Review on Agriculture and Rural Development 2013. vol. 2. (1) ISSN 2063-4803

EFFECT OF CULTIVATION SYSTEMS ON MAIZE PRODUCTIVITY AND PRODUCTION PROFITABILITY

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ABSTRACT
In the past decades maize was produced on the largest scale in Hungary. The extreme weather conditions and the rising energy prices of the last years forced the farmers to produce with the least input and with the highest yield stability possible.
Our research was carried out on the land of Vásárhelyi Róna Kft. where a 9-hectare area was partitioned for three equal parcels. The three parcels were cultivated with different basic cultivating methods: ploughing, loosening and strip tillage. Nine-nine different maize hybrids were sowed in each cultivated parcels. In the course of the research we examined the moisture content of the soil, the morphologic features of the hybrids and average yield by hectares. We calculated the total cost, theoretical incomings and earnings by growing maize per hectare.
According to our one-year research we came to the result that the most productive method was tilling proceeding even though it had the highest cost. On the other hand we found that the hybrids reacted differently to the various cultivation procedures. Realizing the results we suggest farmers should take notice of rational tilling and the importance of choosing hybrids.

Keywords: ploughing, ripping, strip tillage, maize hybrid, profitability

INTRODUCTION

Maize is grown in the largest area of Hungary for decades, its production area is 1.17 million hectares on average and the average yield is 6.96 million tons per hectare (HTTP1.). The extreme weather conditions of the last years in Hungary pointed out that the farmers need to adapt to changing terms by the help of agrotechnical factors. Farmers cannot influence the weather factors, but they can make some steps to prevent and repair weather losses. The soil, which suffers from tillage defects (compaction, texture run-down, gather dust, soil crusting) cannot reduce the losses which were caused by weather extremities. Mankind cultivates the land since ancient times, ploughing was the most widespread cultivation method until the 70's, when they started to think about the disadvantages of the ploughing and started to make steps to replace this cultivation method. It has to be promoted to leave out the traditional cultivation methods in the interest of the reduction of soil compaction, organic matter decrease, gather dust, carbon dioxide issue, soil vaporization (BIRKÁS 2000, GYURICA 2000, HAKANSSSON ÉS VOORHEES 1997, HOLLAND 2004, TÓTH 2005), and because it is more economical and more energy efficient (BIRKÁS 1993). The modernization of cultivation is necessary because of growing environmental burden, cost increase, climate changes and soil degradation. So today we are trying to cultivate our land with fewer turns, lower energy input and with sustainable solutions. There are several possibilities among the available cultivation methods which are suitable to save the moisture of the soil and decrease the number of turns (BIRKÁS 2001). Land use affects the soil in all respects, so it is necessary for the farmers to have specialized knowledge to understand the relationships from the context of soil attribute (GYURICZA 2001) so that they can select more suitable cultivation machines.

The goal of our research is to get practicable, realistic and economic results from the effects of three soil cultivation method (ploughing, ripping, strip tillage) on maize hybrids.

MATERIAL AND METHOD

Our research was carried out in 2012, in the area of the Vásárhelyi Róna Kft., the soil parameters are presented in *Table 1.*, and moisture specifics in *Figure 1.* We split the 9 hectare experimental area into 3 equal parts. The cultivation methods were different on the plots: ploughing, ripping and strip tillage. We sowed 9 maize hybrids (P9528, P9494, PR37N01, PR36V52, PR36V74, DKC4995, DKC5007, NK Lucius, NK Octet) on 25th April 2012 with 77000 seed/ha^{-1} seed densities.

During our field test, in 9 replications, we determined height of plant, area unit (2 running meter) of number of plant and number of corn-cob, length of corn-cob, fertility of corn-cob, number of grains per corn-cob and the yield.

The results were estimated with SPSS 18 program, two-factor analysis of variance. We calculated the requirement of fuel (l ha^{-1}) and work time (minute ha^{-1}) of soil cultivation methods, as well as we reviewed all charges of maize production. We calculated the return of three cultivation systems and all hybrids, than we received the profitability of maize production.

Table 1. Data of soil investigation of experimental area

Soil analysis parameters	Value
pH (KCl)	7.27
K_A	44
$CaCO_3$ (m/m%)	3.51
Humus (m/m%)	3.00
P_2O_5 (mg/kg)	177
K_2O (mg/kg)	581.33

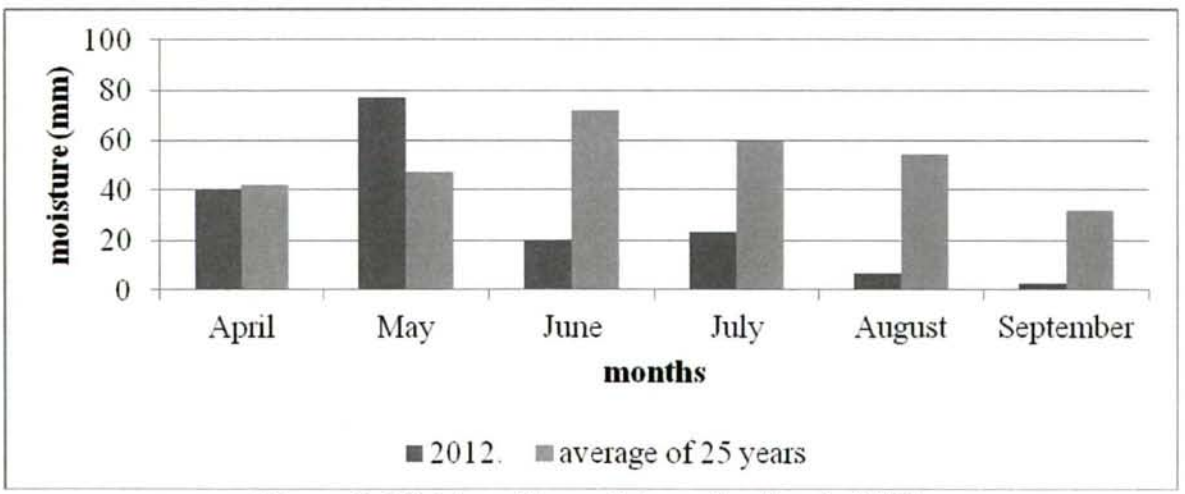

Figure 1. Moisture through investigation in 2012

RESULTS

Table 2. Comparison of soil cultivation systems on the basis of maize productivity parameters

parameters	soil cultivation systems	P9528	P9494	PR37N01	PR36V52	PR36V74	DKC4995	DKC5007	NK Lucius	NK Octet	Average
height of plant (cm)	ploughing	225.78	228.89	233.67	231.00	221.56	227.78	225.67	226.56	241.89	**229.20^a**
	ripping	222.33	219.11	225.22	220.44	222.56	226.89	223.22	229.67	198.67	**220.90^b**
	strip tillage	202.00	191.11	200.33	209.00	194.44	207.89	205.33	180.56	198.67	**198.81^c**
number of plant (piece per 2 running meter)	ploughing	11.56	9.89	11.56	11.78	11.11	11.33	12.11	12.44	11.56	**11.48^a**
	ripping	10.22	12.11	11.89	11.56	11.22	11.00	11.00	12.11	11.89	**11.44^a**
	strip tillage	10.78	10.00	11.56	11.11	10.78	11.33	12.00	11.22	10.89	**11.07^b**
number of corn-cob (piece per 2 running meter)	ploughing	11.00	9.00	9.67	6.89	5.33	8.00	11.11	11.89	8.67	**9.06^a**
	ripping	4.00	7.67	5.22	5.56	5.78	7.56	7.56	10.78	3.89	**6.44^b**
	strip tillage	11.44	6.00	8.11	8.89	3.44	6.11	5.89	10.22	3.89	**7.11^b**
length of corn-cob (cm)	ploughing	12.89	14.43	13.39	12.50	13.00	14.44	13.06	13.39	13.94	**13.45^a**
	ripping	10.33	11.89	11.28	10.17	10.56	13.39	11.89	14.78	9.06	**11.48^b**
	strip tillage	1.61	9.59	10.72	11.44	12.00	13.67	13.00	9.94	10.28	**11.36^b**
fertility of corn-cob (percentage)	ploughing	96.96	94.78	89.73	84.99	88.61	92.64	89.43	89.72	88.67	**90.61^a**
	ripping	82.08	82.09	80.49	66.40	66.08	80.68	68.27	89.15	87.63	**78.10^b**
	strip tillage	95.24	82.09	84.19	88.56	65.26	96.50	92.77	90.40	90.54	**87.28^a**
number of grains (piece per corn-cob)	ploughing	408.67	466.06	344.78	344.39	372.39	457.28	348.67	390.00	404.56	**392.98^a**
	ripping	175.72	201.39	163.89	142.33	145.00	201.56	156.33	268.22	203.56	**184.22^b**
	strip tillage	350.78	203.78	197.22	267.94	169.78	321.39	248.83	275.83	267.72	**255.92^c**
yield (t ha^{-1})	ploughing	4.67	2.72	3.58	3.25	2.21	3.60	3.17	5.57	4.18	**3.66^a**
	ripping	2.40	4.96	3.62	3.72	2.40	1.62	1.98	2.27	2.17	**2.79^b**
	strip tillage	2.66	1.60	1.96	1.29	0.82	1.39	1.27	2.90	2.79	**1.85^c**

On the average of hybrids significant difference showed between the soil cultivation systems considering the height of plant. The highest plants developed in the plough plots, followed by the ripping area and we measured the smallest plants in the strip tillage parcels (*Table 2*).

By studying the effect of soil cultivation systems on the average of hybrids we can claim that significantly bigger number of plant per area unit developed by the ploughing and by the ripping system compared to the strip tillage area (*Table 2*).

On the average of different hybrids, studying the effect of soil cultivation systems we found that those plants developed significantly bigger number of corn-cob per area unit, which came from ploughing primary tillage compared to the ones from ripping or strip tillage (*Table 2*).

By investigating the effect of cultivation systems on the length of corn-cob, significantly higher length values can be observed on the plants, which come from plough cultivation, than by ripping and strip tillage (*Table 2.*).

On the average of the studied hybrids the poorest fertilisation occurred in the case of plants in ripping tillage, while fertility was significantly better on corn-cob of plants from plough tillage and strip tillage parcels (*Table 2*).

We can confirm statistically 5% difference in the number of grain of corn-cob between the soil cultivation systems. The highest number of grains per corn-cob (392.98 grain per corn-

cob) developed in ploughed plots and the fewest grain per corn-cob (184.22 grain per corn-cob) in the area of ripping tillage (*Table 2*).
On the average of 9 hybrids to consider the effect of soil cultivation systems we can claim that there are differences in yields which can be statistically confirmed. The highest yield was in ploughed plots, the lowest yields weighed in the area of strip tillage (*Table 2.*).
We experienced the biggest expense of fuel (53.5 l ha^{-1}) and work time (90 minute ha^{-1}) in plough tillage (*Table 3*). This followed by the ripping with use of fuel (40.5 l ha^{-1}) and work time (71 minute ha^{-1}). We used the fewest fuel (22 l ha^{-1}) on strip tillage, and the strip tillage was the best expenditure of work time (70 minute ha^{-1}).

Table 3. Expense of fuel (l ha-1) and work time (minute ha-1) of soil cultivation methods

	Ploughing		Ripping		Strip tillage	
	l ha^{-1}	minute ha^{-1}	l ha^{-1}	minute ha^{-1}	l ha^{-1}	minute ha^{-1}
Stubble stripping	4	10	4	10	4	10
Fertilization	1.5	6	1.5	6	0	10
Primary tillage	34	42	17	20	14	30
Secondary tillage	10	12	14	15	-	-
Sowing	4	20	4	20	4	20
All	**53.5**	**90**	**40.5**	**71**	**22**	**70**

We studied the profitability of maize production by hybrids and also by soil cultivation systems (*Table 4*). On the average of hybrids the highest cost was on the ploughing tillage system, this was 237230 HUF per hectare expense. The friendliest charge was the strip tillage; its average expense was 221659 HUF per hectare.
By calculating with the maize prices of the Budapest stock exchange at the end of September (*Table 4*) – due to deviation of yield – the ploughed area produced the most return (305512 HUF per hectare), followed by ripping parcels (256361 HUF per hectare), and we could register the fewest return on the strip tillage (188007 HUF per hectare).

Table 4. Profitability calculations (HUF ha-1)

	expense			return			profit		
Hybrids	**ploughing**	**ripping**	**strip tillage**	**ploughing**	**ripping**	**strip tillage**	**ploughing**	**ripping**	**strip tillage**
P9528	238515	234245	262935	371090	223540	240440	132575	-10705	-22495
P9494	239427	235157	218857	244340	389940	171540	4913	154783	-47317
PR37N01	235782	231512	215212	300240	302840	194940	64458	71328	-20272
PR36V52	239427	235157	218857	278790	309340	151390	39363	74183	-67467
PR36V74	239427	235157	218857	211190	223540	120840	-28237	-11617	-98017
DKC4995	237094	232794	216524	301540	238126	157890	64446	5332	-58634
DKC5007	238942	234672	218372	273590	196240	150090	34648	-38432	-68282
NK Lucius	233229	228959	212659	429590	215090	256040	196361	-13869	43381
NK Octet	233229	228959	212659	339240	208590	248890	106011	-20369	36231
Average	**237230**	**232957**	**221659**	**305512**	**256361**	**188007**	**68282**	**23404**	**-33652**

On the basis of our results of one year investigation on 3 soil tillage systems and 9 hybrids we can say that the most effective cultivation system is the ploughing, followed by the ripping and in the end there is strip till, where there was loss in maize production (*Table 4*).
Finally we can conclude that the investigated parameters were influenced by not only the soil cultivation systems, but significantly by the maize hybrids as well

CONCLUSIONS

On the basis of our research, which was carried out in 2012, under extremely dry conditions we can conclude that the height of the plant, the area unit of number of plant and number of corn-cob, length of corn-cob, fertility of corn-cob, number of grains per corn-cob and the final yield are significantly affected by the soil tillage system.
The statement of BIRKÁS (1993) was confirmed, because biggest expense of fuel (53.5 l ha^{-1}) and work time (90 minute ha^{-1}) was in plough tillage. At the same time the two saving tillage methods resulted in fewer yield than the plough, it fundamentally determined the profitability. So our trial shows that we are not able to leave out completely the ploughing from the Hungarian maize production and we can determine that it is very important to compare the cultivation systems in the point of economical view.
Regarding to our field test, we can notice that the speciality of hybrids shows up in the development parameters of plant, in the yield and the result of economic calculations. So the investigated parameters are significantly influenced by not only the soil tillage systems, but also the maize hybrids. This fact drew our attention to take into account not only the parameters of soil and climatic primary tillage, but we mustn't forget the plant central soil tillage (BIRKÁS, 2010), which predicts the effect of hybrid specific tillage.

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