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**INTERDISCIPLINARY DOCTORAL AND NATURAL SCIENCES  
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DOCTORAL (Ph.D) THESIS

**EVALUATION ON THE PRODUCTION OF DEBRECEN-BRED MAIZE  
HYBRIDS IN THE AGRÁRGAZDASÁG Ltd.**

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## 1. INTRODUCTION, OBJECTIVES

The first ear of maize could have been snapped for human consumption somewhere in Mexico about 7000 years ago. After the discovery of America, maize was taken into Europe and spread to all the continents on the Earth.

Although maize became widespread relatively late, it has become one of the most significant crops in the world. Maize constitutes the basis of energy in forage mixes for animals. Moreover, industrial activities produce more than one hundred kinds of maize products (e.g. cooking oil, margarine, invert sugar, sweetener, starches, alcohol, beer, chemical source materials etc.). Maize starch is the primary material for a kind of wrapping, which gets fully decomposed in the soil, so a new era is to be opened for solving the environmental problem of large plastic waste hills all over the world.

In Hungary low and average yield types were grown first, and the production of American dent corn of higher yield started merely in the middle of the 1900s

In 1930 Rudolf Fleishmann, whose success was internationally renowned as well, established the first type of hybrid with production potentials exceeding that of the parents by 30%. However, the economic depression and the war years prevented the utilization of his results. It took more than 30 years to increase average maize yields by 1 t/ha.

The next period of maize production started from the 1950s with the production of inbred hybrids. In Europe, Endre Papp created the first hybrid in 1953, which was used in public production.

From 1956, based on earlier specific successes in corn breeding, modern maize seed industry was established in Hungary, which facilitated the spreading of hybrids and allowed the increasing utilization of genetic product potentials by extra quality seed production. Subsequently, due to the widespread use of higher fertilizer doses, intensive varieties, the application of modern technologies and plant protection, the national average of maize yields grew by 1t/ha on average in every fifth year.

Following the Hungarian political transformation, disadvantageous market impacts, the loss of markets and the changes of economic conditions affected the efficiency of maize production negatively. Despite this, grain maize is the cultivated plant grown on the largest area ( 25% of ploughlands) in Hungary.

For the predecessor of title of the Agrárgazdaság Ltd., the Model Farm of the Debrecen University of Agricultural Sciences, maize became the centre of attention when the hybrid plant was built in 1958. Hybrid maize seed production and processing gradually increased in Debrecen from the 60s, similarly to the other 14 hybrid plants in the country. Besides national production, maize seed grain was exported not only into socialist countries of that time, but into Western-Europe and the USA as well.

At this time the returns of the Agrárgazdaság Ltd. from hybrid maize seed export exceeded 2 million dollars/year. In recent years, this tendency has been interrupted.

It might seem controversial that after the above described successes in the history of maize production, Hungarian genetic values, formerly built seed production and seed conditioning capacities and their driving forces, intellectual potentials remained unutilized. In my view, it is unacceptable that although Hungary used to be the greatest seed supplier in Europe, not a single Hungarian sugar beet variety can be found in general production today, Hungarian medick varieties have not been proposed for awards recently and 90% of Hungarian maize hybrids with state qualification is imported from abroad.

The fact that Hungarian climatic conditions vary from those in other EU member states can justify the significance of Hungarian plant breeding; therefore cultivated plant varieties which are well adaptable to domestic agro-ecological conditions can and should be produced.

Unfortunately, we use the seeds of several foreign plant varieties, which also means that we pay licence fees to foreign companies instead of using the money for the development of Hungarian plant breeding in the country.

The Agrárgazdaság Ltd. tries to make use of available seed production potentials, technical background, skilled labour and earlier trade relations; however, it gradually loses its earlier markets and suffers considerable disadvantages in finding new ones as compared to its competitors.

The present study seeks to find answers to the questions, what kind of agro-technical conditions are required for the Debrecen hybrids bred by the Agrárgazdaság Ltd. to provide the safest production and what marketing strategies are needed for the survival of the company in present-day market economy.

The summary of our research objectives is the following:

*To identify in a multifactoral experiment:*

- regarding a soil cultivation: cultivation x fertilization, cultivation x plant density, cultivation x irrigation, cultivation x genotype,
- regarding the number of plants: plant number x fertilization, plant number x irrigation, plant number x genotype,
- regarding irrigation: irrigation x fertilization, irrigation x genotype,
- regarding fertilization x genotype: the effects of factors on grain crop and the evaluation of the correlation of factors

*In a three-factor experiment:*

- to define the natural nutrient-utilization capacities and their reactions on maize hybrid fertilization and irrigation, and also
- to study the effects of fertilizer reaction and years in irrigated and non-irrigated treatments by regression analysis.

*Marketing analysis of maize seed grain in the Ltd:*

- product policy,
- price policy,
- distribution (selling) policy,
- advertisement policy,
- determination of effectiveness in marketing activities and preparation for seed grain distribution seasons.

Without these pieces of information companies cannot survive in present-day market economy and competition.

## **2. MATERIAL AND METHOD**

In the Látókép Experimental Plant of the Agricultural Centre, University of Debrecen, we investigated the effects of plant production factors on the production of Debrecen maize hybrids in long term experiments on calcareous chernozem soil.

Treatments of the three-factor experiment:

Fertilizer treatments: The basic dose in an NPK dose examination of constant 1 N:0.75 P<sub>2</sub>O<sub>5</sub>:0.88 K<sub>2</sub>O rate was 80 kg/ha including N 30kg/ha and we used its 1,2,3,4,5 times higher doses as compared to controls with no fertilization. Doses of equal NPK rates were simply indicated with their N content in the evaluation.

Irrigation was performed with a NADIR-type drip-irrigation system of 75 cm wide divisions in 2000-2003 and then with linear mobile irrigation systems from 2004.

The irrigation system is equipped with Wobler's sprinkler, hydrant water supply and a GPS. The length of laterals: 420 m and 230 m. The distribution of water is very equable, and water doses can be well adjusted to the water demands of plants.

The experiment includes 4 replications and strips. One replication includes 6 randomized fertilizer treatments with irrigated and non-irrigated variants with the plant number of 70 000. The size of one replication is 1260 m<sup>2</sup> and that of fertilization plots is 210 m<sup>2</sup>.

The multifactorial long-term experiment is set up in doubly divided parcels (split-split-plot), with soil cultivation and irrigation varieties on the main plots. On primary sub-plots maize hybrids had a plant density of 50-70-90 thousand, on secondary sub-plots fertilization was applied randomly in four replications.

#### Treatments of the multifactorial long-term experiment

##### *Soil cultivation variety:*

T<sub>1</sub>= autumn ploughing (27 cm)

T<sub>2</sub>= spring ploughing (23 cm)

T<sub>3</sub>= spring shallow cultivation with disk cultivator (12 cm)

##### *Fertilizer treatment:*

M<sub>1</sub>= N 0 kg/ha P<sub>2</sub>O<sub>5</sub> 0 kg/ha K<sub>2</sub>O 0 kg/ha.

M<sub>2</sub>= N 120 kg/ha P<sub>2</sub>O<sub>5</sub> 90 kg/ha K<sub>2</sub>O 106 kg/ha.

M<sub>3</sub>= N 240 kg/ha P<sub>2</sub>O<sub>5</sub> 180 kg/ha K<sub>2</sub>O 212 kg/ha

##### *Irrigation varieties:*

Ö<sub>1</sub>= irrigated

Ö<sub>2</sub>= non-irrigated

##### *Plant number:*

N<sub>1</sub>= 50000 plant/ha,

N<sub>2</sub>= 70000 plant/ha,

N<sub>3</sub>= 90000 plant/ha

*Figures 1-2* present the arrangement of experiments

*Soil potentials.* The soil in the experimental plant is calcareous chernozem which formulated on the loess of the Plain. The N- and P supplies of the soil are of medium rate, its K content is high (humus content= 2.8-3.0 %, Total N = 0.14-0.18 %; AL-P<sub>2</sub>O<sub>5</sub> = 130-200 mg/kg, AL- K<sub>2</sub>O = 240-280 mg/kg). The humus layer is 70-90 cm thick. The pH (KCl) value is 6.2; the plasticity index according to Arany is 43. Microelement-deficiency cannot be detected. Underground water level is between 6-8m. The VK<sub>min</sub> value of the soil is 27-29 volume %. The soil profile of 0-100 cm is capable of storing humidity of 75 mm, the soil profile of 100-200 is capable of storing humidity of 265 mm. Useful VK is 157 mm on 0-100 cm and it is 150 mm on 100-200 cm.

*Weather characteristics* We analyzed the weather conditions in 2000-2005. The formation of the degree of precipitation supply is presented on *Figure 3*.

The *quality examination* of the Debrecen maize hybrids was performed by the Debrecen Regional Instrument Centre, the largest accredited instrument centre in the Trans-Tisza region in 2003-2005.

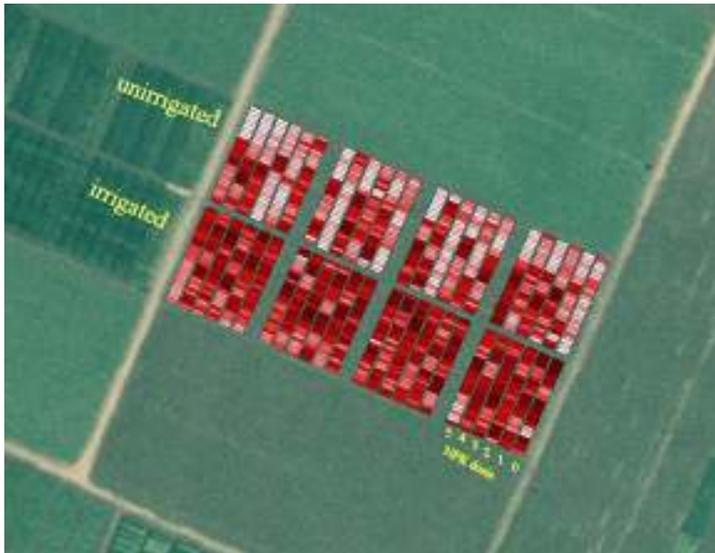


Figure 1. *Set-up of the three factor experiment (Debrecen)*  
(genotype x irrigation x nutrient)



Figure 2. *Set-up of the multifactorial experiment (Debrecen)*  
(soil cultivation x irrigation x plant number x genotype)

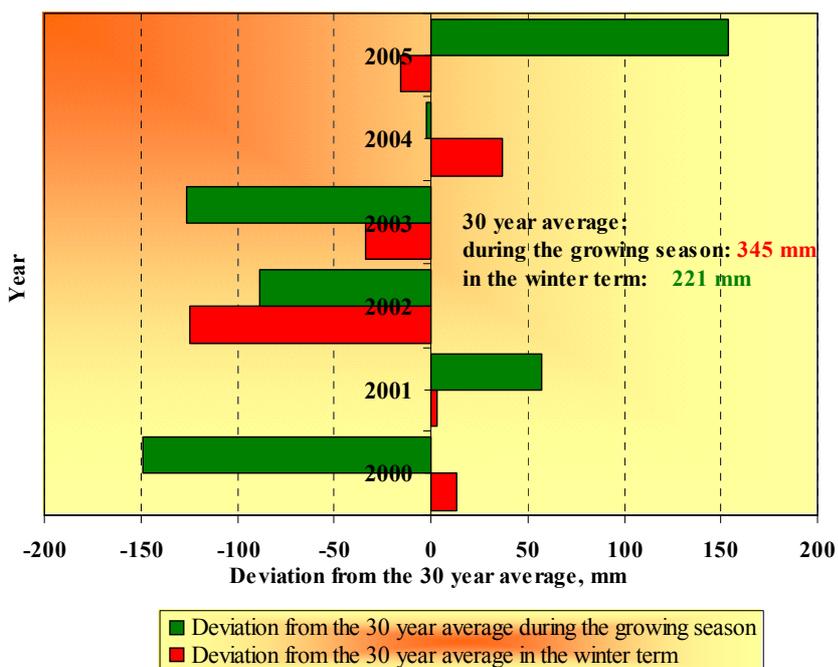


Figure 3. Degree of precipitation supply (mm)  
(Debrecen, 2000-2005.)

*Method of evaluation:* Evaluation was performed by the statistical program package of SPSS for Windows 13.0. We applied a general linear model (GLM) to detect the effects of treatments exerted on crop yield (Huzsvai 2001). Square sums were determined by Yates' method in our calculations. In the comparison of treatment mean values, we determined the significant difference of 5% ( $SzD_{5\%}$ ), and we generated homogenous groups by a comparative test for multiple mean values, the Duncan-Tukey method, where other factors are replicated as compared to the studied factor. In the multiple comparisons confidence intervals were corrected by Bonferroni's method to prevent the accumulation of alpha errors (errors of first kind). At the significance level of 5%, yields within the homogenous group did not differ from each other.

We analyzed the product policy of maize hybrids exclusively owned by the Agrárgazdaság Ltd. taking McCarthy's and Perrcault's (1984) work into consideration.

### 3. RESULTS OF EXPERIMENTS AND THEIR EVALUATION

#### 3.1. Results of the three-factor experiment

In the *three-factor experiment* we investigated the results of the Debrecen 351 and the Debrecen 377 maize hybrids in irrigated and non-irrigated treatments in six years (2000-2005), in 5 treatments of constant NPK ratio, without fertilization. According to our examinations, irrigation and fertilization showed a strong correlation with crop yields. The effect of irrigation varied depending on the natural water supply and the nutrient content of the soil and also on certain fertilizer doses. Based on the results of the analysis of variance (ANOVA) we concluded that the effects of both fertilization and irrigation were significant regarding the crop yields of both Debrecen maize hybrids in the whole study period

Our research findings justified the fact that the highest yields were gained in the case of the Debrecen maize hybrids, in the average of four years, when N<sub>120</sub>+PK kg/ha treatment was applied; however, the yield of N<sub>90</sub>+PK kg/ha treatment was not significantly lower so the dose of N<sub>90</sub>+PK kg/ha is satisfactory to achieve maximum yield (*Table 1.*).

Table 1. *Formation of homogenous groups with Duncan's test (Debrecen, 2000-2005.)*

Fertilization	Homogenous groups			
	1	2	3	4
Not fertilized	5,198			
30 kg N, 23 kg P <sub>2</sub> O <sub>5</sub> , 27 kg K <sub>2</sub> O		7,168		
60 kg N, 45 kg P <sub>2</sub> O <sub>5</sub> , 53 kg K <sub>2</sub> O			8,132	
150 kg N, 113 kg P <sub>2</sub> O <sub>5</sub> , 133 kg K <sub>2</sub> O				8,956
120 kg N, 90 kg P <sub>2</sub> O <sub>5</sub> , 106 kg K <sub>2</sub> O				9,205
Sig	1,000	1,000	1,000	0,174

Significance level 5%

The three-factor analysis allowed the evaluation of the natural nutrient assimilation capacity of Debrecen 351 and Debrecen 377 maize hybrids in various age groups, by using the results of non-fertilized plots. Our research findings proved that the Debrecen 351 maize hybrid could utilize the natural nutrient supply of the soil better than the Debrecen 377 maize hybrid. The greatest difference was measured in the age group (2001) favourable for maize (1.3 t/ha).

Besides the yield results of non-fertilized plots we also present, on the basis of 6 years' results, the effects of 90kg N + 68kg P<sub>2</sub>O<sub>5</sub> + 80kg K<sub>2</sub>O treatments (label: 90kg N/ha) on yields, which can be recommended for practical application. (Figure 4.).

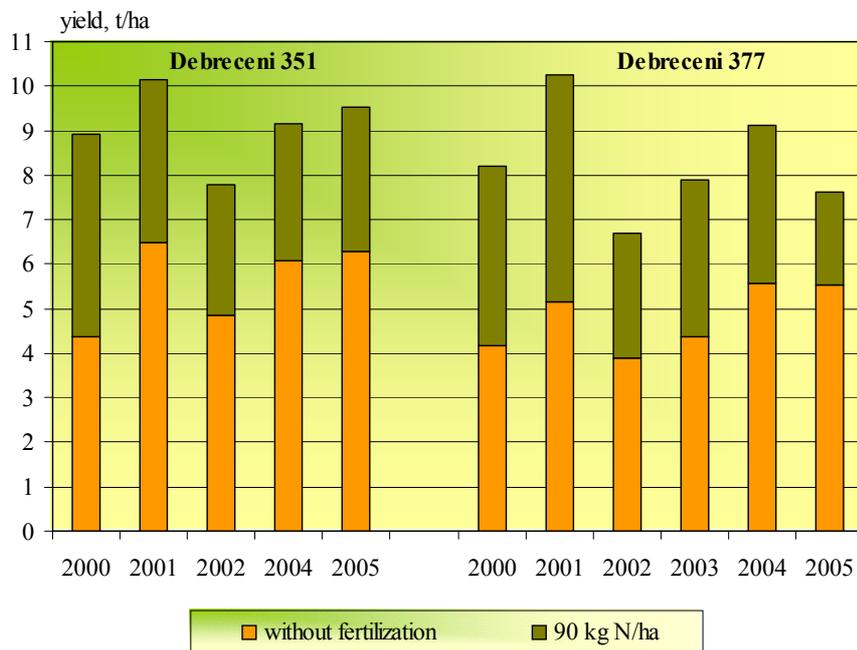


Table 4. Effects of fertilization on the yields of Debrececi maize hybrids (Debrececi, 2000-2005.)

The vegetation season was drought-stricken in 2000, the volume of precipitation was 149 mm less than the 30 years' average; and it exceeded the average by only 13 mm in the winter season. Crop yields formed accordingly.

The Debrececi maize hybrids could use natural nutrients at a low level. The excess yield of fertilization, in the average of fertilization treatments was 4.1 – 3.8 t/ha for Debrececi 351 and Debrececi 377.

The year of 2001 was more favourable for maize than the previous one. The Debrececi maize hybrids could use natural nutrients better. As compared to the year of 2001, significant difference did not manifest in the volume of winter precipitation, as only 10 mm more precipitation was measured in winter. 402 mm

of precipitation was measured in the vegetation period, and it was 196 mm more than in the previous year and 57 mm more than the 30 years' average. The differences were clearly justified in the crop yields. In 2001 the level of yield, in the average of the two hybrids, was 1.2 t/ha higher than in 2000. The excess yield of fertilization, in the average of fertilizer treatments, was more successful in that year for the Debrecen 377 hybrid (3.7 t/ha).

In the year of 2002, the volume of precipitation was 125 mm less in winter and it was 89 mm less in the vegetation season than the 30 years' average. It was especially unfavourable that in April, May, July the volume of precipitation was significantly less than the 30 years' average, which made emerging and initial plant development difficult. The Debrecen 351 maize hybrid could use natural nutrients better than the Debrecen 377. Due to the unprecedented drought the fertilizer reactions of both Debrecen Hybrids were weak (1.7-2.1 t/ha).

The year of 2003 was similar to 2002 as both in winter (34mm) and in the vegetation season (126 mm) less precipitation was measured than the 30 years' average. In April (14mm) and June (22mm) the volume of precipitation was extraordinarily low. In July the weather was a bit more favourable, as at the time of flowering, which is critical for maize, the volume of precipitation was 85 mm, which was 24 mm more than the 30 years' average. As for the Debrecen 377 hybrid, the excess crop yield of fertilization was 1.3 t/ha more than in the previous year.

The year of 2004 was favourable for maize production. The volume of precipitation was 37 mm more in the winter season than the 30 years' average, and in the vegetation period it differed from the average by only 2 mm. However, the distribution of precipitation was unfavourable. In April the volume of precipitation was 5 mm less than the average of many years, but it was 42 mm less in May, which exerted a negative effect. In July the total volume of precipitation was 142 mm, which was 81 mm more than the average of many years. The rate of precipitation supply in June-July-August was satisfactory, and it largely participated in achieving successful yields. The results of Debrecen 351 maize hybrid from non-fertilized plots exceeded those of the Debrecen 377 maize hybrid by 0.5 t under equal treatment. The excess yield of fertilization, in the average of fertilization, was higher in the case of the Debrecen 377 maize hybrid this year as well (3.4 t/ha).

In the vegetation period of 2005 the volume of precipitation was 156 mm more than in the previous year. The volume of precipitation in the winter season differed from it only slightly. The average of crop yields from non-fertilized plots was the largest this year: 5.9 t/ha. The excess yield of fertilization was 2.2 t/ha in the average of the Debrecen maize hybrids.

Our investigations suggest that the fertilization reactions of maize hybrids are largely affected by the year, mainly the volume of precipitation in that year, which can be well characterised by the volume of grain yield per 1mm of precipitation (*Figures 5-6*). For 1 mm of precipitation from green crop harvest to the end of the vegetation season, in non-fertilized treatments 14 kg grain crop of Debrecen 351 and 11kg Debrecen 377 could be calculated. From among the study years, this year saw the largest volume of grain yield per 1 mm of precipitation. As for 90 kg N/ha fertilizer treatments, for 1 mm of precipitation from green crop harvest to the end of the vegetation season, 22 kg grain yield of Debrecen 351 maize hybrid (2002) and 19 kg of Debrecen 377 (2003) could be calculated.

In respect of crop yields calculated for 1 mm of precipitation from green crop harvest to the end of the vegetation period, with the exception of the years 2002 and 2005, there are no significant differences, either in non-fertilized or in fertilized treatments.

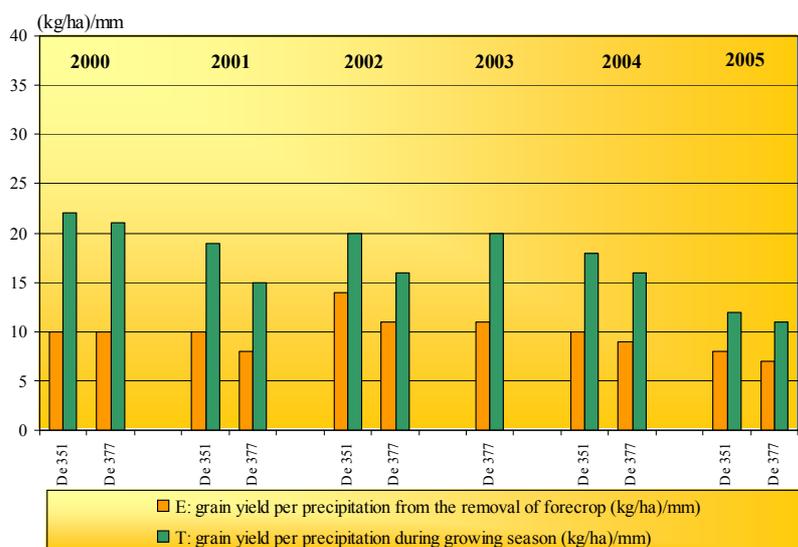


Figure 5. Maize grain yield for 1mm of precipitation in non-fertilized treatment (Debrecen, 2000-2005.)

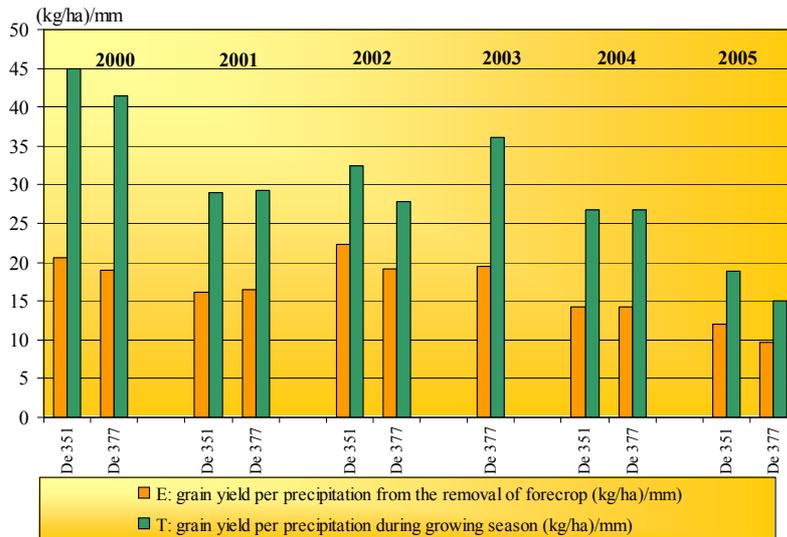


Figure 6. Maize grain yield for 1 mm of precipitation, 90 kg N/ha (Debrecen, 2000-2005.)

We investigated the effects of irrigation and fertilization in irrigated and non-irrigated treatments by using the crop yield data of Debrecen 351 and Debrecen 377 maize hybrids from 6 years, on 6 levels of fertilization annually and in four replications. In the study period, in the droughty year of 2002 maize yields considerably grew under irrigated circumstances. The volume of excess yield was 1.9 t/ha for both hybrids, depending on the rate of soil nutrient supply. The highest efficiency of irrigation (2.7-2.8 t/ha) was achieved for both hybrids on plots fertilized with an agent of 120 kg/ha nitrogen (Figure 7.)

Having examined the yields of the two Debrecen maize hybrids as a result of irrigation separately we concluded that they differed from each other significantly. In our experiments irrigation increased the efficiency of fertilization. The correlation of irrigation and fertilization is different from hybrid to hybrid. In irrigated cultivation the condition of effective farming is to provide the required level of nutrient supply for plants.

Effective maize production should use irrigation to reduce the harmful effects of water shortage in the future as well. It has been proved that the occurrence of both excessive inland water and drought has risen and maize has become more water-sensitive, which often disturbs the operation of markets. The fluctuation of yields

mostly results from the lack of economic and technical difficulties rather than from biological potentials. Despite this, research on the potentials of irrigation farming is necessary, by the technological and economic revision of this complex problem and by the economic use of available water resources.

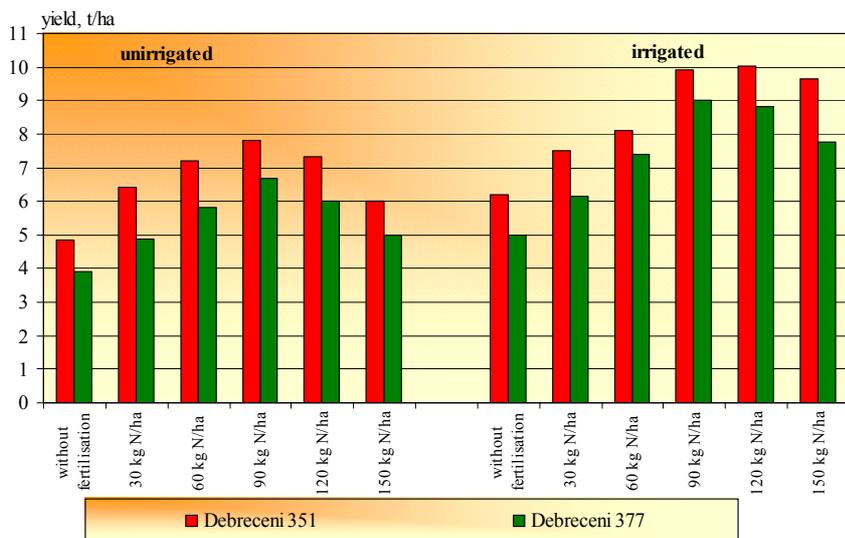


Figure 7. Effect of irrigation and fertilization on the Debrecen maize hybrid yields (Debrecen, 2000)

### 3.2. Results of multifactorial experiments

We evaluated the effects of soil cultivation in the years of 2000, 2001, 2002 and 2003 on the basis of findings from multifactorial examinations. In the area of soil cultivation we investigated the variants of autumn and spring ploughing and disk cultivation.

We evaluated our experimental results annually and then we applied variance analysis for the whole examination period. In our analysis we performed the five treatments in the experiment (soil cultivation, fertilizer, plant number and hybrids) according to the set-up. Fertilizer treatment was of 120kg N + 90kg P<sub>2</sub>O<sub>5</sub> + 106kg K<sub>2</sub>O per hectare and the double of this quantity in the case of non-fertilized treatment. Plant numbers were 50, 70 and 90 thousand /hectare. The studied maize hybrids were Debrecen 351 and Debrecen 377 in irrigated and non-irrigated versions.

According to our variance analysis results soil cultivation at the significance level of 5% in the past 4 years significantly influenced the yields of the Debrecen maize hybrids.

On the basis of the statistical test, in the average of four years, autumn ploughing provided the most favourable conditions for the Debrecen maize hybrids. Their yield was reliably higher by 2.6 t/ha than in disc cultivation (*Table 2.*).

Table 2. *Formation of homogenous groups by Duncan's test (Debrecen, 2000-2003.)*

Cultivation variant	Homogenous groups		
	1	2	3
Disc cultivation	4.850		
Spring ploughing		5.343	
Autumn ploughing			7.478
Sig.	1.000	1.000	1.000

Significance level 5%

Soil cultivation influenced the yields of the two Debrecen maize hybrids differently. We measured significant differences in the variants of autumn ploughing and disc cultivation (*Figure 8.*). The excess yield of the Debrecen 351 maize hybrid was 1.0-0.7 t/ha. Out of the studied years, autumn ploughing proved to be highly advantageous in 2001 (3.2-3.9 t/ha). In the droughty year (2002) the difference in yields was lower (2.3-3.2 t/ha). The Debrecen 351 maize hybrid could utilize the favourable conditions extremely well, e.g. its autumn ploughing resulted in 1 t more yield as compared to Debrecen 377 maize hybrid. In years of average precipitation rates the autumn and spring ploughings and the disc cultivation of the former hybrid proved to be very successful. The results of the droughty year of 2002 proved the good adaptation capacity of the Debrecen 351 maize hybrid and its performance was satisfactory in spring ploughing as well.

The findings of our variance analysis demonstrated that fertilization at the studied significance level in the studied period could steadily increase the yields of the Debrecen maize hybrids. On the basis of Tukey's test we found significant differences between fertilized and non-fertilized treatments in the average of the four years. The highest volume of yield was received under the fertilization treatment of 240kg N, 180kg P<sub>2</sub>O<sub>5</sub>, 216kg K<sub>2</sub>O/ha; however, the yield of 6.7 t/ha received under the treatment of 120kg N, 90kg P<sub>2</sub>O<sub>5</sub>, 106kg K<sub>2</sub>O/ha was not significantly lower.

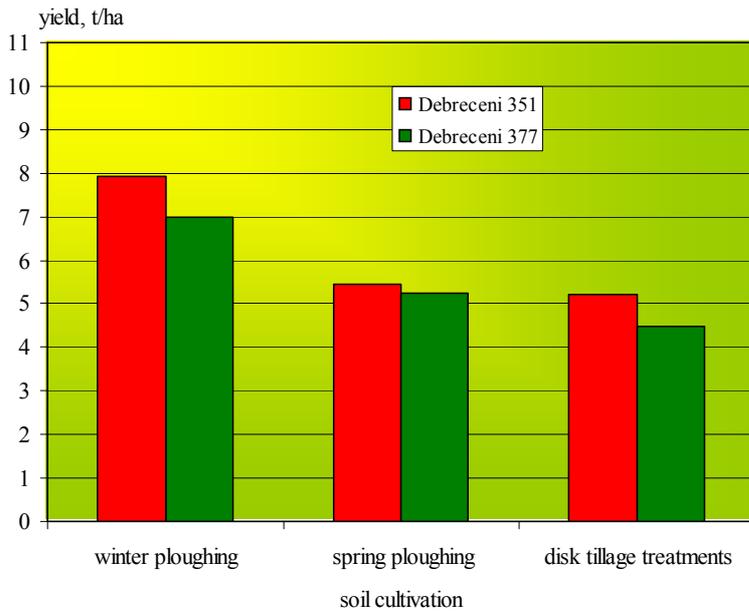


Figure 8. *Effects of soil cultivation on the yields of Debrecen maize hybrids (Debrecen, 2000-2003.)*

The excess yield of autumn ploughing without fertilization was 2.7 t/ha as compared to yields from cultivation without ploughing in the average of the four years. Similar results were gained from fertilization treatments; fertilization increased yields by 2.9 t/ha on average. The correlation of soil cultivation and fertilization was not significant in the average of the four years. In the studied years the excess yields of fertilization were different. Autumn ploughing and disc cultivation resulted in excess yields of 1.5-3.0 t/ha, and spring ploughing gave lower yields of 0.9-1.8 t/ha.

In the studied four years the impact of fertilization and the hybrid-effects were significant separately, but their correlation was not significant. The excess yield of fertilization was 1.9 t/ha in the average of the Debrecen maize hybrids and the years. In the droughty year of 2002 the excess yield of fertilization per hectare was 1.8 t/ha for both Debrecen maize hybrids. We measured the highest fertilizer effect in the case of the Debrecen 351 maize hybrid in 2000 and on the hybrid 377 in 003 (2.7-2.8 t/ha) (Figure 9.).

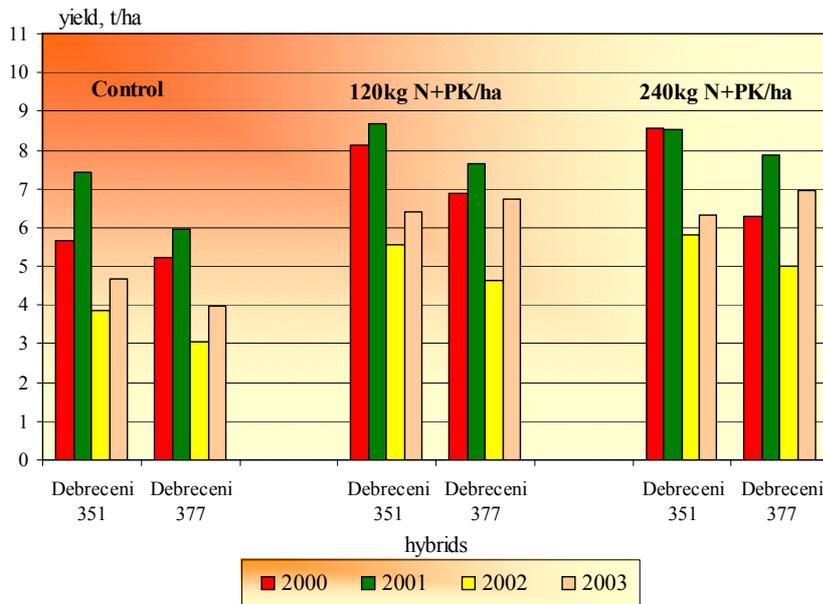


Figure 9. *Effects of years and fertilization on the yields of Debreceni maize hybrids 351 and 377 (Debrecen, 2000-2003.)*

According to the findings of the variance analysis irrigation showed a strong relation with yields in the average of the four years. The correlation of irrigation and soil cultivation, irrigation x soil cultivation showed significant correlations. The effect of irrigation in autumn and spring ploughings in the average of four years resulted in the yield of 1.1 t/ha, but in the case of disc cultivation it did not influence crop yields significantly. In the droughty year (2002) the excess yield from irrigation and autumn ploughing was 1.8 t/ha. Cultivation without ploughing, with the exception of the year 2003, is not recommended for irrigated cultivation.

In the studied four years in the case of non-irrigated cultivation, autumn ploughing was the always the most advantageous. In droughty years spring ploughing for non-irrigated plants produced 25% higher yields than yields from autumn ploughing, whereas disc cultivation produced 20% lower yields than yields from autumn ploughing. In the year of favourable precipitation rates (2001) spring ploughing and disc cultivation produced 36% lower yields than autumn ploughing. In irrigated treatments, with the exception of 2003, autumn ploughing

produced the highest yields every year. In droughty years yields were 48-68% higher than in cultivation without ploughing and in spring ploughing.

In the average of the four examined years the excess yield of irrigation was 0.9 t/ha (Figure 10.). In droughty years it was merely 0.3 t/ha. The effects of irrigation and fertilization are significant separately, but their correlation was not significant in the average of years. The excess yield of fertilization was 1.7 t/ha for non-irrigated plants in the average of years, whereas in droughty years it was only 1.2-1.5 t.

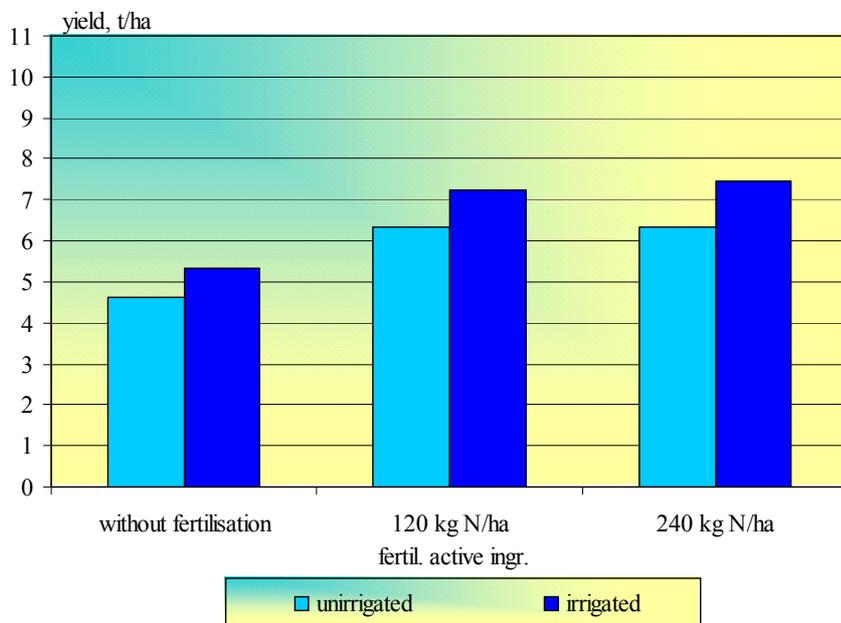


Figure 10. *Effects of irrigation and fertilization on the yields of Debrecen maize hybrids (Debrecen, 2000-2003.)*

The excess yield of irrigated cultivation was 2.3-2.9 t/ha in droughty years, whereas in years of favourable rate of precipitation it was 0.9 t/ha.

In the average of the four years the Debrecen 351 maize hybrid achieved the highest crop yield (7.2 t/ha) in irrigated cultivation. The irrigation effect was 0.8 t/ha. According to the results of the applied variance analysis hybrid effects and irrigation effects were both significant and so was their correlation.

The effect of irrigation between the Debrecen maize hybrids is different. For the Debrecen 351 the excess yield of irrigation was 1.5 t/ha, for the Debrecen 377 maize hybrid it was 0.700 t/ha. (Figure 11.). As a result of irrigation, the excess yield of the Debrecen 351 maize hybrid was the highest in 2000 (3.4 t/ha). The excess yield of irrigation was similar in 2001 and 2003 from the studied years. In the droughty (2002) year the excess yield of the Debrecen 351 maize hybrid was 0.6 t/ha, which was higher than that of the Debrecen 377 maize hybrid.

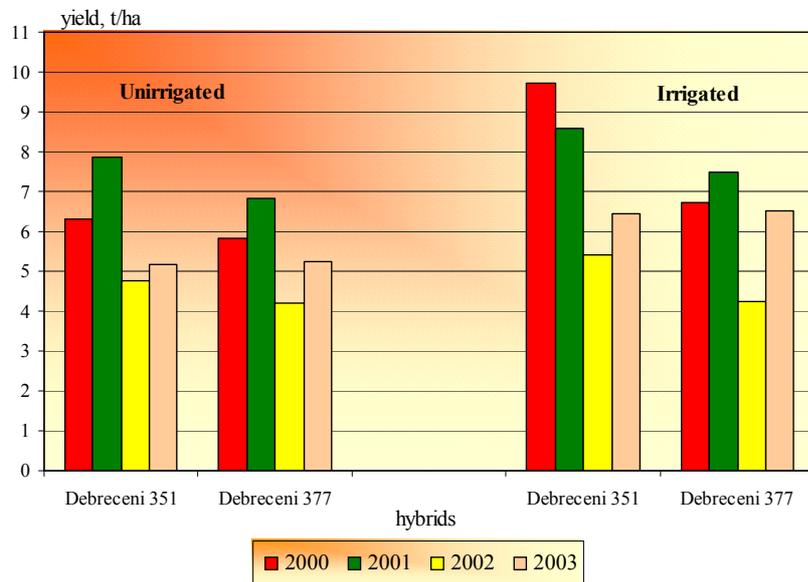


Figure 11. *Effects of years and irrigation on the yields of Debrecen hybrid 351 and Debrecen hybrid 377 (Debrecen, 2000-2003.)*

The findings of Tukey's test, at the significance level of 5% between plant number treatments proved that in the average of the four years there was no significant difference between 50-70000 plant number/ha treatments in group 1. However, there was reliable difference between group 1 and the treatment of 90 thousand plant/ha.

In the average of the four examined years, soil cultivation variations demonstrated a close correlation with plant numbers. In autumn ploughing 70 thousand plant number/ha proved to be the most favourable variation. Within this, a lower plant number was reasonable in the droughty year whereas a higher one in the year of favourable precipitation (2001). The plant number of more than 50 thousand

caused crop failure in spring ploughing; however, there was no significant difference between the treatments of 50 and 70 thousand plant/ha in disc cultivation.

The results of the variation analysis suggested that in the four years' average there was no significant correlation between plant number and fertilization. In the case of 70 thousand plant /ha the average volume of excess yield was 0.71 t/ha more than the yield of 50 thousand plant/ha. When the dose of 120 kg N/ha was applied, the excess yield of fertilization, increasing the plant number from 50 thousand/ha to 70 thousand /ha was 0.7 t/ha; but when plant numbers were increased from 70 thousand plant/ha to 90 thousand plant/ha, the volume of excess yield was merely 0.4 t/ha. When the dose of 240 kg was applied, the difference between the yields of 50 and 70 thousand plant/ha, similarly to the treatment with 120kg N/ha, was 0.7 t/ha, but the excess yield of fertilization was only 0.07 t/ha in the case of treatments on 70 thousand plant/ha and 90 thousand plant /ha (*Figure 12.*).

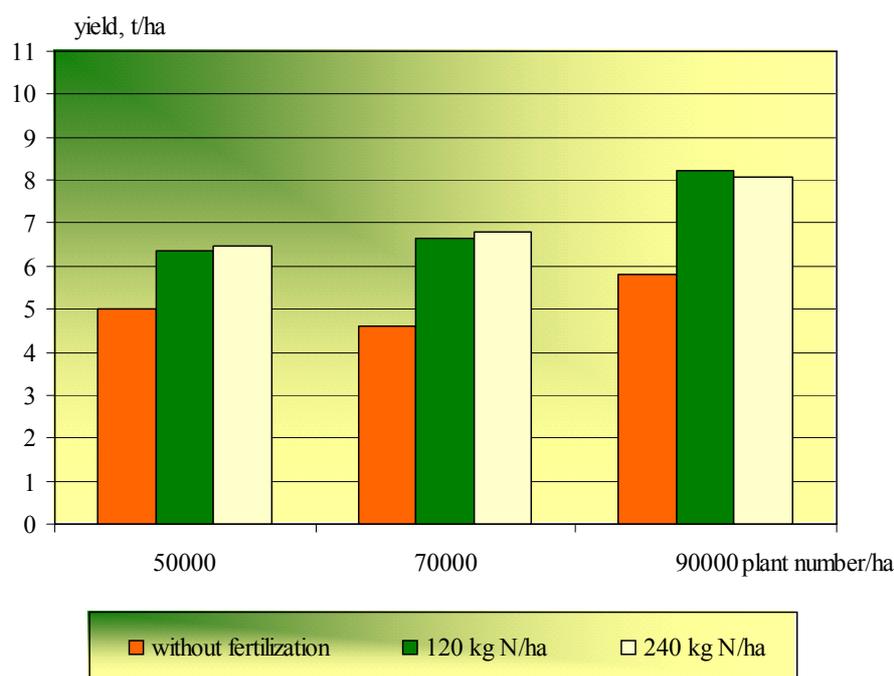


Figure 12. *Effects of plant number and fertilization on the yields of the Debrecen maize hybrids, (Debrecen, 2000-2003.)*

The effect of plant number is different in irrigated and non irrigated treatments as well. The correlation of plant number and irrigation was not significant in the four years' average. In the studied period, the effect of irrigation was the highest in 2000, in the treatment of 70 thousand plant/ha (2.6 t/ha). In the droughty year of 2002 irrigation produced 0.5 t/ha in the same treatment. The effect of irrigation was considerably higher when 90 thousand plant/ha was treated (1.9 t/ha). In irrigated cultivation the effect of irrigation on 90 thousand plant/ha was significantly higher (1.9 t/ha). In irrigated cultivation in the case of 90 thousand plant/ha the yield was 12% higher than in the case of 70 thousand plant/ha.

The correlation of plant numbers and hybrids was not significant in the average of the studied years. In the average of the four years both hybrids produced higher yields in the higher plant number variations (90 thousand plant/ha). There was no significant difference between the variants of 50 and 70 thousand plant/ha in the case of either Debrecen maize hybrids.

In 2001, when the rate of precipitation was favourable, the Debrecen 351 maize hybrid produced 1.9 t/ha more in the variant of 50 thousand plant/ha than the Debrecen hybrid 377. This difference diminished to 0.8 t/ha in the treatment of 90 thousand plant/ha. In the variation of 70 thousand plant/ha there was no reliable difference between the hybrids. However, in the droughty year of 2002 the treatment of 70 thousand plant/ha produced the greatest difference, and the excess yield of the Debrecen 351 maize hybrid was 1.6 t/ha.

The quality examination of the Debrecen maize hybrids was performed by the *Debrecen Regional Instrument Centre*, the largest accredited instrument centre in the Trans-Tisza region. In 2002-2004 the protein, starch, oil; zinc, calcium and strontium content of the Debrecen 377 maize hybrid was examined. In 2005 we analysed and evaluated the carotene, vitamin A and E content of the Debrecen maize hybrids 351 and 377.

The year considerably influenced the raw protein content of the Debrecen 377 maize hybrid, calculated from the nitrogen content of its grain yield. In the droughty year of 2002 we measured a higher average protein content than in 2004 when the rate of precipitation was more favourable.

As a result of fertilized treatments the protein content of the grain yield of the Debrecen 377 maize hybrid increased markedly. Higher fertilizer rates increased protein rates as well. The rate of increase was different in certain years, as in 2002 the fertilizer dose of 60 kg N/ha produced an average excess protein content of 1.22% (1.17 % and 1.27 % on irrigated and non-irrigated plots), 1.21 % in 2003 (1.26 % and 1.15 %) and 1.09 % in 2004 (1.13 % and 1.05 %)

The increased dose of 120kg N/ha increased the protein content by 1.30-1.26 % on average (the rate was lower in 2004 when precipitation was abundant). The rate of increase on irrigated plots, except for 2002, was lower in every case (Figure 13.).

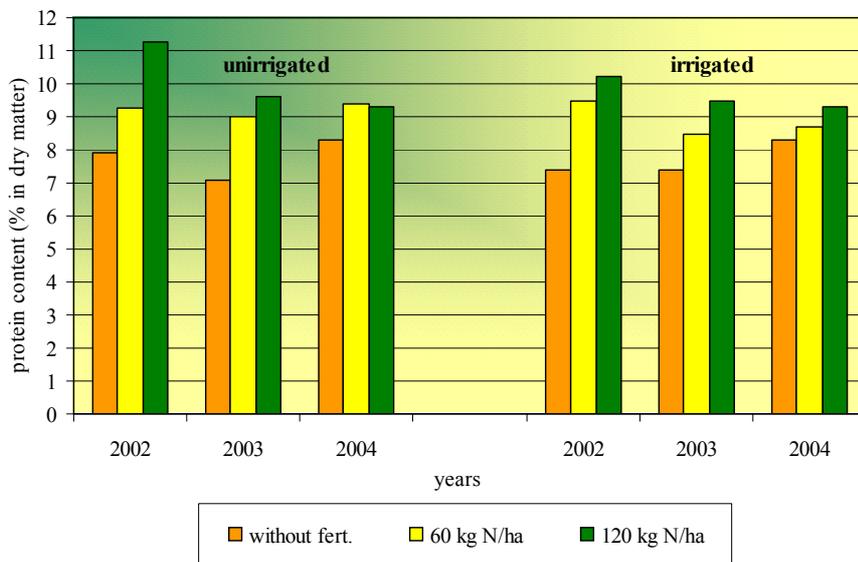


Figure 13. *The effects of year, irrigation and fertilization on the protein content of the Debrecen 377 maize hybrid (Debrecen, 2002-2004.)*

Besides the protein content we examined the oil and starch content of the Debrecen 377 maize hybrid as well. In 2003, under droughty conditions, irrigation did not influence the oil content, but fertilizer doses reduced it. The oil content in non-irrigated treatment was 5.84 %, and it was 5.75 % in irrigated treatment (Figure 14.).

As a result of irrigation, the oil content of the Debrecen 377 maize hybrid increased (from 69.8 % to 71.4%) in the average of fertilized treatments. Under irrigated and non-irrigated conditions the starch content reduced as a result of both fertilized treatments (Figure 15.).

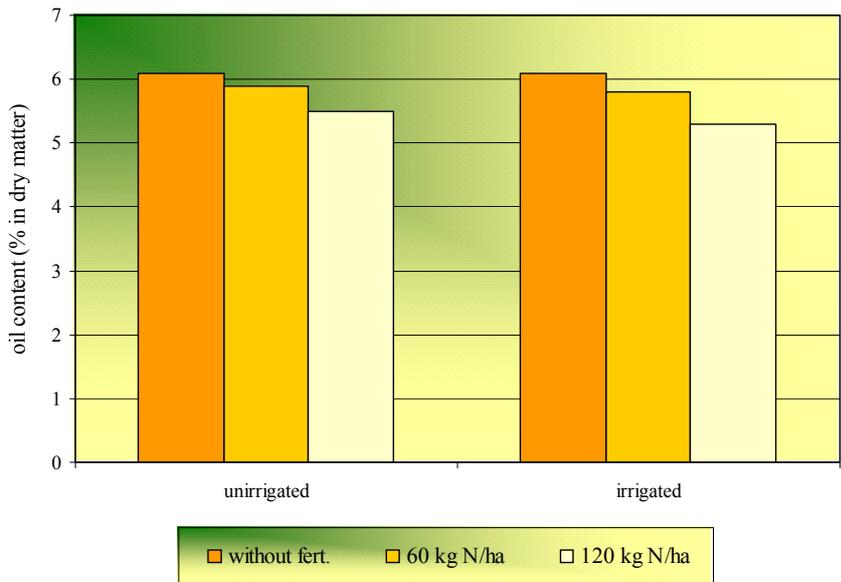


Figure 14. The effects of irrigation and fertilization on the oil content of the Debrecen 377 maize hybrid, (Debrecen, 2003.)

In accordance with the research findings of Győri (1987, 1998, Győri and Mrs. Győri 2002) we experienced that as a result of fertilization the Zn content of the Debrecen 377 maize hybrid reduced under both irrigated and non-irrigated circumstances. As compared to controls, the reduction was 3.50 mg/kg in the average of treatments. On non-irrigated plots the average reduction of Zn volume was the lowest in 2002 (1.76 mg/kg) and the highest in 2003 (5.51). Under irrigated conditions the reduction of Zn content varied between 2.79 mg/kg and 3.86 mg/kg in the studied three years.

We examined the calcium and strontium concentrations of the grain yield of the Debrecen 377 maize hybrid in 2004. We concluded that there was a strong linear correlation between the two elements, i.e. excess nutrient supply resulted in the growth of strontium content as well as that of calcium. The average strontium content of the Debrecen 377 maize hybrid was 0.45-0.50 with the extreme values of 0.36 and 0.80 mg/kg.

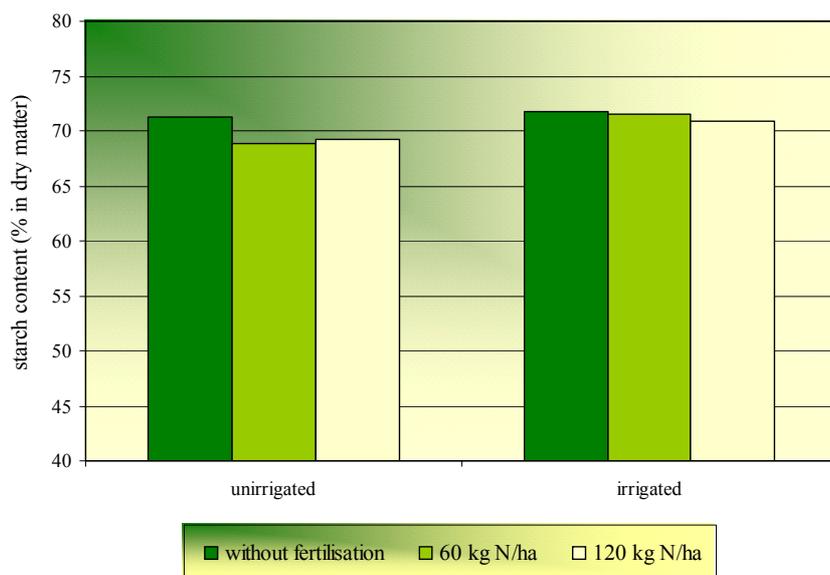


Figure 15. *The effects of irrigation and fertilization on the starch content of the Debrecen 377 maize hybrid, (Debrecen, 2003.)*

In 2005 we examined the carotene, vitamin A and E content of the Debrecen 351 and the Debrecen 377 maize hybrids under non-irrigated circumstances. Variations in the inner content of the hybrids were compared to that of controls. We found that the volume of carotene increased as a result of fertilization in the case of the Debrecen 351 maize hybrid (0.17 mg/kg), and reduced in the case of the Debrecen 377 maize hybrid (0.02 mg/kg) (Figure 16.)

The volume of vitamin A increased considerably as a result of fertilization in the case of the Debrecen 377 maize hybrid (338 NE/kg), whereas a slight reduction was experienced in the case of the Debrecen 351 maize hybrid (Figure 17.).

The Debrecen 377 maize hybrid reacted to the fertilizer dose of 120 kg/ha by increasing its vitamin E content. The volume of increase compared to controls was 0.10 mg/kg (Debrecen 377). In the case of the Debrecen 351 maize hybrid the content of vitamin E reduced (0.40 mg/kg) (Figure 18.)

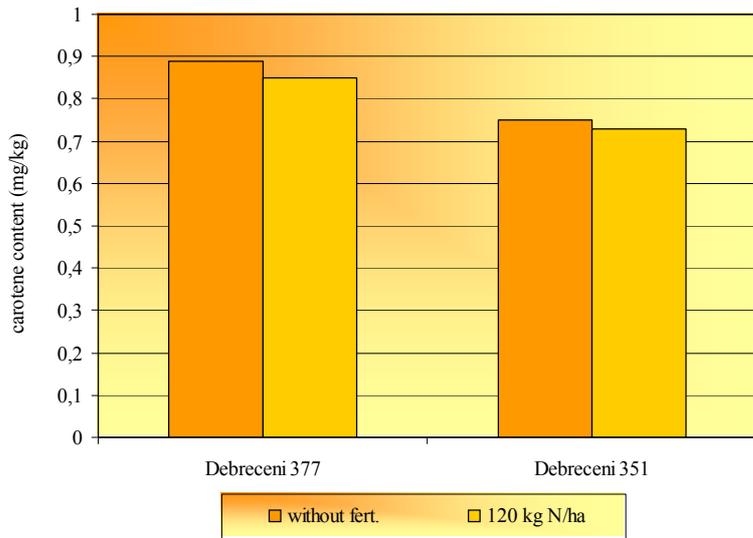


Figure 16. *Effects of fertilization on the carotene content of the Debrecen maize hybrids under non-irrigated circumstances, (Debrecen, 2005)*

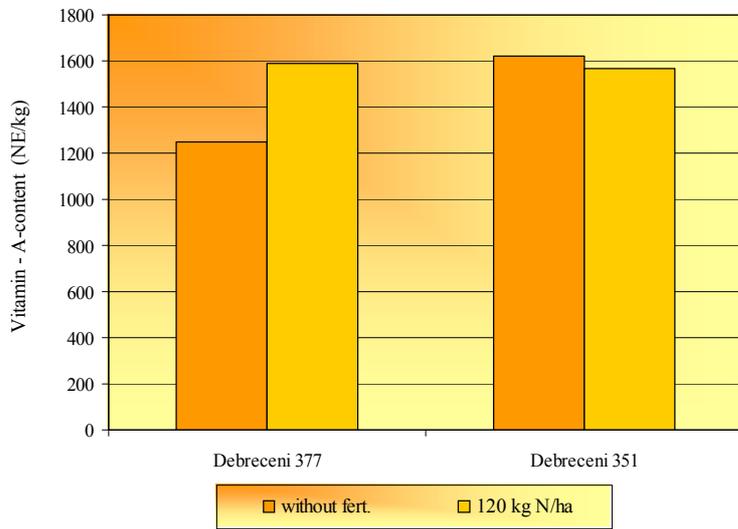


Figure 17. *Effects of fertilization on the vitamin E content of the Debrecen maize hybrids, non-irrigated, (Debrecen, 2005)*

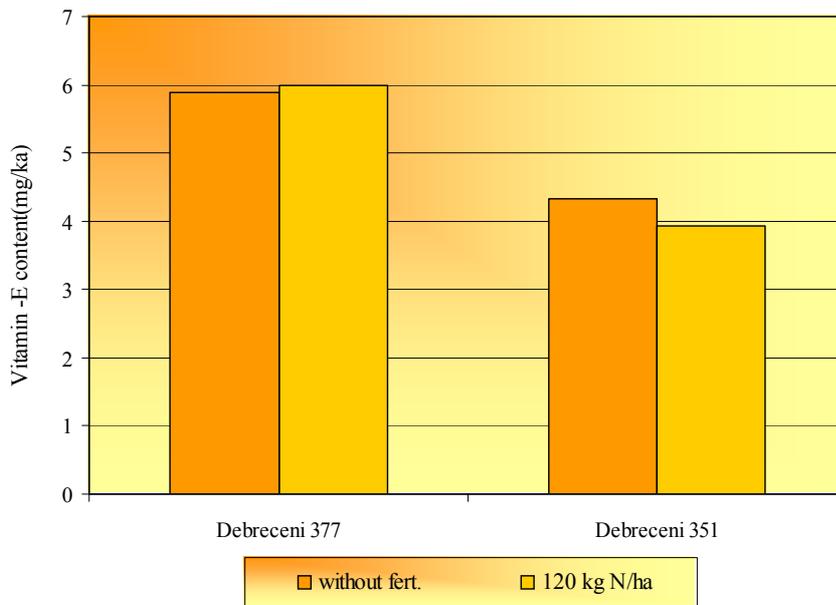


Figure 18. *Effects of fertilization on the vitamin E content of the Debrecen hybrids, non-irrigated (Debrecen, 2005.)*

### 3.3. Marketing analysis on maize seeds in the Agrárgazdaság Kft

#### *Study on product policy (Product) for maize seed*

The primary aspect to develop the appropriate product policy for the maize hybrids exclusively owned by the Agrárgazdaság Ltd. was to emphasize their yields and competitiveness. During the three years of OMMI experiments, the hybrids showed the following results as compared to standards:

Debrecen SC 377	→	+ 10.7 %
Debrecen SC 351	→	+ 7.8 %
Debrecen TC 382	→	+ 5.5 %

We should not leave the fact out of consideration that at the time of the examinations markedly dry years were characteristic, which further increased the stability and reliability of production capacities in the case of the Debrecen varieties.

The next characteristic in the product policy taken into consideration was the water transpiration capacity of the hybrids. The experience of the past years proved that under average weather conditions the moisture content of grains was 18-21 %, i.e. excellent for harvest time. This characteristic is especially important as the costs of drying rise due to changes in energy prices, as drying is one of the most expensive factor in production costs.

Very thin cob, thin, long grains are highly characteristic of the studied Debrecen hybrids, therefore fewer broken grains are to be calculated in drying and cleaning. This trait is a very significant measure of value.

The grains, which are characteristic of competitors are usually flatter and more fragile, so they are more sensitive to fusarium and therefore they are more difficult to sell.

The managers of the company always highlight these hybrid traits in their communications.

Related to the before mentioned favourable traits of the Debrecen maize hybrids, when compared with their competitors, they present the greatest advantages with their inner content values.

The greatest competitive advantage of the Debrecen maize hybrids is their protein content exceeding 2.5% (*Table 3.*). If we consider the fact that proteins of animal origin are banned to be used in animal feed for well-known animal health reasons, this protein volume, which can be naturally involved in animal feed, can be regarded important.

Table 3. *Protein content, as one of the most significant measures of value in the Debrecen hybrids*

Competitors	Debrecen maize hybrids	Excess protein
8.000 kg/ha x 8.5 % = 680 kg	8.000 kg/ha x 10.5 % = 840 kg	<b>160 kg/ha</b>
9.000 kg/ha x 8.5 % = 765 kg	<b>9.000 kg/ha x 10.5 % = 945 kg</b>	<b>180 kg/ha</b>
10.000 kg/ha x 8.5 % = 850 kg	10.000 kg/ha x 10.5 % = 1.050 kg	<b>200 kg/ha</b>

In the case of 10 t crop yield 200 kg of excess protein = 430 kg soy x 65 HUF = **28 000 HUF**

The Debrecen maize hybrids are also highly advantageous regarding their carotene content as compared to competitors. The measured difference was 29% in the average of many years and the inheritance of beneficial trait is extremely safe, as it is proved by experimental findings. This trait in the Debrecen maize hybrids is well visible, as *Photo 1.* illustrates it.



Photo 1. Carotene-rich Debrecen maize  
(Iklódy, 2002)

The fact that gene manipulated food gains increasing grounds in America means an especially good position for our company, as GM food is a major threat in Western Europe and in Hungary as well. It must be highlighted that gene manipulated maize hybrids are not to be put on the market in Hungary and Hungarian genetic substances are positively not gene manipulated. It is especially true of the Debrecen maize hybrids as their genetic basis comes from Transylvanian free-flowering regional varieties. As it has become clear that 70-80 % of the soy delivered from overseas contains manipulated genes and meat meals pose other health risks, demand for the Debrecen maize hybrids has basically changed.

Unfortunately, the Agrárgazdaság Ltd. has not used this market advantage yet but in the future this is a further breakout potential, which is very important in the company's marketing strategy.

Initially, the managers' product policy in the Agrárgazdaság Ltd. did not place a high emphasis on choosing their special brand name.

They chose the brand name "Debrecen" exclusively as an instinctive, self-evident idea. Meanwhile, regarding their experience and their competitors' practice they tried to change the name by consulting an expert. After various temporary solutions they decided to use the name "MAG" uniformly and consistently, and its introduction coincided with the alteration of packaging and presentation as well.

As for packaging, the most up-to-date packaging material in the world is used (a seven-layer paper sack, which provides the best protection for grains as a living substance) by using professional four-colour chromotypography (Figure 19.).



Figure 19. Packaging material for the Debrecen maize hybrids

In the course of a several year analysis, taking *Tartsay's* (1993) product life cycle into consideration, we included the studied hybrids in the sections of the referred literature. We found that the Debrecen SC 377 and the Debrecen SC 382 maize hybrids were clearly in the period of development. The Debrecen SC maize hybrid 351 is in a different situation as the volume of sale and demand have stagnated for the past two years. The managers of the Ltd. chose the most suitable solution to prevent decline: this variety was produced in a merely organic variety in the last two years and thus not only a gap was found in a glutted market for the company as a sole supplier, but the Ltd. can also dictate prices.

### *Study on price policy (Price)*

In its price policy study, when defining the initial distribution prices of the Agrárgazdaság Ltd. it was found that the starting point of price formation was the so-called cost-based price formation. It means that price is deducted from total costs and a certain profit share is calculated as well.

However, mostly the price policy of competitors is to be taken into consideration when distribution prices are formed for the coming distribution season. This is absolutely understandable, as domestic maize seed prices are determined by presently predominant multinational companies. In order to survive, and also as a result of the above mentioned consumer reservations, domestic variety owners, who lack the necessary marketing experience, followed the strategy that they offered Hungarian maize hybrids at considerably lower prices for customers as compared to the real values of hybrids. However, domestic variety owners soon realized their strategic mistakes as Hungarian maize hybrids have excellent measures of value, they are competitive as it is justified by data from *Sárvári and Szabó (2001)*, *Marton et al. (2002)*, *Pásztor et al. (1997)*.

Lower prices can merely be applied if Hungarian intellectual input and the labour of farmers who produce seeds are undervalued. The required other input: energy, fertilizers, pesticides and technical equipment obviously come from Western Europe. Therefore, low seed prices can be achieved in the above mentioned way, which cannot be our long-term objective.

Therefore, Hungarian variety owners, similarly to the Agrárgazdaság Ltd., seek to form their price policies in harmony with the real performance capacity of the maize hybrid and primarily with its inner content of high biological value.

According to our investigations, due to price rises sales interestingly did not reduce but on the contrary, increased, as

- packaging,
- more dynamic marketing activities,
- prices approximating the prices of multinational companies increased customers' confidence as compared to their previous experience.

Similarly to multinational companies, the Agrárgazdaság Ltd. will raise its prices by 1% from January as a part of its annual price policy, as if its fails to do so, customers delay their purchases until the very last minute and then they are not likely to buy the originally selected varieties. Therefore, distribution is continuous from 1 January to the middle of June.

We compared the prices of maize hybrid seeds with Western –European prices and we saw that their prices exceed Hungarian ones by approximately 50%. We can draw the conclusion that multinational companies in Western Europe and in Hungarian markets as well take the general income producing capacity of domestic agriculture into consideration when they form their prices.

Our investigations suggest that the price policy of the Agrárgazdaság Ltd. is in accordance with its competitors' policies as various firms advertise their catalogue prices well before the maize distribution season starts but they frequently change them according to demand and supply fluctuations.

The application of the methods described by *Kotler* (1991) can be found in maize seed markets as well. This means that maize variety owners and distributors, though on the basis of different considerations, use the following typical price deviations compared to the above mentioned and beforehand decided catalogue prices.

It is naturally true of the marketing activities of the Agrárgazdaság Ltd. marketing as well.

Typical features are:

- various price reductions,
- delayed payment,
- instalment discount,
- loans (fertilizer, pesticides, soil cultivation),
- opportunities for paying with finished goods

In the practice of the Agrárgazdaság Ltd. catalogue prices are formed before the distribution season (November-December of the previous year) according to the following aspects:

- 1) factory price of seeds,
- 2) wholesale price,
- 3) retail price, but as stated in the above mentioned,

these prices are often altered as a result of changing conditions, which is not the most successful solution in trade. However, compliance with competitors and survival in markets are of primary importance.

#### *Study on distribution policy (Place-distribution)*

The Agrárgazdaság Ltd. developed its distribution channels according to the following:

**1.)** Most of the sold maize seed is distributed by wholesalers in relation to the Agrárgazdaság Ltd. The volume they sell is usually 60%. These so-called resellers

receive their distributor's commissions depending on the sold quantities, which vary about 15-25 % of the returns of sales.

The managers of the Agrárgazdaság Ltd. do their best to keep their earlier resellers, they increase the rate of sales and invest great amounts of energy in finding new ones, which requires considerable financial sacrifices.

In our study we raised the issue that with the payment of this high distributor's commissions, it seems to be more reasonable to employ young, ambitious agricultural engineers and tradesmen, but we received the following answer to our question:

The output of the seed plant of the Agrárgazdaság Ltd. does not allow making use of these experts' capacity all the year round. However, multinational companies now follow this way primarily according to the practice that I recommended, but after recent characteristic events of merging in trade those who are employed in commerce can come up with product groups. It means that their offer includes seeds, caustics, other pesticides, fertilizers and even various preservatives. Moreover, in the case of seeds, they can not only sell one species, but generally several varieties, e.g. maize, sunflower, rape etc. together.

If we consider the fact that besides the above mentioned resellers, the Agrárgazdaság Ltd. uses a lot of commercial channels, it can be seen that it means several hundred selling points. Their preservation is a basic economic interest, as in the often mentioned market competition survival is impossible without them.

2.) 30% of the distribution takes place directly from the hybrid plant by using old partner and personal relationships. The managers of the hybrid plant look up these buyers long before the distribution period starts (December, January) and they make offers at factory prices for these long-time loyal customers.

These previously made agreements, on the basis of mutualism, are sometimes revised in unison when the future trends of the distribution season can be seen.

3.) The remaining 10% of distribution takes place directly from the seed plant in the form of so-called "small retail sale". The price used here is between the factory price and the wholesale price. The fact is that almost every important agricultural entrepreneur knows about the location of the Debrecen hybrid plant and that they can almost surely buy seeds there, but traditionally buyers just "pop in" and buy products in small lots.

The other parts of those who visit the hybrid plant come consciously, as a result of advertisements and in the hope of shopping at favourable prices. This 10% of distribution is very important not because of its volume but for maintaining live relationships: visiting farmers can see valuable technologies, order, discipline, professional storage recording and quality control. In the long run all these

preserve and further develop markets. It is highly justified to upkeep these “small retail sales” directly from the seed plant.

*Study on advertisement policy (Promotion)*

The study on the advertisement policy of the Agrárgazdaság Ltd. related to seed distribution unveils that the Ltd. generally uses methods partly available in the literature and partly in everyday life. If we study the advertisement of hybrid maize in a historical order, we can see that for the Agrárgazdaság Ltd. it began with the preparation of the first prospectus. This prospectus had all the possible initial problems: it was black and white, it was home-made and copies were prepared with the available technical potentials of those days according to demand.

As a second step, a brochure was published in a more spacious form and it contained more targeted information to improve product sales. Editing and printing was arranged by experts in a printing office suitable for good quality work.

As a third step, with the former experience two kinds of practice were applied:

1.) A prospectus was prepared starting with the brief history of the farm and it introduced the technical background of seed production and processing and the available team of experts.

This was followed by the description of varieties registered by the state, and the documentation of registration. The prospectus presented the breeding work in progress, new experimental and domestic averages.

It summarized the formation and practical outward form of excellent maize hybrid inner content picturesquely and individually, it presented the increasing volumes of sales and then the available benefits of the Debrecen hybrids in 8 points.

The above mentioned “MAG” emblem is a novel feature in the prospectus. The emblem contains individual motives, which can be exclusively found in the portrayal of the peasant world and the selected colours (red, white, green) also relate to the Hungarian origin of the seed. The selected slogan is “HUNGARIAN SEED INTO HUNGARIAN SOIL”, which conception is not only characteristic of the prospectus, but it conveys the message of the company’s whole advertising activity.

This publication was prepared by the most up-to-date digital techniques on quality paper with the best printing techniques, including the expertise of external advertisement specialists.

2.) With respect to the fact that the production of the prospectuses mentioned in details in point 1. is rather costly and they are often thrown away by uninterested people, a shorter and cheaper flyer version has been prepared. As it comes from the name “flyer” the primary motivating factor was not cost efficiency, but that it can get to large numbers of potentially interested people, perhaps buyers in the future.

Most of the costs related to advertising activities emerge in connection with advertisements; they amount to 50% of such expenses. Advertisements are published in the following places:

- professional publications,
- technical materials related to scientific conferences
- informative materials published in scientific books
- daily papers,
- newspapers of advertisements,
- radio commercials (Falurádió (Village Radio), regional and urban editorial offices
- video clips, commercials (regional and urban editorial offices)
- Debrecen Flower Carnival (“János Kukorica”).

The study on advertisement costs reveals that commercials in the Hungarian Radio are the most expensive. Broadcasting a news block of 30 seconds preceding the broadcast of the Falurádió costs 70 000 HUF + VAT (which is equal to the input costs of maize seeds for 5 ha).

In the Hajú-Bihari Napló a three-colour advertisement of 10x15 cm costs 65 000HUF.

In connection with newspaper advertisements we can state that they can only achieve the expected effects, if they are often published, at least in every two days in the distribution season and in the largest possible forms. If they appear next to the advertisements of multinational companies (Westel, Vodafone, banks etc.) from other fields of business, covering whole pages for several thousands HUF with their sizes of 10x15 they often go unnoticed.

If our statement is verifiable, we have to calculate a factual cost increase in this area.

According to *Vágási* (2000) it is typical of certain products e.g. of hybrid maize seeds that the life cycles of products on markets get shorter. This is proved by the fast varietal conversions used by multinationals, which means a new challenge for Hungarian plant breeders.

We are also forced to follow this practice and the presentation, advertisement of newer products naturally raises such expenses dramatically.

As compared to the previously mentioned marketing activities the marketing policy of the Agrárgazdaság Ltd. has a special outward form, which cannot be found anywhere else.

Interestingly, it was called by the journalist of an agricultural technical newspaper “guitar marketing”. This means the following:

The team of experts in the company established a band decades ago, when they were agricultural students, which was reorganized from various top managers of the then Agrárgazdaság Ltd. following some years’ gap.

Parallel to the formation of the band the managerial staff of the Agrárgazdaság Ltd. organizes presentations, meetings for professionals every year. These venues are usually followed by reception parties, which allow open, free discussions and the exchange of professional experience and entertainment as well. Last year increasingly more presentations, standing receptions and subsequently a so-called “maize ball” were organized by the management of the Agrárgazdaság Ltd. These events are usually organized in the following places:

- Hajdúböszörmény – Farmers’ days in March,
- Berettyóújfalú –Shepherds’ Days,
- Püspökladány – Agricultural exhibition and fair etc.

These meetings naturally focus on maize seed, as it is highlighted in the lectures of 25-30 minutes. Questions can be asked from lecturers, and comments can be made publicly or in smaller groups.

Guests are invited on the basis of the previous year’s computerized registrations, and the invited guests feel privileged to be invited. These venues can be considered to be the most effective and most direct marketing activities where expenses are recovered, as the relationships, which are formed here are for the long run, unlike in the case of buyers who read the advertisements in the newspapers.

The other unique solution, which also forms an exclusive part of the marketing and advertisement activities of the Agrárgazdaság Ltd. is appearance at the Debrecen Farmer-Expo International Agricultural and Food Industrial Technical Fair. Here the maize hybrids offered by the Ltd. are sowed in the area of the Expo at the usual time, and they are carefully tended. During the time of the exhibition a stage is set up next to the show plot, and various pieces of music entertain the general public continuously (here, occasionally, the company’s band called “Túlélők” (Survivors) also appear on the stage. The visitors of the fair stop when they here the music and they cannot help seeing the maize which is already growing green and also the informative materials and advertisements related to

maize hybrids. Regarding the spectacularly increasing number of Farmer-Expo visitors year by year, this solution also seems reasonable.

The objective of the Agrárgazdaság Ltd. with its advertisements is to increase distribution. This is the reason why we investigated the correlation of advertisement costs and increased sales. We found that initially the growth of sales does not cover the expenses of advertisement activities. After a time, this process reverses. It is significant to feel how long the costs of advertisement costs are worth increasing.

*Visibility is highly significant, but quality is much more important than quantity, i.e. well organized and well located advertisements are more effective than perhaps the great number of low quality advertisements.*

#### *Study on the efficiency of marketing activity*

The Agrárgazdaság Ltd. allocates increasingly more sums on direct marketing activities annually, which have exceeded 12000 thousand HUF.

The Ltd.'s publications, some meetings for customers, the Farmer Expo and participation in agricultural exhibitions in larger towns (Hajdúböszörmény, Berettyóújfalu, Biharkeresztes) amount to expenses ranging from a couple of hundred thousands to a million HUF occasionally.

Our surveys show that despite high cost demands this is our most effective marketing activity, although according to public belief 50 of expenses spent on marketing and advertisement is a waste of money.

Newspaper advertisements represent considerable sums, but regarding that group of potential buyers (new land owners) has changed, continuous presence in newspapers is indispensable.

The Agrárgazdaság Ltd. participated in the Debrecen Flower Festival in 2001 for the first time, which means an opportunity for the population of the region to gain understanding on the company's significant spiritual potentials. Since the flower Festival was broadcast through several television and radio channels and thus millions of people watch it, the expenditure of about 3000 thousand HUF has been recovered.

Without these expenditures seeds are not marketable, as oversupply is so high and competition is so fierce on seed markets that survival can only be realized by further increasing these expenses. Our statements are supported by the sales data of last year, which suggest that sales practically multiplied by ten during a couple of years. Whereas the sold quantity from the three hybrids was 2136 sacks in 1997, this figure reached 22500 pieces of sold sacks by 2001. The company prepared to start the year of 2002 with more than 25 thousand clasped shut sacks of Debrecen hybrids in its warehouses. Previous buyers showed more intensive

purchasing intentions so much the more, because the Agrárgazdaság Ltd. helped the producers with their problems concerning the buying up of fodder maize in 2001-2002 by purchasing the yields of its own varieties at a 5% higher price.

The above data clearly prove that marketing expenses get many times recovered every year even if returns include a price rise of about 1%.

In the case of 2000 and 2001 the increase of 3700 thousand HUF in marketing costs produced an increase of 67540 thousand HUF in returns.

The further 2000 thousand HUF expenditure (altogether 12000 thousand HUF) seemingly caused an increase of 77500 thousand HUF. However, it must be added that the excess return of 50 million HUF comes from the price rise of 2000HUF/sack (Table 4.).

The question may rise with good reason whether the further increase of marketing expenses would have been reasonable. For the time being, it is groundless as the above mentioned expenses facilitated the distribution of the whole available stock.

Further sales are hindered by the lack of source materials, as a totally new series of varieties is to be introduced and spread.

However, in the near completion of the distribution season in 2002 the problem was not the lack of available products, but the efficiency of further marketing activities determined the positions of the Debrecen maize hybrids on domestic markets.

Table 4. *Distribution of Debrecen maize hybrids*

Year	Sold sack pc	Distribution price HUF/pc	Returns thousand HUF	Marketing expenses thousand HUF
1997.	2.136	7.000	14.952	1.500
1998.	7.169	8.000	57.352	2.500
1999.	13.771	9.000	123.939	4.200
2000.	17.996	10.000	179.960	6.300
2001.	22.500	11.000	247.500	10.000
2002.	25.000	13.000	325.000	12.000

Naturally, the constant improvement of the competitiveness of varieties, the breeding of new varieties and their acceptance are also significant as a result of the often mentioned fierce competition.

### *Preparation for the seed distribution season in 2003*

The seed producing area of the Debrecen hybrids was determined to allow distribution of high volumes without quantitative restrictions in the seed producing season of 2002.

From the viewpoint of seed production the weather in 2002 was extremely unfavourable. Apart from this, the Debrecen hybrids reached the lowest limit of experts' calculations in seed production. The three domestically distributed maize hybrids yielded 30000 sacks of good quality grains.

The lowest yield was produced by the Debrecen SC maize hybrid 351, as it was grown in the Bődönhát area, which earlier had changed over to organic production without fertilizers and pesticides.

As the concerned area had already received "organic" qualification from the Biokontroll Hungária PUC, the approximately 600 clasped sacks of hybrid maize from there also received this qualification. It is all the more important that only this hybrid maize variety possesses this organic qualification in Hungary.

Our examination suggests that at the end of 2002 there was no pre-distribution season for maize seeds although variety owners made their bids. In such cases it is typical that institutions of plant breeding use the final prices from the previous year. (It always means April prices as prices are usually not risen in May).

In autumn 2002 the Agrárgazdaság Ltd. announced the prices of the Debrecen maize hybrids (similarly to previous years) but only one considerable buyer showed up, the previously mentioned KITE Rt. As the Ltd. had liabilities due to an earlier machine purchase, its equivalent was paid in grains.

Multinational companies in domestic markets raised their prices in 2003 by approximately 10%; however, the Agrárgazdaság Ltd. performed a price rise of merely 5%, as it took the previous years' extremely low maize prices and the constantly reducing number of animals into consideration as well.

Distribution was not very favourable until 31 March 2003. There was no pre-distribution season, and the main season was delayed and slow. Farmers waited for the best opportunities

Despite the favourable effects, the managers of the Agrárgazdaság Ltd. hoped to sell the Debrecen maize hybrids, as their harvest results, compared to those of their competitors, were satisfactory.

The marketability of a large volume of Debrecen maize seed was rendered probable by the otherwise sad fact that rape and most part of winter barley were perished by frost. Maize was hoped to be seeded in these plots as well.

8000 sacks of Debrecen seed were sold until 31 March 2003. Last year at the same date the volume of sold seeds exceeded 10000 pieces of sacks. Apart from this fact, the management of the Agrárgazdaság Ltd. calculated the sale of only 25000 sacks of seeds again. To meet the requirements of the above mentioned distribution plan, it has taken the following measures:

It continues all the listed advertisement activities, but reasonably modifies their messages as time goes by and as circumstances change.

On the basis of personal relationships experts from seed factories continuously visit those factories and farmers, who were offered to buy maize seed at individual and reasonable prices at the end of the distribution season.

It made special offers for farmers hit by inland water problems and it offered deferred payment opportunities for those who had payment difficulties. .

It provided opportunities for payment in forage maize, for old and new yields as well.

It announced that the company would buy up the yield of the Debrecen bred hybrids in the autumn buying-up season, due to their previously mentioned inner content, at a 5% higher price than actual prices.

The company's marketing costs in 2003 exceeded the sum of 10 million HUF until 31 March. These expenses have been recovered.

## **5. CONCLUSIONS AND RECOMMENDATIONS**

On the basis of the long-term experiment on calcereous chernozem soil in the Látókép Experimental Plant of the Centre of Agricultural Sciences, University of Debrecen, we drew the following conclusions:

Research findings from a *three-factor experiment* suggest that irrigation and fertilization strongly correlate with production yields. The effect of irrigation depends on the soil's natural rate of water supply, nutrient content and certain doses of fertilizers. On the basis of our variance analysis findings we concluded that the effects of both fertilization and irrigation were significant in relation to the crop yields of both maize hybrids in the whole study period.

Our research findings justified that the Debrecen 351 maize hybrid could use the natural nutrient supply of soil better in all the studied years than the Debrecen 377 maize hybrid.

A close correlation was found between the natural nutrient utilization capacities of the Debrecen maize hybrids and their fertilizer reactions. In the average of fertilizer treatments, the excess yield of fertilization was more successful in the case of the Debrecen 377 maize hybrid in all the examined 6 years.

According to our investigations the fertilization reaction of the maize hybrids is significantly affected by years, mostly precipitation, which can be well characterized with the volume of crop yield per 1 mm of precipitation.

As regards yields on 1 mm of precipitation from green crop to the end of the vegetation season the two Debrecen maize hybrids do not show significant differences with the exception of the droughty year of 2002 and 2005, in fertilized or in non-fertilized treatments either.

Irrigation increased the efficiency of fertilization. The effect of irrigation was different in various years. In the droughty year of 2002, maize yields increased considerably under irrigated circumstances. Their excess yield amounted to 1.9 t in the case of both Debrecen maize hybrids, depending on the level of nutrient supply. For both hybrids, the highest irrigation effect (2.7 t/ha – 2.8t/ha) was gained on plots fertilized with the agent of 120 kg/ha nitrogen.

On the basis of *multifactoral experiments* we concluded that in the average of the four years, autumn ploughing reliably increased the crop yields of the Debrecen maize hybrids.

In autumn ploughing 70 thousand plant/ha, in spring ploughing and in disc cultivation 50 thousand plant/ha can be reasonably used.

The Debrecen 351 maize hybrid produced higher yields in all the three production variants than the Debrecen 377 maize hybrid. In droughty years this difference is less significant.

In the average of the four years, irrigation steadily increased the crop yields of the Debrecen maize hybrids in autumn ploughing. Spring ploughing poses risks even in irrigated cultivation. Disc cultivation on chernozem soil is not recommended for irrigated cultivation.

In the average of the four years, the correlation of soil cultivation and fertilization was not significant. In various years the excess yield of fertilization was different.

Fertilization steadily increased the crop yields of the Debrecen maize hybrids.

In the average of the four years, both Debrecen maize hybrids showed similar volumes of excess yield as a result of fertilization.

The fertilizer dose of N<sub>90</sub>+PK kg/ha is sufficient to reach maximum yields for the two Debrecen maize hybrids.

In the average of the four years, irrigation steadily increased the crop yields of the Debrecen maize hybrids. In droughty years, the volume of excess yield is higher than in years of favourable precipitation rates. The Debrecen 351 maize hybrid performed better as a result of irrigation.

In years of favourable rates of precipitation, treating 50 thousand plant/ha, the excess yield of the Debrecen 351 maize hybrid was 1.9 t/ha as compared to the Debrecen 377 maize hybrid. In the variation of 70 thousand plant/ha there was no difference between the average yields of the hybrids. In the droughty year the production of the Debrecen 351 maize hybrid was reasonable in the 70 thousand plant/ha variant, its excess yield was 1.6 t/ha compared to the Debrecen 377 maize hybrid.

If 90 thousand plant/ha is applied in a droughty year, a crop failure of 40-45% can be calculated. With a lower plant number (70 thousand plant/ha) the crop failure reduces, in the case of the Debrecen 351 maize hybrid to 15%, in the case of the Debrecen 377 maize hybrid to 36%.

Years influenced the raw protein content of grain yield for the Debrecen 377 maize hybrid calculated from the nitrogen content of its grain yield.

As a result of fertilizer treatments, the protein content of the Debrecen 377 maize hybrid considerably increased and its protein content also increased due to higher fertilizer doses. The rate of increase was different in certain years.

Under droughty circumstances the oil content of the Debrecen 377 maize hybrid was not influenced by irrigation, but it reduced by the application of fertilizers.

As a result of irrigation the starch content of the Debrecen 377 maize hybrid increased in the average of fertilizer treatments (from 69.8% to 71.4%). Under irrigated and non-irrigated circumstances the content of starch decreased as a result of both fertiliser treatments.

Due to fertilization, the Zn content of the Debrecen 377 maize hybrid decreased under both irrigated and non-irrigated circumstances.

A close linear correlation was found between the calcium and strontium concentrations in the grain yield of the Debrecen 377 maize hybrid, i.e. extra nutrient volumes resulted in increased calcium and strontium content as well.

It was concluded that as a result of fertilization the volume of carotene increased in the Debrecen 351 maize hybrid (0.17 mg/kg) and it decreased in the case of the Debrecen 377 maize hybrid (0.02 mg/kg).

The quantity of vitamin A significantly grew as a result of fertilization in the Debrecen 377 maize hybrid (338 NE/kg), whereas a slight decrease was experienced in the maize hybrid 351.

The Debrecen 377 maize hybrid reacted to the fertilizer dose of 120kg N/ha with its increased vitamin E content. The content of vitamin E decreased in the case of the Debrecen 351 maize hybrid (0.40 mg/kg).

Based on the *analysis on the marketing activities* of the Agrárgazdaság Ltd. related to maize hybrid seeds in 2001-2002 the following can be stated:

The literary data and facts in the present study clearly justified that average maize yields in Hungary were almost at equal levels in the past 25 years (4.7-6.7 t/ha) depending on years. Regarding this fact it was stated that varieties from any Hungarian breeding institutions were capable of achieving this result, including the Debrecen maize hybrids as well.

The research findings suggest that the reason of the seemingly irrational maize variety use in Hungary was primarily the insufficiency of marketing activities in Hungary. This backwardness

can only be partly justified with the lack of money. The greater problem is that domestic variety owners, commercial houses and tradesmen lack the targeted marketing knowledge.

Besides the above mentioned, it can also be stated that those who work in Hungarian agriculture, have not yet recognized their national interests. Even the potentials of Hungarian ecological conditions can only be exploited with the most intensive cooperation. Internationally renowned Hungarian seeds can only compete with the products of multinational companies, if domestic seeds gain their well-deserved recognition.

Despite the above mentioned, there are available opportunities even under present-day conditions for the Debrecen maize hybrids to gain wider grounds with their reliable production capacities.

It is typical of the activities of the Agrárgazdaság Ltd. that its members bring their own decisions related to the dynamic colours and forms of their prospectuses and other publications; moreover, they directly word their advertisements for publication. Their direct objective is to form an "image" by efficient communication that gives favourable impressions for its customers.

In their marketing activities related to the Debrecen maize hybrids the significance of their protein content, which is verified by almost each examination finding, and which exceeds 2.5% is to be further highlighted.

As a result of the ban on meat meals in Hungarian animal fodders the provision of protein needs raised new concerns and the Debrecen maize seeds can get into more advantageous positions.

Similarly to proteins, other very significant inner content indicators are very favourable in the Debrecen maize hybrids as compared to those of competitors. Out of these, the extra volume of carotene content (29 %) is outstanding. This fact is of utmost significance in animal foddering and should be even more emphasised in advertisements.

An especially good position for Hungarian and thus for the Debrecen maize hybrids can be the fact that reservations and rejection are experienced against GMO-s in Western Europe and in Hungary as well.

Most of the seeds from the USA contain modified genes, so we must make a good use of this situation.

The newest 7-layer sacks (MAG) developed by the personnel of the Agrárgazdaság Ltd. nowadays can compete with the wrapping materials of multinational firms.

The study on the price policy of the Agrárgazdaság Ltd. shows that after initial uncertainties its applied prices are proportionate with the performing capacities of maize hybrids.

The company has to adapt even more flexibly to fast changing market circumstances with various allowances, deferred payment opportunities and services, which are included in its price policy.

The practice in the distribution policy of the Agrárgazdaság Ltd. is that besides the network of its resellers, it pays a special attention to distribution directly from its seed plant and it strives to exploit its traditional relations with the big farms in the region.

Investigations on the company's advertisement policy revealed that the new prospectus was prepared to meet the highest quality demands and professional expectations and thus it satisfies modern demands.

The customer meetings, which are exclusively organized by the Agrárgazdaság Ltd. in certain larger production areas from time to time are unique, interesting and effective events. They should be maintained and expanded as well.

Based on efficiency examinations on the company's marketing activities it can be said these expenses have got recovered many times.

As a result of fierce market competition and oversupply these expenses are expected to rise. As the survival of the Debrecen maize hybrids on markets may depend on the efficiency of the company's marketing activities and the quality of its advertisements, continuous development, further financial sacrifices and the inclusion of marketing experts into these activities are needed.

In the analysis of the marketing activities related to the Debrecen maize hybrids in 2001 and 2002 we highlighted the outstanding protein, carotene and vitamin A content of the hybrids on the basis of field experiments. These excellent inner values can constitute huge benefits as compared to competitors, but this fact has to be accepted by potential customers and the market as well.

The company's price and distribution policies have to be adjusted accordingly. The experts of the Agrárgazdaság Ltd. applied the following prices: 11000 in

2001; 13000 in 2002; 14000 in 2003 HUF/sack/70000 grain, which can be considered proportionate with the performance capacities of the hybrids.

The company makes a proper use of its traditional relations within its distribution policy, but also pays a special attention on its increasingly expanding network of resellers.

It can be clearly seen that it is not enough to produce a good product, it has to be accepted by buyers and it has to be sold in increasing quantities.

Even the most state-of-art products can fail on markets. It occurs mostly when customers' and users' demands are not properly surveyed, if the product is too expensive, if advertisements cannot achieve their expected effects or competitors enter the market with their products way before our company. Therefore, the ideal solution can be the inclusion of marketing at the initial steps of testing and not only at the end, as it was thought earlier.

The management of the Agrárgazdaság Ltd. devotes great energies to make the Debrecen maize hybrids acquainted widely. The company's advertisements can be found in almost every significant professional and daily paper, but the company's marketing activities include radio and television commercials as well. As for our investigation findings, these expenses have been recovered.

#### 4. NEW AND NOVEL RESULTS

1. Our research findings proved the reliable correlation of soil cultivation varieties with irrigation, plant number and genotype.
  - *Based on our four year experimental findings we quantified the advantages of autumn ploughing as compared to spring ploughing and disc cultivation. We proved that this advantage was different in irrigated and non-irrigated cultivation. Autumn ploughing gave reliably higher yields in the average of the four years than disc cultivation.*
  - *70 thousand/ha was the most advantageous plant number in autumn ploughing. In droughty years lower plant numbers, while in years of good precipitation higher plant numbers are recommended. In autumn ploughing, the plant number of 70 thousand plant/ha was the most favourable. Soil cultivation influenced the harvest results of the two Debrecen maize hybrids differently. Significant differences were measured in autumn ploughing and in disc cultivation. The excess yield of the Debrecen 351 maize hybrid was 1.0-0.7 t/ha. The benefit of autumn ploughing in years with good precipitation was 3.2 -3.9 t/ha. In the droughty year the difference between yields was lower (2.3-3.2 t/ha).*
  - *In the average of the four years the correlation of soil cultivation and fertilization was not significant. In non-fertilized and in fertilized treatments the excess yield of autumn ploughing was similar (2.7-2.9 t/ha). However, in various years the excess yields of fertilization were different.*
2. The two examined hybrids reacted to irrigation and plant number differently.
  - *Irrigation was in close correlation with harvest results. It could be detected that in droughty years excess yields were 2.3-2.9 t/ha on average. It was statistically proved that the two hybrids reacted to irrigation differently. The excess yield of irrigation for the Debrecen maize hybrids 351 was 1.5 t/ha, while it was 50% less in the case of the Debrecen 377 maize hybrid.*
  - *In years of good rates of precipitation, with 50 thousand plant/ha, the Debrecen 351 maize hybrid produced 1.9 t/ha more yield than the Debrecen 377 maize hybrid. This difference reduced to 0.8 t/ha in the treatment of 90 thousand plant/ha. With 70 thousand plant/ha there was no difference between the hybrids. However, in the droughty year the treatment of 70 thousand plant/ha showed the greatest difference, when the excess yield of the Debrecen 351 maize hybrid was 1.6 t/ha.*
3. Our research findings proved that the fertilizer dose of 90kg N, 68kg P<sub>2</sub>O<sub>5</sub>, 80kg K<sub>2</sub>O kg/ha was satisfactory to achieve maximum yields for the Debrecen maize hybrids.

4. Our research findings suggested that the Debrecen 351 maize hybrid could use the natural nutrient content of soil better than the Debrecen 377 maize hybrid in all the studied years. The greatest difference was measured in 2001, which was a favourable year for maize (1.3 t/ha).
5. The protein content of the Debrecen 377 maize hybrid increased as a result of higher fertilizer doses. The rate of increase was different in certain years.
6. New results related to the inner content of the two Debrecen maize hybrids are as follows:
  - *As a result of irrigation, the starch content of the Debrecen 377 maize hybrid increased in the average of fertilizer treatments (from 69.8% to 71.4). Under irrigated and non-irrigated circumstances the starch content decreased as a result of fertilized treatments. Fertilization reduced the Zn content of the Debrecen 377 maize hybrid both under irrigated and non-irrigated circumstances.*
  - *A close correlation was found between the calcium and strontium concentration in the grain yield of the Debrecen 377 maize hybrid, i.e. excess nutrients increased not only the calcium, but the strontium content as well.*
  - *It has been concluded that fertilization affected the carotene and vitamin A, E content of the two Debrecen maize hybrid yields. As a result of fertilization the carotene content of the Debrecen 377 maize hybrid decreased, and its vitamin A and E content significantly increased. On the contrary, the carotene content of the Debrecen 351 maize hybrid increased and its Vitamin A and E content decreased.*
7. It has been found that the excellent inner content (protein, vitamin A, E) characteristics of the Debrecen maize hybrids are to be more highlighted in their marketing activities.
8. On the basis of examinations on the efficiency of marketing activities it has been found that these expenses are recovered many times. Due to extremely fierce competition and oversupply, increased marketing expenses are to be taken into consideration. The survival of the Debrecen maize hybrids on markets can be reliant on the efficiency of marketing activities and the quality of advertisements. Therefore, constant development in this area, further sacrifices and the inclusion of marketing experts are reasonable.

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