# Study Regarding Growing and Development Stages at Soybean Genotypes

Adrian NEGREA[1,2*], Teodor RUSU[1], Raluca REZI[2], Camelia URDĂ[2], Vasilena SUCIU[1,2]

[1] University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Calea Manastur 3-5, 400372 Cluj-Napoca, Romania
[2] Agricultural Research and Development Station Turda, Turda , 27, Agriculturii Street, Cluj, Romania
* corresponding author: adrian.negrea@scdaturda.ro

Bulletin UASVM series Agriculture 77(2) / 2020
Print ISSN 1843-5246; Electronic ISSN 1843-5386
DOI:10.15835/buasvmcn-agr: 2020.0028

**Abstract**

Soybean is one of the most important sources of vegetable oil and protein. The aim of this study is to evaluate the behavior of 75 European soybean genotypes from four maturity groups regarding the influence of climatic conditions of 2020 on soybean main growing and development stages. The experiment was conducted at the ARDS Turda in 2020, using a complete randomized block design with three replications. Dates of emergence (VE) and beginning of flowering (R1), were recorded for all 75 soybean cultivars from each of the four maturity groups (000 to I). Results obtained show that growing, and development stages of the studied soybean genotypes are according both with: thermal units and daily period from sunrise to sunset. Effects of daylength and temperature on soybean development were estimated. The rate of development to flowering was fastest for the very early genotypes than for genotypes in the semi-early maturity group (MG).

**Keywords**: flowering, photoperiod, soybean

## INTRODUCTION

Soybean (*Glycine max* (L.) Merill) is one of the world's most important sources of oil and protein. It has highest protein content among Leguminous crops belonging to the family *Leguminosae* (Agam *et al.,* 2019). Extent that soybean cultivation has taken in recent decades is due to: chemical composition of the crop, rich in biochemical constituents with high biological value; very varied possibilities of processing and use of crop (edible fats, animal feed concentrates, protein preparations for food, biofuels, other uses as raw material in very different industries); importance as leguminous plant for land fertility improvement in crop rotation (Lombardi *et al.,* 2013).

Genotype x environment interaction plays a significant role in the phenotypic performance of any cultivar and in the success of any breeding programs for the development of genetic material, adapted to a wide range of environments (Salem, 2004). Potential crop productivity is partially determined by the solar radiation available when temperatures are suitable for plant growth (Egli, 1994). Soybean is a photoperiod-sensitive crop, and the photoperiod response determines the ecological adaptability of soybean genotypes, for the soybean cultivars with different MGs may have different photoperiod responses and thus adapt to different daylength conditions and have different critical photoperiods (Yang *et al.,* 2019).

In the U.S. Cregan and Hartwing (1984) explain, the productivity of soybean cultivars grown under short-day lengths (less than 14 h) often has been limited because flowering and subsequent reproductive growth are initiated before sufficient vegetative growth has occurred.

The reproductive period (RP), a trait measured as days from flowering to maturity, is an important agronomic trait in soybean (Cheng *et al.,* 2011). A number of major genes and quantitative trait loci (QTLs) for flowering have been reported in soybean, these genes and QTLs interact with one another and with the environment to greatly influence not only flowering and maturity but also plant morphology, final yield, and stress tolerance (Watanabe *et al.,* 2012). The aim of this study is to evaluate the behavior of 75 European soybean genotypes from four maturity groups regarding the influence of climatic conditions of 2020 on soybean main growing and development stages.

## MATERIALS AND METHODS

The trials were conducted in 2020 by the department "Soybean Breeding Laboratory" at the

**Table. 1.** Genotypes of the field specified with variety name, maturity group and country of origin

| No. | Romania | | No. | Austria | | No. | Switzerland | |
|---|---|---|---|---|---|---|---|---|
| | **Variety** | **MG** | | **Variety** | **MG** | | **Variety** | **MG** |
| 1 | Perla | 000 | 1 | Merlin | | 1 | Gallec | |
| 2 | Carla TD | | 2 | Sultana | | 2 | Tourmeline | |
| 3 | Eugen | | 3 | Abelina | 000 | 3 | CH 22/174 | |
| 4 | Onix | | 4 | Lissabon | | 4 | CH 21414 | 000 |
| 5 | Felix | | 5 | Malaga | | 5 | CH 22/172 | |
| 6 | Cristina TD | | 6 | ES Mentor | | 6 | Amandine | |
| 7 | Malina TD | | 7 | Sigalia | | 7 | Proteix | 00 |
| 8 | Caro TD | | 8 | Flavia | 00 | 8 | Castetis | I |
| 9 | Ilinca TD | | 9 | Josefine | | No. | Croatia | |
| 10 | Bia TD | | 10 | Christine | | | Variety | MG |
| 11 | Teo TD | 00 | 11 | Atacama | | 1 | Korana | 00 |
| 12 | Miruna TD | | 12 | Picor | | 2 | Lucija | |
| 13 | Nicola TD | | 13 | Terrapro | 0 | 3 | Ana | 0 |
| 14 | Isa TD | | 14 | SG Eider | I | 4 | Ika | |
| 15 | T-295 | | No. | France | | 5 | Zora | |
| 16 | T-165 | | | Variety | MG | 6 | Zagrepcanka | I |
| 17 | T-166 | | 1 | Capnor | | 7 | Sanja | |
| 18 | T-1219 | | 2 | ES Senator | 000 | 8 | Tena | |
| 19 | T-3029 | | 3 | Amphor | | No. | Italy | |
| 20 | Oana F | | 4 | ES Director | 00 | | Variety | MG |
| 21 | Larisa | | 5 | Isidor | | 1 | Aires | |
| 22 | Ada TD | | 6 | Astafor | I | 2 | Bahia | |
| 23 | Felicia TD | | No. | Serbia | | 3 | Hilario | |
| 24 | Raluca TD | 0 | | Variety | MG | 4 | Pepita | 0 |
| 25 | Daciana | | 1 | Fortuna | 00 | 5 | Adonai | |
| 26 | Columna | | 2 | Valjevka | | 6 | Sponsor | I |
| 27 | Triumf | | 3 | Sava | 0 | No. | Germany | |
| 28 | Crina F | I | 4 | Optimus | I | | Variety | MG |
| | | | | | | 1 | Yakari | 00 |

Agricultural Research and Development Station Turda (ARDS Turda), Romania. The experimental design was a complete randomized block with three replications, with the harvested plot of 10 $m^2$. Each soybean variety was sown in faeozem vertical soil, two rows/genotypes, 12 m length and 50 cm distance between rows. Sowing was carried out in the first decade of April with a Wintersteiger seeder at a seed rate of 55 germinating seeds per 1 $m^2$. The 75 soybean genotypes selected for this study included local and foreign cultivars from four maturity groups: very early (000), early (00), semi-early (0) and semi-late (I). The genetic material consisted of soybean varieties and perspective lines from 8 European countries: Romania (28 genotypes), Austria (14 varieties), France (6 varieties), Serbia (4 varieties), Switzerland (8 genotypes), Croatia (8 varieties), Italy (6 varieties) and Germany (1 variety) (Tab. 1). Romanian soybean genotypes were created at ARDS Turda (19) and INCDA Fundulea (9). Fehr and Caviness Method (1977) was used for analyzing the phenological growth stages of studied soybean cultivars. The time interval (number of days) from sowing to emergence (VE) and from emergence (VE) to beginning of flowering (R1) was determined for each genotype using the American system. The cumulative temperature and also daily period from sunrise to sunset was calculated for each interval.

## RESULTS AND DISCUSSIONS

Temperature, photoperiod, rainfall, soil proprieties and other factors play an important role in the development and yield of soybean.

Weather climatic conditions in the first half of 2020 were atypical. After a warm start of spring followed a month of May with dry weather and low night temperatures which led to a delayed emergence of soybeans. Significant quantities of rain have fallen over the June month with the heaviest amounts in the second decade (Tab. 2) having negative consequences on the growth and development of soybean plants.

The four-month mean air temperature ranged from 10.3 to 19.8°C and day length varied, in average, from 5.6 h (June) to 8.2 h (April) during the soybean growing season (Tab. 2). Table 2 also presents data on precipitation conditions experienced during April-July at ARDS Turda in 2020. The rainfall registered on the growing season presented an interesting contrast, the beginning of spring being relatively warm and dry, and the beginning of summer (June) being relatively cool and wet.

The effect of photoperiod and temperature on the pre-flowering phase length of 75 soybean cultivars from four different maturity groups were studied (Figure 1). Heat units (10 to 30°C) and day length (hours from sunrise to sunset) varied

**Table. 2.** Monthly mean air temperature, solar radiation and rainfall values in the experimental field of ARDS Turda (Turda, 2020)

| | Days | April | May | June | July | Four-month average |
|---|---|---|---|---|---|---|
| Temperature (°C) | 1-10 | 8.7 | 12.1 | 7.4 | 20.9 | |
| | 11-20 | 11 | 16.5 | 19.2 | 18.4 | |
| | 21-31 | 11.1 | 13.7 | 19.1 | 20.2 | |
| | Average | 10.3 | 14.1 | 15.2 | 19.8 | 14.9 |
| Day length (h from sunrise to sunset) | 1-10 | 10.4 | 5.4 | 5.8 | 7.8 | |
| | 11-20 | 7.1 | 5.5 | 4.6 | 5.4 | |
| | 21-31 | 7.2 | 6.3 | 6.4 | 7.5 | |
| | Average | 8.2 | 5.7 | 5.6 | 6.9 | 6.6 |
| Rainfall (mm) | 1-10 | 0 | 10.2 | 16 | 23 | |
| | 11-20 | 0.8 | 11.2 | 115 | 51.6 | |
| | 21-31 | 17 | 23 | 35.6 | 12.2 | |
| | Sum | 17.8 | 44.4 | 166.6 | 86.8 | 315.6 |

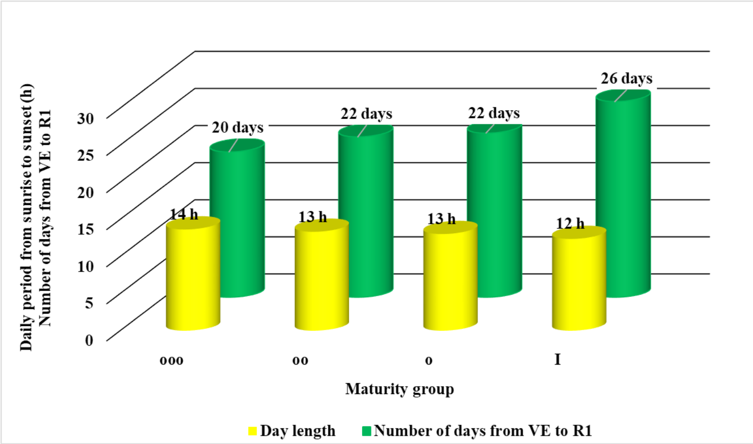


**Figure 1.** Number of days from VE to R1 and photoperiod for each maturity group

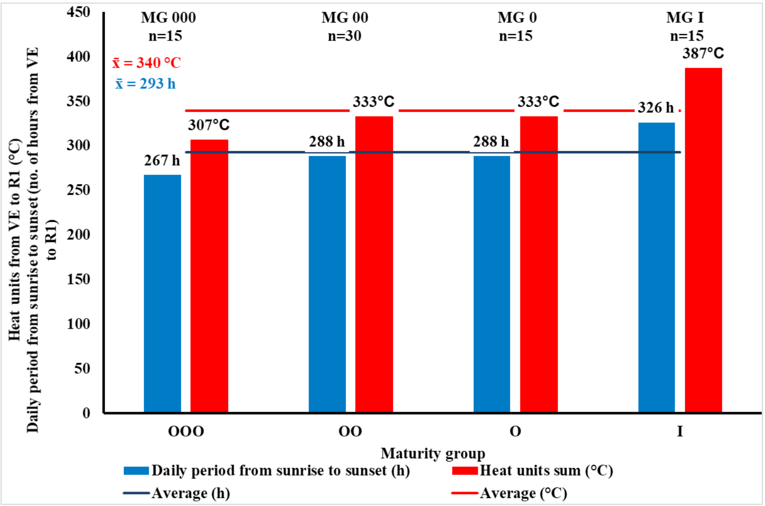


**Figure 2.** Heat unit sum and daily period from sunrise to sunset nedded for reaching first flower in four maturity groups

depending on maturity groups thus photoperiod and temperature played a part in determining pre-flower phase length. Very early soybean maturity group needed 20 days when exposed to an average photoperiod of 14 h/ day, for the MG 00 and MG 0 the results were similar (13 h/ day of sunshine and 22 days until first flower stage) and the semi-early soybean varieties reached flowering in 26 days after emergence when exposed to a photoperiod of 12 h/ day length. This results are in accordance with the work of J. Chapman (1986), who explained that soybean is a quantitative short-day plant with all cultivars flowering within 20-25 days when exposed to photoperiods of 10-12 h or less.

By analyzing the influence of daylength and temperature on reaching first flower in all four soybean maturity groups, we found that same results were obtained for early and semi-early maturity groups (Figure 2). If very early soybean genotypes needed, on average, 267 hours from sunrise to sunset and 307°C units sum between emergence to the beginning of flowering, the genotypes from maturity group I had higher requirements to these factors (387°C heat units sum and 326 h of sun). In average the number of hours of sunshine and cumulative units from emergence to first flower stage for studied maturity groups were: 293 h and 340°C respectively.

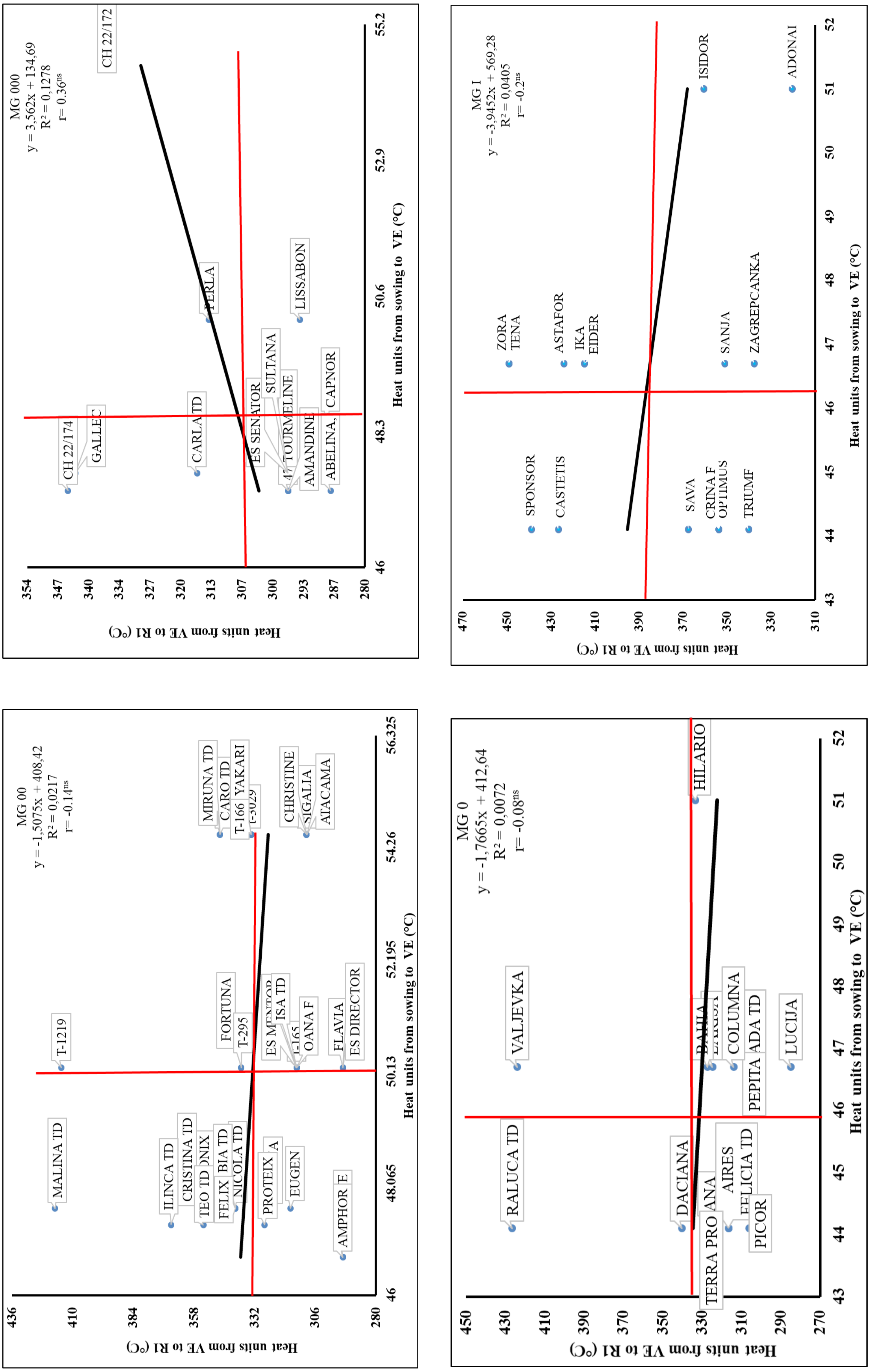


**Figure 3.** Relationship between heat units from sowing to emergence (VE) and from VE to flowering (R1)

The relationship between heat units (10 to 30°C) from sowing to emergence (VE) and from emergence (VE) to first flower (R1) respectively was analyzed for each maturity group highlighting important differences between genotypes and also between studied groups (Figure 3). Simple correlation analysis indicated that VE cumulative units were positively correlated with R1 sum of units for very early soybean genotypes; negative correlation was observed for the other three maturity groups (00, 0, I). The results obtained for the early soybean genotypes revealed that cultivars created at ARDS Turda are well adapted to the conditions of the area with a faster emergence compared to the average of the 30 genotypes analyzed. For the genotypes from maturity groups 0 and I, the heat unit sum required to emergence was about 46°C; early soybean varieties emerged when 48 useful degrees were summed and the semi-early ones after 53°C. Pre-flowering phase length varied depending on the maturity group, the heat demand being between 307°C (000 MG) and 390°C (I MG).

## CONCLUSION

Temperature, photoperiod, and rainfall and also the interaction between genotype and these factors played an important role in the emergence, development and pre-flower phase length.

Results indicated that for very early soybean genotypes long photoperiods (14 h/ day in average) promoted the onset of flowering. The late cultivars also showed a sensitivity to photoperiod, with a 12-hour of day length requirement.

Regarding temperature influence on emergence and first flower stage, medium and late genotypes emergence faster than early and very early soybean cultivars.

The study of photothermal units influence on pre-flower phase length could give important information when initially making cultivar selections for a specific area.

*Acknowledgments.* This work was supported by a grant of the Romanian Ministry of Research and Innovation, CCCDI-UEFISCDI, project number PN-III-P1-1.2-PCCDI-2017-0301, contract no. 28PCCDI/2018 - Integrated management system of the agroecosystem resistance against pests in order to promote sustainable agriculture under the conditions of climate change, within PNCDI III.

## REFERENCES

1. Agam MN, Raut RA, Jejurkar GB, Sable SB (2019). Evaluation of the fungicides, botanicals and bioagents against Colletotrichum truncatum causing anthracnose of Soybean in pot culture. Journal of Pharmacognosy ang Phytochemistry, 8(2):629-634.
2. Chapman J, (1986). The influence of photoperiod and temperature on the pre-flowering phase length of eleven soybean cultivars in northern Natal. South African Journal of Plant and Soil. Doi:10.1080/02571862.1986.10634190.
3. Cheng L, Wang Y, Zhang C, Wu C, Xu J, Zhu H, Leng J, Bai Y, Guan R, Hou W, Zhang L, Han T, (2011). Genetic analysis and QTL detection of reproductive period and post-flowering photoperiod responses in soybean. Theoretical and Applied Genetics. Doi:10.1007/s00122-011-1594-8.
4. Cregan PB, Hartwig EE, (1984). Characterization of Flowering Response to Photoperiod in Diverse Soybean Genotypes. Crop Science. Doi:10.2135/cropsci1984.0011183x002400040
5. Egli DB (1994). Cultivar maturity and reproductive growth duration in soybean. Journal of Agronomy and Crop Science, 173: 249-254.
6. Fehr WR, Caviness CE (1977). Stages of soybean development. Agric and Home Economics Exp. Stn. Spec. Rep. 80. Iowa State University, Ames.
7. Lombardi AR, Epure LI, Roman GV (2013). Studies on soybean growing in Tulcea county. Scientific Papers. Series A. Agronomy, Vol. LVI, 308-313.
8. Salem SA (2004). Yield Stability of Some Soybean Genotypes Across Diverse Environments. Pakistan Journal of Biological Sciences, 7 (12): 2109-2114.
9. Slifka MK, Whitton JL, (2000). Clinical implications of dysregulated cytokine production. J Mol Med. Doi:10.1007/s001090000086.
10. Watanabe S, Harada K, Abe J, (2012). Genetic and molecular bases of photoperiod responses of flowering in soybean. Breeding Science. Doi:10.1270/jsbbs.61.531
11. Yang W, Wu T, Zhang X, Song W, Xu C, Sun S, How W, Jiang B, Han T, Wu C, (2019). Critical Photoperiod Measurement of Soybean Genotypes in Different Maturity Groups. Crop Science. Doi:10.2135/cropsci2019.03.0170.

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

Ionuț RACZ[1,2*], Rozalia KADAR[2], Laura ȘOPTEREAN[2], Adina VARADY[1,2], Diana HIRIȘCĂU[1,2], Loredana SUCIU[1,2]

[1]*University of Agricultural Science and Veterinary Medicine of Cluj-Napoca, Calea Mănăștur 3-5, 400372 Cluj-Napoca, Romania*
[2]*Agricultural Research and Development Station, Agriculturii Street 27, Turda, Romania*
[*]*corresponding author: ionut.racz@usamvcluj.ro*

Bulletin UASVM series Agriculture 77(2) / 2020
Print ISSN 1843-5246; Electronic ISSN 1843-5386
DOI:10.15835/buasvmcn-agr: 2020.0027

**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*, *Macrosteles 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 agro-morphological 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 loses. 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 pe 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 %.

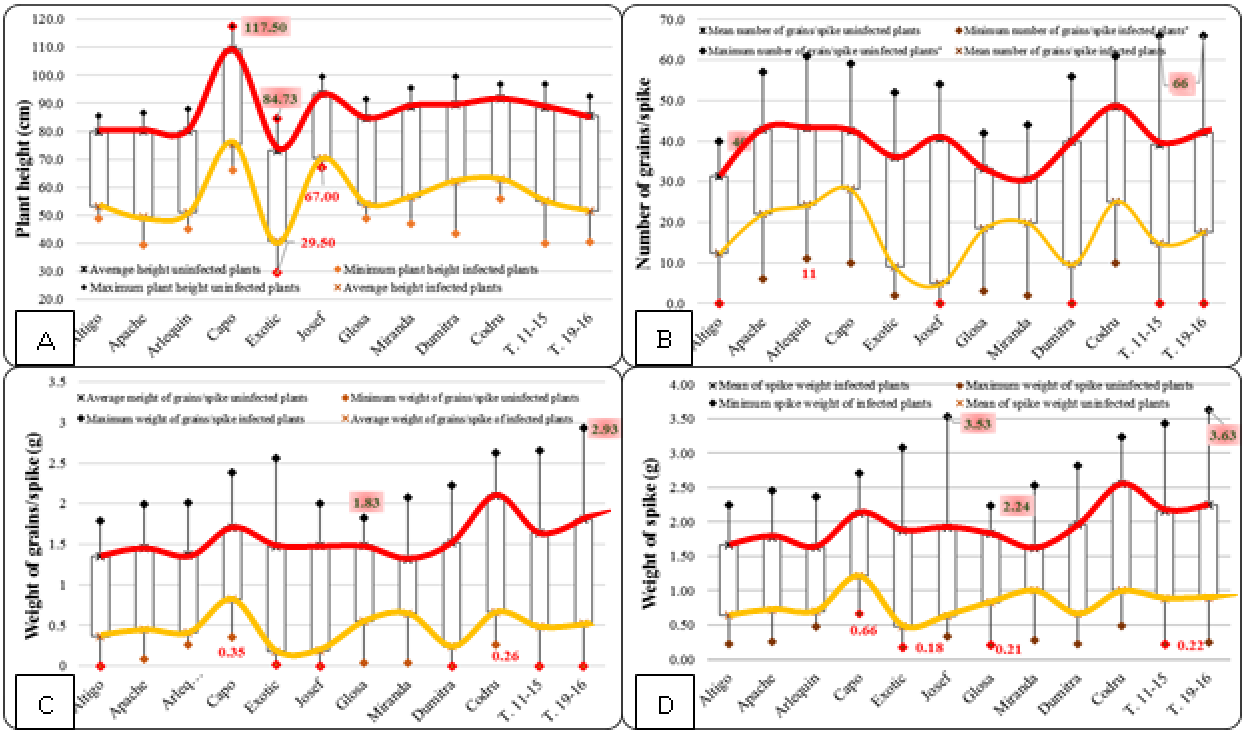


**Figure 1.** Effect of barley yellow dwarf virus on winter wheat: plant height (A); number of grains/spike (B); weight of grains per spike (C) and weight of spike (D)

**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

| | Spike weight | Number of grains/spike | Weight of grains/ spike | Grain yield |
|---|---|---|---|---|
| **Uninfected plants** | | | | |
| 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.

## REFERENCES

1. Baltenberger DE, Ohm HW, Foster JE (1987). Reactions of oats, barley, and wheat to infection with barley yellow dwarf virus isolates. Crop Science, 27: 195-198.
2. Banks PM, Davidson JL, Bariana H, Larkin PJ (1995). Effects of Barley Yellow Dwarf Virus on the yield of winter wheat. Australian Journal of Agricultural Research, 46: 935-946.
3. Burnett PA, Gill CC (1976). The response of cereals to increased dosage with barley yellow dwarf virus. Phytopathology, 66:646-651.

4. Carrigan LL, Ohm HW, Foster JE, Patterson FL (1981). Response of winter wheat cultivars to barley yellow dwarf virus infection. Crop Science, 21:377-380.
5. D'Arcy CJ, Domier LL (2000). Barley yellow dwarf. The Plant Health Instructor. doi: 10.1094/PHI-I-2000-1103-01.
6. Hoffman TK, Kolb FL (1997). Effects of barley yellow dwarf virus on root and shoot growth of winter wheat seedlings grown in hydroponic culture. Plant Disease, 81:497-500.
7. Hoffman TK, Kolb FL (1998). Effects of Barley Yellow Dwarf Virus on yield and yield components of drilled winter wheat. Plant Disease, 82:620-624.
8. Ingwell LL, Zemetra R, Mallory-Smith C, Bosque-Pérez NA (2014). *Arundo donax* infection with Barley Yellow Dwarf Virus has implications for biofuel production and non-managed habitats, Biomass and Bioenergy, 66: 426-433.
9. Kaddachi I, Souiden Y, Dhouha A, Cheour F (2014). Barley Yellow Dwarf Virus (BYDV): characteristics, hosts, vectors, disease symptoms and diagnosis. Journal of Phytopathology, 3 (3): 155-160.
10. Liu XF, Hu XS, Keller MA, Zhao HY, Wu YF, Liu TX (2014). Tripartite interactions of Barley Yellow Dwarf Virus, *Sitobion avenae* and Wheat Varieties. PLoS One, 9(9): e106639; doi: 10.1371/journal.pone.0106639.
11. Oswald JW, Houston BR (1951). A new virus disease of cereals, transmissible by aphids. Plant Disease Reporter, 35: 471-5.
12. Walls III J, Rajotte E, Rosa C (2019). The past, present, and future of Barley Yellow Dwarf management. Agriculture, 9: 23; doi:10.3390/agriculture9010023.
13. Wegulo SN, Hein GL (2013). Yellow Dwarf of wheat, barley, and oats. NebGuide, University of Nebrasca-Lincoln Extension, Institute of Agriculture and Natural Resources.