EFFECT OF DIFFERENT TILLAGE SYSTEMS ON YIELD OF SELECTED FIELD CROPS

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Abstract

The stationary crop rotation was followed by four farming productivity, efficiency and environmental sustainability at Research Plant Production Institute in Piešťany-Borovce, Slovakia. The experiments were established of Method experiments Divided Parts with four types of field crops Winter wheat, Maize, Spring barley, Soya bean with four methods of soil cultivation: Conventional, Minimalization, Mulch till, No-till in 3 repetitions. The results showed that the observed field crops responded differently to the growing use of technology, where the limiting factor for the use of technology is the optimal amount of rainfall. In the drier climate of growing crops in years of mitigation and soil protection technology showed higher yield levels. Maize grain and spring barley reached the highest grain yield, on average of years 2006 - 2009 in the Minimalization technology (10.81 t.ha^{-1}, resp. 5.14 t.ha^{-1}), winter wheat in No-till technology (7.12 t.ha^{-1}) and soya bean in Conventional technology (3.17 t.ha^{-1}).

Keywords: tillage, Winter wheat, Maize, Spring barley, Soya bean, yield

INTRODUCTION

Agriculture without tillage was first systematically assessed in the twenties and thirties of the 20th century (Koller - Linke, 2006). Hůla - Procházková (2008) accept the designation of minimalization procedures technologies: minimizing the loosening soil to a selected, usually small depth, soil protective tillage and sowing into uncultivated soil. The basic philosophy of this soil tillage is kept (preserved) in the soil everything in terms of its fertility and good on the other hand to try to eliminate negative impacts on the land caused by human mismanagement.

The most important reasons for dealing with these technologies, not only in terms of farming practices, as well as science and research, are limiting fuel consumption, facilitate and speed up farming, the knowledge of the impact of mechanical cultivation on soil properties and plant development, preserve soil moisture and many more. The economic aspect is negligible especially in today's time increase in prices of agricultural inputs in primary production.

Reduction of soil permeability for water is increasing surface water runoff and soil erosion (Basic et al. 2004). Feed the soil may have a significant impact on land degradation on sloping land. Cost-effective way by preventing water pollution and it is washed away with tillage leaving crop residues on the soil surface (Ginting et al. 2003). The fact that soil protective tillage technologies play an important role in protecting soil from erosion also discusses Assouline, Ben-Hur (2003). Tillage can not be ignored, so for its multi-faceted significance in relation to the following work operations to achieve the final result - yield.

The aim was to compare the four basic methods of soil tillage to farming productivity, efficiency and environmental sustainability, which will be probably used in our conditions.

MATERIAL AND METHOD

We solved the task in the form of field experiment plots CVRV - RIPP - Research Borovce workplace- Slovakia, where the average annual air temperature is 9.2 °C and average annual rainfall is 625 mm and altitude 167 meters above sea level.

The soil at the experimental area is downgraded muck loam loess at a depth of humus horizon from 400 to 500 mm with a mean supply of P and K and neutral to slightly acid soil reaction. The content of humus in the middle mould profile in under mould horizons is low.

Method of cultivation:

1. **Conventional** (tillage with plow with a mouldboard) - Operation a conventional drill sowing, interline cultivation – sowing with seeder Amazone, sowing Maize with seeder Kinze.
2. **Minimalization** (reduced) - Operation after harvest preceding crop, loosening (Plate tools) of the soil surface was covered with 15 to 30 % plant residues, soil preparation before sowing (or not), sowing with seeder Great Plains, Maize with seeder Kinze.
3. **Mulch till** - Operation undercut of stubble with cultivators Amazone, the soil surface to excite only (lift), crop residues remain on the soil surface - seeder Concord Horsch (Maize seeder Kinze).
4. **No-till** - Operation with seeder Great Plains, Maize seeder Kinze.

The tillage methods were examined in four-acre crop rotations: winter wheat, grain maize, spring barley, soya bean. Crop rotation reflected the current share of the cereal growing areas in Slovakia (more than 50%), represented one leguminous crop and one cereal which was treated as root crop - Maize. The width of one plot was 9 m. The length of one plot was 35 m. The extent of the harvest area of experimental plot one crop was 9 m x 35 m = 315 m^2.

Nutrition and fertilization (by Bujnovský - Ložek):

Crop	The planned yield	Dose
Winter wheat	6 $t.ha^{-1}$	N_{163}, P_{34}, K_{105} $kg.ha^{-1}$
Maize	7 $t.ha^{-1}$	N_{189}, P_{44}, K_{146} $kg.ha^{-1}$
Spring barley	5 $t.ha^{-1}$	$N_{120,}$ $P_{30,}$ K_{80} $kg.ha^{-1}$
Soya bean	2 $t.ha^{-1}$	N_{50}, P_{27}, K_{67} $kg.ha^{-1}$

Machines on postharvest tillage, before seed tillage and seeders were used depending on the level of factor machines (plow, disk, etc.).

The harvest was realized with combine harvester Sampo - Rosenlew, with mounted cutting and spreading crop residue.

The results were processed by analysis of variance in the program package Statgraphics.

RESULTS AND DISSCUSIONS

Weather conditions 2006 - 2009

Growing years 2005/2006-2008/2009 in terms of average total temperatures were above year-round climate normal as well as the average of each month (Figure1). August and September were above normal rainfall, but the months October, November and December were dry. Added to this and higher temperatures compared to the climate normal. The rich rainfall was in January, February and March, but April was the month in terms of risk reductions in all four years of cultivation.

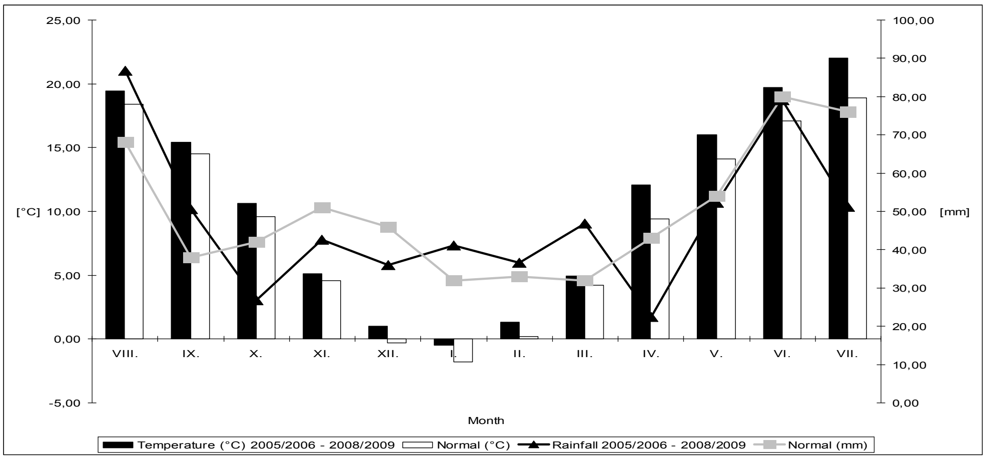

Fig.1 Temperature (°C) and total rainfall (mm) in the area Borovce in years 2005/2006 – 2008/2009

Growing yields 2006-2009

The average yield of winter wheat grain was 7 $t.ha^{-1}$, more at minimalization (7.01 $t.ha^{-1}$) and no-till technology (7.12 $t.ha^{-1}$). For winter wheat the best conditions for reducing the depth and intensity of tillage on soil of moderate to higher natural fertility in drier conditions, maize and beet production area (Procházková - Dovrtěl, 2000, Procházková et al., 2006). The maize grain has an average grain yield over 10 $t.ha^{-1}$ recorded in conventional (10.65 $t.ha^{-1}$), minimalization (10.81 $t.ha^{-1}$) and no-till (10.29 $t.ha^{-1}$) technology. These results clearly didnt confirm the opinions of writers Dick et al. (1991), who pointed out the fact that the cultivation of maize, however, showed that the cultivation of maize and soya bean with no-till technology to be well-drained soils To achieve higher yields than the conventional technology (similar to the date indicated in soybean and Elmore, 1990).

Spring barley showed the highest average yield for the years 2006 - 2009 (5.14 $t.ha^{-1}$) at the minimalization technology. The yield of seed 3$t.ha^{-1}$ and more, reached soya bean at no-till, minimalization, and conventional technology. Only for soya bean was the highest seed yield recorded at the conventional technology (3.17 $t.ha^{-1}$) (Table 1-5). Crop, growing year and tillage participated were statistically high significant to crops. Highly significant were several two-part interactions. The most important were the interactions of crop x year, crop x cultivation, year x cultivation (Table 6).

Winter wheat reached at the conventional technology, the highest yield in 2008 (8.59 $t.ha^{-1}$) during years 2006–2009. Minimalization technology also showed the highest yield in 2008 (8.62 $t.ha^{-1}$), which was also the highest grain yield among the valuated years and soil tillage. The highest yield was at mulch till, as well as conventional and minimalization technology in the year 2008 (8.21 $t.ha^{-1}$).The same situation was also in no-till technology, where we registered yield 8.57 $t.ha^{-1}$. The year 2008 was at winter wheat the best at all modes of cultivation (Table 2). For all the technology in 2008, we had planned yield 6 $t.ha^{-1}$. Average grain yield irrespective of the technology and the year was 6.86 $t.ha^{-1}$, which has exceeded the planned grain yield of winter wheat (6 $t.ha^{-1}$).

In the conventional technology for spring barley the lowest grain yield (2.93 $t.ha^{-1}$) was recorded in 2007. For winter wheat, and spring barley the highest yield was at the conventional technology (6.20 $t.ha^{-1}$) in 2008. This spring barley surpassed the planned yield 5 $t.ha^{-1}$ (about 1.20 $t.ha^{-1}$). However at the minimalization technology was the highest grain yield (6.22 $t.ha^{-1}$) in 2006. Yield above 5 $t.ha^{-1}$ in 2006, 2008 and 2009 led to the highest average yield (5.14 $t.ha^{-1}$) regardless of the growing year. At the mulch till was the highest grain yield 5.51 $t.ha^{-1}$ in 2006 and 2008. At the no-till was the lowest yield 2.76 $t.ha^{-1}$ in 2007. It was the lowest yield of all growing years and tillage. The highest average grain yield in the years 2006 - 2009 was at the minimalization technology (5.14 t.ha^{-1}) (Table3).

Maize grain reached of yield 11 t.ha^{-1}, respectively to 12 t.ha^{-1} (11.96 t.ha^{-1}, 12.46 t.ha^{-1}) at the conventional technology in the years 2008 and 2009. The highest average yield in the years 2006 - 2009 (10.81 t.ha^{-1}) was achieved at minimalization technology. At the mulch technology was the lowest yield 6.08 t.ha^{-1} in 2006. Zimolka et al. (2008) for maize indicate that the effects of varying the intensity of tillage and management of crop residues are largely dependent on soil and climatic conditions. In drier and warmer conditions are achieved the same or even higher yields after technology. Conversely, in colder conditions and humidity not usually yield response of maize to reduce the intensity of tillage so good.

As at mulch, both at no-till technology we recorded the highest grain yield in 2008 and 2009. Similarly, Marko (1995) was sowing maize in marginal land in the pilot trials of selected companies on average years from 1993 to 1995 of 0.2 t.ha^{-1} higher grain yield than in the conventional production technology. Projected grain yield 7 t.ha^{-1} in the average year from 2006 to 2009 was to overcome all the technologies from 2.40 t.ha^{-1} (at mulch technology) to 3.81 t.ha^{-1} (at minimalization technology) (Table 4).

The projected yield 2 t.ha^{-1} for soya bean was always overcome, regardless of the growing year, or tillage, except in 2007 at mulch technology. Conventional technology showed the highest seed yield (4.05 t.ha^{-1}) in 2008. The minimalization technology, we have the same value as in 2006. The projected yield 2 t.ha^{-1} was crossed by more than 100%. Only at mulch technology in 2007 we reached the planned harvest, the difference was only 0.05 t.ha^{-1} (Table 5). The year 2006 was favorable for soya bean at the no-till technology; the yield was higher about 100 %. The lower yields of the soya bean at no-till technology over conventional manner found Philbrook et al. (1991) and West (1996) (average of 20 years about 4-7% depending on the method of minimalization technology). The results corresponded with our state Wagger and Denton (1992). Turman (1995) indicate that in their experiments, the soybean yield at no-till and conventional technology did not differ. Average soybean seed yield was 3.05 t.ha^{-1}, irrespective on the growing year and technology, making the planned yield of seeds overcome about 1.05 t.ha^{-1}.

Table 1

Economic yield [t.ha^{-1}] from 2006 to 2009

	Winter wheat	Maize	Spring barley	Soya bean
	Astella Bardotka	DKC 3511	Ezer	Quito, London
Conventional technology	6.84	10.65	4.78	3.17
Minimalization technology	7.01	10.81	5.14	3.10
Mulch till	6.48	9.40	4.78	2.91
No till	7.12	10.29	4.26	3.00

Table 2

Yield of grain [t.ha^{-1}] Winter wheat 2006 – 2009

	2006	2007	2008	2009	Average
Conventional technology	6.63	5.85	8.59	6.29	6.84
Minimalization technology	7.10	5.80	8.62	6.52	7.01
Mulch till	6.33	5.41	8.21	5.98	6.48
No till	7.16	6.34	8.57	6.41	7.12
Average	6.81	5.85	8.50	6.30	6.86

Winter wheat: Cultivation Hd0,05: 0,30279 ++ Winter wheat: Year Hd0,05:0,30279 ++
Winter wheat: Cultivation Hd0,01: 0,30279 ++ Winter wheat: Year Hd0,01:0,30279 ++

Table 3

Yield of grain [t.ha^{-1}] Spring barley 2006 – 2009

	2006	2007	2008	2009	Average
Conventional technology	4.72	2.93	6.20	5.27	4.78
Minimalization technology	6.22	3.14	5.99	5.21	5.14
Mulch till	5.51	2.99	5.51	5.09	4.78
No till	5.34	2.76	5.02	3.92	4.26
Average	5.45	2.96	5.68	4.87	4.74

Spring barley: Cultivation Hd0,05: 0,26698 ++ Spring barley:Year Hd0,05: 0,26698 ++
Spring barley: Cultivation Hd0,01: 0,34064 ++ Spring barley: Year Hd0,01:0,34064 ++

Table 4

Yield of grain [t.ha^{-1}] Maize 2006 – 2009

	2006	2007	2008	2009	Average
Conventional technology	9.81	8.38	11.96	12.46	10.65
Minimalization technology	10.59	8.57	11.57	12.49	10.81
Mulch till	6.08	8.76	11.06	11.69	9.40
No till	9.58	9.21	10.48	11.87	10.29
Average	9.02	8.73	11.27	12.13	10.29

Maize: Cultivation Hd0,05: 0,56549 ++ Maize: Year Hd0,05: 0,56549 ++
Maize: Cultivation Hd0,01:0,72150 ++ Maize: Year Hd0,01:0,72150 ++

Table 5

Yield of seed [t.ha^{-1}] Soya bean 2006 – 2009

	2006	2007	2008	2009	Average
Conventional technology	3.76	2.05	4.05	2.83	3.17
Minimalization technology	4.05	2.14	3.50	2.70	3.10
Mulch till	3.87	1.95	3.14	2.68	2.91
No till	4.04	2.17	3.29	2.51	3.00
Average	3.93	2.08	3.50	2.68	3.05

Soya bean: Cultivation $Hd_{0,05}$:0,10916 ++ Soya bean: Year $Hd_{0,05}$: 0,10916 ++
Soya bean: Cultivation $Hd_{0,01}$: 0,13927 ++ Soya bean: Year $Hd_{0,01}$: 0,13927 ++

Table 6

Analysis of Variance (Yield of grain [t.ha^{-1}] in years 2006 – 2009)

Source of variation	Degree of freedom	Mean square	F-ratio	Significant level	
Crop	3	468.23672	1790.732	0.0000	++
Year	3	45.41209	173.675	0.0000	++
Cultivation	3	3.69512	14.132	0.0000	++
Repetition	2	0.47369	1.812	0,.673	-
Crop x Year	9	10.27219	39.281	0.0000	++
Crop x Cultivation	9	1.251282	4.785	0.0000	++
Crop x Repetition	6	0.164146	0.628	0.7078	-
Year x Cultivation	9	1.508140	5.768	0.0000	++
Year x Repetition	6	0.116680	0.446	0.8466	-
Cultivation x Repetition	6	0.226567	0.866	0.5214	-
Residual	135	0.2614778	-	-	-
Total	191	-	-	-	-

CONCLUSIONS

We found out that the unsettled climate of growing years, particularly, with regard to rainfall and temperature conditions, to better respond to these conditions, the height reached in terms of production, crops growing at the minimalization and soil protective technologies. As we seem to be critical spring months, especially when the lack of winter moisture and early onset of high temperatures (short onset of spring and early summer) for a significant part on shaping the future harvest. In the climatic drier growing years, crops showed a higher level at minimalization and conservation technology. The highest average yield was reached by maize (10.81 t.ha^{-1}) and spring barley (5.14 t.ha^{-1}) the in years 2006-2009, at the minimalization technology, winter wheat (7.12 t.ha^{-1}) at the no-till technology and soya bean (3.17 $t.ha^{-1}$) at the conventional technology. In this context, minimalization and conservation tillage are showed as friendly technologies.

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