

VARIATION OF CURRENT MAIZE (*Zea mays* L.) COBS BY MORPHOLOGICAL CHARACTERS

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Abstract

Currently in obvious progress, studies on the variability of morphological characters, along with the biochemical and molecular ones, are considered very useful for the improvement of new maize hybrids. The rich genetic endowment and the cultivation conditions of the maize lead to the characteristic expression of the plant morphology. In case of maize, the hybrids SUM 405 and DKC 4590, some new directions have been found, which have recently been improved, by morphological characters. Thus, the cobs had an average length of 18 to 20 cm, the thickness was 4.5 to 4.7 cm and weighed 210 to 261 g. The number of grains on the cob was 544 to 612, weighed 179 to 222 g, and the one thousand grains was 325 to 361 g. Compared to the cobs it had 14 to 16 rows of grains, and the proportion in grains of the cobs was 85% in both hybrids. The grains of hybrids were 12 to 13 mm long, 8.7 to 8.2 mm wide and 4.4 to 4.6 mm thick. Between the analyzed characters of the cobs of the two hybrids, most positive correlations were obtained. The new hybrids, from the semi-late category (FAO 400), cultivated, have shown a good adaptability for a new and efficient agriculture.

Key words: cob, grains, maize, variability.

INTRODUCTION

With a long history, maize (*Zea mays* L.) is one of the most important crop plants (Tokatlidis & Koutroubas, 2004). At world level, as a surface, it occupies the place between wheat and rice. The content of grains in nutrients is diverse and specific (Winkel-Shirley, 2001), having a special importance in animal nutrition, in industry, as well as in the human diet (maize flour). Over time, the plant evolved through different characters (Fasoula & Fasoula, 2002; Doebley, 2004; Haş et al., 2008; Haş et al., 2010). Thus, maize is still considered an important organism model for future genetics and biology (Duvick & Cassman, 2009; Haş et al., 2011). The origin of the plant is lost in time (Wilkes, 2004; Roney, 2009), so that the beginning moment constituted a rustic species that produced small cobs, with a single grain of 25 mm in length. This cultivated plant interspersed with *Zea mays mexicana*, or *teosinte*, has evolved, and in time it has been possible to obtain several small cobs (a few centimeters) on a single plant. From the period

there are still three species of *Zea*, namely: *Z. mays* - common maize, *Z. diploperennis-teosinte* perennial form and *Z. mays mexicana-teosinte* annual form. Corn is expressed in the world both by maize- originating in maize (Spanish), and by corn, which in some parts means cereal culture, with expression and in a culinary context. Elsewhere corn was developed from Indian corn = maize, referring to flint multicolored corn, used for decorations (you know with different colored grains and sheets woven and hung). The diploid plant contains $2n = 2x (2 \times 10) = 20$ chromosomes, fixes carbon to the C4 type, and also has a higher efficiency of water recovery (Widdcombe & Thelen, 2002; Tolleaar et al., 2004; Troyer, 2006). Being an unisexual monoecious species, maize has female flowers grouped in a spike-like inflorescence (Sarca et al., 1990; Schnable et al., 2009), with a much thickened axis (spadix). The corn spikelet has a long stigma with role in capturing pollen grains, an ovary from which the specific grains, glume and paleo at the base develop (Ştefan, 2004). The mature cobs have lengths of 3- 50 cm and a diameter of 1.5-6 cm,

being cylindrical, cylindrical-conical or fusiform. Their weight is between 50 and 500 g, and formed 8-20 rows. Grain is a caryopsis with a great variability in shape, size and color (Osorno & Carena, 2008). The literature shows maize grains 2.5-22 mm long, 3-18 mm wide and 2.7-8 mm thick, and the mass of one thousand grains of 30-1200 g. The studied SUM 405 and DKC 4590 hybrids have relatively medium size, with red spadix and characteristic yellow grains. Both hybrids belong to the *Zea mays indentata* (Sturtey.) L.H. Bayley.

The researches carried out to observe the variation of certain characteristics of the corm cobs included: total length, diameter in the central portion, absolute weight, total number of grains, number of rows, weight of grains/ cobs, TGW-thousand grain weight, the percent of grains, length, width and thickness of grains.

MATERIALS AND METHODS

The variants have been cultivated in recent years with hybrids SUM 405 and DKC 4590, semilate (Osorno & Carena, 2008). These hybrids with high productive potential could express a certain degree of adaptability in the analyzed area. The experience was established according to the block method, with 25 m² variants in 4 repetitions (replicates). The technology used was that recommended by the resort (Farnham, 2001; Tokatlidis et al., 2005). At full maturity, 25 cobs were randomly selected from each replicates (in total 100), cut and brought to the laboratory. The 100 cobs were measured and determined: total length, thickness in central area, weight, total number of grains, number of rows, total weight of grains, mass of one thousand grains, grains percent, grain length, width grain size and grain thickness.

The morphological characters obtained were analyzed by the histograms (or frequency polygons, FP,%). In their expression were used the class intervals established according to the specific string of values obtained. The study carried out highlighted several aspects, namely: i) the modal values (with the highest frequencies), ii) the limits of the intervals of variability of the studied characters and iii) the specificity of each character of the maize ecotypes in the analyzed area. Between the analyzed characters, the correlations were

established, with the help of which we could also observe their tendencies within the studied ecotypes. The Excel program was used to express the values. The significance of the correlation coefficients was obtained by comparing with the max values (Erba Weber, 1961) for the 5%, 1% and 0.1% levels of the transgression probabilities.

In the statistical calculation of all the obtained values the analysis of variance (Anova test) was used on the ranges of variation. Statistical parameters were calculated using formulas: $\bar{a} = \Sigma x/n$, where \bar{a} = media of determinations, and x = values, S^2 (variance) = $1/(n-1) \cdot [\Sigma x^2 - (\Sigma x)^2/n]$, S (standard error) = $\sqrt{S^2}$ and $S\%$ (variation coefficient) = $s \cdot \bar{a}^{-1} \cdot 100$.

RESULTS AND DISCUSSIONS

Variability of maize cobs. The appearance and dimensions of these corn hybrids are characteristic (Haş et al., 2008; Haş et al., 2010). Thus, their length was between 9 and 25 cm in hybrid 405 and between 17.1 and 23 cm in hybrid 4590. The lengths of 17-19 cm (37%) in 405 and those of 19-21 cm in 4590 (63%) were dominated (Figure 1). The sampling close in length were those of 19-21 cm (28%) in hybrid 405 and those of 21-23 cm (21%) in hybrid 4590. In the case of hybrid 4590 the longest samplings (25 cm) as well as those shorter (10-13 cm) made up 1% of the total. In the case of the lengths of these hybrids, there is a greater fluctuation of variability in the case of SUM 405 hybrid and much more restricted in the case of DKC 4590 hybrid, possibly due to the specific culture conditions.

The thickness of the cobs in the central portion was relatively wide (Figure 2). There were between 4.1 and 5.0 cm in hybrid 405 and between 4.2 and 5.2 cm in hybrid 4590. They dominated the specimens with thicknesses of 4.5 cm (23%) in the case of the first hybrid and 4.7 cm (23%) in the case of the second hybrid. They followed the specimens with a thickness of 4.4 cm (17%) and 4.6 cm (14%) at SUM 405 and those with 4.8 cm (20%) at DKC 4590. Smaller and larger thickness generally constituted 1%, with 5% exception for thinner cobs in the 405 hybrid. The adaptability and the culture conditions showed significant differentiations between the two hybrids (Figure 3 and Figure 4).

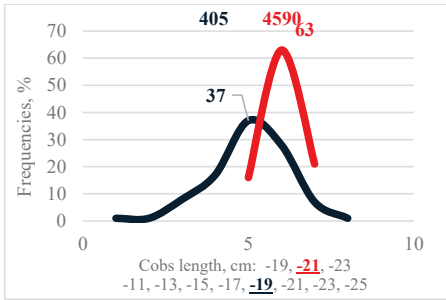


Figure 1. Frequencies of cob lengths

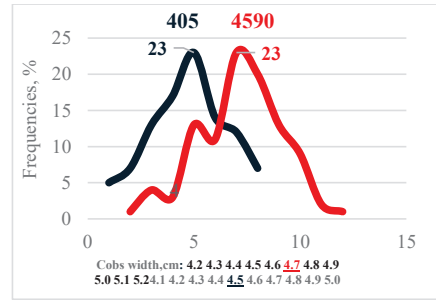


Figure 2. Frequencies of cob widths



Figure 3. SUM 405 hybrid



Figure 4. DKC 4590 hybrid

The weight of the cobs has experienced relatively wide variability. In the case of the 405 hybrid, values ranging from 120 to 320 g were determined. The 4590 hybrid had limits between 180 and 340 g. It was dominated the cobs with 180-200 g (19%) in 405 hybrid and those with 260-280 g (29%) in 4590 hybrid (Figure 5). Close values were obtained at weights of 220-240 g (17%) in the case of the first hybrid and 240-260 g (21%) in the case of second hybrid. Values of 300-320 g constituted

only 3% at SUM 405 and 340 g (1%) at DKC 4590.

The number of grains on a cob had greater variability at SUM 405. In this case, between 250 and 750 grains were determined, and the dominant ones were the cobs with 500-600 grains (23-22%). DKC 4590 formed grains as a number between 450 and 700. They dominated the cobs with 600-650 grains (45%) and were followed by those with 550-600 grains (28%) (Figure 6).

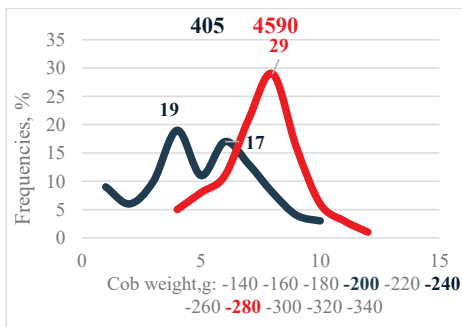


Figure 5. Frequencies of cob weights

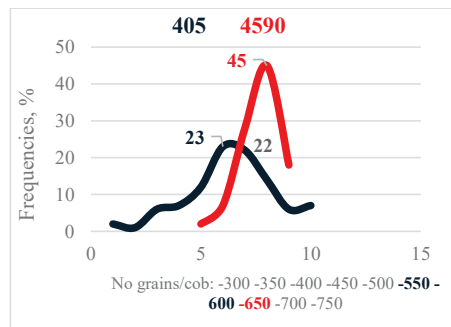


Figure 6. Frequencies of no. grains/cob

The weight of the grains on a cob was between 100 and 300 g on both hybrids. The modal value was 160-180 g (21%) in the SUM 405 hybrid.

The frequencies followed with 140- 160 g (16%) and those with 180-200 g (15%). In the case of the DKC 4590 hybrid, the modal value

was 220-224 g (36%). Close to it were the limits of 200-220 g (18%) and 240-260 g (17%). In the case of the SUM 405 hybrid, the maximum value from the 260-280 limit constituted only 1%. The DKC 4590 hybrid formed as a sample, only 2 cobs in total (2%) whose grain weights were within the maximum limit of 280-300 g (Figure 7).

The mass of one thousand grains (TGW) ranged between the limits of 200-220 g and 400-420 g in the hybrid 405 and between 260-280 g and

400-420 g in the hybrid 4590. However, the modal value were 300-320 g (28%) in the case of the SUM 405 hybrid and at 360-380 g (29%) in the DKC 4590 hybrid. The minimum values of TGW in the case of the 405 hybrid, in 4 intervals between 200 and 280 g represented only 1-2% (Figure 8). The maximum values for this hybrid were included in 4 other class intervals, between 280 and 360 g. the 4590 hybrid had the maximum grouping of TGW values between 340 and 420 g.

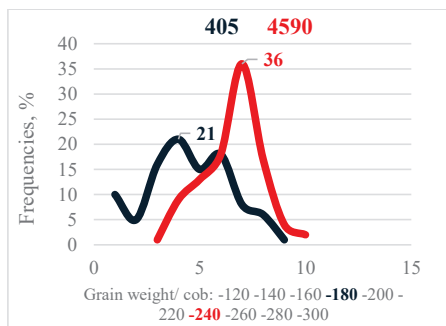


Figure 7. Frequencies of grains weight/cob

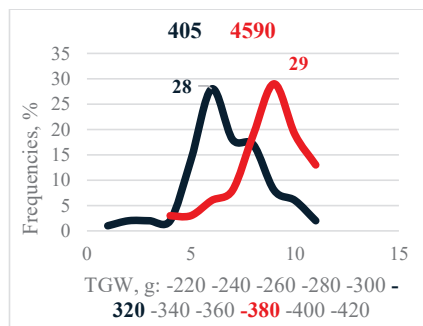


Figure 8. Frequencies of thousand grains weight

Variability of maize grains. Research has shown that both the cobs and the grains they form have a relatively high morphological diversity. From the data presented and in the case of hybrid SUM 405 and DKC 4590, the scientists had different and varied features, specific. And in case of grain morphology, some peculiarities have been found.

The degree of filling of the cobs with grains is characterized by special aspects (%). Both hybrids have proven very good coverage grades of grains on cobs. From the data it turned out that the percent ranged between 80 and 92% in the case of the SUM 405 hybrid and between 78 and 89 % in the DKC 4590 hybrid. The modal value was at 84-85% (20-24%) at 405 and 86% (31%) at 4590. The analyzed character proved quite wide limits (Figure 9), fact proven by the appearance of the proportion of the grains of the SUM 405 hybrid cobs (Figure 10). The cobs with the lowest grain percent, as well as those with the

highest ones, they made up only 1% of the total, on both hybrids.

Regarding the characteristics of the maize grains, determinations were made for length, width and thickness. The first character- the grain length, had values between 9 mm and 15 mm at the level of both hybrids. The hybrid 405 had the grain length between 9 and 14.5 mm, with the modal value at 11.5-12 mm (35%). The dimensions of 11-11.5 mm (15%) followed and those of 12-12.5 mm (15%) (Figure 11). Grains with shorter and larger lengths constituted 1-3%. The hybrid 4590 had grains between 11 and 15 mm in length. It dominated the range by 12.5-13 mm (29%).

The width of the grain was between equally wide limits, namely between 6.5 mm and 10 mm on both hybrids. The modal value was 8.9-9.1 mm (38%) in the hybrid 405. The grains of the 4590 hybrid had the modal value the width of 8-8.2 mm (35%). And with this character there is a great variability, with large oscillations between categories (Figure 12).

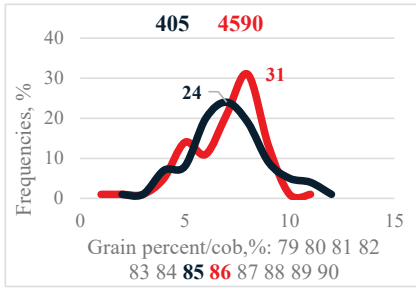


Figure 9. Frequencies of grain percent/cob



Figure 10. Hybrid SUM 405 grains aspect

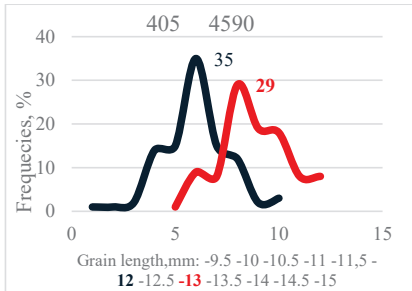


Figure 11. Frequencies of grains length

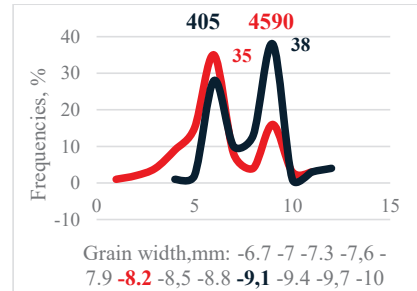


Figure 12. Frequencies of grains width

The third grain size, the thickness had values between 3.7 and 5.6 mm considering both hybrids. Thickness of 4.1-4.2 mm dominated, both in the case of SUM 405 hybrid (32%) and in the case of the DKC 4590 hybrid (22%). The grains with the smallest thicknesses were 1% at 405 and 5% at

4590, while the grains with the thickness of 5.3-5.4 mm were determined in the case of the first hybrid, and those with the thickness of 5.5-5.6 mm constituted 2% (Figure 13). Characteristic aspects of the grains were thus found in the case of the DKC 4590 hybrid (Figure 14).

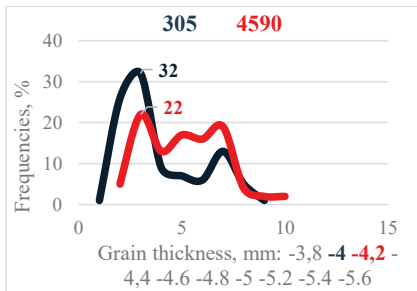


Figure 13. Frequencies of grains thickness



Figure 14. Hybrid DKC 4590 grains aspect

Correlations between the main characters. If we analyze the two sets of correlations between all the analyzed characters, we find both positive and negative situations (Haş et al., 2011). Very obvious positive correlations were observed between the characteristics of the cob: length, thickness, weight, all number of grains, total weight of grains, mass of one thousand grains

and size of grains (length, width, thickness). Negative correlations were observed between the grain percent of the cobs and the other characteristics of the cob. Also some negative correlations were observed between the grains thickness with some studied characters. The cause can be the condition of cultivation of these hybrids and of the climatic factor, both

determinants in the formation of the maize yields. Significant positive correlations were also found between the TGW with the other characters of the cobs (Table 1 and Table 2), which could demonstrate a high degree of adaptability to both maize hybrids in this area.

Statistical analysis of the variability of the morphological characters in maize. The results obtained in the morphological analysis of some maize characters showed specific aspects (Eberhart & Russel, 1966). Thus, the length of the cob measured 18.1 cm at SUM 405 and 20.1 cm at DKC 4590. The variability showed a slightly higher value at SUM 405 (13%). The width of the cob measured 4.48 cm on the first hybrid and 4.72 cm on the second hybrid, both with reduced variability, below 5%. The weight

of the cob ranged from 210 g (SUM 405) to 261 g (DKC 4590). The variation was large for the first hybrid (SUM 405 with 23%) (Table 3). The percent of grains was approximately equal, 85%, with reduced variability (2%). The grains consisted of 14-16 rows on the cobs. The average number of grains on the cob was 544 to SUM 405 compared to 612 to DKC 4590. The character variability was higher to the hybrid 405 (18%).

The weight of the grains from a cob ranged from 179 g to 222 g, the variability of the character was 22 to 12%. The absolute weight of the grains was 325 g at SUM 405 and 361 g at DKC 4590, with a slight variation (12%) (Table 4). SUM 405 had slightly longer grains, with smaller widths and more obvious thickness.

Table 1. Correlations between the main characters of maize cobs, SUM 405 hybrid

Character	Grain thickness, mm	Grain width, mm	Grain length, mm	% grains/cob	TGW, g	Grain weight, g	No.grains/cob	Grains weight, g	Cob width, cm	Cob length, cm
Cob length, cm	-0.77	.258	.539	-.376^a	.538	.881	.807	.883	.605	1
Cob width, cm	-0.60	.067	.597	-.345	.440	.812	.769	.816	1	
Cob weight, g	-1.00	.211	.702	-.396	.615	.996	.876	1		
No. grains/cob	-1.37	-.048	.517	-.265	.263	.879	1			
Grains weight, g	-1.04	.210	.703	-.317	.612	1				
TGW, g	.044	.460	.583	-.305	1					
% grains/cob	-0.28	-1.25	-.247	1						
Grain length, mm	-0.82	.361	1							
Grain width, mm	-0.47	1								
Grain thickness, mm	1									

DL 5 % = 0.19 DL 1 % = 0.25 DL 0.1 % = 0.32

Table 2. Correlations between the main characters of maize cobs, DKC 4590 hybrid

Character	Grain thickness, mm	Grain width, mm	Grain length, mm	% grains/cob	TGW, g	Grain weight, g	No.grains/cob	Grains weight, g	Cob width, cm	Cob length, cm
Cob length, cm	.137	.275	.308	-.020	.437	.637	.533	.638	.365	1
Cob width, cm	.292	-1.23	.684	-0.77	.656	.836	.596	.843	1	
Cob weight, g	.204	.053	.732	-.169	.827	.977	.613	1		
No. grains/cob	.146	-.283	.385	.259	.114	.669	1			
Grains weight, g	.180	.028	.736	.017	.813	1				
TGW, g	.127	.257	.656	-.173	1					
% grains/cob	.144	-1.38	.002	1						
Grain length, mm	.082	-2.37	1							
Grain width, mm	-0.91	1								
Grain thickness, mm	1									

DL 5 % = 0.19 DL 1 % = 0.25 DL 0.1 % = 0.32

Table 3. Statistical indices of maize cobs

Indices	Cob length, cm	Cob thick, cm	Cob weight, g	% grains/cob	No. rows/ cob
SUM 405					
Mean, \bar{a}	18.11	4.48	210.25	85.08	14.8
Variance, s^2	5.672	0.049	2360.1	3.809	1.778
Std. error, s	2.382	0.222	48.581	1.952	1.333
Var. coef., s%	13.15	4.95	23.11	2.29	9.01
DKC 4590					
Mean, \bar{a}	20.14	4.72	261.15	84.86	16.8
Variance, s^2	1.309	0.038	1102.7	3.119	1.707
Std. error, s	1.144	0.196	33.206	1.766	1.307
Var. coef., s%	5.68	4.15	12.72	2.08	7.77

Table 4. Statistical indices of maize grains

Indices	No. grains/cob	Grains weight, g	TGW, g	Grain length, mm	Grain width, mm	Grain thick, mm
SUM 405						
Mean, \bar{a}	544.2	178.51	324.55	11.86	8.67	4.35
Variance, s^2	9414.7	1608.4	1536.6	0.687	0.260	0.150
Std. error s	97.029	40.105	39.199	0.829	0.510	0.387
Var. coef., %	17.83	22.47	12.08	6.99	5.88	8.90
DKC 4590						
Mean, \bar{a}	611.6	221.83	361.43	13.26	8.19	4.57
Variance, s^2	1546.7	786.65	1898.7	0.695	0.166	0.142
Std. error s	39.328	28.047	43.574	0.834	0.408	0.376
Var. coef., %	6.43	12.64	12.06	6.29	4.98	8.23

CONCLUSIONS

The morphological characteristics of the corn stalks were specific to the analyzed hybrids. Thus, the average length of the cob was in order of SUM 405- DKC 4590 from 18 to 20 cm, the thickness in the middle portion was 4.48 to 4.72 cm. The cobs weighted 210 g to 261 g, formed 544 to 612 grains, on 14-16 rows. The grains weighted 179 to 222 g and had a mass of one thousand grains from 325 to 361 g. the corn kernels were 12-13 mm long, 8.7-8.2 mm wide and 4.4-4.6 mm thick.

Simple correlations were established between all the studied characters, with some differentiations. Thus, between the characters of the cobs the

correlations were generally positive and significant, in both hybrids. Negative correlations were observed between the grains percent of the cobs with all the other characters, more evident in the hybrid SUM 405. By highlighting the characters of the two hybrids, they demonstrate the important productive possibilities that they have demonstrated in this area of culture.

The statistical indicators studied have shown two maize hybrids that form medium to big sized cobs, with many grains and with a mass of one thousand grains of 325 (SUM 405) and 361 g (DKC 4590). The grains specific to the var. indented, had the length, the width and the thickness to relatively close values.

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