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Doctoral School of Plant Cultivation and Horticulture

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EFFECTS OF PLANT CULTIVATION FACTORS ON THE PRODUCTIVITY OF CORN

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1. Introduction

Corn has the most profitable yield potential, among crops – under suitable climatic and soil conditions -, and the importance of its cultivation is increasing on all the continents. Variety, as the factor involving biological bases, is remarkably significant considering the development of corn production. Ecological conditions of the region of cultivation (temperature, water, insolution and soil) determine, which variety gives the highest yield from the available sortiment on the

given area. Domestic corn grain hybrids, which can compete with foreign varieties in productivity, population density-tolerance in several cases should be given preference.

In the past, when nutrient supply hardly changed and was in a low level, only the variety ensured the yield increase of corn. Nowadays, widening of biological bases is also a condition of yield increase: production and spreading hybrids in everyday use with high productivity and other good characteristics. Besides the requirements of modern agrotechniques, fertiliser doses have to be adapted for the hybrid in question. Large-scale and sudden increase is demonstrated by the fact that while the utilised active ingredient per 1 ha agricultural area was 1,6 kg on the average between 1931 and 1941, increased up to 278 kg by 1986.

Nowadays, water release of hybrids is more and more important. Hybrids with slow-, medium-, and fast water-release-rate are known. Hybrids with slow-, medium-, and fast water-release-rate give down 0,4-0,5 %, 0,6-0,8 % and 1-1,2 % of kernel moisture content during a day in their maturity period, respectively. There is a difference between the speed of water release of hybrids with dent, semident and flint kernels. Dent hybrids have the fastest water release from kernels.

Decrease in corn yields in monoculture is significant, especially in dry years. It is practical to form the sowing structure in a way that corn would not follow itself for more than 6-8 years. The well-chosen prae crop has an influence not just on the extent of weed growing, but also on the efficiency of fertilisers.

The values of Leaf Area Index (LAI) are 4-8 in stands of fully developed hybrids. In such plant density, productivity of each corn plant decreases, but the primer production of the stand is a value close to the maximum. Higher plant density decreases light energy supply of each corn plant, water and nutrient supply deteriorates, but till a value, decreased productivity is compensated by higher plant density, therefore the productivity of the stand increases.

In my research project the following themes were examined in the three experimental years:

- Productivity of corn hybrids
- Natural nutrient exploration and utilisation capacity,
- Water-release capacity of hybrids, moisture content at time of harvest,
- Leaf area index of hybrids,
- The effect of variety and fertilisation on growing dynamics of the total leaf area,
- The effect of NPK fertilisation on protein and starch value of different hybrids of different genotype, and
- The effect of fertilisation and climatic factors on the rate of photosynthesis concerning different hybrids

The experiment was set in the demonstration garden of the Department of Crop Production and Applied Ecology in the Agricultural Centre, at the University in Debrecen.

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2. Materials and Methods

2.1. Soil properties of the experimental field

The soil of the experiment is calcerous chernozem soil. Humus accumulation and easy tillage are typical for this soil. In the topsoil leaching is typical, lime can not be found there. The amount of carbonates is increasing gradually downwards, and forms a precipitate in the form of colloid or

microcystal in one layer. The soil was susceptible to cracking in dry periods originating from lime deficiency.

The nutrient supply of the soil is satisfactory, its nutrient dynamism is good. Humus is 50 to 70 cm thick in "A" horizon. Organic matter content is 2.57 %. Soil plasticity value (Ka) = 36, pH=7.0, N-content = 0.12 %, Al-soluble P_2O_5 = 100 mg/kg, K_2O-content = 165 mg/kg.

Main properties of the experimental field are shown in table 1.

Table 1.

pH (H_2O)	**$CaCO_3$**	**P_2O_5 (mg/kg)**	**K_2O (mg/kg)**	**Humus (%)**	**Soil plasticity value (Ka)**
7	In traces	100	165	2.57	36

2.2.Weather in the experimental years

The weather between 1997 and 1999 was favourable on the whole for corn in the region of Debrecen.

Distribution of precipitation was really favourable within the vegetative period, as a consequence of which corn developed well, and the development of cob and grain was also adequate. In comparison with the average of the last 50 years, the average temperature was higher, which was especially advantageous for the development of a good average yield., besides the favourable amount of rainfall.

In the year of 1998 and 1999 the amount of precipitation was higher than that of the average of several years and there was also a positive deviation of average temperature in the vegetation period of corn.

2.3. Main characteristics of corn hybrids tested in the experiment

10 hybrids were set into the experiment in 1997-98-99, that is summarised in table 2.

Table 2.

Hybrid	**Vegetative period (FAO-number)**
1. Monessa SC (Pi. 3905)	**270**
2. Mv Mara TC	**290**
3. Clarica SC (Pi. 3893)	**310**
4. Ella (Sze SC 361)	**360**
5. Mv Norma SC	**380**
6. Evelina SC (Pi.3752)	**390**

7. Veronika (Sze SC 427)	**460**
8. Dk 527 SC	**490**
9. Filia SC (Pi. 3515)	**500**
10. Florencia SC (Pi. 3573)	**530**

The aim of the experiment was to involve hybrids of domestic and foreign improvement and with different genetic background to receive comparison among them. Therefore, hybrids of Szeged, Martonvásár, Dekalb and Pioneer were tested in the experiment.

2.4. Main features of the agrotechnique applied

Five fertilisation steps were applied in I-IV replication apart from the control in the three experimental years (1997, 1998, 1999), where the smallest dosage was 40 kg N; 25 kg P_2O_5; 30 kg K_2O of active ingredients. The largest dosage was five times more than the smallest one: 200 kg N; 125 kg P_2O_5; 150 kg K_2O, which is equal to 475 kg mixed active ingredients. Nitrogen was applied in autumn and spring in 50-50 %; the total amount of phosphorus and potassium was applied in autumn in one dosage.

Fall tillage involved deep ploughing at 28-32 cm depth in all three of the experimental years.

Secondary tillage in spring and the preparation of the seedbed took place with mounted rotary harrow and spring-hoe with cage roller in 1997, with harrowing twice in 1998, while in 1999 with spring hoe with cage roller. Sowing was carried out by hand-sowing-gun by doubled plant density, then the final stand was set at 3-4 leaved stage of the plant.

Chemical weed control was applied, which is summarised in table 3.

Table 3.

1997	1998	1999
Primextra 6 l/ha	Titus 25 DF 50 g/ha +Banvel 480 0,5 l/ha +Motivell 1 l/ha	Primextra 6 l/ha +Motivell 1 l/ha

2.5. Supplementary tests and their method

2.5.1. Photosynthesis measuring device and description of its method

The portable photosynthesis measuring device of LI 6400 is the product of LI-COR Company. Its operation is based on infra-red laser light absorption. Its task is to measure CO_2, that operates under the following principle:

At the beginning of the measure the leave of the corn (or of any other plant) is fixed in the measuring reference chamber. The CO_2 content of the air leaving the chamber is compared to that of the incoming air and calculates the CO_2 absorbed. Intensity of photosynthesis, the amount of intercellular CO_2 (CO_2 between cells), stoma openness and permeability are then calculated by

different algorithms from the amount of CO_2 absorbed.

Before measuring, the device must be calibrated. Measuring is carried out under controlled light intensity. Apart from foton-intensity, temperature (temperature of the leave and the surrounding air) and atmospheric pressure are also recorded.

2.5.2. Method and time for measuring leaf area (LA)

In the vegetative period leaf area for each hybrids of Monessa, Mv Norma, Dk 527 and Florencia are FAO 270, 380, 490 and 530, respectively.

Measuring took place in the control (without fertiliser application), and the II-IVth replication at the fertilisation levels of 3 and 5, during which the length and width of the leaf of the living plant was measured, from which leaf area (LA) for each leave and leaf area index (LAI) was calculated by applying Montgomery-formula:

LA (m^2/piece)=leaf length (m) leaf width (m) x 0.75

LAI (m^2/m^2)=LA(m^2/piece) x PPD (piece/m^2)

PPD=plant population density (piece/m^2)

Measured plants were marked, therefore the same plants were measured every time in each lot.

Measuring dates are shown in table 4.

Table 4.

Measuring	1997	1998	1999
1st	23 June	24 May	24 June
2nd	16 July	16 June	8 July
3rd	6 August	6 August	28 July
4th	25 August	26 August	25 August

2.5.3. Measuring the moisture content of kernels

Samples needed for measuring were picked in every fifth day and were put into the airing cupboard and were dried until they reached their permanent weight and then moisture content was measured. Samples were picked from several different lots, the control lot, and from the repetitions of second and fourth at fertilisation levels of 1,3 and 5. All of the ten hybrids' moisture content and water releasing rate were measured. Sampling took place 8 times between 8 September and 13 October in 1997 and 14 times between 27 August and 31 October in 1998. On the basis of the results effects of weather and agrotechnique on the water-releasing rate of corn hybrids were tested.

2.5.4. Analysis of the total element content of kernels

a) Preparation for the analysis of the element content: measuring was carried out at the

Agricultural Device Centre at the University of Debrecen.

Sample preparing method of wet-destruction by HNO3-H2O2 was applied to determine the macro-, meso-, and micro element content of the samples of fodder-basic material and the fodder. Depending on the type of the appropriately prepared (dried, grinded) sample, the quantity of the weighed material is 1.2 or 3 g. During prae-destruction, 10 cmł of HNO3 was applied on 60 °C for 30 minutes. Before the main destruction 3 cmł 30 % H2O2 was added, then the destructed material was kept on 120 °C for 90 minutes.

b) Concerning the element content of kernels the change of NPK macro elements, Ca and Mg meso elements, Cu, Zn, Mn microelemts were tested in connection with the different nutrient applications: N content was determined by Wagner-Parnas's Microkjeldahl method according to the Hungarian Standard of 6830-66 5, 23. As regards mineral substances the plant material was prepared by cremation, then K was determined by flame-photometry, Cu, Mn, Zn, by atom-absorption method from the stock-solution, Ca, Mg by the same procedure after adequate dilution. P content was determined by the method of molybdovanadate.

2.5.5. Testing method for protein and starch content of kernels

All of the three measurements were also carried out at the Agricultural Device Centre at the University of Debrecen by Győri Zoltán and his colleagues.

a) Protein content analysis: According to the principle of the method the fodder was destructed with concentrated sulphuric acid, its N-content was converted into ammonium-salt, then the ammonia released was titrated into sulphuric acid or boric acid by destillation. Destillation of protein was carried out with Kjeltec half-automatic device. The protein content was an average calculated from two parallel analyses.

b) Starch content analysis: fodder sample was boiled with diluted hydrochloric acid for a given period of time. After the precipitation of proteins, optical rotational capacity of the filtrated solution was measured by polarimeter. The rotation value obtained was corrected by the value of the optical rotational value of components soluble in 40 (V/V)% ethanol and treated with dilute hydrochloric acid.

2.6. Method of evaluation

Comparison, correlation tests. Yields were converted into equal dry-matter content, and the results obtained in the experiment were evaluated by analysis of variance. The change and closeness of the correlation between fertilisation and the yield was determined by parabolic regression analysis.

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3. RESULTS

1. The effect of NPK-fertilisation on the yield of corn hybrids

Corn hybrids have different productivity and reaction for fertilisers. Productivity depends mainly on the vegetative period of hybrids, those with longer vegetative period have higher potential productivity. On the other hand, the moisture content of kernels is higher at time of harvest, and drying costs may reduce the significant part of the yield increase.

Basically, hybrids of FAO 300-400 have to be taken into consideration, because several hybrids can be found among them, which have favourable productivity and moisture-content at time of harvest. Apart from the natural nutrient uptake and utilisation of hybrids, their reaction for fertilisers is different. Recently, as a result of purposeful improving work, the reaction for fertilisers of hybrids has been improved significantly.

Hybrids reached the highest yield in 1997:

1. Filia SC 13.60 t/ha

2. Florencia SC 13.39 t/ha

3. Evelina SC 13.27 t/ha

4. Dk 527 13.16 t/ha

These hybrids reached significantly higher yields than the hybrid Mara SC (11,20 t/ha) with shorter vegetative period (SzD 5%=2,0 between hybrids). The optimal fertiliser dosage depending on hybrids was 40-120; 27-75; 30-90 kg/ha of N; P2O5; K2O, respectively (figure 1).

The yield of hybrids in 1998 fell behind those of 1997. Effects of weather conditions caused 2-5 t/ha yield increase in 1997.

The order of hybrids reaching the highest yield in 1998:

1. Florencia SC 10.73 t/ha

2. Filia SC 10.63 t/ha

3. DK 527 10.37 t/ha

4. Evelina SC 10.00 t/ha

In the previous, favourable year, the hybrids mentioned above reached a higher yield with approximately 3 t/ha. The yield of the other tested hybrids stayed under 10 t/ha in 1998 (figure 2).

In 1999 yields reached a medium-level. There are big differences regarding the productivity of hybrids.

Hybrids reaching the highest yields in 1999:

1. Florencia SC 11.66 t/ha

2. Mv Norma SC 11.66 t/ha

3. Evelina SC 11.33 t/ha

Effects of weather conditions determine the efficiency of NPK fertilisers besides yields to a great extent. Depending on the hybrid and the effects of weather conditions significant yield increase was reached up to the smallest dosage of 40 N; 25 P_2O_5; 30 kg K_2O kg/ha active ingredients. Fertiliser doses higher than this did not increased significantly the yield (figure-3).

On the basis of the above-mentioned facts, NPK fertiliser treatment of 40-120 N; 25-75 P_2O_5; 30-90 K_2O kg/ha was the most favourable and most efficient depending on the effects of weather conditions and the hybrids.

2. Evaluation of water release of corn hybrids

Observing the dynamics of water-release capacity of hybrids it can be found that, taken into consideration the precipitation fallen down, the rate of water-release was slower, 1-3 %, after then it decreased by 4-5 %, or occasionally by 6-8 % measuring on every five days. Dynamics of water release was influenced by the quantity of the fertiliser applied to a great extent. Hybrids with very short or short maturity period (Monessa, Mara) released water faster at higher doses (80 N; 120; 200 N + PK kg/ha), while hybrids with longer maturity period at doses that of the control (without applying fertilisers) and maximum 40-120 N + PK kg/ha. It can be also found that hybrids with longer vegetative period had higher moisture content at time of harvest than that of the hybrids with shorter vegetative period.

Nowadays, hybrids with fast water-release-rate are more and more important, because significant drying costs can be saved this way.

3. Correlation between nitrogen fertilisation and environmental protection

The most conspicuous environment damaging effect of N-fertilisation is the accumulation of NO_3-N and its leaching into the subsoil water, furthermore the decrease of the values of soil acidity.

It is an essential requirement for energy safe, environment-protective technology that higher doses than 60-120 kg/ha N must not be applied for corn, depending on the effects of weather conditions, prae crops, the intensity of the current hybrid and other agrotechnical factors applied such as irrigation.

In autumn in 1996 NO_3-N accumulation was examined in the layer of 0-200 cm of the soil on the control lot and on lots where the other five fertilisation steps were applied (figure 4).

On control lots the NO_3-N content of the soil was low, 5.87 mg/kg in the layer of 0-20 cm in autumn, 18.07 mg/kg in spring in 1997, but deeper in the soil profile 10 mg/kg was found (figure 5).

At doses of 40 N kg/ha applied in autumn in 1996, in the soil layer of 0-100 cm the NO_3-N content was less than 10 mg/kg, but in deeper layers even 40 mg/kg could be found. In spring the quantity of the analysable NO_3-N was low, it was under 25 mg/kg in the whole soil profile, which means that corn was able to take up and utilise the fertiliser active ingredient of 40 N kg/ha.

The accumulation of NO_3-N can be observed at applications of 200 N kg/ha, which was approximately 60 mg/kg in the layer of 120-140 cm, especially in autumn.

It can be stated that in the three years of the experiment, the weather conditions were favourable for corn, dry, draught periods did not occurred as in the previous years. Despite the favourable conditions NO_3-N accumulation still took place (even not to a great extent) in the soil layer of 100-140 cm.

4. The effects of NPK-fertilisation on the quality of hybrids with different genetical

properties

At a dose of 40 N kg/ha compared to the control (without fertiliser application) there was hardly any change in the protein content of hybrids. More significant increase can be observes at the treatment of 120 kg/ha dose.

The change of protein content in hybrids with different genetical properties was examined in connection with the maturity period as well. It was concluded that in the control treatment, hybrids with short maturity period had lower protein content than those of with medium maturity period. The increase in the protein content of hybrids with greater productivity was not as significant as in hybrids with lower productivity. With certain hybrids the lower protein content was accompanied by higher starch content, but with other hybrids vice versa.

Analysing the starch content on the average of ten hybrids it was concluded that it decreased in the majority of hybrids as a result of increasing fertiliser doses compared to the control. More significant starch decrease was found compared to the control at higher doses of 120 N; 75P_2O_5; 90 K_2O kg/ha. Concerning the maturity period, it can be concluded that the initial starch content was higher in hybrids with medium maturity period when compared the control to hybrids with very short, short maturity period. Hybrids with longer maturity period had lower starch content.

5. The effect of hybrids with different genetical background and fertilisation on the extent of fungi-infection

The extent of the infectedness of Mv Mara, Mv Norma, Dk 527 and Filia hybrids with Penicillium spp., Aspergillus spp., Fusarium spp. was examined.

It can be concluded that under control conditions Penicillium spp. (5,5-10,75%) and Fusarium spp. (5-14%) showed the greatest infectedness on hybrids. The infectedness of Alternaria spp. occured to a smaller extent (2,5-4%). Aspergillus spp. almost did not infected at all, its presence was only 0,25-0,5%). At fertiliser doses of 40 N; 25 P_2O_5; 30 K_2O kg/ha the extent of infectedness was similar to the control. Penicillium spp. (2,5-16,25%) and Fusarium spp. (6,75-24,25%) showed the highest infectedness. Presence of Alternaria spp. (0-1,75%) and Aspergillus spp. (0-0,25)was insignificant. By increasing the dose of fertilisation there was not outstanding change at the fifth fertiliser step of 200 N; 125 P_2O_5; 150 K_2O kg/ha dose regarding fungi infectedness.

Several Fusarium species produce toxins even after harvesting corn. Concerning all the four analysed toxins (F2, T2, DON, DAS) T2 toxin was present more frequently in the control (without fertilisation) and at the treatment of 40 N+PK, 120 N+PK. The contamination of F2, DON and DAS was minimal or it was not analysable.

6. The effect of variety and NPK-fertilisation on the LAI-value of corn hybrids

The individual leaf area of Monessa, Mv Norma, Dk 527 and Florencia hybrids was measured four times in all of the three experimental years (1997, 1998, 1999).

It was concluded on the bases of the results in 1997 that the leaf area index value of hybrids with short vegetative period was smaller than that of hybrids with longer vegetative period. Furthermore, it can be also stated that the increase of LAI-value can be observed especially up to the treatment of 120 N; 75 P_2O_5; 90 K_2O Kg/ha doses, by applying higher doses increase was not achieved.

In 1998 it was concluded – similarly to that of the year of 1997 -, that the LAI-value of hybrids with short vegetative period was smaller than that of the hybrids with longer vegetative period that showed a correlation to the yield. In this year the LAI-value was lower than in 1997 and 1999, because the effects of weather conditions the height of plants was lower than the typical

that influenced unfavourably the development of leaf surface and of course, the yields were also lower.

In 1999 obvious increase in LAI-value was experienced during the vegetative period

of corn hybrids. It can be also concluded that in the beginning of the vegetative period increase in LAI-value of great extent was reached at the fertiliser treatment of active ingredient doses of 40N; 25 P_2O_5; 30 K_2O kg/ha. Further increase of the active ingredient did not increase leaf surface or just to a smaller extent.

LAI-value showed a close correlation with the yield up to a certain value. The effects of fertilisation changed depending on the effects of weather conditions, because LAI-values also differed.

7. The effects of fertilisation and climatic conditions on the photosynthetic activity of hybrids with different genetical background

Measurements were carried out four times during the vegetative period on the 20th June, 15th July, 30th July and 15th August in 1999.

It was observed that the photosynthetic activity of corn hybrids with different maturity period and genetical background increased with the increase of the active ingredients of the fertiliser. The photosynthetic activity of Monessa, a hybrid with short maturity period, was the highest among the hybrids. Photosynthetic activity decreased gradually with the progress of the vegetative period because during drying of corn the active leaf surface was getting smaller. The variance analysis obviously showed that the effects of hybrid and fertilisation both respectively and together significantly influenced the photosynthetic activity of corn hybrids by this means their productivity. (figure 6).

Figure 6

Photosyntetic activity of corn hybrids with different genetical background as function of maturity period and fertilization 1999

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4. THE NEW SCIENTIFIC RESULTS

- The most important characteristics of the new hybrids can be determined by experiments on arable lands.
- Under given experimental conditions nutrient supply among agrotechnical factors, climatic conditions and the amount of precipitation among ecological factors determined the development of yield to the greatest extent. The effects of weather conditions modified the yield by 2-3 t/ha.
- Determining elements of variety-specific corn production technologies are the selection of hybrids suitable for the ecological conditions, a well-balanced NPK nutrient supply suitable for the vegetative period and productivity of the hybrid, which influences the dynamics of

water release during the maturity period. Regarding variety-specific technologies efficiency and environmental protection are also important factors. The technological version of low input system can be applied for hybrids with good nutrient exploration and utilisation capacity.

- Interactive effects between ecological-biological and agrotechnical factors must be utilised better in order to reach sustainable development in variety-specific corn production.
- The value of the hybrid is remarkably described by yield reached without and at fertilisation treatments of lower doses. There are hybrids, which have excellent natural nutrient exploration and utilisation under partial monoculture (e.g Monessa) and are able to reach high yields without fertilisation as well.
- NPK fertilisation significantly influenced the yields of hybrids with different vegetative period. The change of doses modifies the efficiency of fertilisation and the NO_3-content of the soil.
- Taking into consideration the efficiency issues depending on prae crops and the effects of weather conditions for corn hybrids under soil conditions similar to that of the experiment application of 60-120 N; 40-75 P_2O_5; 50-90 K_2O kg/ha active ingredient is enough.
- N fertilisation with higher doses significantly increases the NO_3-N content of the soil in the soil profile of 120-140 cm the maximum value of which reached even the 60 mg/kg NO_3-N level.
- LAI-values changed depending on the hybrid and the effects of weather conditions to a great extent. LAI-values for hybrids with very short, short vegetative period changed between 2-4 $m_{\text{ˬ}}/m_{\text{ˬ}}$ under favourable weather conditions and they were close to the value of 5 $m_{\text{ˬ}}/m_{\text{ˬ}}$ for hybrids with middle and middle-long vegetative period. LAI-values hardly reached 2 $m_{\text{ˬ}}/m_{\text{ˬ}}$ in years when weather conditions were unfavourable for corn. LAI-values also changed at each hybrids depending on fertilisation and the vegetative period. LAI-values show a close correlation with the yield.
- Photosynthetic activity of each corn hybrids is different, which was also influenced by different treatments of fertilisation. It was the most intensive for the majority of hybrids at fertilisation with the highest doses (200 N+PK) of active ingredients. Photosynthetic activity shows correlation with the yields, though to a different extent.
- The water-release-rate of corn hybrids during the maturity period demonstrated big differences. Water-release changed depending on the hybrid, to the greatest extent, NPK fertilisation and the effects of weather conditions. It can be concluded that the water-release-rate is slower for the majority of hybrids in treatments without fertilisation (e.g Monessa, Evelina, Sze SC 425, Dk 527, Filia, Florencia). It occurred only at hybrids, which have an extremely fast water-release capacity (e.g. Monessa, Mv Norma) that water-release from kernels was intensive at time of harvest even without fertilisation. In general, water-release-rate is the most favourable at optimal fertilisation treatments.
- It can be concluded that the susceptibility to Fusarium ssp. of hybrids differs to a great extent. The extent of infectedness is significantly modified by the amount of nutrient supplement as well. When nutrient supplement is higher than the optimal susceptibility to Fusarium increases. It can be added that the production capacity of Fusarium toxin was higher in hybrids of Mv Norma and Filia than the average.

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5. SCIENTIFIC REPORTS PUBLISHED IN THE FIELD OF THE DISSERTATION

I. Lectured scientific reports:

1. Sárvári M. – Futó Z. - **Zsoldos M**.: The effect of the date of sowing and plant density on the yield of corn in 2001

Plant Cultivation (in press), 2001.

2. Sárvári M. – Jakab P. – **Zsoldos M**.: Development of variety-specific corn production technologies in tartamkísérletben (in press)

Tartamkísérletek, Regional Production, International Conference on Rural Development, 6-8 June 2002.

3. Sárvári M – Futó Z. – **Zsoldos M**.: Correlation between plant density and the yield of corn hybrids. Proceedings.

2nd Plant Cultivation Scientific Day, Budapest 2001, p 26-34

4. Jakab P. – **Zsoldos M**.: Analysis of the different effects of weather conditions in the experiment of fertilisation of corn (in press)

Conference on the role of Science and Research in the development of the Agriculture in the North of the Great Plain, Debrecen, 2001.

II. Non lectured scientific reports, posters:

1. Sárvári M. – **Zsoldos M**.: Energy-Fertiliser-Environmental Protection

Hungarian Agriculture, May 4 1994.

2. **Zsoldos M.:** Energy-safe, environment –protective technology for corn production

Essay for Scientific Students' Club, 1994.

3. **Zsoldos M.:** Energy-safe, environment –protective technology for corn production

Essay for Scientific Students' Club, 1995.

4. Sárvári M. – Szabó P. – **Zsoldos M**.: Productivity of corn hybrids

Hungarian Agriculture, March 19 1997.

5. Sárvári M. – Szabó P. – **Zsoldos M**.:Population density at the optimum

Hungarian Agriculture, March 26 1997.

6. Sárvári M. – Szabó P. – **Zsoldos M**.: The effect of monoculture

Hungarian Agriculture, April 16 1997.

7. Zsoldos M.: Energy-safe, environment –protective technology for corn production

3rd Scientific Forum for Youth in Keszthely, 19 March 1997.

8. Sárvári M. – **Zsoldos M.** – Szabó P.: Effects of plant cultivation factors on corn production

XL. Georgikon Days in Keszthely, 24-25 Sept. 1998.

9. **Zsoldos M.:** Analysis of the productivity and reaction for fertilisation of corn hybrids

XL. Georgikon Days in Keszthely, 24-25 Sept. 1998.

10. **Zsoldos M.:** Analysis of the productivity, reaction for fertilisation, water-release and moisture content at time of harvest of corn hybrids

6th Scientific Forum for Youth in Keszthely, 29 Sept. 2000.

11. **Zsoldos M.:** Analysis of the productivity and reaction for fertilisation of corn hybrids

Meeting of the Scientific Corporation of Szabolcs-Szatmár-Bereg County of Hungarian Scientific Academy (MTA)

Nyíregyháza, Collage of Nyíregyháza, 29 Sept. 2001.

12. **Zsoldos M.:** Energy-safe, environment –protective technology for corn production

Analysis of the productivity and reaction for fertilisation of corn hybrids (posters)

Trans-Tiszanian Agricultural Scientific Days in Karcag, 12-13 June 1997.