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RESEARCHES CONCERNING THE INFLUENCE OF THE MAIZE HYBRID MATURITY AND THE IRRIGATION REGIME ON THE THOUSAND KERNEL WEIGHT AND HECTOLITER MASS

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Abstract

The scientific data presented in this paper were obtained in an experiment unfolded in 2017, 2018 and 2019 at ARDS Marculesti, Călărași County, Romania. The experiment was set up using the two-factor subdivided plot method, the A-factor was the corn hybrid and B factor-irrigation regime. The subdivisions of A factor have been: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO (FAO 480). The subdivisions of B factor have been: b1 - rainfed; b2 - stressed at and after flowering: b3 - stressed before flowering and b4 - full irrigated throughout the vegetation period. The highest hectoliter mass values, as average, were obtained by the Bellavista hybrid and the lowest by the P9175 hybrid. As regard HLM, no significant values between irrigation treatments were recorded. The lowest TKW values were recorded in the Bellavista and Smaragd hybrids. The mass of one thousand grains registered very significantly positive differences between rainfed and irrigated, with very large amplitudes, close to 100 g.

Key words*: the thousand kernel weight (TKW), the hectoliter mass (HLM), corn hybrids, irrigation regimes.*

INTRODUCTION

Nowadays global warming has become an obvious, perceptible phenomenon. The global average soil surface temperature of 2022 year has recorded a 0.79^{0}C increase as compared to the last century. Moreover, the soil surface average temperature in 2022 was 0.24^{0}C higher than the last decade (1991-2020) (Figure 1).

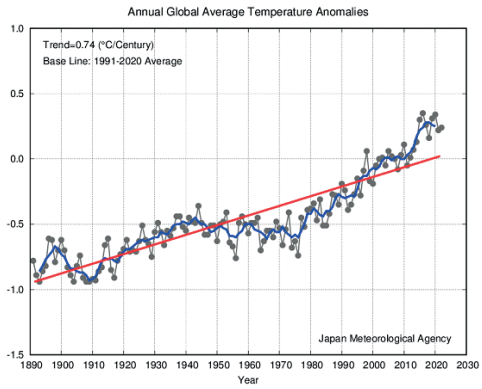

Figure 1. The soil global surface average temperatures since meteorological data have been taken (1890). Source: https://ds.data.jma.go.jp/tcc/tcc/products/gwp/temp/ann_wld.html

However, some researchers are of the opinion that the increase in the amount of carbon dioxide in the atmosphere is generated, to a greater extent, by natural phenomena, such as volcanic eruptions and the breathing of living things, and its fixation from the atmosphere can be efficiently produced by the absorption of ocean water and through more active photosynthesis. The effects of warming the Earth's atmosphere through the greenhouse effect are diverse and include increasing the number and intensity of extreme weather events such as storms and hurricanes, extreme drought, floods, etc. As the meteorological data show, in our country and in Europe, the warmest years were recorded in the last 20 years and the amplitude between very rainy and very dry years became much larger also in this time interval (Jaehyuk and Nazif, (2016). Other significant effects are the already felt water crisis, the decrease in ecological diversity, increased pest attack and the migration of human populations.

Modern agricultural technologies must take these changes into account. This can be done through two main directions: the creation of

new corn hybrids, better adapted to the new climatic conditions and the improvement of technological measures related to soil tillage, plant density, weed, disease and pest control, fertilization, etc. (Campos et al., 2004; Duvick, 2005; Food and Agriculture Organization of the United Nations (FAO), FAO Statistical Databases, 2013; Löffler et al., 2005; Marin, 2004; Marin et al., 2008; Marin et al., 2015; Tardieu, 2012),

MATERIALS AND METHODS

The hectolitre mass (HLM) and the weight of a thousand grains (WTG) are defined as the ability of the grain to be able to form powder; this is also referred to as flour efficiency of the grain. These qualitative factors are the determinant of the economic value of grains as well as the packaging properties (Oniya et al., 2019).

Unfavorable climatic conditions, such as drought or heavy rainfall, the attack of diseases and pests can lead to a high percentage of chaff and a low content of flour. Therefore, the mass of one thousand grains and the hectoliter mass are very important economic and qualitative properties. The intrinsic features of maize hybrid are, also, important in this respect. Maize with low HLM often has a lower percentage of hard endosperm and consequently, produces a lower yield of prime, large grits when milled indicating that HLM can indeed be used as a quality indicator of maize (Engelbrecht, 2008).

Evaluation of maize quality is generally limited to visual inspection and laboratory milling tests (Watson, 1987, cited by Engelbrecht, 2008). Visual tests include inspection of the kernels for blemishes and insect damage. The hardness of maize kernels is also determined because of its importance during the maize milling process as it determines the milling performance (Engelbrecht, 2008). The way we have measured these units are presented in the current article.

The results regarding the mass of one thousand grains and the hectoliter mass presented in this article come from an experiment carried out at Agricultural Research and Development Station of Marculesti, Calarasi County, Romania, in 2017, 2018 and 2019 years. This experiment has had 2 factors, the factor A - maize hybrid and the factor B - irrigation regime. The setting up method was randomized blocks, with three replications. The investigated hybrids (factor A) were: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480). The B factor (irrigation regime and period) had 4 graduations, namely: b1-rainfed; b2-stressed at and after flowering; b3-stressed before flowering and b4-full irrigated throughout the vegetation period. The irrigation method was drip to drip and there were automatic sensors to determine the actual soil moisture. Sowing and harvesting were done mechanically using the seed drilling machine and BAURAL SP2100 combine harvester (Figure 2). The production obtained on each experimental plot, the humidity of the grains at harvesting and the hectoliter mass were determined automatically with the equipment installed on the combine.

Figure 2. The Baural SP 2100 combine harvester for experiments

The mass of a thousand grains was determined using a photocell device for counting, along with a precision balance. Along with these determinations, measurements were made on the height of the cob's insertion, the height of the plant, the number of rows per cob, the number of kernels per row as well as the yield. The statistical interpretation was made by variance analysis.

RESULTS AND DISCUSSIONS

The climatic conditions of the experimental years, 2017, 2018 and 2019, as well as the 30 years average are presented in Figures 3, 4, 5 and 6.

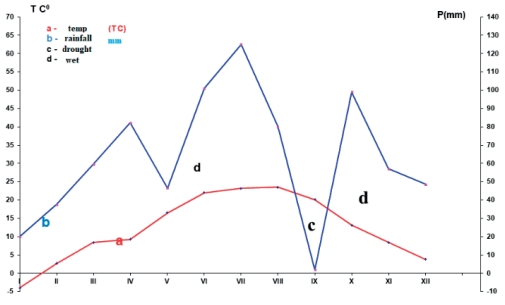

Figure 3. Climatic conditions of 2017 year at ARDS Marculesti by Walter Lieth climograme

From these data, it can be seen that 2017 was a year with average monthly temperatures close to the thirty years average but with very abundant precipitation in the summer months, June, July and August. In September, only 2 mm of precipitation was recorded, but this did not affect the maize production. Also, in May, 25 mm were recorded, compared to 45 mm, which is the thirty years average, something that determined the phenomenon of drought in the first growth phases of maize.

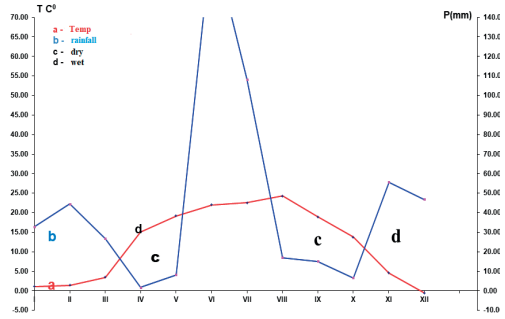

Figure 4. Climatic conditions of 2018 year at ARDS Marculesti by Walter - Lieth climograme

The year of 2018 recorded a very dry period in the spring months and May, with extremely low rainfall amounts of only 10 mm in two months, April and May. This greatly affected germination and growth in the early stages of maize growth. The situation changed dramatically in the summer months of June and July, when there were recorded rainfall of 180 mm, in June and 108 mm in July. The abundant rainfall from this activity favored the growth and development of maize plants in optimal conditions. The months of August and September were dry but this did not affect the maize production.

Temperatures recorded in 2018 were generally lower than the thirty years average in June and July due to the extremely heavy rainfall recorded. These climatic conditions led to very good pollen viability and fertility in maize.

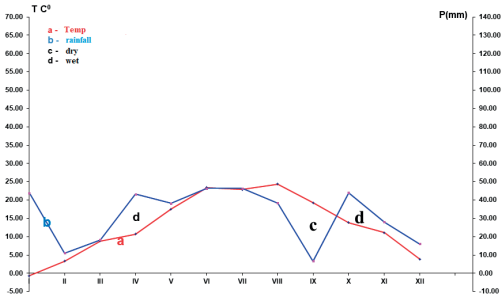

Figure 5. Climatic conditions of 2019 year at ARDS Marculesti by Walter - Lieth climograme

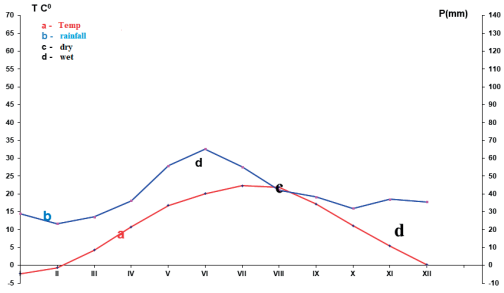

Figure 6. Climatic conditions of 30 years average from ARDS Marculesti, Walter - Lieth climograme

The year 2019 recorded average monthly values close to the thirty years average values, namely 10.7^{0}C in April, 17.8^{0}C in May, and 23^{0}C in June and July. Rainfall, however, was lower than the thirty years average and did not ensure optimal growth of corn plants. Thus, in May there were 30.2 mm compared to the 55.8 mm of thirty years average, 46.4 mm in June, compared to the 65.2 mm of thirty years average and 46.4 mm in July, compared to 55, 1 mm of thirty years average.

a. Hectoliter mass results

Hectoliter mass determination is believed to have been performed as earlyas the 17th or 18th centuries and to be of British origin (Greenaway et al., 1977, cited by Engelbrecht

Mandy, 2008). The first reported HLM determination was, however, performed in 1858 and the result was used as a grading factor for spring wheat in Milwaukee, Wisconsin (Phillip et al., 1936, cited by Engelbrecht, 2008). The Chicago Board of Trade adopted this measurement as a grading factor for spring wheat in 1859 (Phillip et al., 1936, cited by Engelbrecht, 2008). However, little is known about the design of early HLM devices or the procedure used to perform the tests (Engelbrecht Mandy, 2008). Hectoliter mass as a quality indicator for maize has not been proven very useful (Dorsey-Redding et al., 1991, cited by Engelbrecht, 2008). However, it has been shown that maize with low HLM has lower percentage of hard endosperm and therefore produces lower yield when milled (Rutledge, 1978, cited by Engelbrecht, 2008); thus HLM can be useful as an indicator of milling yield of maize (Engelbrecht, 2008).

The hectoliter mass data for 2017, 2018 and 2019 years are presented in Tables 1, 2 and 3.

From the hectolitre mass data, in 2017 year, it can be seen that the highest values of this character were recorded with the Bellavista hybrid and the lowest with the Kashmir hybrid (Table 1).

It is, also, observed that the rainfed and irrigated variants after flowering gave higher hectoliter masses than those irrigated before flowering and irrigated throughout the vegetation period, with very significantly positive differences (Table 1).

Other scientists have been had same results as we have been reported. This way, the nitrogen rate as well as the irrigation regime has influenced the mass of a thousand grains as well as the hectoliter mas in a way which means that the more nitrogen is applied and more water, the loose is the mass of a thousand grains. The hectoliter mass decreases with the increasing of the nitrogen rate and the amount of water applied by irrigation (Sapucay et al., 2020). Moreover the maize hybrid has been influencing the maize grain mass and bulk. This way, we have gained that several hybrids that have been researched have shown differential mass of a thousand grains as well as the hectoliter mass.

Table 1. The HLM values in function of corn hybrid and irrigation regime in 2017 at ARDS Marculesti

Hybrid	b1 - rainfed				b2 - stressed before flowering				b3- stressed after flowering			
	HLM. kg/hl	%	Dif. kg/hl	Sign.	HLM. kg/hl	%	Dif. kg/hl	Sign.	HLM. kg/hl	%	Dif. kg/hl	Sign.
a1	81.90	100	Ct		79.43	100	Ct		81.88	100	Ct	
a2	85.40	104	3.46	***	85.09	107	5.66	***	85.22	104	3.33	***
a3	80.00	97	-1.95	00	78.80	99	-0.63		80.00	97	-1.89	00
a4	79.43	96	-2.52	000	78.67	99	-0.75		78.74	96	-3.14	000
a5	82.3	100	0.38		82.32	103	2.89	***	82.64	100	0.75	
LSD 5% =1.19; LSD 1% = 1.61; LSD 0.1% =2.13												

Hybrid	b4 - full irrigated				Average of irrigation regimes				
	HLM. kg/hl	%	Dif. kg/hl	Sign.	Irrigation regimes	HLM. kg/hl	%	Dif. kg/ha	Sign.
a1	79.68	100	Ct		Rainfed	81.82	100	Ct	
a2	84.46	105	4.78	***	Stressed after flowering	80.86	99	-0.96	000
a3	78.80	98	-0.88		Stressed before flowering	81.69	100	0.13	
a4	78.42	98	-1.26	0	Full irrigated	80.63	99	-1.19	000
a5	81.76	102	2.08	**	LSD 5%=0.53; LSD 1%=0.72; LSD 0.1%=0.95				
LSD 5% =1.19; LSD 1% = 1.61; LSD 0.1% =2.13									

Legend: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480).

The data obtained in 2018 year show the hybrids with the highest hectoliter mass values were Bellavista and Smaragd. However, all other hybrids compared to the a1 control gave highly significant positive differences (75.06 and 76.00 versus 73.14) (Table 2).

As regard the researched irrigation regimes, the highest values were also given by irrigation before flowering and irrigation throughout the maize vegetation period (Table 2).

The same trends are observed when we analyze the interaction of the two researched factors namely, the hybrid and the irrigation regime.

Table 2. The HLM values in function of corn hybrid and irrigation regime in 2018 at ARDS Marculesti

Hybrid	b1 - rainfed				b2 - stressed before flowering				b3- stressed after flowering			
	HLM. kg/hl	%	Dif.. kg/hl	Sign.	HLM. kg/hl	%	Dif.. kg/hl	Sign.	HLM. kg/hl	%	Dif.. kg/hl	Sign.
a1	72.63	100	Ct		73.55	100	Ct		72.21	100	Ct	
a2	79.44	109	6.81	***	80.32	109	6.76	***	79.93	110	7.73	***
a3	74.74	102	2.11	**	76.59	104	3.03	***	75.50	104	3.29	***
a4	74.66	102	2.03	**	75.32	102	1.76	**	74.77	103	2.56	**
a5	77.31	106	4.67	***	77.39	105	3.84	***	77.91	107	5.70	***
LSD 5% = 1.49 kg/hl; LSD 1% = 2.01 kg/hl; LSD 0.1% = 2.67 kg/hl												

Hybrid	b4 - full irrigated				Average of irrigation regimes			
	HLM. kg/hl	%	Dif. kg/hl	Sign.	Irrigation regimes	HLM. kg/hl	%	Dif.. kg/ha	Sign.
a1	74.19	100	Ct		Rainfed	75.75	100	Ct	
a2	80.52	108	6.34	***	Stressed after flowering	76.63	101	0.88	*
a3	77.20	104	3.02	***	Stressed before flowering	76.06	100	0.31	
a4	75.55	101	1.37		full irrigated	77.10	102	1.35	***
a5	78.09	105	3.90	***	LSD 5%= 0.66 kg/hl; LSD 1%= 0.90 kg/hl; LSD 0.1%= 1.19 kg/hl				
LSD 5% = 1.49; LSD 1% = 2.01; LSD 0.1% = 2.67									

Legend: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480).

Unlike the previous two years, in 2019 the highest hectolitre mass values were obtained for the Smaragd hybrid, of 74.5 kg/hl and the lowest, for P9175, of 68.3 kg/hl. Almost all the hybrids compared with P9175 gave very significantly positive differences, except the Kashmir hybrid, in rainfed conditions, which gave a distinctly significant negative difference compared to the control P9175 (Table 3).

In 2019, the highest value of the hectoliter mass was obtained for rainfed treatment, of 73.33 kg/hl and the lowest, for irrigated throughout the vegetation period, of 71.67 kg/hl, the other irrigation regimes recording intermediate values. The differences between the irrigated and rainfed regimes, this year, were very significantly negative.

Table 3. The HLM values in function of corn hybrid and irrigation regime in 2019 at ARDS Marculesti

Hybrid	b1 - rainfed				b2 - stressed before flowering				b3- stressed after flowering			
	HLM. kg/hl	%	Dif. kg/hl	Sign.	HLM. kg/hl	%	Dif. kg/hl	Sign.	HLM. kg/hl	%	Dif. kg/hl	Sign.
a1	71.36	100	Ct		68.93	100	Ct		67.43	100	Ct	
a2	77.13	108	5.77	*	74.07	107	5.13	***	71.97	106	4.53	***
a3	75.20	105	3.83	***	73.60	106	4.67	***	73.46	108	6.03	***
a4	70.36	98	-1.00	00	71.96	104	3.03	***	73.23	108	5.80	***
a5	72.60	101	1.23	**	74.06	107	5.13	***	75.06	111	7.63	***
LSD 5% = 0.59 kg/hl; LSD 1% = 0.86 kg/hl; LSD 0.1% = 1.29 kg/hl												

Hybrid	b4 - full irrigated				Average of irrigation regimes				
	HLM. kg/hl	%	Dif. kg/hl	Sign.	Irrigation regimes	HLM. kg/hl	%	Dif. kg/ha	Sign.
a1	65.5	100	Ct		Rainfed	73.33	100	Ct	
a2	69.53	106	4.03	***	Stressed after flowering	72.52	99	-0.81	000
a3	71.56	109	6.07	***	Stressed before flowering	72.23	99	-1.1	000
a4	75.50	115	10.00	***	full irrigated	71.67	98	-1.66	000
a5	76.26	116	10.77	***	LSD 5%= 0.37 kg/hl; LSD 1%= 0.50 kg/hl; LSD 0.1%= 0.66 kg/hl				
LSD 5% = 0.59; LSD 1% = 0.86; LSD 0.1% = 1.29									

Legend: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480).

On average over the three years of experimentation, the highest hectoliter mass values were obtained by the Bellavista hybrid and the lowest by the P9175 hybrid. The differences between these two hybrids were distinctly significantly positive at all irrigation regimes. The other hybrids, compared with P9175, did not show significant differences, except for the Smaragd hybrid, when irrigated, which gave a distinctly significant positive difference compared to the control P9175.The highest hectoliter mass values were recorded in 2017 and the lowest in 2019. These values are inversely proportional to the mass of a thousand grains (Table 4).

Table 4. The HLM values in function of corn hybrid and irrigation regime as average over three years of experimentation, 2017, 2018 and 2019 at ARDS Marculesti

Hybrid	b1 - rainfed				b2 - stressed before flowering				b3- stressed after flowering			
	HLM. kg/hl	%	Dif. kg/hl	Sign.	HLM. kg/hl	%	Dif. kg/hl	Sign.	HLM. kg/hl	%	Dif. kg/hl	Sign.
a1	75.31	100	Ct		73.97	100	Ct		73.84	100	Ct	
a2	80.66	107	5.34	**	79.82	107	5.85	**	79.04	107	5.20	**
a3	76.64	101	1.33		76.33	103	2.36		76.32	103	2.48	
a4	74.81	99	-0.50		75.32	101	1.35		75.58	102	1.74	
a5	77.41	102	2.10		77.92	105	3.96	*	78.53	106	4.69	**
LSD 5% = 3.10 kg/hl; LSD 1% = 4.51 kg/hl; LSD 0.1% = 6.77 kg/hl												

Hybrid	b4 - full irrigated				Average of irrigation regimes			
	HLM. kg/hl	%	Dif. kg/hl	Sign.	Irrigation regimes	HLM. kg/hl	%	Dif. kg/ha	Sign.
a1	73.12	100	Ct		Rainfed	76.97	100	Ct	
a2	78.17	106	5.05	**	Stressed after flowering	76.67	99.61	-0.30	
a3	75.85	103	2.73		Stressed before flowering	76.66	99.59	-0.31	
a4	76.49	104	3.37	*	full irrigated	76.47	99.35	-0.50	
a5	78.70	107	5.58	**	LSD 5%= 1.11 kg/hl; LSD 1%= 1.50 kg/hl; LSD 0.1%= 1.98 kg/hl				
LSD 5% = 3.10; LSD 1% = 4.51; LSD 0.1% = 6.77									

Legend: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480).

b. Thousand kernel weight (TKW) results

Thousand kernel weight (TKW) is the average weight of a kernel, with a factor of 1,000 included to provide the necessary precision of the measurement (Hlynka & Bushuk, 1959, cited by Engelbrecht, 2008). Thousand kernel weight is a function of kernel size and density (Halverson & Zeleny, 1988, Dorsey-Redding et al., 1991, cited by Engelbrecht, 2008) and it gives the miller important information regarding the flour yield of wheat considering that large, dense kernels normally have higher ratio of endosperm to bran than smaller, less dense kernels (Halverson & Zeleny, 1988, cited by Engelbrecht, 2008) (Engelbrecht, 2008). The TKW data for 2017, 2018 and 2019 data are presented in the tables 5, 6 and 7. In 2017 year, the lowest TKW values were recorded by the Bellavista hybrid and the highest by the Kashmir hybrid. Irrigation at Management Allowable Depletion (MAD) point throughout the vegetation period or only in the two researched phenophases, were superior to the rainfed treatment in terms of the weight of a thousand grains; all these differences were very significantly positive (Table 5). In the same manner, within each hybrid, irrigation positively influenced the mass of a thousand grains. The interaction between hybrid and irrigation highlighted, through very significantly positive differences, the Kashmir hybrid and the irrigated treatment (Table 5).

Table 5. The TKW values in function of corn hybrid and irrigation regime in 2017 at ARDS Marculesti

Hybrid	b1 - rainfed				b2 - stressed before flowering				b3- stressed after flowering			
	TKW. g	%	Dif. g	Sign.	TKW. g	%	Dif. g	Sign.	TKW. g	%	Dif. g	Sign.
a1	269.3	100	Ct		284.67	100	Ct		316.67	100	Ct	
a2	245.6	91	-23.66	0	273.67	96	-11.00		295	93	-21.6	0
a3	280.6	104	11.34		296.33	104	11.66		309.67	97	-7.00	
a4	290.6	107	21.34	*	307.67	108	23.00	*	331	104	14.33	
a5	269.3	100	0.00		284.67	100	0.00		316.67	100	0.00	
LSD 5% =20.30; LSD 1% = 27.37; LSD 0.1% =36.32												

Hybrid	b4 – full irrigated				Average of irrigation regimes				
	TKW. g	%	Dif. g	Sign.	Irrigation regimes	TKW. g	%	Dif. g	Sign.
a1	337.33	100	Ct		Rainfed	272.73	100	Ct	
a2	335	99.30	-2.33		Stressed after flowering	292.06	107	19.33	***
a3	338.33	100.29	1.00		Stressed before flowering	313.46	115	40.73	***
a4	379.33	112.45	42.00	***	full irrigated	348.79	128	76.06	***
a5	337.33	100.00	0.00		LSD 5%=9.08; LSD 1%=12.24; LSD 0.1%=16.24				
LSD 5% =20.30; LSD 1% = 27.37; LSD 0.1% =36.32									

Legend: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480).

During the 2018 year, the highest values of a thousand kernel weight were recorded by the Durango, Kashmir and P 9175 hybrids. The Bellavista and Smaragd hybrids showed very significantly negative differences compared to the control P 9175 and the Durango hybrid showed a very significantly positive difference compared to control (Table 6).

The irrigation before flowering and throughout the vegetation period gave de highest results on TKW (Table 6).

Table 6. The TKW values in function of corn hybrid and irrigation regime in 2018 at ARDS Marculesti

Hybrid	b1 - rainfed				b2 - stressed before flowering				b3- stressed after flowering			
	TKW. g	%	Dif. g	Sign.	TKW. g	%	Dif. g	Sign.	TKW. g	%	Dif. g	Sign.
a1	338.90	100	Ct		367.70	100	Ct		336.02	100	Ct	
a2	308.07	90	-30.83	000	321.79	87.51	-45.92	000	304.34	90.57	-31.68	000
a3	361.29	106	22.39	***	373.53	101.58	5.83		365.84	108.87	29.82	***
a4	343.17	101	4.27		353.37	96.10	-14.33	00	335.85	99.94	-0.17	
a5	289.85	85	-49.05	000	298.91	81.29	-68.79	000	291.22	86.66	-44.80	000
LSD 5% = 9.14 g; LSD 1% = 12.32 g; LSD 0.1% = 16.36 g												

Hybrid	b4 - full irrigated				Average of irrigation regimes				
	TKW. g	%	Dif. g	Sign.	Irrigation regimes	TKW. g	%	Dif. g	Sign.
a1	376.96	100	Ct		Rainfed	327.40	100	Ct	
a2	324.23	86	-52.73	000	Stressed after flowering	345.92	105	18.52	***
a3	382.98	101	6.02		Stressed before flowering	326.68	100	-0.72	
a4	364.34	96	-12.62	00	full irrigated	352.56	107	25.16	***
a5	301.72	80	-75.24	000	LSD 5%= 4.08 g; LSD 1%= 5.51 g; LSD 0.1%= 7.31 g				
LSD 5% = 9.14 ; LSD 1% = 12.32; LSD 0.1% = 16.36									

Legend: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480).

The results recorded in 2019 highlighted the hybrid P9175, with a TKW of 318 g. The differences recorded compared to all other hybrids were significant and very significantly negative. The lowest value of TKW, this year was recorded for the hybrid Smaragd, of 258 g (Table 7).The researched irrigation regimes recorded increasing values, starting with the rainfed regime and ending with the irrigated one throughout the vegetation period.

The differences between all irrigated and rainfed regimes were very significantly positive (Table 7).

Table 7. The TKW values in function of corn hybrid and irrigation regime in 2019 at ARDS Marculesti

Hybrid	b1 - rainfed				b2 - stressed before flowering				b3- stressed after flowering			
	TKW. g	%	Dif. g	Sign.	TKW. g	%	Dif. g	Sign.	TKW. g	%	Dif. g	Sign.
a1	238.33	100	Ct		324	100	Ct		342.66	100	Ct	
a2	228.00	95	-10.3	000	262	80.86	-62.00	000	289.66	84	-53.00	000
a3	233.66	98	-4.67	0	278.33	85.90	-45.67	000	301.66	88	-41.00	000
a4	228.66	95	-9.67	000	279	86.11	-45.00	000	308.00	89	-34.67	000
a5	230.66	96	-7.67	00	255	78.70	-69.00	000	262.66	76	-80.00	000

LSD 5% = 4.39 g; LSD 1% = 6.39 g; LSD 0.1% = 9.59 g

Hybrid	b4 - full irrigated				Average of irrigation regimes				
	TKW. g	%	Dif. g	Sign.	Irrigation regimes	TKW. g	%	Dif. g	Sign.
a1	368.66	100	Ct		Rainfed	231.86	100	Ct	
a2	310.00	84	-58.67	000	Stressed after flowering	279.66	121	47.8	***
a3	342.66	92	-26.00	000	Stressed before flowering	300.93	130	69.07	***
a4	336.33	91	-32.33	000	full irrigated	329.00	142	97.14	***
a5	287.33	77	-81.33	000	LSD 5%= 3.72 g; LSD 1%= 5.02 g; LSD 0.1%= 6.67 g				

LSD 5% = 4.39 g; LSD 1% = 6.39 g; LSD 0.1% = 9.59 g

Legend: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480).

On average over the three years of experimentation, the lowest TKW values were recorded in the Bellavista and Smaragd hybrids, with values of 291 and 288 g, respectively. The highest values were obtained by the P9175 hybrid, of 325 g. The Kashmir and Durango hybrids recorded TKW values close to those of the P9175 hybrid, the differences being insignificant at all irrigation regimes. As for the differences between the P9175 hybrid and the two hybrids with the lowest values, they were significantly and distinctly significantly negative, with the exception of the rainfed irrigation regime (Table 8).

Regarding the TKW values recorded by the 5 hybrids tested in the three years, it can be noted that the highest values were recorded in 2018, when the highest yields were, also, obtained for all hybrids. The highest value was obtained by the Durango hybrid, in 2018, of 371 g and the lowest, by the Smaragd hybrid, in 2019, of 259 g, with an amplitude of the recorded values of over 100 g.

The irrigation regimes recorded increases in TKW, from rainfed to irrigated throughout the vegetation period, from 277 g to 343 g, with an amplitude, as average, of 66 g.

However, throughout these three years of the experimentation period, taking in comparison each year to each other, the highest amplitude were recorded in 2018, in rainfed, compared to 2019, of almost 100 g. This shows the favorable influence of the massive rainfall recorded in 2018 on TKW and, finally, on production.

Table 8. The TKW values in function of corn hybrid and irrigation regime as average over three years of experimentation, 2017, 2018 and 2019 at ARDS Marculesti

Hybrid	b1 - rainfed				b2 - stressed before flowering				b3- stressed after flowering			
	TKW. g	%	Dif. g	Sign	TKW. g	%	Dif. g	Sign	TKW. g	%	Dif. g	Sign
a1	282.18	100	Ct		325.45	100	Ct		331.78	100	Ct	
a2	260.57	92	-21.61		285.81	87	-9.64	0	296.33	89	-35.45	0
a3	291.87	103	9.69		316.06	97	-9.39		325.72	98	-6.06	
a4	286.07	101	3.89		318.12	97	-7.33		325.00	97	-6.78	
a5	265.94	94	-16.24		283.97	87	-1.49	0	289.62	87	-42.16	0
LSD 5% = 34.82 g; LSD 1% = 50.66 g; LSD 0.1% = 75.99 g												

Hybrid	b4 - full irrigated				Average of irrigation regimes				
	TKW. g	%	Dif. g	Sign.	Irrigation regimes	TKW. g	%	Dif. g	Sign.
a1	360.98	100	Ct		Rainfed	277.33	100	Ct	
a2	323.07	89	-37.91	00	Stressed after flowering	305.88	121	28.55	***
a3	354.65	98	-6.33		Stressed before flowering	313.69	130	36.36	***
a4	364.20	100	3.22		full irrigated	343.45	142	66.12	***
a5	314.34	87	-46.64	00	LSD 5%= 15.53 g; LSD 1%= 20.94 g; LSD 0.1%= 27.80 g				
LSD 5% = 34.82 g; LSD 1% = 50.66 g; LSD 0.1% = 75.99 g									

Legend: a1- P9175 (FAO 330), a2 - KWS BELLAVISTA (FAO 330), a3 - KWS SMARAGD (FAO 350), a4 - KWS KASHMIR (370 FAO) and a5 - KWS DURANGO 480).

CONCLUSIONS

Maize is the most cultivated plant in Romania, with areas that exceed 3 million hectares every year. Romania's maize production and export are among the 15 largest corn producers in the world. In this context, the creation of new hybrids, more adapted to the constantly changing climatic conditions, is a perpetual task.

The hectoliter mass (HLM) and the thousand kernel weight (TKW) are very important indicators of grain yield, respectively the ratio of chaff and flour. Also, these qualitative indicators of maize kernels influence the packaging for transport as well as storage.

Regarding the hectoliter mass, in 2017, the highest values were obtained by the Bellavista hybrid (85.04 kg/hl) and the lowest by the Kashmir hybrid (78.82 kg/hl). The rainfed treatment and the one irrigated after flowering gave higher hectoliter mass values (81.82 kg/hl and, respectively, 81.69 kg/hl) than irrigation before flowering and irrigation throughout the growing season (80.86 kg/hl and, respectively, 80.63 kg/hl) at half of the AWC (Available Water Capacity).

In 2018, the results regarding the hectoliter mass of maize kernels were similar to those obtained in 2017, both in terms of the cultivated hybrid and the irrigation regime.

Due to unfavorable climatic conditions, much lower hectoliter mass values were obtained in 2019 than in the previous two years. So, the highest hectoliter mass values were obtained for the Smaragd hybrid, of 74.5 kg/hl and the lowest, for P9175, of 68.3 kg/hl.

About HLM, on average over the three years of experimentation there can be concluded the following:

- the highest hectoliter mass values were obtained by the Bellavista hybrid and the lowest by the P9175 hybrid;
- there were no significant differences between irrigation regimes;
- the highest hectoliter mass values were recorded in 2017 and the lowest in 2019.

Regarding TKW, in 2017, the lowest values were recorded for the Bellavista hybrid (287.33 g) and the highest, for the Kashmir hybrid (327.16 g), i.e. the opposite to the hectoliter mass values.

Irrigation at Management Allowable Depletion (MAD) point throughout the vegetation period or only in the two researched phenophases, were superior to the rainfed treatment in terms of the weight of a thousand grains; all these differences were very significantly positive.

Due to the very favorable vegetation conditions, in 2018, different results were obtained compared to the other two years, 2017 and 2019, in the sense that the P 9175 hybrid, taken as a control, had intermediate values compared to the other 4 researched hybrids.

The irrigated treatments gave higher values compared to the rainfed treatment.

In 2019, the P 9175 hybrid stood out, with a value of 318 g. The lowest TKW was recorded for the Smaragd hybrid, of only 258 g. The differences between the irrigated and rainfed Treatments were very significantly positive.

About TKW, on average over the three years of experimentation there can be concluded the following:

- the highest TKW values were obtained by the P9175 hybrid, of 325 g and the lowest, by the Bellavista and Smaragd hybrids, with values of 291 and 288 g, respectively;
- the irrigation treatments gave very significant positive differences over the rainfed treatment;
- the highest average TKW values were obtained in 2018 due to very favorable vegetative conditions in terms of rainfall.

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