

EFFECT OF WEATHER CONDITIONS ON SUGAR MAIZE YIELD (*Zea mays* ssp. *saccharata* Koern.)

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Abstract. An experiment was carried out at the Experimental-Didactic Station in Swadzim (52°26' N; 16°45' E), which is part of the Poznań University of Life Sciences, in years 2006-2008. The aim of the research was to examine the effect of weather conditions on the yield of ten sugar maize hybrids. Length of growth period, yield size, first class cobs share, number of grains in the cobs, and cob length were defined. It was found that the length of growth period and weather conditions have an effect on yield size and first class cobs share. The best sugar maize hybrids for processing proved to be 'Sweet Wonder', 'Rebecca', and 'Sweet Nugget'. The best for direct consumption were 'Sweet Wonder', 'Rebecca', and 'Sweet Talk'.

Key words: cob length, consumption hybrids, heterosis hybrids, hybrids for processing, maize cob, number of grains per cob

INTRODUCTION

Sugar maize is a warmth-loving plant that requires significant insolation and proper humidity. Although maize has low transpiration coefficient, it produces a lot of biomass and therefore its water needs are large during the whole growth period [Waligóra et al. 1998]. According to Źarski et al. [2004], water shortages are a frequent cause of smaller maize yield. Periodical water shortages during growth period occur first of all on lighter soils. An effective solution to this problem can be the application of irrigation.

Choice of proper maize hybrid, like with no other plant, is a factor that significantly determines growth success. One of the most important traits in our weather conditions is proper maturity earliness. Longer growth period, and thus a higher number of assimilation days, makes it possible to produce greater yield. Therefore, indeed later hybrids usually yield a little bit higher. However, sowing faster maturing hybrids gives such advantages as: smaller cultivation risk, better quality, or earlier appearance on the market [Waligóra et al. 1998].

The purpose of sugar maize growth is the cobs. Basic criteria that a farmer follows in the choice of a hybrid for industrial processing, in addition to good technological values of grain for canning, is the yield of cobs with covering leaves from hectare and cob grain productivity. Sugar maize hybrids grown for direct consumption are evaluated mainly on the basis of cob size and settlement, number of cobs, and first class cob yield (cobs fully grained) [Waligóra 2002/2003].

The aim of the research was the evaluation of the effect of weather conditions on the yield formation of several sugar maize hybrids.

MATERIAL AND METHODS

The experiment was carried out in years 2006-2008 at the Experimental-Didactic Station in Swadzim (52°26' N; 16°45' E), which is part of the Poznań University of Life Sciences. It was set up on lessives, quality class IVb. Ten sugar maize hybrids were studied, namely 'Bliss', 'GSS 5022', 'Harvest Gold', 'Merkur, Rana', 'Rebecca', 'Sweet Nugget', 'Sweet Talk', 'Sweet Trophy', and 'Sweet Wonder'. Cobs were collected manually, after the plants came to milk ripeness (BBCH 70). Subsequently, in every year of the research, the following features were determined: leafless cobs yield ($t \cdot ha^{-1}$), share of first class cobs (%), number of grains per cob (piece), length of cobs (cm), and length of the growth period of the particular hybrids counted from sowing to milk ripeness (days). The obtained results underwent the analysis of variance with the use of the ANVAR programme. Significance of differences and the lowest significant difference were set at the level of 0.05.

During plant growth and development, meteorological data was collected: average monthly temperature (Table 1) and precipitation sums (Table 2), on the basis of which Sielianinow's hydrothermal coefficient was calculated (Table 3). In the work, the effect of weather course on the length of the growth period and the formation of yield of chosen sugar maize hybrids were determined.

Table 1. Average monthly air temperature at the E-DS Swadzim
Tabela 1. Średnia miesięczna temperatura powietrza w ZDD Swadzim

Year – Rok	May Maj	June Czerwiec	July Lipiec	August Sierpień	September Wrzesień	Growth period Okres wegetacji
Temperature – Temperatura, °C						
2006	13.9	18.7	24.4	17.7	17.2	18.4
2007	15.2	19.3	18.9	19.2	13.7	17.3
2008	15.1	19.6	20.7	18.8	13.5	17.5
Long-term average Średnia z wielolecia	13.4	16.7	18.4	17.8	13.6	–

Table 2. Sum of monthly precipitation at the E-DS Swadzim
Tabela 2. Suma miesięcznych opadów atmosferycznych w ZDD Swadzim

Year – Rok	May Maj	June Czerwiec	July Lipiec	August Sierpień	September Wrzesień	Growth period Okres wegetacji
Precipitation – Opady, mm						
2006	57.4	26.9	23.1	100.7	22.0	230.1
2007	77.0	59.6	87.0	48.1	33.4	305.1
2008	14.3	8.6	65.6	95.1	19.4	203.0
Long-term average Średnia z wielolecia	51.9	56.8	72.2	56.8	43.6	–

Table 3. Sielianinow's hydrothermal coefficient
Tabela 3. Współczynnik hydrotermiczny Sielianinowa

Year Rok	May Maj	June Czerwiec	July Lipiec	August Sierpień	September Wrzesień	Growth period Okres wegetacji
2006	1.33	0.48	0.43	1.84	0.42	0.90
2007	1.63	1.03	1.48	0.81	0.81	1.15
2008	0.31	0.15	1.02	1.63	0.48	0.72

values – wartości: 0.00-0.50 – drought – 0,00-0,50 – susza, 0.51-1.00 – semi-drought – 0,51-1,00 – półsusza, 1.01-2.00 – good humidity – 1,01-2,00 – dobra wilgotność, 2.01 and above – large humidity – 2,01 i powyżej – duże uwilgotnienie

RESULTS AND DISCUSSION

Length of the growth period of the studied sugar maize hybrids oscillated during the course of the experiment between 85 days for 'Bliss' hybrid and 110 days for hybrids 'Merkur' and 'Rebecca' (Fig. 1). Therefore, the differences were large, as they reached 25 days. Weather course in the year of the experiment affected the number of days of the growth period. The longest growth period occurred in 2007 when Sielianinow's coefficient indicated optimal humidity. In other years of the experiment, semi-drought occurred and the number of days of the growth period was smaller. Kossowski and Cierkoń [1986] stated that the length of maize growth period depended on the weather course in the particular years of the experiment. Similar results were obtained by Waligóra [2002/2003].

The studied sugar maize hybrids varied significantly in regard to the yield of cobs with no covering leaves (Table 4). This trait decides to a large extent about the economic results in the growth mainly for process manufacturing [Waligóra 2002/2003]. The highest yield was reached by hybrids: 'Rebecca', 'Sweet Wonder', 'Sweet Nugget', and 'Sweet Talk'. The lowest yield proved to have been obtained by 'Harvest Gold' hybrid, whose yield was lower by 1.48 t than the one of the best yielding hybrids.

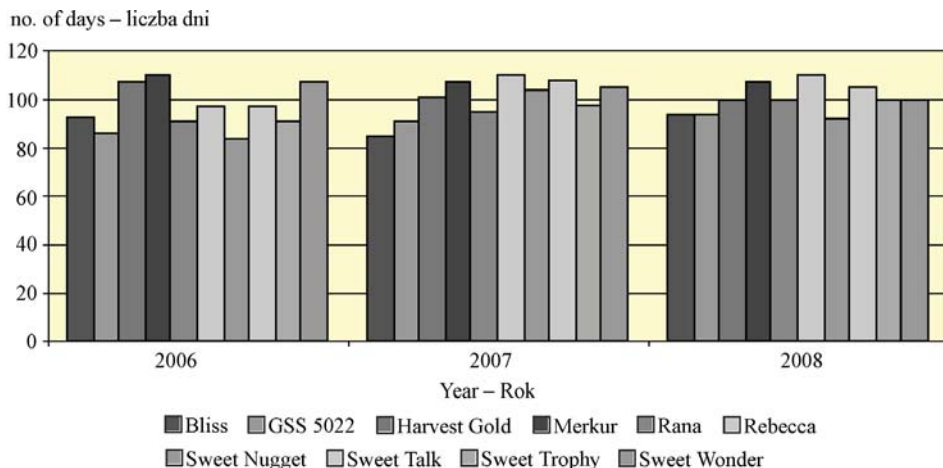


Fig. 1. Length of the growth period of the studied sugar maize hybrids
Rys. 1. Długość okresu wegetacji badanych odmian kukurydzy cukrowej

Table 4. Leafless cobs yield, $t \cdot ha^{-1}$
Tabela 4. Plon kolb odkoszulkowanych, $t \cdot ha^{-1}$

Hybrid – Odmiana	Year – Rok			Mean – Średnia
	2006	2007	2008	
Bliss	6.90	12.75	8.40	9.35
GSS 5022	7.80	12.43	7.80	9.34
Harvest Gold	6.00	14.60	4.30	8.30
Merkur	7.48	17.13	4.33	9.64
Rana	8.28	11.70	5.68	8.55
Rebecca	7.65	19.03	5.53	10.73
Sweet Nugget	6.78	17.03	5.83	9.88
Sweet Talk	6.98	17.48	4.88	9.78
Sweet Trophy	4.85	15.60	7.65	9.37
Sweet Wonder	5.53	17.88	6.60	10.00
Mean – Średnia	6.82	15.56	6.10	–
LSD _{0,05} – NIR _{0,05}				1.121

Yield size in the years of the research depended on the weather conditions. The studied hybrids gave the highest yield in 2007, and the average reached $15.56 t \cdot ha^{-1}$. The smallest yield occurred in 2008 and was equal to $6.10 t \cdot ha^{-1}$. Żarski et al. [2004] stated that big differences in maize yield in years 1995-2002 resulted from different weather conditions and yield to the greatest extent depended on precipitation sums in the third decade of July and the first decade of August. Dragońska et al. [2008] showed that temperatures affect yield significantly, particularly in the period from germination to the emergence of stigma. Increase in precipitation in the period from the emergence of stigma to ripeness affects, on the other hand, yield increase. Michalski et al. [1996] found that in Poland access to water for plants decides about yield size to a greater degree than average air temperature. Waligóra et al. [2010] state, however, that both precipitation and air temperature play a significant role in yield formation.

It was shown in the present study that yield size is influenced not only by weather conditions, but also by the length of the growth period. In 2007, when growth period was the longest, also the highest cob yield was found. Similar interaction was found by Michalski et al. [1996] in their experiment, whereas Sulewska et al. [2006] stated that minimum and maximum values of yield were in agreement with hybrid earliness groups.

In the experiment, also the share of fully grained cobs was determined. In sugar maize grown for direct consumption, their maximum share has a great significance [Waligóra 2002/2003]. The highest percentage share of first class cobs occurred in hybrids 'Sweet Wonder', 'Rebecca', 'Merkur', and 'Sweet Talk' (above 65.8% – Table 5). The smallest share of fully grained cobs was characteristic for hybrids 'Bliss', 'GSS 5022', 'Rana', 'Harvest Gold', 'Sweet Trophy', and 'Sweet Nugget' (below 58.8%).

Table 5. Share of first class cobs, %
Tabela 5. Udział kolb I klasy, %

Hybrid – Odmiana	Year – Rok			Mean – Średnia
	2006	2007	2008	
Bliss	60.0	81.5	34.8	58.8
GSS 5022	57.5	84.5	32.8	58.3
Harvest Gold	56.8	87.0	18.0	53.9
Merkur	68.0	91.0	51.8	70.3
Rana	65.8	75.8	29.8	57.1
Rebecca	76.5	88.5	49.3	71.4
Sweet Nugget	16.0	71.0	60.5	49.2
Sweet Talk	41.8	91.3	64.3	65.8
Sweet Trophy	74.3	76.3	7.0	52.5
Sweet Wonder	66.0	93.0	59.5	72.8
Mean – Średnia	58.3	84.0	40.8	–
LSD _{0,05} – NIR _{0,05}				14.1

Share of fully grained cobs depends on the weather course during growth period. In 2007, the highest share of first class cobs, that is 84.0%, was obtained in the studied hybrids. The smallest occurred in 2008 and was lower by 43.2% than in the year before. Kossowski and Cierkoń [1986] state that the share of first class cobs in the yield is a trait that is modified by the environment. Waligóra [2002/2003] has a similar opinion, basing on the results of the research conducted in years 1998-2000 on chosen sugar maize hybrids.

On the basis of the present study, it was found that the share of first class cobs is significantly influenced by, next to the weather course, the length of growth period. Sulewska et al. [2006] give similar conclusions, claiming that the formation of yield depended on maize earliness group.

Studied sugar maize hybrids varied significantly in regard to the number of grains per cob, as well as cob length (Tables 6 and 7). The highest number of grains was characteristic for 'Harvest Gold' hybrid (790 pieces). Slightly fewer grains occurred in hybrids: 'Rebecca', 'Sweet Talk', 'Bliss', 'Sweet Wonder', and 'Merkur' (over 590 pieces). However, the smallest number of grains per cob was characteristic for 'Sweet Nugget' hybrid (460 pieces).

The longest cobs were produced by hybrids ‘Sweet Nugget’, ‘Rebecca’, and ‘Sweet Wonder’, and the shortest by ‘Bliss’ hybrid. Number of grains per cob and cob length are significant traits for the selection of sugar maize hybrids for direct consumption. Cob length is also of significant importance to process manufacturing [Waligóra 2002/2003].

It was found in the present study that the environment and length of growth period had no effect on average cob length and grain number in the years of the experiment.

Table 6. Number of grains per cob, piece
Tabela 6. Liczba ziaren w kolbie, szt.

Hybrid – Odmiana	Year – Rok			Mean – Średnia
	2006	2007	2008	
Bliss	553	696	645	631
GSS 5022	499	495	609	534
Harvest Gold	834	718	819	790
Merkur	648	599	523	590
Rana	541	608	589	579
Rebecca	662	673	620	652
Sweet Nugget	519	441	423	461
Sweet Talk	643	680	624	649
Sweet Trophy	486	540	518	515
Sweet Wonder	569	666	648	628
Mean – Średnia	595	612	602	–
LSD _{0,05} – NIR _{0,05}		ns – ni		71.1

ns – ni – non-significant difference – różnica nieistotna

Table 7. Cob length, cm
Tabela 7. Długość kolb, cm

Hybrid – Odmiana	Year – Rok			Mean – Średnia
	2006	2007	2008	
Bliss	18.8	17.1	18.0	18.0
GSS 5022	18.8	19.9	17.9	18.9
Harvest Gold	21.0	18.8	18.8	19.5
Merkur	21.8	19.1	17.4	19.4
Rana	20.8	18.5	18.0	19.1
Rebecca	23.0	19.5	20.5	21.0
Sweet Nugget	21.0	21.5	20.8	21.1
Sweet Talk	20.3	18.6	17.3	18.7
Sweet Trophy	18.8	20.7	17.0	18.8
Sweet Wonder	20.5	21.2	19.8	20.5
Mean – Średnia	20.5	19.5	18.6	–
LSD _{0,05} – NIR _{0,05}		ns – ni		1.41

Weather course and the length of plant growth period affect yield size and the share of first class cobs. They do not affect, however, the number of grains per cob or cob length. Sugar maize hybrids for process manufacturing are evaluated mainly on the basis of cob yield per hectare and cob length [Waligóra 2002/2003]. Results of the present study indicate that for process manufacturing hybrids ‘Rebecca’, ‘Sweet

Wonder', and 'Sweet Nugget' may be recommended. Basic traits that are taken into account during the selection of sugar maize hybrids for direct consumption are first of all the share of first class cobs, cob length, and the number of grains per cob [Waligóra 2002/2003]. The best hybrids for this purpose proved to be 'Sweet Wonder', 'Rebecca', and 'Sweet Talk'.

CONCLUSIONS

1. Weather conditions in years 2006-2008 and the number of days of plant growth period had a significant effect on the yield and share of first class cobs of the studied sugar maize hybrids; however, these factors were not significant for cob length or the number of grains per cob.

2. The compared hybrids varied significantly in regard to yield and share of first class cobs. The ones that gave the highest yield demonstrated to be hybrids 'Rebecca', 'Sweet Wonder', 'Sweet Nugget', and 'Sweet Talk', whereas the highest share of first class cobs was characteristic for 'Sweet Wonder', 'Rebecca', 'Merkur', and 'Sweet Talk'.

3. Differences were found between hybrids in regard to the number of grains per cob and cob length. The highest number of grains was characteristic for 'Harvest Gold' hybrid, whereas the longest cobs for 'Sweet Nugget', 'Rebecca', and 'Sweet Wonder'.

4. From the studied hybrids, for process manufacturing hybrids 'Rebecca', 'Sweet Wonder', and 'Sweet Nugget' may be recommended, whilst hybrids particularly suitable for direct consumption are 'Sweet Wonder', 'Rebecca', and 'Sweet Talk'.

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WPLYW WARUNKÓW POGODOWYCH NA PLONOWANIE ODMIAN KUKURYDZY CUKROWEJ (*Zea mays ssp. saccharata* Koern.)

Streszczenie. Doświadczenie przeprowadzono w latach 2006-2008 w Zakładzie Doświadczalno-Dydaktycznym w Swadzimiu (52°26' N; 16°45' E), należącym do Uniwersytetu Przyrodniczego w Poznaniu. Celem badań było określenie wpływu warunków pogodowych na kształtowanie plonu dziesięciu odmian kukurydzy cukrowej. Określono długość okresu wegetacji, wielkość plonu, udział kolb I klasy, liczbę ziaren w kolbie oraz ich długość. Stwierdzono, że warunki pogodowe mają istotny wpływ na wielkość plonu, udział kolb I klasy oraz na długość okresu wegetacji odmian kukurydzy cukrowej. Najwyższe plony kolb uzyskano z odmian Rebecca, Sweet Wonder, Sweet Nugget oraz Sweet Talk. Najwyższym udziałem kolb I klasy charakteryzowały się Sweet Wonder, Rebecca, Merkur oraz Sweet Talk. Najlepszymi odmianami do przetwórstwa okazały się: Sweet Wonder, Rebecca oraz Sweet Nugget, a do bezpośredniej konsumpcji Sweet Wonder, Rebecca oraz Sweet Talk.

Słowa kluczowe: kolba kukurydzy, mieszańce heterozyjne, odmiany do przetwórstwa, odmiany konsumpcyjne, długość kolby, liczba ziaren w kolbie

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