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„ THESIS"

EXAMINING THE EFFICIENCY OF ALTERNATIVE TILLAGE SYSTEMS

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1. Introduction

Hungary's greatest natural resource is the capacity of agricultural production. Agricultural production is an essential component of the economy. The efficient or inefficient operation of this sector cannot be disregarded by anyone in the society. No economic activity, including agriculture, should be pursued by harming the environment. Throughout the history, agriculture has been providing livelihood for the population living in a specific area, while later it also ensured economic growth. These factors should be in harmony, at the same time production should preserve fertility by all means.

A number of harmful processes began during industrial scale agriculture, making rational soil use the primary objective. In many cases, other unfavourable effects also occured in intensive tillage methods, for example during the cultivation of excessively wet or dry soils which was accompanied by increased energy consumption and resulted in physical and biological degenaration of the soil. Since stubble was not recycled and utilised, organic matter cycles were damaged making erosion and deflation processes more extensive.

The new social and economic conditions following the change of regime resulted in new difficulties for Hungarian farmers and land owners. Scattered property structure, old machinery, the loss of eastern export markets resulted in daily livelihood problems. The protection of soil, which is only renewable if specific conditions are fulfilled, became less important. Enterprise managements became aware that the biological and physical sustainability and improvement of soils provides the basis for sustainable plant production, safe food production and environmental conservation. A basic requirement in land use is to fit the environment and ensure sustainability.

Sustaining rational cultivation practise should always be a primary objective when choosing soil cultivation methods. After the energy price boom of the 1970's, endavours to promote energy- and water sparing as well as other sustainable methods strengthened.

The spread of alternative tillage methods can be promoted through two factors:

- Suitable soil conditions for plants can be established through reduced tillage methods which also require less input and expenditures,
- Alternative tillage methods, compared to traditional methods, also inflict less harmful direct and indirect effects on the soil.

The previous two factors have changed soil cultivation approaches significantly. Presently, farming organisations are striving globally to reduce production costs along with preserving and improving environmental conditions. Therefore, professionals are recommending the application of preventive methods.

Adaptive cultivation means adapting to specific cultivation site and climatic conditions. Of course, alternative soil cultivation systems also have take economic factors along with environmental conditions into account.

Accordingly, the most productive plants, from both an ecologic and production aspect, have to be included in alternative farming. All these endavours, the application of economic and reduced tillage methods, have to be implemented in such a way that they do not increase production risks even over the long term.

Agronomical issues have to be extended to economic areas in all cases. The maximum and optimal production average is among the most important fertilisation and plant protection issues in plant production today and our near future.

2. Objectives

During the examination of alternative tillage systems we were concentrating on the following:

- Examining the efficiency of different tillage systems.
- Evaluating the efficiency of different degrees of fertilisation.
- Examining the relationships of the two.

3. Material and method

3.1. Research conditions

The examinations were carried out in two growing sites with different agroecologic conditions:

- Polyfactorial, long-term experiment set up at the Látókép Experimental Station of Debrecen University, Center of Agricultural Sciences by the Department of Land Use and Regional Development
  Time of examination: 2001-2004.
- Petőfi Agr. Cooperative, Csárdaszállás
  Time of examination: 2001-2004.

Altogether, seven tillage systems were compared:

Látókép:

- Winter tillage
- Spring tillage
- Basic, disk tillage

Csárdaszállás

- Winter tillage
- Disk loosening
- Shallow, spring tillage
- Direct sowing

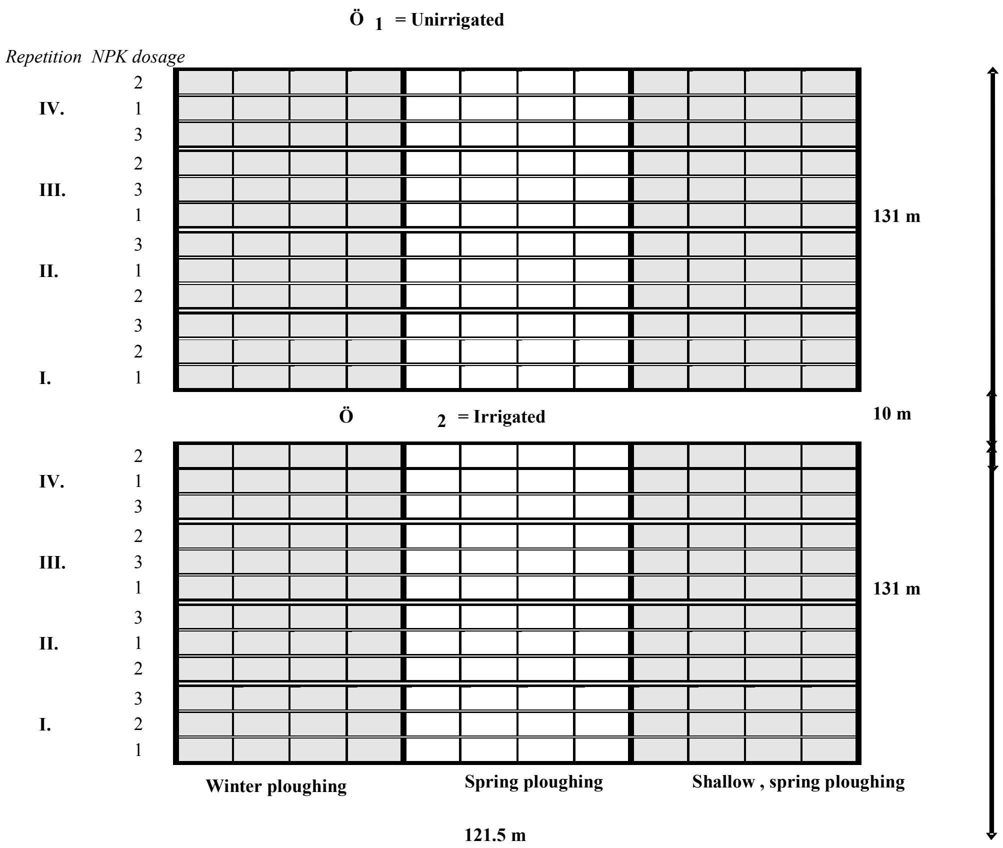
Soil conditions

The experimental station can be found at the Loess-back of Hajdúság , west of Pece, directly between the path of Ér and Nagyhegyes. The difference in level is between 113-118 m (Adriatic). The highest point of the area (118 m) can be found in the NW corner of the area with a 1% slope to SE. The greater part of the area is covered by „lowland chernozem with lime deposits". The low lying, somewhat of a catchment basin, not an extensive area, is leached chernozem with meadow features. The physical soil characteristic is medium bound clay.

3.2.1.1. *Details of experimental setup*

The experiments, covering four years (2001-2004), were set up in polyfactorial, long-term tillage structure by professor János Nagy, at the Experimental Station at Látókép, of the Department of Land Use and Regional Development, Debrecen University (figure 1). The long-term tillage experiment included, *winter tillage (27 cm)*, *spring tillage (23 cm)* and *shallow spring tillage (12 cm).* The fertiliser treatments were: $N_0P_0K_0$ *(unfertilised control)*, $N_{120}P_{90}K_{106}$, and $N_{240}P_{180}K_{212}$ *kg ha*$^{-1}$ dosages.

Figure 1. The set up of the polyfactorial long-term, tillage experiment



Source: Database of DU CAS Department of Land Use and Regional Development

3.2.1.2. *Cultivation technique data of the experiment*

Presowing in the exeperiment was monoculture maize. The sequence and time of soil preparation in the examined years is summarized in table 1.

Table 1. The sequence and time of soil preparation in the examined years

year	Winter ploughing	Spring ploughing	Shallow spring tillage
2000/2001	stalk crushing disk applic.(2X) fertilisation winter ploughing combinator (2X) sowing chemical control (2X) harvest	stalk crushing disk applic. (2X) fertilisation spring ploughing combinator (2X) sowing chemical control (3X) harvest	stalk crushing fertilisation disk applic. basic disk tillage +combinator sowing chemical control (4X) harvest
2001/2002	fertilisation stalk crushing disk applic. (2X) winter ploughing combinator (2X) sowing chemical control (2X) harvest	fertilisation stalk crushing disk applic. (2X) spring ploughing combinator (2X) sowing chemical control(3X) harvest	fertilisation stalk crushing disk applic. basic disk tillage + combinator sowing chemical control (4X) harvest
2002/2003	stalk crushing fertilisation disk applic. (2X) winter ploughing combinator (2X) sowing chemical control (2X) harvest	stalk crushing fertilisation disk applic. (2X) spring ploughing combinator (2X) sowing chemical control (3X) harvest	stalk crushing fertilisation disk applic. basic disk tillage +combinator sowing chemical applic. (4X) harvest
2003/2004	stalk crushing fertilisation disk applic. (2X) winter ploughing combinator (2X) sowing chemical applic. (2X) harvest	stalk crushing fertilisation disk applic. (2X) spring ploughing combinator (2X) sowing chemical control (3X) harvest	stalk crushing fertilisation disk applic. basic disk tillage+combinator sowing chemical control (4X) harvest

Source: Database of DU CAS Department of Land Use and Regional Development

3.2.2. The location of the experiment at Csárdaszállás

3.2.2.1. <u>The agroecological features of the experimental site</u>

Soil conditions

The soil of the low lying, flat surface and constant water condition growing site: carbonate type meadow soil formed on sandy soil. The soil profile is accordingly (figure 2):

Figure 2. Soil profile ditch in the plant experiment at Csárdaszállás

Source: Own photo

3.2.2.2. *Details of the experimental setup and production technology data*

Four cultivation technology versions were included in the plant experiment set up at the Petőfi Agricultural Cooperative at Csárdaszállás (Table 2):

- *basic tillage with winter tillage (control),*
- *direct sowing with no tillage,*
- *basic tillage with disk ripper (disk loosener)*
- *unrotated, shallow spring tilage with mulch finish.*

Machinery used in reduced tillage technology at Csárdaszállás:

- primary tillage equipment: **John Deere 510 Disk Ripper** (disk loosener), width 3,5 meters,
- secondary (seedbed preparator) equipment: **JD 726 Mulch Finisher** (mulch cultivator), width 6,6 meters, **JD 980 Field cultivator**,
- sowing machinery: **JD 750 wheat sowing machine** (suitable for direct sowing), width 4,5 meters,
- **JD 1750, 6 row maize sowing machine,** (suitable for direct sowing) width 4,57 meters.

Table 2. Technologies and plant sequence applied in the plant experiment

Plant experiment at Csárdaszállás Petőfi Agr. Cooperative
Production technology types
➢ **Traditional tillage** (control) ➢ **Reduced tillage I.** (JD 510 disk ripper) ➢ **Reduced tillage II.** (JD 980 field cultivator or JD 726 mulch finisher) ➢ **Reduced tillage III.** (JD 1760 sowing machinery)
Plant sequence
2001: maize 2002: maize 2003: sunflower 2004: winter wheat

Source: Database of DU CAS Department of Land Use and Regional Development

3.3. Research methods

3.3.1. Evaluation of the soil cultivation systems in the Látókép experiment

We have prepared, in accordance with the practice of the Department of Land Use and Regional Development, direct production expenditure account model. This was applied because the experiment was carried out within the framework of the Model Farm and Landscape Research Institute of the Center of Agricultural Sciences, Debrecen University. Because of this, the settlement of various expenditures in the experiment is difficult, in many cases an impossible task. We have included nine experimental units every year into the model, which were repeated four times since the experiment covered four years. We have carried out our examinations in winter ploughing, spring ploughing and basic disk tillage versions on control plots, with 120 kg N+PK fertiliser (316 kg mixed active agent) and 240 kg N+PK (632 kg mixed active agent). All nine plots were included with a one hectare area in our experiments, which made further calculations easier. Altogether, we have executed 36 different models (4 years x 3 tillage types x 3 fertilisation variations). During the calculation of direct production cost we have taken the costs of nutrient management (fertiliser prices), water, sowing seed, applied herbicides and pesticides into account. The supplementary services required for maize production technology are listed in table 9. We have considered similar prouduction technology in the three tillage versions, in all four years, which is most typical of the Látókép experiment. The material and supplementary sector expenditures were considered at price levels of 2004 in all four years.

The produced yield amounts were obtained from the database of Debrecen University, Center of Agricultural Sciences, Department of Land Use.

Maize prices were determined in accordance with EU intervention prices in all four years. We could filter the effect of seasonality this way, since a great degree of changeability occured in the examined period (eg. 2003: 29000 HUF/tonnes, 2004: 17000 HUF/tonnes):

3.3.2. Evaluation of tillage systems in the Csárdaszállás experiment

We have carried out a full economic evaluation (expenditure-income) in the case of the Csárdaszállás experiment. The reason for this is that the experiment was set up at the Petőfi Agricultural Cooperative at Csárdaszállás. The primary objective of the cooperative is to achieve the highest profit while fulfilling directives of sustainable land use. During the evaluation according to expenditure types (material-, labour, supplementary sector service, other and general expenditures) income conditions were also taken into account. Incomes were determined by considering both.

The outputs of specific indicator plants in a given year and tillage type were obtained from the database of Debrecen University, Center of Agricultural Sciences, Department of Land Use.

The retail price of specific indicator plants – similarly to the evaluation of the Látókép experiment – were determined by considering the intervention prices of the European Union (table 3).

Table 3. The intervention prices of European Union in 2004

Cultivated plant	Intervention price (euro/tonne)	Intervention price (HUF/tonne
Winter wheat	101	25000
Maize	101	25000
Sunflower	206	51000

Source: Agricultural Research and Informatics Institute

4.1. The agronomical and economic examination of the Látókép experiment

Yields were different in the examined years and specific treatments, but great diversity was also detected among the xamined years (table 4 and figure 3).

Table 4. Yields of specific treatments in the Látókép experiment (2001-2004)

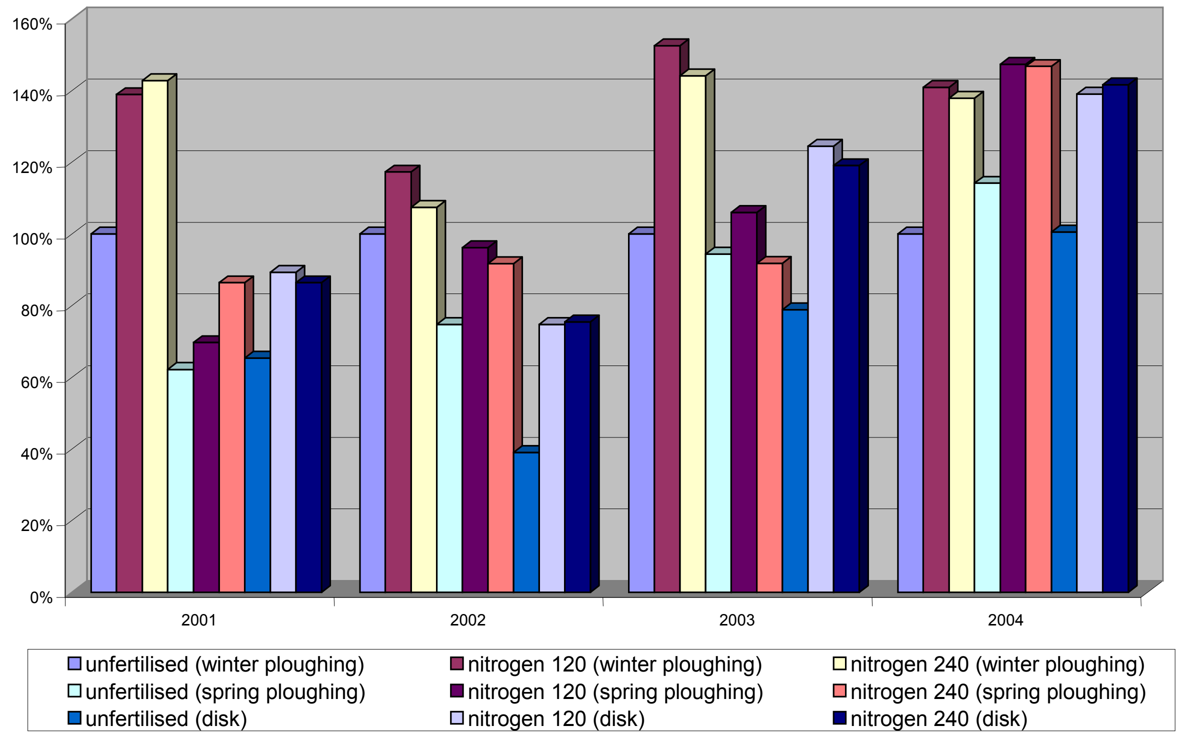
Treatment		2001	2002	2003	2004
winter ploughing	*unfertilised*	7.86	5.79	5.35	7.68
	nitrogen 120	10.92	6.79	8.16	10.82
	nitrogen 240	11.22	6.22	7.71	10.59
spring ploughing	*unfertilisedt*	4.89	4.33	5.05	8.77
	nitrogen 120	5.48	5.57	5.67	11.32
	nitrogen 240	6.79	5.31	4.91	11.27
disk applic.	*unfertilised*	5.14	2.26	4.22	7.72
	nitrogen 120	7.02	4.33	6.66	10.68
	nitrogen 240	6.79	4.37	6.37	10.88

Source: Database of DU CAS Department of Land Use and Regional Development

Altogether it can be stated that the highest yield increase compared to the control plot were achieved in the winter ploughing, 120 kg N+PK treatment. In years with good precipitation conditions the 240 Kg N+PK treatments, both in winter and spring ploughing, resulted in further yield increase this was significantly lower, the principle of lowering output dominated. In droughty years, (2002, 2003) the 240 kg N+PK treatment resulted in yield depression, in the case of all three treatments, therefore its application is not recommended.

When comparing control plots it can be found that in the case of spring ploughing yield was 5-30 % less, except for 2004. This result was 20-60 % less in disk tillage. Yields exceeded the results of winter ploughing in both spring ploughing and disk treatments in 2004.

Figure 3. The formation of specific treatments compared to the control plots of winter ploughing in the Látókép experiment (2001-2004)



Source: Own calculation

The material and supplementary sector costs of specific treatments differ from each other, which can be explained by different fertiliser, plant protection and machinery costs. The data of winter ploughing control treatments were considered as a hundred percent and cost data of other treatments were compared to this (table 5, figure 4).

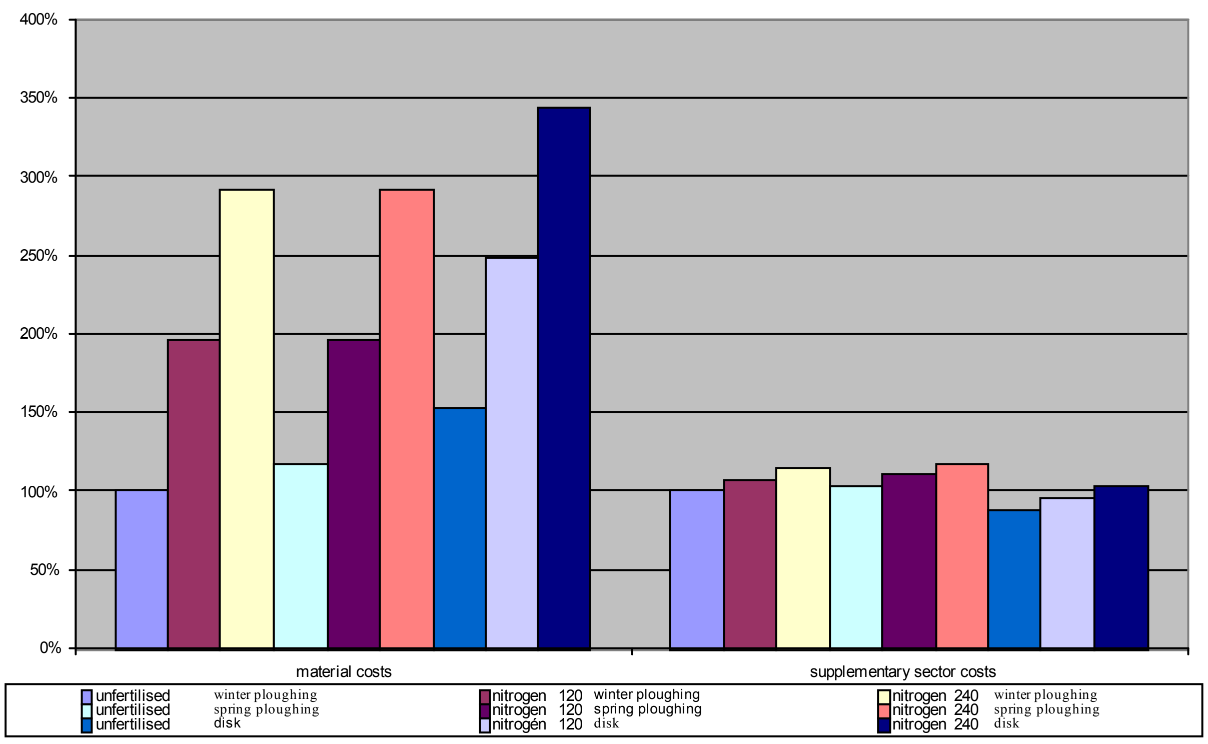
Table 5. The formation of treatment expenditures in the Látókép experiment (2001-2004)

Treatment		material costs	supplement. sect. serv.	total
winter ploughing	unfertilised	42 759 HUF	64 060 HUF	106 819 HUF
	nitrogen 120	83 839 HUF	68 800 HUF	152 639 HUF
	nitrogen 240	124 919 HUF	73 540 HUF	198 459 HUF
spring ploughing	unfertilised	50 259 HUF	66 150 HUF	116 409 HUF
	nitrogen 120	83 839 HUF	70 890 HUF	154 729 HUF
	nitrogen 240	124 919 HUF	75 630 HUF	200 549 HUF
disk treatment	unfertilised	65 259 HUF	56 320 HUF	121 579 HUF
	nitrogen 120	106 339 HUF	61 060 HUF	167 399 HUF
	nitrogen 240	147 419 HUF	65 800 HUF	213 219 HUF

Source: Own calculation

The cost of the applied fertiliser significantly increased material costs in the case of winter ploughing. In the case of 120 kg N+PK the surplus cost was 41.080 HUF, which increased material costs by 96 %. The cost of the applied fertiliser in the 240 N+PK treatment was 92.160 HUF, which resulted in an additional 96 increase in material costs. The increase of supplementary sector costs was more modest than material costs, 7 and 15%, which can be explained by fertiliser costs. Altogether, winter ploughing, compared to the control, the 120 kg N+PK treatment resulted in 43% while the 240 kg N+PK treatment resulted in 86% expenditure increase. Material costs on the control plot of spring ploughing were 18% higher compared to winter ploughing. A reason for this is that 33% more herbicides and pesticides are needed in spring ploughing treatments than in winter ploughing. The supplementary sector costs are also higher by 3% which can be explained by plant protection activities. The expenditure ratios of spring ploughing 120 kg N+PK and 240 N+PK fertiliser treatments formed similarly than in the case of winter ploughing. Supplementary sector costs were higher due to the increase in plant protection expenditures. Altogether, it can be said that in spring ploughing treatments the control plots required 9% more, the 120 kg N+PK treatment 45% more and the 240 N+PK fertiliser treatment 88% more expenditure compared to the control winter ploughing treatment. The direct production cost was more in the case of spring ploughing than with winter ploughing, which is due to increased plant protection costs. Material costs were 53% higher on the control plots with disk treatment. This is due to the fact that plant protection costs are 100% higher than on plots where winter ploughing was applied. The supplementary sector costs, due to the different tillage system (basic disk treatment) and increased number of operations because of plant protection tasks, were 12% lower than the comparative basis. The costs of fertilisers and fertiliser application increased material costs similarly in the case of the two other disk treatments than in the case of winter and spring ploughing treatments. Altogether we have found that the direct production costs were 14% higher with disk treatment than compared to the control plot of winter ploughing,while the costs of 120 kg N+PK treatment was 57% higher and the costs of 240 N+PK treatment was 100 % higher.

Figure 5. The formation of material and machinery operation costs compared to the control plots of winter ploughing at Látókép (2004)



Source: Own calculation

The retail price of maize was calculated with the intervention price of the European Union, which is 101 euro/tonne. The income can calculated by multiplying yields (table 5) with the 101 euro/tonne purchase price. The incomes are compared to the data of the winter ploughing control plot in the case of all treatments, similarly to yields and direct production costs (table 6).

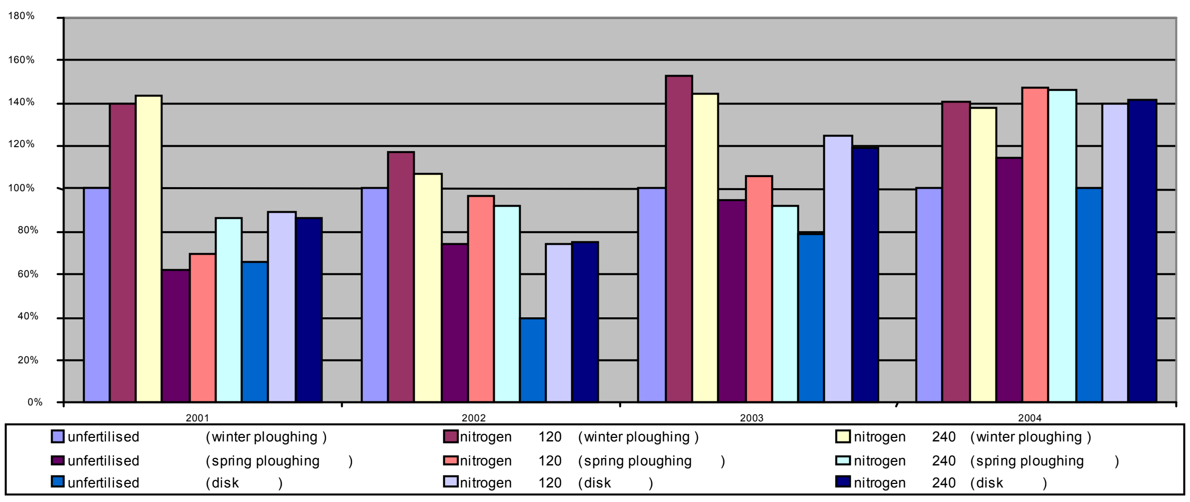
Table 6. The formation of incomes in different treatments in the Látókép experiment (2001-2004)

treatment		2001	2002	2003	2004
winter ploughing	*unfertilised*	196 500	144 750	133 750	192 000
	nitrogen 120	273 000	169 750	204 000	270 500
	nitrogen 240	280 500	155 500	192 750	264 750
spring ploughing	*unfertilised*	122 250	108 250	126 250	219 250
	nitrogen 120	137 000	139 250	141 750	283 000
	nitrogen 240	169 750	132 750	122 750	281 750
disk treatment	*unfertilised*	128 500	56 500	105 500	193 000
	nitrogen 120	175 500	108 250	166 500	267 000
	nitrogen 240	169 750	109 250	159 250	272 000

Source: Own calculation

The incomes have increased significantly in all four examined years in winter ploughing due to fertilisation. There was another but significantly lower increase with the application of the second fertiliser dosage in 2001, while in the other three examined years the income decreased with the application of the 240 kg N+PK fertiliser dosage. The income of the spring ploughing control plot was lower in the first three years of the examination than the comparative basis. In 2004 the income from the spring ploughing control plot was higher compared to the winter ploughing control. The application of the first fertiliser dosage achieved favourable effect in all four years, increasing incomes to different extent (8-33%). The second fertiliser dosage induced new increase in incomes in 2001, resulting a decrease in incomes in 2002 and 2003, while in 2004 incomes did not change. The control plot in the case of disk treatment resulted less income in the 2001-2003 period, while the control of winter ploughing exceeded that in 2004 by one percent. The 120 kg N+PK treatment, similarly to the previous two treatments, induced significant increase in incomes in all four examined years. The 240 N+PK treatment resulted further increase in incomes only in 2004, while we detected decrease in 2001 and 2003, resulting identical income in 2002 than the 120 kg N+PK dosage. Altogether, it can be said about all three tillage systems that compared to the control, the 120 kg N+PK fertiliser dosage had favourable effect on the income, increasing it in all years and all tillage versions. In years with good precipitation, the 240 kg N+PK treatment with winter ploughing induced furher increase in incomes. This could not be clearly detected in spring ploughing treatments, income only increased in 2001 as a result of this treatment, and could not be detected at all in disk tillage (figure 6)

Figure 6. The formation of incomes in different treatments compared to the winter ploughing control plot of the Látókép experiment (2001-2004)



Source: Own calculation

During the calculation of the gross margin the following data were taken into account: the direct production costs (material costs and costs of supplementary services) were subtracted from the income. The result includes the income, general costs and other direct costs (land lease costs and insurance cost). Calculations were carried out for all tillage variations amd fertilisation treatments for all four years of the examination. It was considered as 100% similarly to previous calculations (table 7, figure 7).

Table 7. The formation of gross margin in different treatments in the Látókép experiment (2001-2004)

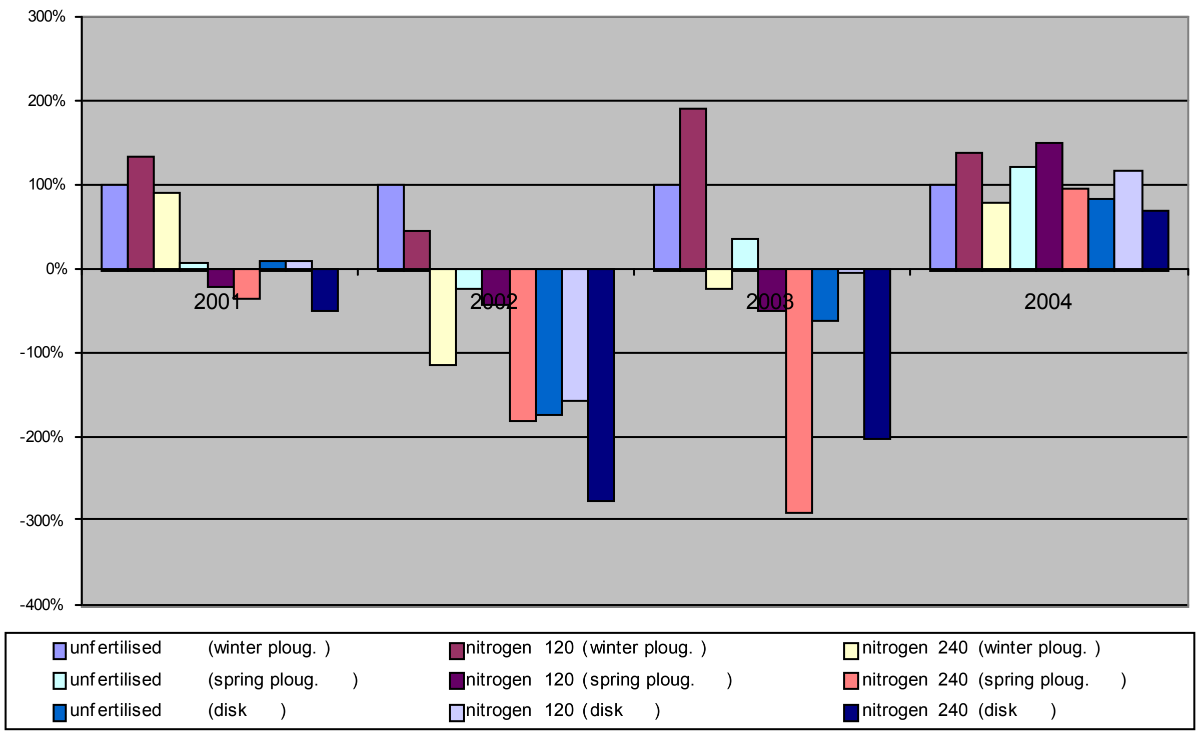
treatment		2001	2002	2003	2004
winter plo.	*unfertilised*	89 681	37 931	26 931	85 181
	nitrogen	120 361	17 111	51 361	117 861
	nitrogen	82 041	-42 959	-5 709	66 291
spring plo.	*unfertilised*	5 841	-8 159	9 841	102 841
	nitrogen	-17 729	-15 479	-12 979	128 271
	nitrogen	-30 799	-67 799	-77 799	81 201
disk t.	*unfertilised*	6 921	-65 079	-16 079	71 421
	nitrogen	8 101	-59 149	-899	99 601
	nitrogen	-43 469	-103 969	-53 969	58 781

Source: Own calculation

The gross margin of the 120 kg N+PK increased in the case of three years (2001, 2003, 2004) in winter ploughing. In 2002 the application of the 120 kg N+PK dosage resulted in a 55% gross margin loss, so less fertiliser dosage would have been more favourable that year in order to achieve maximum gross margin. In the case of the 240 kg N+PK treatments, we have found in all years that the value of gross margin did not reach the level of the control plot. This value was so outstanding in 2002, that we registered a 113% loss but production was also accompanied by loss (-21%) in 2003, while in 2001 the gross margin decreased by 9% in 2001 and by 22% in 2004 compared to the data of the control plot. In the unfertilised spring ploughing treatment groos margin was only higher in 2004, than in the winter ploughing control plot, used as a comparative basis. A 22% loss was produced in 2002, while in 2001 the gross margin was 93% lower and in 2003 this value was 63% lower than in the case of the unfertilised winter ploughing treatments. The 120 kg N+PK fertiliser dosage resulted further decrease in gross margin in the first three years of the examination (2001-2003): 27% in 2001, 19% in 2002 and 85% in 2003. By considering these gross margins we have found that the 120 kg N+PK treatment made loss at gross margin between 2001-2003. In 2004 the 120 kg N+PK resulted 30 % increase in gross margin. The 240 kg N+PK treatment reduced the amount of gross margin in all four examined years, so the application of this treatment should be avoided to achieve maximum gross margin. In disk tillage treatments, the control plot brought positive gross margin in two years. In 2001 it was 92 % less than the winter ploughing treament and 16% less in 2004. It produced a 172 % loss in 2002, while in 2003 this was 60%. The 120 kg N+PK fertiliser dosage increased the value of gross margin in all four years. In 2001 from 8 to 9 %, in 2002 from 172 to156%, in 2003 from 60 to 3 %, while in 2004 from 84 to117 %. The 240 kg N+PK fertiliser dosage did not result in a favourable effect similarly to the 120 kg level, since it decreased gross margin in all years.

In winter ploughing, the 120 kg N+PK fertiliser dosage increased the value of gross margin in three years (2001, 2003 and 2004) compared to the control plot, while it resulted a 55% decrease in 2002. The favourable effect can be explained by the fact that yield increase was higher than the increase in expenditures, so the gap between gross margin and production costs widened. This favourable effect could not be detected in 2002, which is probably due to weather anomalies (little and not favourable distribution of precipitation). The 240 kg N+PK fertiliser dosage resulted gross margin depression in all years, resulting in unprofitable production in 2002 and 2003 (droughty years) closing the gap between gross margin and direct production cost. Gross margin was lower in spring ploughing between 2001-2003 than in the case of winter ploughing control plot. The examined value was also negative in 2002, so the improvement of this should be an objective. Gross margin was 21% higher in 2004 than the comparative basis. The 120 kg N+PK fertiliser dosage resulted in gross margin depression for the years of 2001-2003 in the case of spring ploughing, while in 2004 it increased gross margin by 30 %. The 240 kg N+PK fertiliser dosage reduced gross margin in all four years, so the application of this is not recommended. Gross margin was lower in all four examined years than in the case of the comparative basis. Gross margin was negative was negative in the two droughty years (2002-2003). The 120 kg N+PK dosage had favourable effect in all years, while the 240 kg N+PK treatment resulted gross margin depression.

Figure 7. Gross margin formation of different treatments compared to the winter ploughing control plots in the Látókép experiment (2001-2004)



Source: Own calculation

The highest gross margin, 120.361 HUF was achieved with the 120 kg N+PK treatment in winter ploughing in 2001 in the Látókép experiment. This was followed by 117.861 HUF in 2004 in the 120 kg N+PK spring ploughing treatment. We also achieved good results in winter ploughing control treatments in 2004 making 85.101 HUF and 89.681 HUF in 2001, and 66.091 HUF in 2004 with disk 120 kg N+PK treatment and 88.041 HUF in 2001. From these results it can be seen that gross margin values are the best in the case of winter ploughing treatments, except for 2002, with the application of 120 kg N+PK fertiliser dosage. In 2002 the control resulted the best gross margin. In the case of spring ploughing treatments, except for 2004, the highest gross margins were achieved in the control. In 2004, the 120 kg N+PK treatment had the highest gross margin. In the case of disk treatment, similarly to winter ploughing, the 120 kg N+PK dosage was the most favourable.

The 240 kg N+PK dosage was not favourable in any of the years, decreasing gross margin in all cases, which is due to the fact that it caused depression in yields in most cases and in some cases the yields did not change or changed to a small extent (table 5). On the other hand, direct production costs increased significantly. These two factors resulted in the above mentioned unfavourable effect.

4.2. The Csárdaszállás experiment

Due to different tillage systems, yield volumes and expenditures differed (table 8-15).

Table 8. Yields of the different treatments in the Csárdaszállás plant experiment (2001-2004)

	Plants	2001	2002	2003	2004
Direct sowing	maize	11.4	8.31	3.68	7.5
Shallow, spr. tillage	maize	11.6	8.43	3.97	7.77
Disk loosening	sunflower	11.4	7.92	3.66	7.17
Winter ploughing	winter wheat	13.0	9.13	3.75	7.63

Source: Databaseof DU CAS Department of Land Use and Regional Development

Table 9. The formation of expenditures in the winter tillage treatments of the Csárdaszállás plant experiment (2001-2004)

	2001	2002	2003	2004
I.) Direct expenditure:				
1.) Material cost	71 385 HUF	71 385 HUF	35 539 HUF	27 123 HU
2.) Suppl. service exp.	43 281 HUF	43 281 HUF	43 281 HUF	36 395 HU
Total direct cost:	114 666 HUF	114 666 HUF	78 820 HUF	63 518 HU
3.) Other exp. (field rev.)	1 353 HUF	1 353 HUF	1 353 HUF	1 353 HU
Total indirect costs:	116 019 HUF	116 019 HUF	80 173 HUF	64 871 HU
II.) General costs				
a.) distrib. costs (main sector and gen. economic)	28 989 HUF	28 989 HUF	28 989 HUF	28 989 HU
b.) land lease fee	30 000 HUF	30 000 HUF	30 000 HUF	30 000 HU
Total indirect costs :	58 989 HUF	58 989 HuF	58 989 HUF	58 989 HU
III.) Production costs	*175 008 HUF*	*175 008 HUF*	*139 162 HUF*	*123 860 HUF*

Source: Own calculation

Table 10. The formation of expenditures in the shallow spring treatment of the Csárdaszállás plant experiment (2001-2004)

	2001	2002	2003	2004
I.) Direct cost:				
1.) Material cost	71 385 HUF	71 385 HUF	35 539 HUF	27 123 HUF
2.) Supplementary serv. cost	62 681 HUF	62 681 HUF	53 615 HUF	50 995 HUF
Total direct cost	134 066 HUF	134 066 HUF	89 154 HUF	78 118 HUF
3.) Other exp. (field rev.)	1 353 HUF	1 353 HUF	1 353 HUF	1 353 HUF
Total direct cost:	135 419 HUF	135 419 HUF	90 507 HUF	79 471 HUF
II.) General cost				
a.) distrib. costs (main sector and gen. economic)	28 989 HUF	28 989 HUF	28 989 HUF	28 989 HUF
b.) land lease fee	30 000 HUF	30 000 HUF	30 000 HUF	30 000 HUF
Total indirect costs	58 989 HUF	58 989 HUF	58 989 HUF	58 989 HUF
III.) Production costs	*194 408 HUF*	*194 408 HUF*	*149 496 HUF*	*138 460 HUF*

Source: Own calculation

Table 11. The formation of expenditures in the disk loosening treatment of the Csárdaszállás plant experiment (2001-2004)

	2001	2002	2003	2004
I.) Direct cost:				
1.) Material cost	71 385 HUF	71 385 HUF	35 539 HUF	27 123 HUF
2.) Supplementary serv. cost	62 681 HUF	62 681 HUF	50 417 HUF	49 295 HUF
Total direct cost:	134 066 HUF	134 066 HUF	85 956 HUF	76 418 HUF
3.) Other cost (field rev.)	1 353 HUF	1 353 HUF	1 353 HUF	1 353 HUF
Total direct cost:	135 419 HUF	135 419 HUF	87 309 HUF	77 771 HUF
II.) General cost				
a.) distrib. cost (main sector and gen. econ.)	28 989 HUF	28 989 HUF	28 989 HUF	28 989 HUF
b.) land lease fee	30 000 HUF	30 000 HUF	30 000 HUF	30 000 HUF
Total indirect cost:	58 989 HUF	58 989 HUF	58 989 HUF	58 989 HUF
III.) Production cost	*194 408 HUF*	*194 408 HUF*	*146 298 HUF*	*136 760 HUF*

Source: Own calculation

Table 12. The formation of expenditures in the direct sowing treatment of the Csárdaszállás experiment (2001-2004)

	2001	2002	2003	2004
I.) Direct cost:				
1.) Material cost	71 385 HUF	71 385 HUF	35 539 HUF	27 123 HUF
2.) Supplementary serv. cost	73 081 HUF	73 081 HUF	65 307 HUF	71 071 HUF
Total direct cost :	144 466 HUF	144 466 HUF	100 846 HUF	98 194 HUF
3.) Other cost (field rev.)	1 353 HUF	1 353 HUF	1 353 HUF	1 353 HUF
Total direct cost:	145 819 HUF	145 819 HUF	102 199 HUF	99 547 HUF
II.) General cost				
a.) distrib. cost (main sector and gen. econ.)	28 989 HUF	28 989 HUF	28 989 HUF	28 989 HUF
b.) land lease feej	30 000 HUF	30 000 HUF	30 000 HUF	30 000 HUF
Total indirect cost:	58 989 HUF	58 989 HUF	58 989 HUF	58 989 HUF
III.) Production cost	*204 808 HUF*	*204 808 HUF*	*161 188 HUF*	*158 536 HUF*

Source: Own calculation

During the examination of the four cultivation technology systems it can be found that from all the occuring costs the material cost, the special equipment costs and other direct costs, the distributed costs (insurance fees, membership fees), land lease fee all represent the same value. In the case of different technologies the cost of supplementary sector service changes. It is the lowest in the case of direct sowing while it is the highest in winter ploughing. The difference betwen the highest and the lowest value is 15% in 2001 and 2002, 14% in 2003 and 22% in 2004 per hectare. This value modifies the different cost structures and the cost of different cultivation technology types.

During the examination of profitability, the difference of production value and production cost provides net income and this will be evaluated.

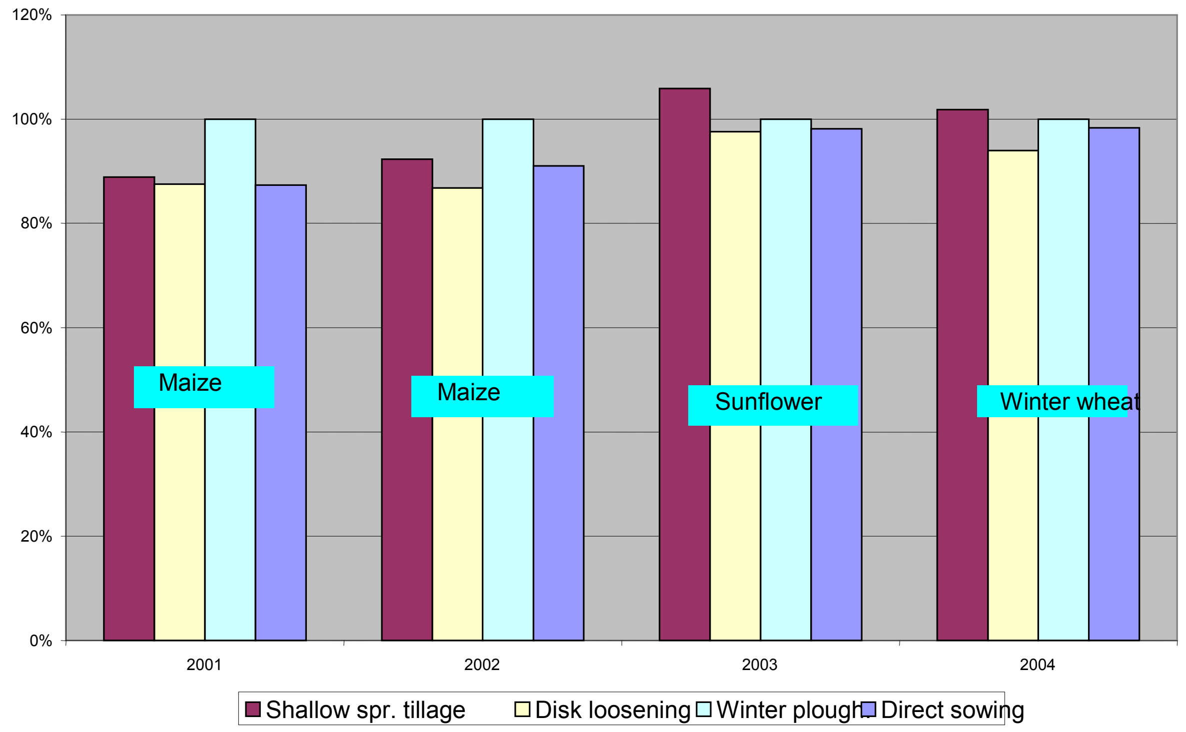
In the case of different cultivation systems different production values, production costs, net incomes, cover sums and expenditures were formed.

Table 13. The formation of incomes in the Csárdaszállás plant experiment compared to winter ploughing (2001-2004)

	Plants	2001	2002	2003	2004
Direct sowing	**maize**	285000.00	207850.00	187680.00	187500.00
Shallow spring tillage	**maize**	290000.00	210900.00	202470.00	194250.00
Disk loosening	**sunflower**	285500.00	198225.00	186660.00	179250.00
Winter tillage	**Winter wheat**	326250.00	228400.00	191250.00	190750.00

Source: Own calculation

Figure 8. The formation of incomes in the Csárdaszállás plant experiment compared to winter ploughing (2001-2004)



Source: Own calculation

The incomes were considered 100% in the case of winter ploughing in all four examined years (table 13, figure 8). The incomes of other tilage treatments were compared to winter ploughing. We have taken the yields of different plants into consideration when calculating incomes (table 3) and the purchase prices of the European Union: maize and winter wheat 101 euro/tonne, sunflower: 204 euro/tonne. The income compared to winter ploughing treatment was 6% higher in 2003 for disk loosening technology and 2% higher in 2004. In the other years we have received lower incomescompared to winter ploughing and rate loss was 2-13%. When examining expenditures, we have stated in the above mentioned section that the cost of production were 5-22% lower compared to the winter ploughing control.

Table 14. The formation of income compared to winter ploughing in the Csárdaszállás plant experiment (2001-2004)

	Plants	2001	2002	2003	2004	Total
Direct sowing	maize	111345.00	32842.00	48518.00	63640.20	**256345.20**
Shallow spring tillage	maize	104300.00	-17083.28	50048.00	24574.05	**161838.77**
Disk loosening	sunflower	-23108.00	10317.00	53992.00	25458.72	**66659.72**
Winter ploughing	winter wheat	51284.00	25602.00	49776.00	23492.79	**150154.79**

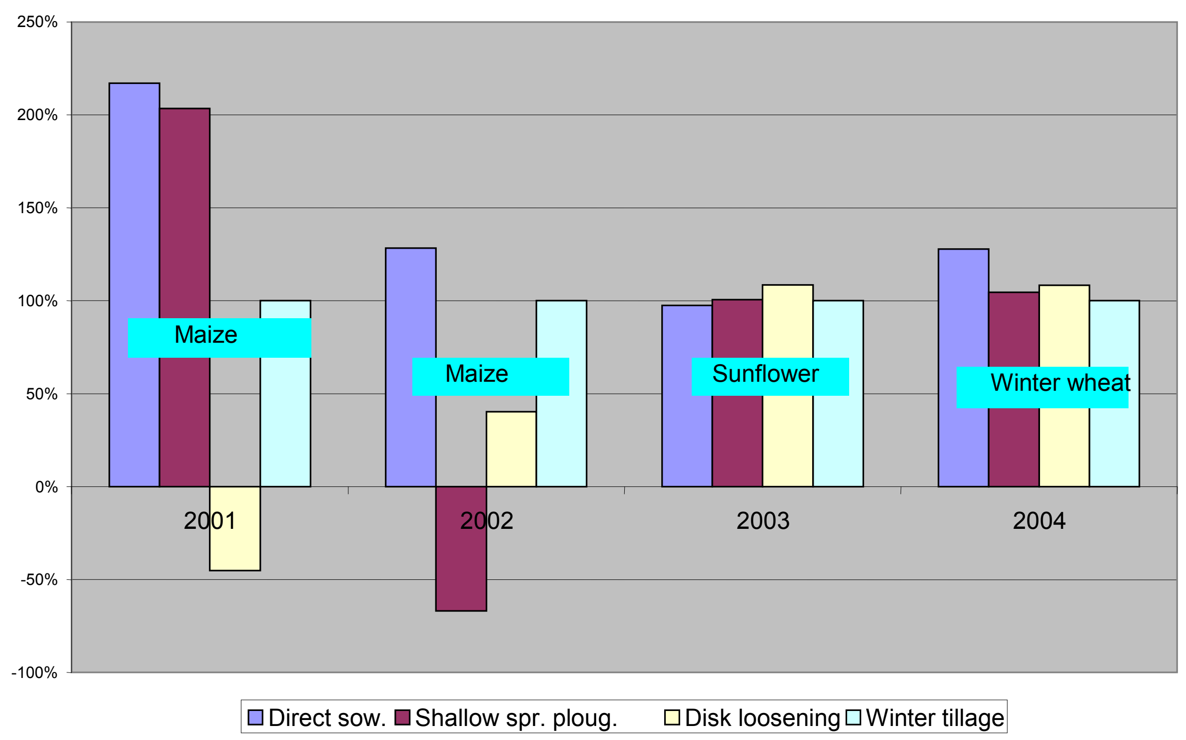
Source: Own calculation

Table 15. The formation of income compared to winter ploughing in the Csárdaszállás plant experiment (2001-2004)

	Plants	2001	2002	2003	2004	Income fluctuation (Winter ploughing 100 %)
Direct sowing	maize	217%	128%	97%	128%	**171%**
Shallow spr. Plough.	maize	203%	-67%	101%	105%	**108%**
Disk loosening	sunflower	-45%	40%	108%	108%	**44%**
Winter ploughing	Winter wheat	100%	100%	100%	100%	**100%**

Source: Own calculation

Figure 9. The formation of income compared to winter ploughing in the Csárdaszállás plant experiment (2001-2004)



Source: Own calculation

If we consider the incomes of winter ploughing as 100% in all four years, then it can be stated that in the case of shallow spring tillage, lower incomes can be achieved by cultivating maize indicator plant (2001 and 2002) in the case of shallow spring ploughing, in fact loss occurred in 2001 (table 14 and 15). In the case of sunflower and winter wheat, we have detected an 8-8% increase in income compared to winter ploughing. The application of the disk loosening technology resulted in a high degree of increase in income (103%) in 2001. The technology based on disk loosening in 2002 produced loss, which compared to winter ploughing technology can be explained by yield loss. In the case of sunflower 1% while in the case winter wheat 5% increase in incomes were gained. In the case of direct sowing technology 117% (2001) and 28% (2002) increase in income was experienced with maize indicator plant compared to the winter ploughing technology. In the case of sunflower, income was 3% less than in direct sowing than in the case of winter ploughing. In the case of winter wheat production (2004), the profitability of direct sowing exceeds the basis of comparison by 28%.

In the Csárdaszállás plant experiment, in the four examined years and four tillage variations we have achieved the highest income in direct sowing (117% higher than with winter ploughing) and disk loosening treatment (103% higher than with winter ploughing) by using maize as indicator plant and considering winter ploughing as one hundred percent. In the case of direct sowing, we have also experienced significant increase in incomes (28%) when cultivating maize as indicator plant in 2002 and the same degree of increase was also present with winter wheat (2004). The cultivation of winter wheat based on disk loosening also brought favourable results, since the income exceeded that of winter ploughing system by 5%. Shallow spring tillage showed a favourable picture in the case of sunflower and winter wheat, since in both cases (2003 and 2004) 8-8% increase in income was experienced compared to winter ploughing. In the four examined years, in direct sowing the cultivation of sunflower was accompanied by 3% loss in income but if we consider that in the other three examined years direct sowing resulted higher income than winter ploughing then it could be considered as favourable. In 2002, the technology based on disk loosening resulted a 67% loss compared to winter ploughing. This adat differs from the data of other years. If the technology based on disk loosening is treated collectively for the four examined years, then it is more profitable than winter ploughing. Shallow spring ploughing is recommended for application for sunflower and winter wheat on the basis of the four examined years. As for maize it resulted a 45% loss in 2001, and a 60% loss in 2002 compoared to winter ploughing. By considering these data, we do not recommend the application shallow spring ploughing when cultivating maize. Traditional tillage proved to be profitable with all indicator plants. The highest income was achieved with maize in 2001. The profitability of sunflower was also significant in 2003. The yield result of winter wheat was average in 2004, similarly to the maize production of 2002.

5. New scientific results

- Environmentally sound cultivation technologies have higher profitability than traditional cultivation. This is due the fact that the achieved yields had lower decrease, 5% to 12% in the case of maize, or reduced tillage methods resulted in higher yield averages than traditional cultivation, sunflower 6%. The formation of expenditures is also an important factor from the aspect profitability. In the case of reduced tillage technologies, the cost of machinery operation are significantly lower than that of winter ploughing. By considering the two factors we have found that the profitability of environmentally sound systems is 3-5% more favourable than that of traditional systems.

- Yields were lower on both experimental location in the case of shallow spring ploughing (Látókép: spring ploughing and disk tillage, Csárdaszállás: shallow spring ploughing (mulch finisher)) when using maize as indicator plant than in the case of winter ploughing. This trend occured in all years of the examination, which made us conclude that maize requires winter rather than spring ploughing.

- It can be seen from the polyfactorial long term experiment of Látókép and Csárdaszállás when examining costs that we cannot simply talk about „alternative tillage systems", but rather about alternative cultivation technology systems. This can be explained by the differences of cost among the different variations due to machinery, material, applied chemicals and water costs. The suplementary, mechanic weeding activity is also included among machinery operations.

- We have found in the Csárdaszállás plant expriment that direct sowing ensured higher profitability with all three indicator plants – maize, sunflower, winter wheat – than that of traditional winter ploughing, so among the ecologic conditions of Csárdaszállás, as long as it is possible (the necessary machinery for the technology are provided) it is recommended for application.

- At both experimental sites, traditional winter ploughing rsulted good yields and good gross margins. As a result we have concluded that professionally applied winter ploughing technology will have great significance in the future in Hungary's plant production technologies.

- By taking the yields of the Csárdaszállás plant experiment into account, we have found that the yield of maize (row crops) decreased to a small extent and the yield average of sunflower (oily plants) and winter wheat (eared crops) did not decrease at all, in some cases the yield increased, when applying alternative tillage methods compared to the winter ploughing method.

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