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COMPARATIVE TESTING OF COMMON WINTER WHEAT LINES AND THEIR SUITABILITY FOR CHANGING ENVIRONMENTAL CONDITIONS

Zlatina UHR[1], Vanya DELIBALTOVA[2] Evgeniy DIMITROV[1], Petar CHAVDAROV[1]

[1]Institute of Plant Genetic Resources, 2 Druzhba Street, Sadovo, Bulgaria
[2]Agricultural University of Plovdiv, 12 Mendeleev Blvd, Plovdiv, Bulgaria

Corresponding author email: zlatinapg@abv.bg

Abstract

The trial was carried out on the field from IPGR, Sadovo, during the period 2017-2019. The test was performed by means of a block method with four repetitions; experimental field area - 10 m2 after leguminous predecessor. The aim of the study of the study was to establish the mass of 1000 grains, hectolitre mass, plant height and yield from 31 lines and candidate varieties obtained by the method of the variety and remote hybridization were tested. In the experiment were involved two standard varieties - Sadovo 1 and Enola. The adopted in IPGR - Sadovo technology for growing of winter common wheat was used. The grain yield is determined with standard grain moisture of 13%. The indices; thousand kernel weight (g), test weight (kg), and grain yield (kg/ha) were determined. Data obtained for the plant height, the grain yield and the physical properties of the grain were statistically processed by the method of dispersion and correlation analyses. The results show: environmental factors have the most influence on the grain yield, 1000 grain weight and test weight; was found that the plant height is significantly influenced by the genotype. The highest average yield for the period is reported on the lines MX 286-1777, MX 258-3355 and candidate variety Yilzla

***Key words**: common winter wheat, lines, suitability, plant height, grain yield.*

INTRODUCTION

In the near future agriculture, especially field plant production, will face various challenges, one of these will be the need to satisfy the food requirements of a growing population while the available freshwater reserves are declining steadily (Paks & Reynolds, 2013). Wheat production plays an important role in the food supply not only today but also in the future, as this sector is highly sensitive to the climatic and environmental changes (Semenov & Stratonovitch, 2013). Extreme weather is occurring more frequently due to climate change in many parts of the world, including changes in precipitation patterns. The decreasing precipitation in combination with increased air temperature is the most important yield-limiting factors and these are threatening food security worldwide (Daryanto et al., 2017). Drought is one of the most important stressors for cereals (Fahad et al., 2017), it can reduce the amount of biomass by more than 25% and can cause a large yield loss (Zhang et al., 2018). When endeavouring optimum yields with limited water supplies, farmers must choose to use new water-saving technologies or growing varieties that use water more efficiently (Jabran et al., 2015). Besides the deficit of rainfall, the unusually high amount of precipitation can also affect the plant growth negatively. Waterlogging affects 25% of the wheat plantation worldwide (Powell et al., 2012). Wheat can tolerate the waterlogging for different time of period and its resistance depends on both the plant's maturity stage and the temperature (Ding et al., 2018). The use of different breeding methods for the creation of great genetic diversity, its evaluation, the use of new technological solutions is a prerequisite for the creation of varieties suitable for changing conditions.
The present study aims to determine the suitability of advanced lines of common winter wheat to changing environmental conditions

MATERIALS AND METHODS

The experiment was conducted in the period 2017-2019 by a block method in four replicates with a plot size of 10 m^2 after a bean precursor to the experimental field of IRGR, Sadovo - central southern Bulgaria. The adopted in IPGR - Sadovo technology for growing of winter common wheat was used. 31 lines and candidate varieties obtained by the method of the variety and remote hybridization were tested. Two standard varieties - Sadovo 1 and Enola - were included in the experiment. All the stages of the established technology for wheat growing were followed. Soil tillage included single disking (10-12 cm) after harvesting of the previous crop, and double disking after the main fertilization (Dallev and Ivanov, 2015). The area was treated by $N_{120}P_{80}$ and the whole quantity of the phosphorous fertilizer and 1/3 of the nitrogenous fertilizer were applied before main soil tillage. The remaining amount from the nitrogen norm was applied before the beginning of permanent spring vegetation. Triple super phosphate and ammonia nitrate were used. Sowing was completed within the agrotechnical term optimal for this region at sowing norm 550 germinating seeds/m^2.

Control of weeds, diseases and pests was done with suitable pesticides when necessary (Mitkov et al., 2017). Harvesting was done at full maturity. The grain yield is determined with standard grain moisture of 13%.

The indices grain yield (kg da^{-1}); test weight (kg); thousand kernel (grain) weight (g), and plant height were determined.

The analysis of the variance, the effect of the individual factors on the studied traits and the correlations between them was made using the statistical program SPSS ver. 19.

The period of the research (2016-2019) is characterized with variety of temperature and rainfall conditions which enables to evaluate the reaction of the studied lines in accordance with their yields and quality characteristics under different climatic conditions (Figures 1, 2).

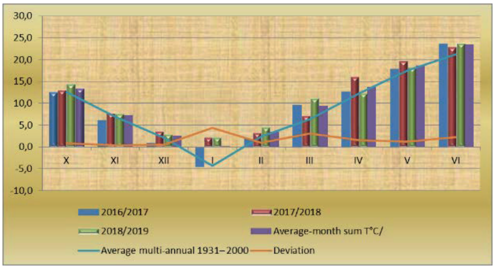

Figure 1. Average monthly temperature during three vegetation years, t°C

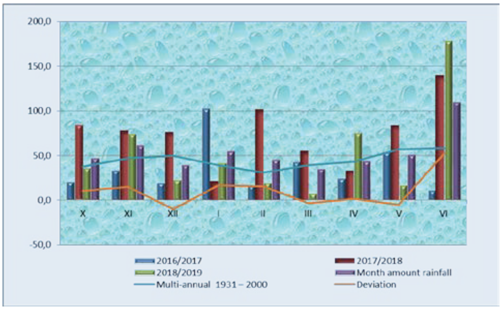

Figure 2. Monthly rainfall sum during three vegetation years (mm/m²)

The most favorable for plant growth and development was the first experimental year (2016-2017), followed by the second (2017-2018), and unfavorable was the third year (2018-2019), of the experiment, having an effect on yield and grain quality of winter wheat.

RESULTS AND DISCUSSIONS

The growth and development of common winter wheat plants took place under different meteorological conditions. During the three years of the survey the environmental conditions were not typical. This also applies to the development of wheat plants by phase. In agroclimatic terms, the harvest year 2017 can be described as "very different". Rainfall in October /21.4 mm/ was a favourable factor for /allowed for/quality soil tillage. We sowed at the end of the optimal period October 27 to November 2. Winter damage and frost in the area were not observed as the crops had not emerged. The average monthly air temperatures in January and February 2017 are close to normal. Due to the low temperatures in November and December, massive and heavy snow cover until February 15th reported on February 21st. This resulted in a shortening of all interphase periods. The plants formed lower than the typical height. In March, average monthly temperatures were higher than the multi-annual values, with precipitation falling by about 20 mm below normal. The wilting and flowering phase passed very quickly until the first ten days of May and passed at temperatures close to normal and very good moisture supply (+26.2 mm). The flowering to milky maturity has taken place in about 10-15 days. The dough maturity was marked on June 20, and full maturity was reported in late June and early July.

In agrometeorological terms, the 2017-2018 growing season can also be defined as "very different". Rainfall in October /84.6/ impeded soil tillage. We sowed at the end of the optimal period - 23.10. An emergence was reported on 3.11.2017. Their development proceeded normally and in appropriate weather conditions for the vernalization. In the months of November and December, the average maximum daily temperatures reached, respectively, 11.5°C and 8.2°C, and the average daily temperatures reached 8.0°C and 3.8°C. The average minimum temperatures were positive in November (3.46°C) and slightly negative in December (-0.44°C), with negative average daily temperatures occurring in 4 days in December and snow cover lasting only two days, also in December. Meteorological conditions in January and February did not differ from those in December, with longer lasting snow cover in the second half of January. The average monthly air temperature in January was much higher than normal and in February 2018 it was closer to normal. Winter damage and frost in the area were not observed, as winter was mild. During the harvesting period the plants were well supplied with moisture and the formed plants were higher than the previous year. The phasing-out phases (26 April-2 May) and flowering (early May) were almost merged due to the warm weather. Full maturity was reported in the third ten days of June - 25.06. Due to heavy rainfall, the harvest was delayed between June 26 and June 29 and early July. The quality of the grain was impaired. The monthly rainfall was 139.9 l/m^2.

In the last year of the study, the autumn was very dry and the plants were late on 14.11.2018 after the fall of rain. The tillering phase was also delayed. The fallen rain after 40 days of drought led to the normal development of the plants and the jointing was reported. Heading was observed in the period 30.04.-04.05.2019, and milk maturity on 20-22.05.2019 and dough maturity on 29-31.05.2019. We can summarize that the average monthly temperatures for all the months of vegetation were higher than the annual average and the rainfall was not evenly distributed.

The three-year competitive varietal yield test included 31 lines and candidate varieties obtained by the method of variety and remote hybridization (crosses with durum wheat). Grain yield is an integral indicator that expresses the complex of qualities that a variety possesses, including resistance to stress factors. Therefore, the primary task of any breeding program for common wheat is to increase the yield potential of new varieties.

The average yield for the period by variety varies from 410.3 to 672.0 kg / da. (Table 1). The value of the indicator for all varieties is 538.7 kg / da and for the average standard is 501.2. The highest values were reported at MX 258/3355 - 672 kg / da, Ayilizla - 655.2 kg/da and MX 286/1777 - 633.9 kg/da and differences against the standard were statistically proven. During the three-year period, 2017 is the most favourable year and then the highest yields are formed. They range from 469.2 kg/da to 840.5 kg/da. The lines РУ 48/2553, MX 258/3355, MX 274/711, MX 286/1777, РУ 49/2300, MX 289/2048 and Ayilzla have best expressed their productivity. In 2018, due to the rainfall at the end of June, the crops fell and high losses were reported, however, the candidate Ayilzla yielded 714.0 kg, MX 258-3355 - 650 kg/da, MX 260 / 1175-645.0 and Sashez - 631 kg/da. The table shows that the lowest yields are in 2019.

For the three-year period the 1000 grains weight is from 36.0 to 47.5 g, and the average for all varieties is 43.5 g. With proven largest grain average for the period are varieties Sashets - 47.5 and MX 270 / 3462- 47.4 g. In 2017 and 2018, the average values are higher than in 2019 and the average for the period.

A test weight is an important indicator of wheat. The average for 3 years is 71.6 kg/hl, ranging from 65.4 to 75.9 kg/hl. (Table 1)

Table 1. Complex characteristic of winter common wheat lines for the period 2017-2019

№	Name	Yield, kg							1000 kernel weight, g					
		2017	2018	2019	mean	± D	Sign.	%St	2017	2018	2019	mean	± D	Sign.
1.	мх 265-3430	633.3	472.4	551.4	552.4	50.5	n.s.	110.1	46.6	44.5	38.4	43.2	0.4	n.s.
2.	мх 270-3461	658.8	462.3	431.2	517.4	15.5	n.s.	103.2	50.1	48.0	42.8	47.0	4.2	n.s.
3.	мх 270-3462	606.5	378.1	499.3	494.6	-7.3	n.s.	98.7	51.1	51.0	40.0	47.4	4.7	+
4.	мх 270-3463	617	392.9	497.3	502.4	0.5	n.s.	100.2	52.0	47.7	39.8	46.5	3.8	n.s.
5.	мх 270-3464	623.5	496.6	411.0	510.4	8.4	n.s.	101.8	52.1	49.5	38.0	46.5	3.8	n.s.
6.	мх 274-717	618.4	486.6	367.1	490.7	-11.2	n.s.	97.9	50.3	47.9	43.4	47.2	4.5	n.s.
7.	мх 286-1759	761.8	516.6	460.3	579.6	77.7	n.s.	115.6	47.5	46.2	38.1	43.9	1.2	n.s.
8.	мх 286-1777	777.1	567.1	557.6	633.9	132.0	+	126.5	50.0	48.1	40.6	46.2	3.5	n.s.
9.	мх285-1058	592.9	459.6	580.8	544.4	42.5	n.s.	108.6	40.0	35.0	36.0	37.0	-5.7	+
10.	мх289-2048	774.9	347.1	574.3	565.4	63.5	n.s.	112.8	48.2	46.0	44.0	46.1	3.3	n.s.
11.	мх295-2524	694.2	562.5	474.5	577.1	75.2	n.s.	115.1	52.0	49.2	40.0	47.1	4.3	n.s.
12.	мх298-2582	673.6	379.5	459.1	504.1	2.1	n.s.	100.6	50.6	38.0	36.0	41.5	-1.2	n.s.
13.	мх298-2622	694.3	330.0	483.1	502.5	0.6	n.s.	100.3	37.1	35.8	38.0	37.0	-5.8	-
14.	мх298-2580	717.2	320.1	521.0	519.4	17.5	n.s.	103.6	45.6	35.7	35.0	38.8	-4.0	n.s.
15.	7621x Demetra 611-4	757.8	486.4	341.8	528.7	26.7	n.s.	105.5	43.3	36.9	33.6	37.9	-4.8	-
16.	7621x Demetra 612-1-2p	469.2	433.1	328.6	410.3	-91.6	n.s.	81.9	49.0	43.1	40.3	44.1	1.4	n.s.
17.	7621x Demetra 612-4-2p	476	457.1	512.9	482.0	-19.9	n.s.	96.2	48.3	43.0	34.0	41.8	-1.0	n.s.
18.	7621x Demetra 613-1	662.9	494.3	330.7	496.0	-5.9	n.s.	99.0	41.9	40.8	39.1	40.6	-2.1	n.s.
19.	7621x Demetra 613-2	479.3	406.4	481.7	455.8	-46.1	n.s.	90.9	46.6	47.1	38.6	44.1	1.4	n.s.
20.	мх 270-24	704.3	461.6	494.4	553.4	51.5	n.s.	110.4	49.4	43.9	36.9	43.4	0.7	n.s.
21.	мх 270-27	634.1	510.0	385.7	509.9	8.0	n.s.	101.7	47.1	52.0	37.9	45.7	3.0	n.s.
22.	мх 270-28	679.3	434.6	378.7	497.5	-4.4	n.s.	99.3	48.3	48.5	36.6	44.5	1.8	n.s.
23.	мх 270-50	638	304.5	472.1	471.5	-30.4	n.s.	94.1	44.8	46.7	39.2	43.6	0.8	n.s.
24.	мх 270 -86	673.8	438.0	416.0	509.3	7.3	n.s.	101.6	45.9	51.3	40.0	45.7	3.0	n.s.
25.	Sashez	683.3	631.0	523.3	612.5	110.6	n.s.	122.2	47.9	52.9	41.6	47.5	4.8	+
26.	мх 260-1175	646.5	645.0	527.1	606.2	104.3	n.s.	120.9	46.6	52.0	40.7	46.4	3.7	n.s.
27.	Ayilzla	730.6	714.0	520.9	655.2	153.3	+	130.7	52.8	46.0	38.9	45.9	3.2	n.s.
28.	ру 48-2553	840.5	540.0	499.9	626.8	124.9	n.s.	125.1	43.2	45.5	33.0	40.6	-2.2	n.s.
29.	ру 49-2300	787.6	541.0	484.8	604.5	102.6	n.s.	120.6	47.8	47.1	38.0	44.3	1.6	n.s.
30.	мх 258-3355	801.3	650.0	564.8	672.0	170.1	++	134.1	43.1	44.4	37.2	41.6	-1.2	n.s.
31.	мх 274-711	795.3	438.3	527.0	586.9	85.0	n.s.	117.1	39.5	35.2	33.4	36.0	-6.7	--
32.	Sadovo 1	612.2	477.0	439.0	509.4	7.5	n.s.	101.6	51.1	47.3	39.5	46.0	3.3	n.s.
33.	Enola	649.3	345.4	488.6	494.4	-7.5	n.s.	98.6	44.4	40.0	34.0	39.5	-3.3	n.s.
Mean for Standarts		630,8	411.2	463.8	501.9				47.8	43.7	36.8	42.7		
mean		671,7	472.1	472.3	538.7				47.1	45.0	38.3	43.5		
min		469.2	304.5	328.6	410.3				37.1	35.0	33.0	36.0		
max		840.5	714.0	580.8	672.0				52.8	52.9	44.0	47.5		
GD		GD 5.0%=125,7 GD 1.0%=167,1 GD 0.1%=217,0							GD 5.0%=4,6 GD 1.0%=6,1 GD 0.1%=7,9					

Table 1 – continued. Complex characteristic of winter common wheat lines for the period 2017-2019

№	Name	Test weight, kg/hl						Plant height, cm					
		2017	2018	2019	mean	± D	Sign.	2017	2018	2019	mean	± D	Sign.
1.	мх 265-3430	79.2	69.2	71.1	73.2	-	n.s.	92.0	90.0	90.0	90.7	4.3	n.s.
2.	мх 270-3461	76.0	67.1	67.5	70.2	-	--	78.0	90.0	90.0	86.0	-0.3	n.s.
3.	мх 270-3462	77.5	68.3	67.0	70.9	-	n.s.	80.0	87.0	94.0	87.0	0.7	n.s.
4.	мх 270-3463	75.8	65.9	68.2	70.0	-	--	83.0	90.0	86.0	86.3	0.0	n.s.
5.	мх 270-3464	76.7	65.8	67.0	69.8	-	--	80.0	86.0	83.0	83.0	-3.3	n.s.
6.	мх 274-717	82.1	71.5	73.3	75.6	0.9	n.s.	107.0	105.0	90.0	100.7	14.3	+
7.	мх 286-1759	84.3	67.4	75.9	75.9	1.1	n.s.	78.0	72.0	90.0	80.0	-6.3	n.s.
8.	мх 286-1777	82.6	68.6	74.9	75.4	0.6	n.s.	80.0	72.0	83.0	78.3	-8.0	n.s.
9.	мх285-1058	80.3	64.5	71.6	72.1	-	n.s.	73.0	80.0	90.0	81.0	-5.3	n.s.
10.	мх289-2048	82.0	66.9	68.0	72.3	-	n.s.	85.0	82.0	82.0	83.0	-3.3	n.s.
11.	мх295-2524	80.0	65.9	69.5	71.8	-	n.s.	87.0	85.0	93.0	88.3	2.0	n.s.
12.	мх298-2582	80.0	66.9	68.2	71.7	-	-	75.0	75.0	75.0	75.0	-	n.s.
13.	мх298-2622	78.9	66.2	67.5	70.9	-	-	79.0	70.0	74.0	74.3	-	-
14.	мх298-2580	82.0	64.2	68.9	71.7	-	-	75.0	80.0	81.0	78.7	-7,7	n.s.
15.	7621x Demetra	75.3	65.4	68.9	69.9	-	--	78.0	79.0	78.5	78.5	-7.8	n.s.
16.	7621x Demetra	79.0	65.0	67.1	70.4	-	--	104.0	115.0	84.0	101.0	14.7	+
17.	7621x Demetra	79.7	65.1	68.9	71.2	-	-	108.0	115.0	90.0	104.3	18.0	++
18.	7621x Demetra	80.5	65.3	69.5	71.8	-	n.s.	80.0	80.0	85.0	81.7	-4.7	n.s.
19.	7621x Demetra	79.4	64.4	68.0	70.6	-	-	105.0	105.0	84.0	98.0	11.7	+
20.	мх 270-24	76.1	63.6	66.1	68.6	-	---	75.0	72.0	90.0	79.0	-7.3	n.s.
21.	мх 270-27	79.2	69.1	66.5	71.6	-	-	82.0	95.0	83.0	86.7	0.3	n.s.
22.	мх 270-28	77.3	67.0	71.0	71.8	-	n.s.	88.0	87.0	94.0	89.7	3.3	n.s.
23.	мх 270-50	72.9	62.5	67.1	67.5	-	---	83.0	85.0	90.0	86.0	-0.3	n.s.
24.	мх 270 -86	72.2	60.7	63.4	65.4	-	---	85.0	85.0	92.0	87.3	1.0	n.s.
25.	Saschez	78.9	66.9	70.0	71.9	-	n.s.	82.0	98.0	96.0	92.0	5.7	n.s.
26.	мх 260-1175	80.0	67.4	73.2	73.5	-	n.s.	78.0	90.0	90.0	86.0	-0.3	n.s.
27.	Ayilzla	83.2	69.6	71.0	74.6	-	n.s.	84.0	104.0	100.0	96.0	9.7	n.s.
28.	ру 48-2553	82.6	64.5	68.9	72.0	-	n.s.	68.0	80.0	86.0	78.0	-8.3	n.s.
29.	ру 49-2300	80.2	64.1	68.6	71.0	-	n.s.	82.0	93.0	92.0	89.0	2.7	n.s.
30.	мх 258-3355	81.4	66.9	69.6	72.6	-	n.s.	65.0	85.0	82.0	77.3	-9.0	n.s.
31.	мх 274-711	80.7	58.4	63.4	67.5	-	---	75.0	83.0	82.0	80.0	-6.3	n.s.
32.	Sadovo 1	83.3	70.9	70.7	75.0	0.2	n.s.	90.0	100.0	90.0	93.3	7.0	n.s.
33.	Enola	82.0	70.3	71.3	74.5	-	n.s.	75.0	76.0	87.0	79.3	-7.0	n.s.
Mean for Standarts		82.7	70.6	71.0	74.8			82.5	88.0	88.5	80.1		
mean		79.4	66.2	69.1	71.6			83.0	87.6	87.2	85.9		
Min		72.2	58.4	63.4	65.4			65.0	70.0	74.0	74.3		
Max		84.3	71.5	75.9	75.9			108.0	115.0	100.0	104.3		
GD		GD5.0%=3.0 GD1.0%=4.0 GD0.1%=5.3						GD5.0%=11.4 GD1.0%=15.1					

The highest test weight are expressed by MX 286/1759, MX 274/717 and MX 286/1777, but the differences to the standard Sadovo 1 are insignificant. The highest values of this indicator were determined in 2017 whereas the ones for 2018 are the lowest (Table 2).

Plant height is a major feature of breeding, which is crucial for the logging resistance, especially at higher fertilization levels. The average value for the period is 85.9 cm and they are in the range 74.3 for MX 298/2622 and 104.3 cm 7621 x D 612-4-2p, ie the deviations are from -11.6 to 18.4 cm. The highest plants were formed in 2018 - 70-115.0 cm. It should be noted that the highest values were measured at crosses with durum wheat. According to this criterion, a selection was made and plants of smaller height were selected.

For the region of Sadovo, south Bulgaria, the analysis of variance revealed that grain yield, 1000 grains weight and test weight were most strongly influenced by environmental conditions (Table 3).

Table 2. Effect of sources of variation on yield, 1000 kernel weight, test weight, and plant hight of winter common wheat lines for the period 2017-2019 (ANOVA)

Productivity Elements	Sources of variation	SS	df	MS	F exp.	F tab.	ŋ
Yield	Genotype -A	354121.1	32	11066.2	1.9*	1.6	22.0
	Enviromental condition,	875273.8	2	437636	73.7***	7.7	54.4
	Error	380148.9	64	5939.8			23.6
	Total	1609543.	98				100
1000 kernel weight	Genotype -A	1116.3	32	34.9	4.4***	2.5	36.8
	Enviromental condition,	1410.9	2	705.5	89.2***	7.7	46.5
	Error	506.4	64	7.9			16.7
	Total	3033.0	98				100
Test weight	Genotype -A	544.4	32	17.0	4.9***	2.5	13.8
	Enviromental condition,	3176.3	2	1588.2	456.6***	7.7	80.5
	Error	222.6	64	3.5			5.6
	Total	3943.3	98				100
Plant height	Genotype -A	5865.2	32	183.3	3.8***	2.5	62.3
	Enviromental condition,	426.5	2	213.2	4.4*	3.1	4.5
	Error	3122.0	64	48.8			33.2
	Total	9413.7	98				100

SS - sum of squares; gf - degrees of freedom; MS variant; F exp. - F experienced; F tab. - F is tabular; ŋ - force of influence of the factor (%); *, **, *** - proved respectively at p <0.05, p <0.01, p <0.001, n.s.- not proven

Table 3. Correlation coefficients between the investigated indicators

Indicators	Yield	1000 kernel weight	Test weight	Plant hight
Yield	1			
1000 kernel weight	0.037	1		
Test weight	0.316	0.171	1	
Plant height	-0.325	0.491**	0.091	1

**Correlation is proven at significance level α = 0.01

On the basis of the correlation analysis, a positive, medium-strength relationship (Connection) between plant height and 1000 kernel weight was found during the study period (Table.3). Correlations between yield and other indicators have not been proven.

In other studies, carried out by us, for the period 2005-2009, it was also found that meteorological conditions had a greater influence than genotype (Rachovska et al., 2011). Other authors report that as a result of their studies in northern Bulgaria, it was found that meteorological conditions over the years have been decisive for both indicators plant height and test weight. (Nankova and Penchev, 2006; Penchev and Popova, 2005).

It is therefore worth further testing and studying the response of varieties under different environmental conditions. For breeding of modern varieties, it is extremely important to have a low and non -logging stem and at the same time to have the biomass at the level of the old varieties (Tsenov and Tsenova, 2004).

Plant height is significantly influenced by genotype. By studies of other winter common wheat lines was found that the height of the plants was most influenced by the environment (53.4%), followed by the genotype (28.6%) (Dimitrov, 2017).

CONCLUSIONS

The highest values were reported at MX 258/3355 - 672 kg/da, Ayilzla - 655.2 kg/da and MX 286/1777 - 633.9 kg/da and differences against the standard were statistically proven.

Analysis of variance revealed that yields, 1000 grains weight, and test weight were most strongly influenced by environmental conditions. Plant height is significantly influenced by genotype.

A positive, medium-strength relationship (connection) between plant height and 1000 kernel weight was found during the study period. Correlation between yield and other indicators have not been proven.

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