THE EFFECT OF AGROTECHNICAL FACTORS AND CROPYEAR ON SWEET CORN PRODUCTION ON CHERNOZEM SOIL

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Abstract

The effect of three agrotechnical factors (sowing time, fertilization, crop density) and two genotypes was examined on the cropyield and agronomic features of sweet corn. 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 plant 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 cropyear of 2009 was dry and warm. and the other examined year (2010) was significantly humid. In dry and humid cropyear both in the early and late sowing time the highest yield was obtained with Jumbo (27253 kg^{-1}, 20921 kg ha^{-1}). On the contrary, in 2010 in both sowing times Enterprise gave the highest yield at 23437 kg^{-1} and 22237 kg ha^{-1}. The correlation between the agrotechnical factors and yield and agronomic features was analysed by Person's correlation.

Key words: sweet corn, plant density, sowing time, fertilization, yield, cob number.

INTRODUCTION

Sweetcorn 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 sweetcorn is around 500 thousand ha in the world. The leading countries in sweetcorn production are the USA and Canada, but Hungary is also important with over 100 thousand tons export (Zsombik-Daróczi, 2008). According to Tracy (2001) sweetcorn is a field vegetable suitable for both fresh use and for processing. The growing demand for sweetcorn 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).

As regards the marketing point of view of sweet corn products, we have to emphasize the GMO free status of Hungary that can gain importance in the future (Kovács, 2005). Based on his experiments in 2005 and 2006, Kumar (2009) found that the optimal plant density for sweet corn is 83 thousand plants ha^{-1} and the optimal fertilization level is 120 kg ha^{-1} N. According to the calculations of Debreceniné (2005), the dry matter production of sweet corn can reach 245 kg ha day^{-1}. This rate decreases to 204, 200 and 82 kg ha day^{-1} in case of phosporus, potassium and nitrogen deficiency, respectively. 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. Hallauer and Miranda (1981) published the heritability (h2) of the yield components of sweet corn hybrids and found that the number of kernel rows is least affected by environmental factors. Veneni (1974) examined the variability of yield components and found that the variability of kernel weight per cob is highest for crop years and varieties (CV=16.8-35.4%), followed by cob lenght (CV=9.2-15.6%) and cob diameter (CV=4.66-8.24%). Analysing the stability of yield components, Gyenesné et al. (2002) found that individual cob production (CV=79.3-42.4%) and kernel weight (CV=17.5-30.0%) are the most variable features. The variability of the main cob was medium (CV=77.1-13.3%), while the most stable yield component that was least affected by environmental effects was the kernel number per row (CV=76.6-9.2%).

MATERIAL AND METHOD

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 is of semi-compacted clay category and of good physical state. The precrop of the examined stands was winter wheat, which is an excellent precrop for sweet corn. In the cropyear of 2009 two commercially produced hybrids of the mid late matury group were used, namely Jumbo and Enterprise. Both hybrids were sown with two sowing times. The first (early) sowing time was at the beginning of the main sowing period (April 21, 2009 and April 27, 2010); the second (late) sowing time was a month later at the end of the main sowing period (May 19, 2009 and 26 May, 2010). 6 fertilization levels and two plant density levels were analysed 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. Two plant density levels were used (45 thousand ha^{-1}, 65 thousand ha^{-1}) in both years. The arrangement of the plots was random block in four repetitions; the plot size was 11.4 m^2. The sweet corn cob in husk 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 cropyears. In the crop year of 2009 with the early sowing time, the total amount of precipitation in the vegetation period was 110.6 mm below the 30-year average 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 cropyear 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 1.50 °C above the 30-year average (April, May, June, July). With the late sowing time the surplus precipitation was 24.7 mm and the tempereature was 0.7 °C over the 30-year average.

Table 1

Meteorological data of the cropyear (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**

RESULTS AND DISSCUSIONS

Some important agrotechnical factors (sowing time, crop density, fertilization) and two 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 artificial fertilizers as well. The efficiency of fertilization is significantly influenced by soil conditions, water supply, genotypes and agrotechnical factors.

Analysing the cob yield (Table 2 and 3) we found that the number of harvested cobs was higher in the first sowing time in both crop years. In the dry cropyear of 2009 it was due to the fact that the warm weather was favourable for sweet corn production. Due to the higher plant density level, both hybrids gave the highest cob yield at 65 thousand ha^{-1} at NPK_{120}+PK fertilization level. Due to the very dry circumstances in the second sowing time the cob yield of both hybrids was highest on the control plots. In the extremely dry cropyear of 2010 the cob yield was highest with the first sowing time. The less favourable climate in the second sowing time caused the cob yield per plant to decrease. Due to the higher plant density, the higher cob yield was proportionate with the higher plant density at the two plant density levels (45 thousand ha^{-1}, 65 thousand ha^{-1}). Regardless of the treatment, the cob yield of Jumbo and Enterprise was as follows: Jumbo: 52302–71710 cob ha^{-1}, Enterprise: 43157.6–72367.9 cob ha^{-1}.

Table 2

The effect of agrotechnical factors on the cob number (db 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*	*LSD5%*	
I.	45 000 ha^{-1}	Jumbo	61842	72368	68421	71052	77631	68421	10874,8 (A)	9724 (AxB)
		Enterprise	59210	67105	67105	69736	67105	61842	6876,2 (B)	
	65 000 ha^{-1}	Jumbo	72368	77631	80263	77631	84210	73684	7116,2(A)	8274 (AxB)
		Enterprise	64473	67105	67105	71052	72368	64473	5850,4 (B)	
II.	45 000 ha^{-1}	Jumbo	47368	44737	44737	48684	36842	46052	10114,9 (A)	9852 (AxB)
		Enterprise	57894	48684	51315	46052	44737	47368	6966,0 (B)	
	65 000 ha^{-1}	Jumbo	49460	42105	46052	46052	44737	38158	8416,3 (A)	7805 (AxB)
		Enterprise	50000	46052	43421	44737	46052	35526	5518,7 (B)	

Table 3

The effect of agrotechnical factors on the cob number (db 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*	*LSD5%*	
I.	45 000 ha^{-1}	Jumbo	45789	48684	51973	51973	55921	60921	6763,1 (A)	7697 (AxB)
		Enterprise	46052	53947	56579	69079	67105	65789	3855,2 (B)	
	65 000 ha^{-1}	Jumbo	49737	55921	64868	67105	71710	68815	6013,1 (A)	5303 (AxB)
		Enterprise	64473	63157	63815	71710	72368	71710	2644,7 (B)	
II.	45 000 ha^{-1}	Jumbo	43092	41118	46710	46710	52302	42434	7763,1 (A)	6697 (AxB)
		Enterprise	39605	40131	40789	39802	43158	41118	3355,2 (B)	
	65 000 ha^{-1}	Jumbo	52631	51644	53289	50658	57894	53618	6907,8 (A)	7868 (AxB)
		Enterprise	49342	51644	53947	52631	53947	52237	3934,2 (B)	

Analysing the cob yield at the control and at NPK_{120} + PK fertilization levels we found that in the first sowing time in the dry cropyear Jumbo gave the highest yields; while in the first sowing time of the humid cropyear Enterprise performed better (Figure 1). The highest cob yield was harvested at 65 thousand ha^{-1} crop density level in the first sowing time in 2009 and in both sowing times in 2010; while the highest cob yield was harvested at 45 thousand ha^{-1} crop density level in the second sowing time of 2009. Based on the data above we found that water supply has a great influence on the cob yield. The optimal fertilization level of the specific hybrids was examined at different fertilization doses. Table 4 and 5 shows the crop yields of the hybrids, while the bold numbers indicate the agroecologic maximum crop yield of the hybrid. The agroecologic fertilization optimum is the level over which the increase of the crop yield is not significant. In the cropyear 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 4).

Table 4

The effect of agrotechnical factors on crop yield (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.	*45 000 ha^{-1}*	**Jumbo**	22401	22270	24967	**25674**	27007	24243	3322 (A)	2964 (AXB)
		Enterprise	22336	24605	**25592**	25312	25132	22220	2029 (B)	
	65 000 ha^{-1}	**Jumbo**	24589	25806	26464	25757	**27253**	24194	2143 (A)	2491 (AXB)
		Enterprise	22385	24260	24095	25526	**26382**	24013	1762 (B)	
II.	*45 000 ha^{-1}*	**Jumbo**	**17187**	17747	17286	19145	14507	17944	4130 (A)	3054 (AXB)
		Enterprise	**22270**	17862	19161	17368	15757	17681	2160 (B)	
	65 000 ha^{-1}	**Jumbo**	**20921**	17812	19572	19293	19194	17072	2925 (A)	3401 (AXB)
		Enterprise	**21513**	20444	18569	19441	19128	14852	2405 (B)	

Table 5

The effect of agrotechnical factors on crop yield (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.	*45 000 ha^{-1}*	**Jumbo**	12582	15395	15937	16809	17007	**18487**	3991(A)	1970 (AxB)
		Enterprise	16612	19457	20428	22500	22105	**23437**	985(B)	
	65 000 ha^{-1}	**Jumbo**	14296	15543	19030	20099	**22253**	21464	2000(A)	2048 (AxB)
		Enterprise	16546	18536	20641	20444	**23061**	22204	1024(B)	
II.	*45 000 ha^{-1}*	**Jumbo**	13470	15724	17056	17730	**18454**	16414	2727(A)	2267 (AxB)
		Enterprise	16266	17714	17993	18536	18273	**18635**	1134(B)	
	65 000 ha^{-1}	**Jumbo**	18289	18882	18980	17845	**20888**	18602	2132(A)	2428 (AxB)
		Enterprise	18306	19687	21546	20444	21546	**22237**	1214(B)	

The agroecologic optimum of Jumbo was at N_{90}+PK (25674 kg ha^{-1}) at the lower plant density level and at N_{120}+PK (27253 kg ha^{-1}) at the higher crop density level. The agroecologic optimum of Enterprise was at N_{60}+PK (25592 kg ha^{-1}) and N_{120}+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 highest yield of both hybrids was obtained at the control fertilization level. Increasing the fertilization induced yield depression as a result of water deficiency in the plant stand. In the crop year of 2010, the crop yields (Table 5) at the agroecologic optimum fertilization levels (N_{150}+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 different 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 representing the natural nutrient supply of the soil; the nutrient supply was utilized at different extent in the different cropyears. 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 the examined dry cropyear (2009) the yield of control plots was relatively high (22336-24589 kg ha^{-1}) with the early sowing time, which proves 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 the crop yield. With the late sowing time, the crop yields decreased at all fertilization levels. On the contrary, in the 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 the deflation caused by intensive precipitation that washed off the nutrients from the root zone or immature root or too much vegetative mass. The crop yield increase was significantly higher in 2010 compared to the dry year. It ranged between 39.4 and 55.7 % with the early sowing time and between 14.2 and 37.0 % with the late sowing time. Pearson's correlation was used to analyse the correlation between the agrotechnical factors, crop yield and agronomic features of the harvested cobs in two different cropyears (Table 6). In the crop year of 2009 we found weak negative correlation (-0.067) between fertilization and crop yield; the reason was that because of moisture deficiency in the soil the effect of fertilization was low. On the contrary, we found medium positive correlation between these factors in the crop year of 2010. In both examined cropyears medium positive correlation was found between sowing time and cob weight (0.502-0.484). Both in the dry and humid cropyear the highest cob weight was obtained with the first sowing time. Strong negative corrlation (-0.711) was found between crop density and cob diameter in 2009; the optimal plant density was lower due to the dry weather. Strong and very strong correlation was found (0.590-0.871) between cob weight with and without husk both in 2009 and 2010.

Table 6

Pearson's correlation of the examined factors in two cropyears
(Debrecen)

	2009	**2010**
fertilizer x yield	-0,067	0,528**
Sowing time x cob weight (with husk)	0,502**	0,484*
Crop density x cob diameter	-0,711**	-0,178*
Cob weight (with husk) x kernel number	0,531**	0,519**
Cob weight x kernel number	0,332**	0,556**
Cob weight (with husk) x cob weight	0,590**	0,871**
Cob length x kernels per row	0,164*	0,648**

CONCLUSIONS

We found that the early sowing time was most favourable for sweet corn production in the cropyear of 2009; the moisture content of the soil was sufficient for the plants. The number of harvested healthy cobs was highest and the cropyield of both hybrids was above 24 t ha^{-1}. In the lower crop density treatment the agroecologic fertilization optimum was lower (N_{60}+PK for Enterprise, N_{90}+PK for Jumbo), while with the higher crop densities the higher fertilization level proved to be better (N_{120}+PK). Late sowing time enhanced the unfavourable effects of dry and hot weather. On the average of the fertilizer levels, the cropyields of both Jumbo and Enterprise exceeded 19 t ha^{-1}, while the highest cropyields were obtained with both hybrids on the control plots. In both treatments the higher plant density levels proved to be better.

In the cropyear of 2010, no significant differences were found (16-20.5 t ha^{-1}) 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 the plant density levels was mitigated by sufficient water supply in the first and more favourable sowing time; with the low crop density level plants could compensate for the smaller number of plants by producing a second corncob. Nevertheless, we found that the interval of the agroecolgic fertilization optimum was wider (N_{60-120}+PK) with the early sowing time than with the second sowing time ($N_{120-150}$+PK), irrespectively of treatments and hybrids.

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