

Researches on Some Biological and Ecological Characteristics of Sweet Corn

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BulletinUASVM Horticulture 76(1) / 2019

Print ISSN 1843-5254, Electronic ISSN 1843-5394

DOI:10.15835/buasvmcn-hort: 2018.0023

Abstract

Lately, genetic factor involvement in climate change response is of great importance. Addressing some issues regarding the behavior of agronomic characters of production in a set of hybrids may lead to recommendations on the choice of the most suitable hybrids for growing in Transylvanian Plateau. Thus, in 2016, we set up an experience in two locations of Cluj county, Turda and Vișoara, on the lower terrace of Arieș river. Biological material chosen for this study was represented by seven hybrids, of which six indigenous Prima, Estival, Estival M, Dulcin, Deliciul Verii (released by SCDA Turda), Delicios (INCDA Fundulea) and foreign hybrid Jubilee (produced by Syngenta). The earliest hybrids Prima and Estival, have the lowest average number of grains/row, with very significant differences compared to control (experience average). Estival, Estival M and Jubilee hybrids show the highest number of rows of grains/cobs, with very significant differences over the average.

Keywords: sweet corn, row number, grain number, plant height

Introduction

In the U.S. and Canada, sweet corn is considered to be a symbol of summer, being one of the most popular 'vegetables'. In some regions of the two countries, even festivals are celebrated, where new achievements in the field of amelioration and new food dishes are presented (Haș, 2004). For example, in the US, maize occupies an important place on the vegetable market, ranking second as value for processing, and fourth for fresh consumption (Muhammad and Syed, 1999).

Sweet corn is a stenothermal plant that undergoes limited temperature variations requiring adequate levels of humidity (Apahidean and Apahidean, 2016). Together with the genetic factor and crop technology, strict adherence to specific requirements regarding climate and soil, are decisive factors in obtaining quality and

profitable sweet corn crops. The involvement of genetic factors in response to climate change equation, is of great importance nowadays. Sweet corn quickly loses its taste qualities, due to the intense process of transformation of sugars into starch if technical maturity is exceeded and because of high water loss. Due to the fact that sweet corn is often sold as cobs, many attributes that are of lesser importance to other types of corn are particularly important for sweet corn. Thus, cob characters as number of grains/row, length of corn cobs, corn cob covering, cob shape, the width and depth of the grain, row configuration and cob weight, have become objectives for breeding.

Lately, there has been an increase in cultivated areas with this crop in less specific areas of Transylvania (lower thermal potential, high temperature oscillations). Growing hybrids

Table 1. Variance analysis regarding plant height (cm) in seven sweet corn hybrids (Turda and Viișoara 2016-2017)

Variation of source	SS	DF	s ²	F
Year(Y)	24651.44	1	24651.44	924.84***
Location (L)	13860.01	1	13860.01	316.62***
Y × L	56.68	1	56.77	1.30
Hybrid (H)	26401.80	6	4400.30	136.91***
Y × H	945.98	6	157.66	4.95***
L × H	337.07	6	56.18	1.74
A × L × H	288.40	6	48.07	1.50
Error Y	53.31	2	26.66	
Error L	175.09	4	43.77	
Error H	1542.76	48	32.14	
TOTAL	68312.54	81		

adapted to these areas is an essential prerequisite for ensuring profitability of this crop, being closely correlated with the moment of exploiting cob production. Most of the sweet corn production is destined for fresh consumption, due to the fact that the canning industry in this sector is not well developed in our country.

Materials and Methods

In order to achieve the proposed objective regarding the behavior of sweet corn hybrids in Transylvanian Plain, an experience was set in two locations in Cluj County, Tuda and Viișoara, first locality being placed on the upper terrace of Arieș River and the second on lower terrace of the same river. Biological material for this experience was represented by seven sweet corn hybrids, including six local creations: Prima, Estival, Deliciul Verii, Dulcin, Estival M (SCDA Turda) and Delicios (INCDA Fundulea) and Jubilee produced by Syngenta. Experience was carried out over a two-year period, 2016 and 2017, and was based on randomized three-rectangular blocks, the area of the experimental plot being 5 m², using a 25 cm plant/row spacing corresponding to 57000 plants/ha. Cultivation technology was the same in both localities. Harvest date of corn cobs destined for biometric determinations was about 21 days after the appearance of silk, when it began to turn brown. Plant height was determined by measurement after the panicle was fully developed. Number of plants and corn cobs analyzed for each repetition was 10. Morphoproductive and morphological characters

analysed in seven sweet corn hybrids are: cob weight, number of grains/row, number of rows/cob and plant height. To complete this study, a number of chemical parameters of the grains were estimated with Tango-Nir Spectrophotometer, but at full maturity rather than at technical maturity.

Estimation of variances and the influence of experimental factors were made using the polyfactorial statistical model, of the type $a \times b \times c$: factor A represented by the year, factor B - the locality and factor C, the seven hybrids.

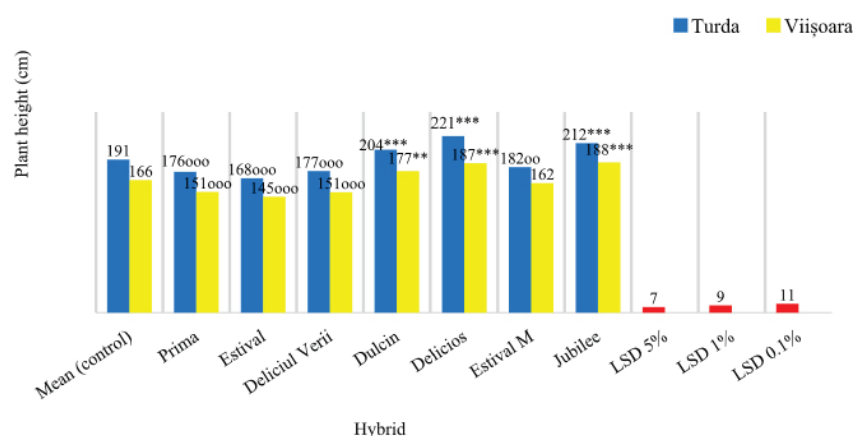
Results and Discussions

Morphoproductive and morphological traits are directly under the influence of pedoclimatic factors and implicitly contribute to the variation of productive potential of hybrids. Thus, it can be noticed that an important morphological attribute, plant height is very significantly affected by two climatic factors represented by the year and agroecosystems. Variance values, corresponding to the two factors, suggest their important role in controlling plant height, or more precisely in displaying the expressiveness of genes involved in controlling this character. In addition to the two ecological factors, the hereditary factor represented by genotype has a very significant importance in phenotypic variations of the plant height (Tab. 1). Among the factors interactions, it is worth mentioning the interaction between years and hybrids with a significant contribution to variation of this attribute, values of the F sample being very significant.

Table 2. Average plant height of seven sweet corn hybrids in the two localities and years (Turda and Viișoara 2016-2017)

Hybrid	Plant height (cm)	(%)	Diference	Significance
Average (control)	178	100	0,00	-
Prima	163	92	-15	000
Estival	156	88	-22	000
Deliciul Verii	164	92	-15	000
Dulcin	190	107	12	***
Delicios	204	114	26	***
Estival M	172	96	-7	00
Jubilee	200	112	21	***

LSD 5% = 5; LSD 1% = 6; LSD 0.1% = 8

**Figure 1.** Average height of plants in two locations and two years (Turda and Viișoara 2016-2017)

From data presented in Table 2, it can be noticed that there are important differences between the seven hybrids analyzed concerning average plant height. In this respect, in four of the seven hybrids, plant height records values lower than control (experience average), but with very significant or distinctly significant differences only in a single hybrid, Estival M. Dulcin, Delicios and Jubilee hybrids show superior values to control, with very significant differences, highest values being recorded for Delicious hybrid of 204 cm, exceeding control with 26 cm. All these data come to strengthen the direct relationship known between plant height and precocity. Garcia *et al.*, 2009, states that sweet corn plant height is also influenced by planting date.

All hybrids presented higher plant height in Turda as compared to Viișoara (Fig. 1), recording differences that in most cases exceeded 20 cm. Prima, Estival and Deliciul Verii hybrids, recorded the lowest vegetative growths regarding plant height, with very significant negative differences

compared to control in both agroecosystems. On the other hand, with a similar reaction in both locations, but in opposite direction regarding plant growth, there are the Dulcin, Delicios and Jubilee hybrids. Even though hybrids reacted differently in the two locations, the fact that they maintained same significance thresholds with exception of Estival M hybrid, suggests the pronounced heredity of this character.

Variance and sample F values, as well as its meanings, for an important component of corn cob, namely the number of grains/row, are shown in Table 3. From the s^2 value of 125.47 corresponding to the factor hybrid, it can be concluded that this component of grain production especially for processing, is strongly influenced by genotype. At the same time, the important role of environment is not neglected in the potentiation of this character; values of sample F indicating the very significant contribution of the year factor in realization of that attribute. Number of grains per row is not necessarily associated with the length of

Table 3. Variance analysis for the number of grains/row in seven sweet corn hybrids (Turda and Vișoara 2016-2017)

Variation of source	SS	DF	s ²	F
Year (Y)	86.01	1	86.01	138.94***
Location (L)	60.01	1	60.01	7.95*
Y × L	82.01	1	82.01	10.87*
Hybrid (H)	752.81	6	125.47	24.42***
Y × H	133.90	6	22.32	4.34***
L × H	142.57	6	23.76	4.62***
A × L × H	105.57	6	17.59	3.42***
Error Y	1.24	2	0.62	
Error L	30.19	4	7.55	
Error H	246.57	48	5.14	
TOTAL	1640.88	81	430.49	

Table 4. Average number of grains/row in seven sweet corn hybrids in two localities and years (Turda and Vișoara 2016-2017)

Hybrid	No. grains/row	(%)	Difference	Significance
Average (control)	37	100.0	0.00	-
Prima	33	89	-4	000
Estival	33	89	-4	000
Deliciul Verii	37	98	-	-
Dulcin	40	108	3	**
Delicios	39	104	2	-
Estival M	39	104	2	-
Jubilee	41	109	4	***

LSD 5% = 2; LSD 1% = 3; LSD 0.1% = 4

corn cobs because the shape and size of the grains differ according to genotype. However, these two characters are mostly in direct correlation. Also, the interactions between experimental factors (with one exception Y × L) show values of sample F, statistically assured as very significant (Tab. 3). Therefore, it can be said that this character is closely related to genotype with significant fluctuations from one year to the other.

Seven hybrids exhibit a fairly differentiated behavior of this important direct component of grain production and indirect of quality, regarding the commercial aspect of cobs (Tab. 4). Earliest hybrids Prima and Estival, record lowest average number of grains/row, with very significant negative differences reported to control. The most pronounced, but positive, differences are noted in Dulcin (distinctly significant positive) and in Jubilee hybrid (very significant positive). These two hybrids develop an average of three or four grains more on a row, compared to the other hybrids. Deliciul Verii, Delicios and Estival M, did not register statistical differences compared to control (Tab. 4).

Comparison between the average of these characters in Estival - trilinear hybrid and Estival

mother - simple hybrid (maternal form of Estival) reveals that in simple hybrids heterosis for this character is more pronounced.

Differentiated occurrence of number of grains/row (Fig. 2) in two agroecosystems reflects that in addition to the heredity factor pedoclimatic conditions also intervene in the fine tuning of the manifestation of this character. In most hybrids, average of this two-year trajectory records higher values in the conditions of Turda compared to Vișoara, except for Dulcin and Delicios hybrids. Thus, Dulcin hybrid forms the same average number of grains/row in two years, in both locations and hybrid Delicios reacted more favorably in conditions of Vișoara.

Of the seven hybrids, the highest performances of this feature belong to Jubilee hybrid, with very significant positive differences compared to average, but only under the conditions of Turda. Under the conditions of this agroecosystem, Prima and Estival hybrids present a lower number of grains/row, with distinctly significant negative or significant differences, while the other hybrids are not statistically assured. Under conditions of Vișoara, situation changes slightly, so the negative differences of Prima and Estival hybrids on average

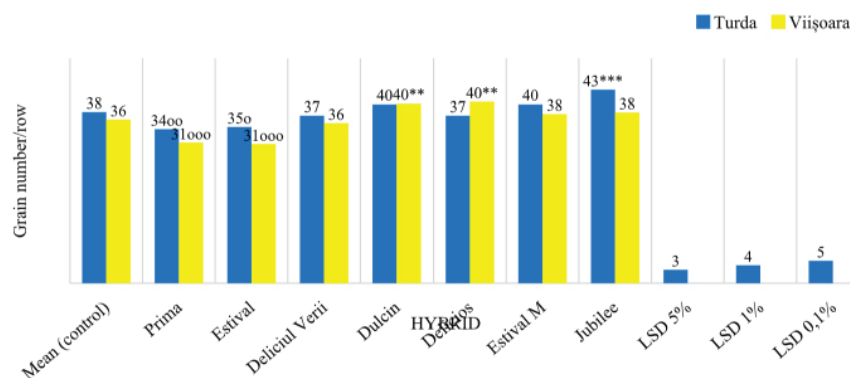


Figure 2. Average number of grains/row in two locations and two years (Turda and Vișoara, 2016-2017)

Table 5. Variability analysis for the number of rows of grains/cob in seven sweet corn hybrids (Turda and Vișoara 2016-2017)

Variation source	SS	DF	s ²	F
Year (Y)	8.68	1	8.68	11.57
Location (L)	2.01	1	2.01	15.34*
Y × L	2.68	1	2.68	20.46***
Hybrid (H)	273.83	6	45.63	59.29***
Y × H	4.40	6	0.73	0.95
L × H	3.07	6	0.51	0.67
A × L × H	3.74	6	0.62	0.81
Error Y	1.50	2	0.75	
Error L	0.52	4	0.13	
Error H	36.95	48	0.77	
TOTAL	337.38	81	62.51	

are accentuated, becoming very significant, and the performer Jubilee from Turda is replaced by two other hybrids, Dulcin and Delicieux, which record distinctly positive differences.

All these aspects reflect that the expressiveness of this character is closely related to the hereditary factor, but also to environment, which may intensify it one way or another, even under conditions with a similar microclimate. On this basis, it is possible to extrapolate complexity and other features of production, which ultimately converge to the biological potential of production and achievements of hybrids. In view of these considerations, we can recommend cultivation of a larger assortment of sweet corn (at least two hybrids) or even testing several hybrids on smaller surfaces, before making the final decision on choosing the hybrids. Thereby, the crop losses due to climatic differences, which are becoming more and more acute in similar micro-regions, may be limited to some extent.

Tracy in 1994, presented certain requirements regarding some morphological aspects of cobs destined for market sale or for boiling: grains

should cover a large percentage of the cobs, length of grain rows to be about 20-23 cm, a minimum number of at least 16 rows of grains/cob, deep grains and straight rows, and corn cobs well covered by husks. According to these statements, the biological material was also analyzed in terms of the number of grains/row.

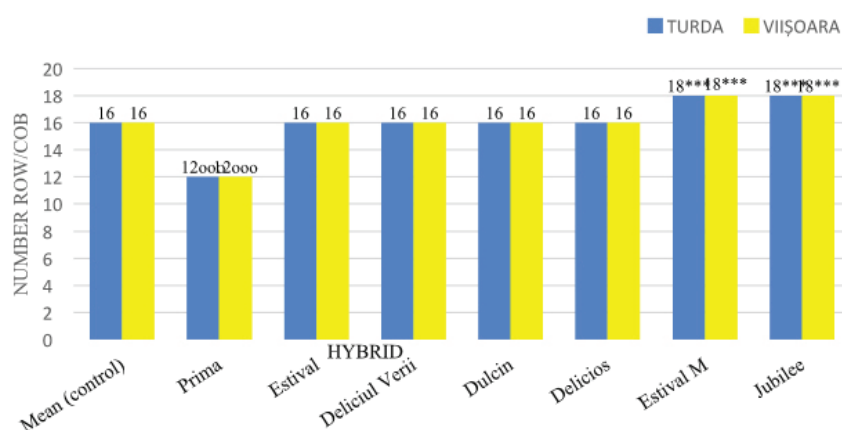
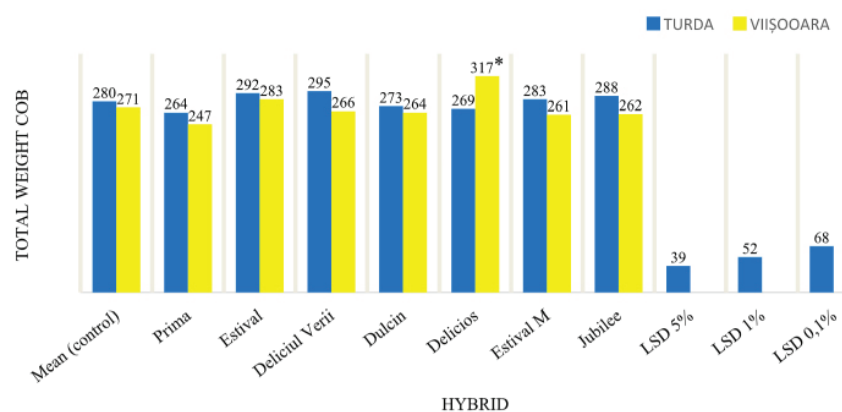
Both in common and sweet corn, the number of rows/cob, is quite typical for the cultivar, variations being relatively small or accidental. Therefore, the major involvement of genotype in quantification of this character, is also reflected in this study, the magnitude of variance attributed to genotype as well as the significance of F sample being eloquent in this respect (Tab. 5). The s² values for pedoclimatic factors (years and localities) are much lower compared to those of hybrids, and the F test shows that only localities contribute significantly to the variation of this character.

Previously, there were presented certain aspects that can positively influence corn cob market sales. Regarding number of rows/cobs all studied hybrids meet these requirements, except for Prima hybrid. Probably the precocity

Table 6. Average number of rows of grains/cobs in two localities and two years (Turda and Viișoara 2016-2017)

Hybrid	No. row/cob	(%)	Diference	Significance
Average (control)	16	100.0	0.00	-
Prima	12	74	-4	000
Estival	18	110	2	***
Deliciul Verii	16	100	0	-
Dulcin	16	100	0	-
Delicios	16	100	0	-
Estival M	18	110	2	***
Jubilee	18	110	2	***

LSD 5% = 2; LSD 1% = 1; LSD 0.1% = 0.5

**Figure 3.** Number of rows of grains/cob in the two locations and two years (Turda and Viișoara, 2016-2017)**Figure 4.** Average weight of sweet corn cobs with husks (2016-2017)

of this hybrid is associated with reduction of the expressivity of certain morphological cob features. Estival, Estival M and Jubilee hybrids show the highest number of rows of grains/cobs, with very significant differences from experience average (Tab. 6).

Data presented in Figure 3 reinforce once again the pronounced stability of this important element of production but also in the general aspect of cobs. Hybrids have different values of this character, but it can be noticed that each

hybrid records in both locations, similar values. The highest values are recorded in Estival M and Jubilee hybrids with very significant differences from experience average.

Prolongation of delivery period and the delay of harvest after the technological moment may adversely affect qualitative properties of sweet corn as a result of transformation processes of sugars into starch and accentuated dehydratation. A measure for slowing down these processes is that cobs are well covered by husks, particularly

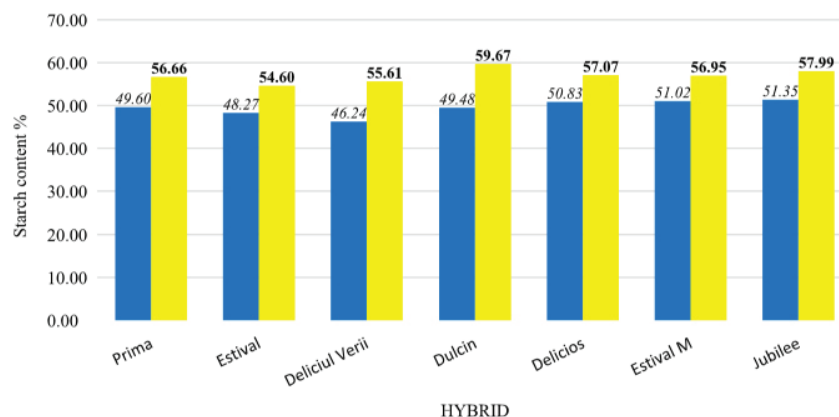


Figure 5. Starch content of grains (2016-2017)

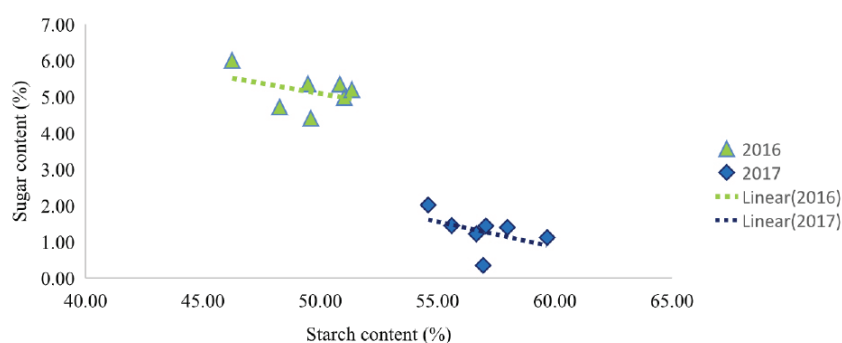


Figure 6. Relationship between starch and sugar content in seven sweet corn hybrids

important when selling cobs with husks. In this sense, cob weight was determined, results of these measurements being shown in Figure 4. In both localities, differences between hybrids are not statistically assured, except for Delicios hybrid, which in the conditions of Vișoara made special performances with highest cob weight, with significant differences compared to the average in this locality. The fact that the climatic conditions in the two locations are quite similar, with a slight advantage for Turda, reflects an acceptable stability for this character. Under conditions of Turda, Deliciul Verii and Estival hybrids with 295g and 292g weight are distinguished. Estival hybrid also reacted favorably to conditions of Vișoara, being on the second place and differences between the two locations are quite low. Based on the constant behavior of Estival hybrid in two agroecosystems, it can be recommended for the stability of this character.

Multiple possibilities of using sweet corn for preparation of puree, compotes, cornflakes and cornmeal which is component of many pastries (Vâlceanu, 1982; Bereșiu *et al.*, 1983) has led us to expand this research. There are many situations

when the entire production of sweet corn can not be capitalized for a variety of reasons, selling sweet corn flour or corn cobs that reached maturity is an alternative. For this purpose, three samples of flour/repetition from cobs of hybrids that reached full maturity were analyzed using the Tango-Nir spectrophotometer. Please note that these analyses were made only on samples from Turda. Very pronounced starch accumulation gap in the two years clearly reflects the considerable influence of environment on starch granules formation. Similar results were obtained by Ganesan *et al.*, 2017. Thus, in 2016, the percentage of grain starch level did not exceed 51.35% (recorded at Estival M hybrid) compared with 2017 when this chemical parameter increases up to 59.67% (in Dulcin hybrid). Among the seven hybrids, differentiations are more unclear than those of the two years.

Figure 6 shows the relationship between two important chemical parameters of corn flour, namely starch and sugar content. It can be noticed that there is an indirect relationship between the two chemical indicators and the relatively large spacing of two regression lines suggests that the process of converting sugar into starch

can be affected to a significant extent by climatic conditions, during fermentation and maturation phases. Thus, conditions of 2017 probably indicated an intensification of processes of transformation sugar into starch, this year the sugar level was under the scale of spectrophotometer. In contrast, conditions for 2016 caused a slowdown in these processes, so sugar content recorded between 4-6% in all genotypes, while the starch did not exceed 50%.

Conclusions

Even though hybrids reacted differently in terms of height of the plants in two locations, the fact that they maintained same significance thresholds except Estival M hybrid suggests the heredity of this character.

Earliest hybrids Prima and Estival, record lowest average number of grains/row, with very significant negative differences reported to control.

Based on hybrid behavior, we recommend growing a larger assortment of sweet corn (at least two hybrids). In this way, crop losses due to climatic differences, which are becoming more and more acute in similar micro-regions, may be limited to some extent. Very pronounced starch

accumulation gap in the two years clearly reflects considerable influence of the environment on starch granules formation.

References

1. Apahidean AS and Apahidean AI (2016). Legumicultura. Ed. AcademicPres, Cluj-Napoca.
2. Bereşiu I, Bendorf F, Frumuşelu L (1983). Materii prime vegetale pentru prelucrarea industrială şi casnică. Editura Ceres - Bucureşti.
3. Ganesan KN, Kumara BS, Senthil N, Kavithamani D (2017). Influence of quality traits on green cob yield in hybrids of sweet corn (*Zea mays* L. *saccharata*), Electronic Journal of Plant Breeding, 8(1): 385-389.
4. Gracia AGY, Guerra LC, Hoogenboom G (2009). Impact of planting date and hybrid on early growth of sweet corn. Agronomy Journal, 101: 193-200.
5. Haş, V. (1999). Influenta unor elemente tehnologice asupra hibrizilor de porumb zaharat. Horticultura, 4: 15-18.
6. Muhammad JA and Syed SM (1999). Variability for Grain Yield, its Components and Quality Traits in a Sweet Corn Population. Pakistan Journal of Biological Sciences, 2: 1366-1370.
7. Tracy WF (1994). Speciality types of maize CRC, Sweet Corn (pp.147-187), Boca Raton, Florida
8. Vâlceanu G (1982). Cultura legumelor mai puţin răspândite, porumbul zaharat (pp.209-212), Editura Ceres, Bucureşti,.