

Site and hybrid-specific agrotechnical models in sweet corn production

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SUMMARY

The effect of three agrotechnical factors (sowing time, fertilization, plant density) and two genotypes on the crop yield of sweet corn was examined on chernozem soil in the Hajdúság region in two different crop years. Compared to the 30-year average, the climate was dry and warm in 2009 and humid in 2010. The experiments were conducted at the Látókép Research Site of the University of Debrecen. In the experiments we applied two sowing times (end of April, end of May), six fertilization levels (control, $N_{30}+PK$, $N_{60}+PK$, $N_{90}+PK$, $N_{120}+PK$, $N_{150}+PK$) and two crop density levels (45 thousand ha^{-1} , 65 thousand ha^{-1}). The hybrids we used were Jumbo and Enterprise. As regards the requirements of sweet corn production, the crop year of 2009 was dry and warm. The effect of moisture deficiency was more adverse on the crop yields with the second sowing time. On the contrary, the other examined year (2010) was significantly humid; the precipitation was 184 mm above the 30-year average and the temperature was average.

In the dry and hot crop year, the best yields were obtained with the hybrid Jumbo (25677 kg^{-1}) at 65 thousand ha^{-1} plant density level on the average of the fertilization levels. The crop yields of Enterprise were also the highest at high plant density level (24444 kg^{-1}). With the second sowing time the highest yields were obtained at the higher plant density level (65 thousand ha^{-1}) with both hybrids (Jumbo 18978 kg^{-1} , Enterprise 18991 kg^{-1}), which confirmed the good adaptation capability of these hybrids at high plant density level.

In humid crop year with early sowing time the highest yielding hybrid was Enterprise (at 45 thousand ha^{-1} crop density level 20757 kg^{-1}), at the same time, Jumbo was best yielding at the higher plant density level (18781 kg^{-1}). With the second sowing time the highest crop yield was obtained with Enterprise again (20628 kg^{-1} at 65 thousand ha^{-1} plant density level). With this sowing time the average yields of Jumbo, was 18914 kg^{-1} respectively. We found that dry crop year and early sowing time provided the best conditions for sweet corn production; the highest yields were obtained under these circumstances, which might be the results of the outstanding water management of chernozem soils.

REVIEW OF SCIENTIFIC LITERATURE

Sweet corn is a subspecies of maize; it differs from maize in that it has a recessive gene (sugary endosperm) on the 4th chromosome. The total production area of sweet corn is around 500 thousand ha globally. The leading countries in sweet corn production are the USA and Canada, but Hungary is also important, with over 100 thousand tons of export (Zsombik-Daróczy, 2008).

According to Tracy (2001), sweet corn is a field vegetable suitable for both fresh use and for processing. The growing demand for sweet corn triggered the increase of the production area in Europe, Asia and South America, and the processed amount has increased by 60 % during the last 25 years in the United States (Williams et al., 2006). The major physiological processes of sweet corn are determined by temperature; however, as yield potential is high, harmonized and abundant water supply is equally important. According to Hodossi (2004), the monthly water demand of sweet corn is over 100 mm. Of field vegetables, sweet corn has the longest sowing period, which is over three months, lasting from mid April (early) to early July (late) (Williams, 2008). According to Perczes (1999), sweet corn requires warm temperatures and germination starts only if soil temperature is higher than 10 °C. Based on its temperature requirement, it is suitable to be produced in the whole country.

According to the calculations of Debreceniné, the dry matter production of sweet corn can reach 245 kg/ha/day. This rate decreases to 204, 200 and 82 kg/ha/day in case of phosphorus, potassium and nitrogen deficiency, respectively. According to the new environmentally conscious agricultural advisory systems the specific nutrient content of sweet corn at 11 t/ha CCM yield is N 10 kg; P_2O_5 4 kg; K_2O 11 kg (based on Terbe et al., 2004).

Géczi (2003) claims that the nutrient requirement of sweet corn is 120 kg/ha of nitrogen, 80-100 kg/ha of phosphorus and 100 kg/ha of potassium active agent, which can be increased if irrigation is applied.

According to Nígicsér (1997), depending on the nutritional supply of the soil 60-80 kg of phosphorus and 80-100 kg of potassium should be applied as base fertilizer before ploughing. In his cultivation and plant spacing experiment, Akmar (2002) applied 80 kg of phosphorus in autumn and 150 kg of nitrogen in autumn and in spring in the 8-10 leaves stage. Sárvári showed that the difference between the nutrient utilization capacity of sweet corn hybrids may exceed 50%. According to Hodossi et al., (2004) the crop density ranges between 40 thousand and 70 thousand plants/ha according to the moisture conditions. Based on his experiments in 2005 and 2006, Kumar (2009) found that the optimal plant density for sweet corn is 83 thousand plants/ha and the optimal fertilization level is 120 kg/ha N.

MATERIAL AND METHODS

The experiment was carried out at the Látókép Plant Cultivation Research Site of the Debrecen University. The site is about 15 km from Debrecen, near Route 33 on the loess ridge of the Hajdúság region. Based on its physical characteristics, the soil belongs to the semi-compacted clay category.

The pre-crop of the examined stands was winter wheat, which is an excellent pre-crop for sweet corn.

In the crop years two commercially produced hybrids of the mid-late maturity group were used, namely Jumbo and Enterprise. The first sowing time (early) was at the beginning of the main sowing period (April 21, 2009 and April 27, 2010), the second (late) was a month later at the end of the main sowing period (May 19, 2009 and 26 May, 2010).

Six fertilization levels and two crop density levels were analyzed in the experiment.

The following fertilizer levels were applied: control (untreated), N=30 kg ha⁻¹, P₂O₅=22.5 kg ha⁻¹, K₂O=26.5 kg ha⁻¹ as base fertilizer and 2, 3, 4 and 5 times these quantities.

In both years two plant density levels were used (45 thousand ha⁻¹, 65 thousand ha⁻¹).

The arrangement of the plots is random block in four repetitions; the plot size was 11.4 m². Sweet corn with the husk on was harvested by hand. The moisture content of the kernels ranged between 67 and 69 %, which is optimal for the canning industry.

Table 1 shows the monthly precipitation and temperature values in the examined crop years.

The crop year of 2009 was dry and hot as regards sweet corn production. With the early sowing time, the total amount of precipitation in the vegetation period was 110.6 mm below and the average temperature was 2.5 °C above the 30-year average (April, May, June, July). With the late sowing time the moisture deficiency was even higher (160 mm) while the temperature was 2.6 °C above the average (April, May, June, July, August). On the contrary, the crop year of 2010 was outstandingly wet. With the early sowing time, the total amount of precipitation in the vegetation period was 339 mm, which was 93 mm above the 30-year average; the average temperature was 1.5 °C above the 30-year average (April, May, June, July). With the late sowing time the surplus precipitation was 24.7 mm and the temperature was 0.7 °C over the 30-year average.

Table 1

Meteorological data of the crop year (Debrecen)

Month	Monthly precipitation (mm)			Monthly average temperature (°C)		
	Year 2009	Year 2010	30 year average	Year 2009	Year 2010	30 year average
April	9,9	83,3	42,4	14,9	11,6	10,7
May	20,1	111,4	58,8	17,4	16,6	15,8
June	96,6	100,9	79,5	19,8	19,7	18,7
July	9,2	97,2	65,7	23,4	22	20,3
August	11,3	98,3	60,7	22,6	19	19,6
Total/average	147,1	491,1	307,1	19,6	17,8	17

EVALUATION OF THE RESULTS

The yield potential of hybrids is different and genetically determined. Yield potential is equally influenced by the crop year and the applied agrotechniques.

In the dry and hot crop year of 2009 the total precipitation was 160 mm below the 30-year average. The highest moisture deficiency was detected in July, when only 14 % (9.2 mm) of the average amount (65.7 mm) was obtained. June was the only month when the precipitation was (by 17.1 mm) above the 30-year average (96.6 mm). With the early sowing time, the moisture deficiency in April and May was well compensated by the moisture gathered in autumn and winter; the precipitation in June ensured sufficient moisture until the end of the vegetation period. On the contrary, due to minimal precipitation values in July (9.2) and August (11.3 mm), there was significant yield loss with the second sowing time.

In the 2010 crop year, the precipitation increased the 30-year average by 184 mm in the vegetation period (from April to August). In the first month, the precipitation was double and the temperature was higher by almost 1 °C than the 30-year average with the first sowing time (April). Similarly, in May (second sowing time) the precipitation was almost double and the temperature was 0.8 °C above the 30-year average. The high amount of precipitation and the extreme temperature values caused yellowing of the plant leaves. In the flowering stage in the first sowing time (beginning of July), the temperature increased the 30-year average by 1.7 %, while the precipitation was almost 1.5 times higher. August was the only month when the monthly mean temperature was below the average, but even in this month the precipitation was 31.5 mm higher than the average. Due to the high amount of precipitation, the vertical movement of soil nutrients increased and unfavorably influenced the nutrient uptake of plants. Additionally, the soil compacting effect of the intensive rainfall caused significant depression in the plant stands and led to anaerobic soil conditions.

Table 2

The effect of agrotechnical factors on the yield of sweet corn in dry crop year (kg ha⁻¹)
(Debrecen, 2009)

Sowing time	Plant density	Hybrid(A)/Fert(B)	Ø	N ₃₀ +PK	N ₆₀ +PK	N ₉₀ +PK	N ₁₂₀ +PK	N ₁₅₀ +PK	LSD _{5%}	
I.	45 thousand ha ⁻¹	Jumbo	22401	22270	24967	25674	27007	24243	3322 (A)	2964 (AXB)
		Enterprise	22336	24605	25592	25312	25132	22220	2029 (B)	
	65 thousand ha ⁻¹	Jumbo	24589	25806	26464	25757	27253	24194	2143 (A)	2491 (AXB)
		Enterprise	22385	24260	24095	25526	26382	24013	1762 (B)	
II.	45 thousand ha ⁻¹	Jumbo	17187	17747	17286	19145	14507	17944	4130 (A)	3054 (AXB)
		Enterprise	22270	17862	19161	17368	15757	17681	2160 (B)	
	65 thousand ha ⁻¹	Jumbo	20921	17812	19572	19293	19194	17072	2925 (A)	3401 (AXB)
		Enterprise	21513	20444	18569	19441	19128	14852	2405 (B)	

Some agrotechnical factors (sowing time, crop density and fertilization) and two different sweet corn genotypes were investigated in small plot field experiments under excellent conditions at the Látókép Research Site of the University of Debrecen, Faculty of Agriculture.

Sweet corn has a high requirement for nutrients and well utilizes both the natural nutrient supply of the soil and the artificial fertilizers as well. The efficiency of fertilization is significantly influenced by soil conditions, water supply, genotypes and agrotechnical factors.

The optimal fertilization level of the specific hybrids was examined at different fertilization doses. Table 2 and Table 3 shows the crop yields of the hybrids, the bold numbers indicate the agroecologic maximum crop yield of the hybrid. Agroecologic fertilization optimum is the level over which the increase of the crop yield is not significant. In the crop year of 2009, the crop yields of Jumbo and Enterprise obtained with the agroecologic fertilization optimum were similar with the early sowing time at both plant density levels (Table 2). The agroecologic optimum of Jumbo was at N₉₀+PK (25674 kg ha⁻¹) at the lower crop density level and at N₁₂₀+PK (27253 kg ha⁻¹) at the higher plant density level. The agroecologic optimum of Enterprise was at N₆₀+PK (25592 kg ha⁻¹) and N₁₂₀+PK (26382 kg ha⁻¹). With the second (late) sowing time, the crop yield of Enterprise was higher (45 thousand ha⁻¹: 22270 kg ha⁻¹, 65 thousand ha⁻¹: 21513 kg ha⁻¹) at both plant density levels. The agroecologic optimum was the control fertilization level in both cases and for both hybrids. Increasing fertilization induced yield depression as a result of water deficiency in the crop stand. Similarly, the average crop yield of Enterprise was highest (24444 kg ha⁻¹) in this treatment.

Table 3

The effect of agrotechnical factors on the yield of sweet corn in humid crop year (kg ha⁻¹)
(Debrecen, 2010)

Sowing time	Plant density	Hybrid(A)/Fert(B)	Ø	N ₃₀ +PK	N ₆₀ +PK	N ₉₀ +PK	N ₁₂₀ +PK	N ₁₅₀ +PK	LSD _{5%}	
I.	45 thousand ha ⁻¹	Jumbo	12582	15395	15937	16809	17007	18487	3991(A)	1970(AxB)
		Enterprise	16612	19457	20428	22500	22105	23437	985(B)	
	65 thousand ha ⁻¹	Jumbo	14296	15543	19030	20099	22253	21464	2000(A)	2048(AxB)
		Enterprise	16546	18536	20641	20444	23061	22204	1024(B)	
II.	45 thousand ha ⁻¹	Jumbo	13470	15724	17056	17730	18454	16414	2727(A)	2267(AxB)
		Enterprise	16266	17714	17993	18536	18273	18635	1134(B)	
	65 thousand ha ⁻¹	Jumbo	18289	18882	18980	17845	20888	18602	2132(A)	2428(AxB)
		Enterprise	18306	19687	21546	20444	21546	22237	1214(B)	

In the humid 2010 crop year, the crop yields (Table 3) at the agroecologic optimal fertilization levels (N₁₅₀+PK) was highest with Enterprise in both sowing times (1st sowing time: 23061 kg ha⁻¹, 2nd sowing time: 22237 kg ha⁻¹). In the second sowing time, there was significant difference between the average yields of Jumbo and Enterprise at the higher plant density level with the agroecologic fertilization optimum.

We examined the effect of fertilizer treatments on the increase of crop yields. The basis of the relation is the control treatment that represents the natural nutrient supply of the soil; the nutrient supply was utilized at different extent in the different crop years. This proportion well represents the effect of the specific fertilizer levels on the

increase or decrease of crop yield, which can be considered as abiotic stress (Bocz, 1976). In dry crop year the yield of control plots were relatively high (22336-24589 kg ha⁻¹), which proves the sufficient uptake and utilization of soil nutrients. In this case the increasing fertilizer levels (10.8-17.9 % surplus yield) caused no significant increase in crop yield. With the late sowing time, crop yields decreased at all fertilization levels. On the contrary, in humid year the crop yield of the control plots was well below that of the yields obtained at the agroecologic fertilization optimum. The reason might be that the intensive precipitation washed off the nutrients from the root zone. Crop yield increase was significantly higher in 2010 compared to the dry year. It ranged between 35.4 and 53.3 % with the early sowing time and between 14,2-37,0 % with the late sowing time.

CONCLUSIONS

The effects of the genotype and agrotechnical factors on the crop yield of sweet corn were analyzed in two sowing times in two different crop years. The crop year of 2009 was rather warm and dry; the precipitation was less than half of the 30-year average. On the contrary, the crop year of 2010 was extremely humid and the amount of rainfall was significantly above the 30-year average, through washing off the nutrients and deteriorating soil structure it had an unfavorable effect on the crop yield of 2010.

We found that the early sowing time in the crop year of 2009 was most favorable for sweet corn production; the moisture content of the soil was sufficient for the plants. The crop yield of both hybrids was above 24 t ha⁻¹. In the lower crop density treatment the agroecologic fertilization optimum was lower (N₆₀+PK for Enterprise, N₉₀+PK for Jumbo), while with the higher crop densities the higher fertilization level proved to be better (N₁₂₀+PK). The late sowing time enhanced the unfavorable effects of dry and hot weather. On the average of the fertilizer levels, the crop yields of both Jumbo and Enterprise exceeded 19 ha⁻¹, while the highest crop yields were obtained with both hybrids on the control plots (agroecological fertilization optimum). In both treatments the higher plant density levels proved to be better.

In the crop year of 2010, no significant differences were found between the average yields of the two hybrids with the two sowing times. However, as regards the maximum crop yields, the first sowing time proved to be better (18487 kg ha⁻¹ - 23437 kg ha⁻¹). At the same time, the difference between crop density levels was mitigated by the sufficient water supply with the first and more favorable sowing time, since with the low plant density level plants could compensate for the smaller number of plants by producing a second corncob. We also found that the interval of the agroecologic fertilization optimum was wider (N₆₀₋₁₂₀+PK) with the late sowing time than with the first sowing time (N₁₂₀₋₁₅₀+PK), irrespective of treatments and hybrids.

Summarizing, based on crop yields obtained with the agroecologic fertilization levels both Jumbo and Enterprise gave excellent yields in dry crop year, while in humid crop year the yield of Enterprise was higher.

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