvement Institute: http://www.spii.ir
Baz	BW	S	-	Mousavi et al., 2014
Sanabad	T	S	2013	Ghodsi et al., 2013

*BW, bread wheat; DW, durum wheat; T, triticale

Table 2. BYDV disease severity on commercial wheat and triticale cultivars in different planting dates (2012-2013)

	BYDV disease severity (0–5 scale)							
Cultivar	D1	D2	D3	D4	D5	D6	D7	D8
Pishgam	0.7	0.3	1.3	0.0	0.3	0.3	1.3	0.7
Gascogne	4.0	2.0	2.0	0.7	0.0	0.7	1.3	0.3
Falat	0.0	0.0	0.0	0.0	0.3	0.7	0.3	0.0
Chamran	1.0	0.3	0.3	0.0	0.3	0.0	0.3	0.0
Rooshan	1.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0
Parsi	0.3	0.0	0.0	0.0	0.0	0.3	0.0	0.0
Pishtaz	1.0	0.3	0.7	0.3	0.0	0.3	0.3	0.3
Sirvan	0.0	0.0	0.0	0.3	0.0	0.0	0.7	0.0
Mihan	1.7	0.0	0.0	0.3	0.3	0.0	1.3	0.3
Oroom	0.3	0.3	0.0	0.0	1.7	1.3	0.3	0.3
Bezostaya	2.0	1.7	1.0	2.3	0.0	0.3	0.0	0.0
Behrang	4.0	2.3	1.7	1.7	2.0	1.0	1.3	1.7
Baz	0.3	0.3	0.0	0.7	0.0	0.0	0.7	0.0
Sanabad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7

Table 3. Summary of Analysis of variance on grain yield and KTW

Sources of variation	df	KTW (Ms)	Grain yeild (Ms)
Replication	2	30.691**	ns 0.346
Sowing date	7	4316.976**	210.779**
Error a	14	0.569	0.479
Cultivar	13	297.676**	12.812**
Sowing date * cultivar	91	**93.488	4.931**
Error a	208	0.233	0.217
Coefficient of variation (CV)%		5.2%	12.73%

Table 4. Mean of grain yield and KTW on different sowing dates

Treatment	Grain yield (DMRT 5%)*	KTW (DMRT 5%)
D1	3.245 E	38.28 D
D2	6.388 B	44.64 B
D3	7.049 A	46.01 A
D4	5.542 C	40.16 C
D5	3.615 D	31.77 E
D6	3.450 DE	31.93 E
D7	2.153 F	27.81 F
D8	0.349 G	15.03 G

Duncan multiple range test at α = 0.05

Table 5. Mean of grain yeild of different cultivars on different sowing dates

Cultivar	Sowing dates							
	D1	D2	D3	D4	D5	D6	D7	D8
Pishgam	5.3	8.6	8.4	7.3	4.2	3.8	1.0	0.0
Gascogne	7.3	7.0	6.0	4.4	1.5	0.9	0.0	0.0
Falat	1.3	5.5	7.4	5.6	4.0	5.1	3.2	0.7
Chamran	1.6	6.3	7.2	5.3	4.2	3.6	3.3	0.7
Rooshan	3.1	4.7	4.3	3.5	3.0	3.0	2.3	0.4
Parsi	1.0	5.4F	8.6	5.5	4.2	4.9	3.4	0.5
Pishtaz	2.8	6.6	8.3	6.4	4.7	4.1	3.5	0.4
Sirvan	2.5	6.0	6.2	5.6	4.3	4.1	3.5	0.8
Mihan	4.6	9.0	8.9	7.4	4.4	4.3	1.0	0.0
Oroom	3.7	8.0	8.3	6.5	3.2	2.8	0.5	0.0
Bezostaya	6.0	6.9	5.2	3.5	0.6	0.6	0.0	0.0
Behrang	0.9	3.6	5.1	4.4	3.3	2.5	1.5	0.4
Baz	1.0	4.9	7.7	5.9	3.7	4.6	3.8	0.8
Sanabad	4.6	7.1	7.3	6.4	5.4	4.1	3.3	0.3

EVALUATION OF BYDV INFECTION

Visual assessments of typical BYDV symptoms was observed and scored based on the proportion of infected plants and the severity of the symptoms in the plot on a 0–5 Scale (Niks et al., 2004). In this scale score 0 represented no visible BYDV symptoms in the plot; score 1 represented a few plants showing some leaf yellowing and discoloration; score 2 represented about 10% of the plants showing yellowing and mild dwarfing; score 3 represented 30% of plants showing yellowing and dwarfing; score 4 represented about 50% of the plants showing severe dwarfing; score 5 represented nearly complete dwarfing with few or no spikes emerging. Disease evaluation was done on 19 April. Diseases scorings were averaged over the three replicates. Samples were taken from the infected plants to confirm presence of the virus and to distinguish its serotype by Enzyme-linked Immunosorbent Assay (ELISA).

RESULTS AND DISCUSSION

Results of Analysis of variance on grain yield and Kernel thousand weights (KTW) in 2012-2013 cropping season are presented in Table 3. As can be seen in Table 3, the effect sowing date, cultivar and the interaction between sowing date and cultivar grain yield and KTW was statistically significant. The results showed that the highest grain yield was related to the third sowing date (D3, 05-Nov) and the lowest grain yield was related to the last sowing date (D8, 05-Apr). The same trend was observed on KTW data. The triticale cv. Sanabad had the highest grain yield and KTW compared to the other tested cultivars. As can be seen from the results of interaction between sowing date and cultivar (Table 5) some cultivars had a very low grain yield or had no grain yield when planted on the last date because these cultivars did not entered the flowering stage. Some cultivars had a very low grain yield when planted on the first date since due to severe frost damage the secondary tillers had delayed flowering. The wheat cultivars, Gascogne and Bezostaya when sown in D7 (05-Mar) and Pishgam, Gascogne, Mihan, Orum and Bezostaya when sown in D8 did not entered the flowering stage and had no grain yield (table 5). In D1 sowing date, Falat, Chamran, Roshan, Parsi, Pishtaz, Sirvan, Behrang and Baz where totally damaged by frost and their secondary tillers had delayed flowering. The grain yield obtained from these cultivars is related to the secondary tillers. The best sowing date for the winter and facultative cultivars was D2 (05-Oct), D3 (05-Nov) respective. The best time to sow the spring cultivars was on D2 (05-Oct) or D3 (05-Nov) depending on the cultivar.

In 2012-2013 cropping season, the first year of the trial, climatic conditions were more conducive to disease development and severe BYDV infection was observed in the experiment plots of susceptible cultivars. The results of ELISA tests that carried out in the Plant Virology Research Center (PVRC), Shiraz University, confirmed the presence of Barley yellow dwarf virus-PAV serotype (BYDV-PAV) in the samples taken in 2013 (Yasaei personal communications). In the second year (2013-2014) BYDV infection appeared only sporadically in the experiment plots due to unfavorable climatic conditions including severe freezing during the winter time. The results of BYDV disease severity on wheat genotypes in different planting dates is presented in Table 2. The wheat genotypes planted in different dates, showed different level of BYDV symptom expression. There was a high correlation between the growth habit and the level of BYDV severity. In general, spring wheat cultivars showed more BYDV infection than the winter cultivars. The spring durum wheat cultivar, Behrang was an exception. Behrang and the French winter wheat cultivar, Gascogne showed the highest level of infection especially in the earlier sowing dates (Figure 1).

Figure 1. Severe infection of BYDV on Goscogne cultivars in the first sowing date

Most of the susceptible cultivars showed their highest level of infection in the first (earlier) sowing date. The only triticale tested genotype, Sanabad showed no symptoms in almost all sowing dates. Our results demonstrated the role of planting date in the level of BYDV infection.

In agreement with other reports, our results highlights that the early planted wheat is prone to attack by the barley yellow dwarf virus infection. Delayed planting date is considered in some regions as the most important and reliable management practice for the farmers. Management of vector-borne viral diseases including BYDV is very complex. Using cultivars carrying genetic resistance to the virus or the aphid vectors is considered as the most economical and practical methods of BYDV control (Ayala et al., 2001). However, the wheat gene pool showed to be not rich regarding BYDV resistance genes so little sources of resistance/tolerance is available in wheat. In addition to resistance breeding other major strategies recommended to manage BYDV are avoidance of early planting, use of insecticide treated seed and application of foliar insecticide. Efficacy of each strategy varies between localities (Bowen et al., 2002; Van Riessen, 2002; Flanders et al., 2006). Optimization of the planting date should be considered always as a strategy to manage the disease.

Wheat and barley are typically planted in the Khorasan region with the intent of being used as a dual-purpose crop especially in small-scale farming systems. In this region, wheat may be planted over a wide range of dates from late October to late December depending upon location, cultivar and the availability of the land due to agricultural practices of the previous crop. Planting wheat early for use as a dual-purpose crop significantly increases the prevalence of the BYDV infection.

Corn (*Zea mays* L.) is considered as an important BYDV reservoir and a host to the aphid vectors. Corn is mostly grown in the region as a forage crop.The majority of corn fields are being planted by early April to mid May in the region. Forage corns are generally harvested early to late in the fall (September-November). So there is relatively long overlapping period between wheat and corn.

By the time wheat planting season begins, corn is still in the ripening stage. Due to the long overlapping period between corn and wheat, corn fields may play an important role in the epidemiology of BYDV in the region. At the beginning of autumn, when most of winter wheat and barley fields are already emerged, the vector aphids leave corn and infest young seedlings potentially transmitting viruses. In southern parts of the region where winter frost is moderate and usually spring or facultative cultivars are being planted, the vectors may overwinter parthenogenetically in cereal crops and multiply again during the spring when temperature rises. During spring and early summer depending on the location, aphids may leave maturing barley and wheat and transmit viruses to the young corn crops. Insecticide treatments aimed at controlling other pests of the corn field the aphids which transmit BYVD.

Barley yellow dwarf resistance or tolerance is reported to be associated with a number of agronomic characteristics including growth habit and earliness. Winter wheat and winter triticale cultivars are reported to be more resistant or tolerant to BYDV infection than the spring cultivars (Comeau and Jedlinski, 1990). However, our data contradict the other reports since most of the spring wheat cultivars tested in our study showed a high level of resistance under the field conditions. Field resistance to BYDV is defined as reduced symptoms of disease infection independent of the virus concentration in the infected plants (Kosová et al., 2008). The cultivars that showed field resistance may contain substantial amounts of virus particles despite their phenotype of infection. Further experiments needed to determine the genetic basis of the resistance reported here.

CONCLUSIONS

Our results can be used by the local extension services to recommend modifying the sowing dates as a means to escape the disease in the BYDV hot spot regions. However, in the long term, further investigation is needed to determine the effects of aphid vectors as well as the wild host grasses in the regional epidemiology of BYDV to arrange a forecasting system or at least estimate disease severity.

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