RESULTS OF FOURTEEN-YEAR MONITORING OF TECHNOLOGICAL AND ECONOMIC PARAMETERS OF OILSEED RAPE PRODUCTION IN SELECTED FARM BUSINESSES

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Abstract

Since the year 2001, field trials focused on technological and economic comparison of conventional and reduced-tillage technologies of soil cultivation and drilling of oilseed rape have been carried out in around 40 farm businesses located in all of the districts of the Czech Republic. Average seed yields didn't prove any significant difference between traditional technologies comprising ploughing and reduced tillage technologies. The same can be said about the difference with respect to the sowed varieties (hybrid and traditional), to the application of organic fertilisers, and to the fertilisation during sowing. The results were influenced by an uneven location of trial fields into the individual production areas. With respect to seed yields and costs per production unit, the production area most suitable for winter rape production proved still to be the potatoes one, in opposite to the corn production area as the worst one. Over the fourteen-year time, the average unit production costs attained by reduced-tillage technology were by 232 CZK.ha^{-1}, i.e. by 4.1 %, lower compared to those gained by conventional technology. The highest differences in favor of reduced-tillage technology were demonstrated on heavier soils.

Key words: winter oilseed rape, conventional technology, reduced tillage, costs, fuel consumption.

INTRODUCTION

Conservation tillage is primarily used as a means to protect soils from erosion and compaction, to conserve soil moisture and to reduce production costs (HOLLAND, 2004). Soil erosion is, also in Europe, a major environmental problem. Recent estimates put the total soil loss from agricultural land in Europe between 3 and 40 t.ha^{-1}.yr^{-1} (VERHEIJEN ET AL., 2009). In the intensive agricultural systems generally used in Europe, the effects of erosion on crop yields mainly occur due to the reduction of the amount of water the soil can store and make available to plants. If soil depth is sufficient, yield losses may be very small as the nutrient losses due to erosion can be compensated for by the increased application of fertilizers (BAKKER ET AL., 2004, 2007). However, the implementation of conservation agriculture and conservation tillage is clearly lagging in Europe in comparison to other continents (HOLLAND, 2004; LAHMAR, 2010; WAUTERS ET AL., 2010).

Over the last three decades, there has been considerable research on the effects of conservation tillage on crop yield in many areas in Europe. Often, detailed reports were published both on the economic and environmental effects of conservation agriculture (e.g. LOPEZ AND ARRUE, 1997; TEBRÜGGE AND BÖHRNSEN, 1997). However, the evidence from different studies often seems contradictory and is therefore difficult to interpret (e.g. CANTERO-MARTINEZ ET AL., 2003; LOPEZ AND ARRUE, 1997). This is to be expected: both the agro-environmental conditions as well as the type of conservation tillage applied vary greatly between individual studies. The recent study of MADARÁSZ ET.AL (2016) however suggested that over the ten trial years, tillage type was a more important factor in the question of yields than the highly variable climate of the studied years. During the first three years of technological changeover to conservation tillage, a decrease of 8.7% was measured, respective to ploughing tillage. However, the next seven years brought a 12.7% increase of conservation-tillage yields of all the crops grown.

According to the analysis of 563 observations carried out by VAN DEN PUTTE ET AL. (2010), no significant yield effect of soil tillage practices was observed for fodder maize, potatoes, sugar beet and spring cereals. Only for grain maize and winter cereals a significant yield reduction occurred under conservation agriculture.

When choosing tillage technology, it is necessary to respect agricultural and ecological conditions. At large, the most suitable conditions for tillage depth and intensity reduction are on medium-textured soils with higher natural fertility in drier conditions of maize and beet production regions (PROCHÁZKOVÁ AND DOVRTĚL, 2000; HORÁK ET AL., 2007).

Reduced-tillage technology of soil cultivation and stand establishment are often applied to heavy-textured soils, where soil environment frequently impede quality stand establishment using conventional soil cultivation technology including ploughing. In such case, reduced-tillage technology is practically the only way of stand establishment. Replacing ploughing with a shallow soil loosening followed by sowing using no-till drills is a suitable alternative (HŮLA AND PROCHÁZKOVÁ, ET AL., 2008). BEDNÁŘ ET AL. (2013) suggests a decrease in sowings and the number of plants per m^2 (35 and fewer), and an increase in between-the rows spacing (to 37.5 cm) which has a positive influence on the decrease of competition among individual oilseed rape plants.

A comparison of the different components of the total costs revealed that reduced-tillage required larger machinery and herbicide costs, but these costs were largely offset by reduced operating costs (SANCHEZ-GIRON ET AL., 2004, 2007). In various other studies, it was concluded that slightly lower crop yields can be offset by the reduced fuel inputs and labour consumption (BONCIARELLI AND ARCHETTI, 2000; GEMTOS ET AL., 1998; TEBRÜGGE, 2000). However, this may be dependent on local situation and farm-specific properties such as farm size (SANCHEZ-GIRON ET AL., 2007), cropping system, etc.

MATERIALS AND METHODS

Around 40 agricultural businesses growing winter oilseed rape in various production areas were chosen in the Czech Republic where different production technologies were monitored. At least one field was monitored in every business. Especially the following values were monitored:

• The nature of individual fields (area, type of soil cultivation, previous crop, the usage of crop residues, last application of organic fertilizers);

• The nature of soil (in particular bulk density - evaluated with the so called Kopecky sampling rollers for soil moisture constant determination, humidity, the degree of compactness – penetration resistance measurement by a penometer);

• The nature of crop (yield, the number of plants per m^2, the weight of roots, hybrid / line variety);

• The data on conducted work operations (machinery, fuel and labour consumption, costs and other supplementary information).

After the completion of terrain experiments there was evaluation of the obtained data and information, economic evaluation of the efficacy of money spent (with every business the amount of expenses spent was evaluated compared to the achieved seed yield and the technology used for cropstand establishment), setting conclusions with a subsequent proposal for a suitable technology for effective growing of winter oilseed rape.

RESULTS AND DISCUSSION

During six production years starting in 2001/02, trials were set up in 507 fields located in all of the districts of the Czech Republic. Reduced-tillage technology of oilseed rape growing was employed in 282 cases, conventional in 225 cases only, partly because during the monitored period, some of the farm businesses changed their technology from conventional to reduced-tillage.

The most frequent tillage procedures within the reduced-tillage technology consisted of two soil cultivations, followed in some cases by a seedbed preparation. Within the conventional technology, the most frequent tillage procedures consisted of stubble cultivation followed by ploughing, and seedbed preparation done once or twice.

Disc cultivators prevailed within conventional technologies, whereas within the reduced-tillage technologies, where two stubble cultivations were common, tine cultivators were more frequent, particularly for the second cultivation.

Prior to oilseed rape sowing, manure was applied mainly in forage and potatoes production areas (30 %, resp. 36 %, of the cases) compared to lower frequencies of cereal, beet and maize production areas (only 16 %, 10 %, resp. 6 % of the cases).

Tab. 1. – Average oilseed rape yields and frequencies of cases according to the tillage technology other criteria over the whole monitored period of fourteen years

	Tillage Technology				Aggregate	
	Reduced		Conventional			
	Yield ($t.ha^{-1}$)	Frequency	Yield ($t.ha^{-1}$)	Frequency	Yield ($t.ha^{-1}$)	Frequency
Production Area						
Forage	3.45	32	3.62	12	**3.49**	**44**
Potato	4.18	12	3.81	65	**3.87**	**77**
Cereal	3.56	90	3.50	46	**3.54**	**136**
Beet	3.90	132	3.73	102	**3.83**	**234**
Maize	3.33	16	—	—	**3.33**	**16**
Variety						
Conventional	3.64	116	3.61	84	**3.63**	**200**
Hybrid	3.80	164	3.77	133	**3.78**	**297**
Mixed	2.33	2	3.58	8	**3.33**	**10**
Organic Fertilisers						
No	3.69	209	3.69	125	**3.69**	**334**
Yes	3.82	73	3.71	100	**3.76**	**173**
Fertilizers at Sowing						
No	3.70	166	3.69	220	**3.70**	**386**
Yes	3.76	116	4.07	5	**3.77**	**121**
Aggregate	**3.72**	**282**	**3.70**	**225**	**3.71**	**507**

Over the period of fourteen production years, the average oilseed rape yield of all 507 fields was 3.71 $t.ha^{-1}$. Tab. 1 shows average rape yields according to several criteria. Reduced-tillage technology reached average yield matching almost exactly the one attained by conventional technology.

Concerning regionalization, the highest average yield demonstrated potatoes production area, followed by beet production area, while maize production area, where only reduced-tillage technology was used, proved inferior results. In all of the production areas except the forage one, average rape yield attained by reduced-tillage technology surpassed the one produced using conventional technology.

The average yield of more expensive hybrid varieties surpassed by 4.3 % the one given by conventional varieties. If organic fertilizers those were applied, the average yield attained by merely 1.8 % higher value. With fertilizer application during rape sowing, which was mainly the case of reduced-tillage technology, the average yield exceeded the yield produced when no fertilizers were applied while sowing by 2.1 %. Relatively small frequencies and uneven distribution of cases in individual categories may have influenced the results.

Among technological and economic indicators, the following were monitored or calculated (see Tab. 2): length of vegetative period, fuel consumption, labour consumption, machinery, material and total costs, and unit costs per ton of production.

With respect to the tillage technologies, the average fuel consumption of the reduced-tillage technology was by 20.6 % lower than the one of the conventional technology, and the labour consumption was lower by 24.3 %. The difference may be stressed by an uneven distribution of organic fertilizer application between the groups. If it is applied, the fuel consumption will rise in average by 28.8 %. The same can be stated about the total costs that were also lower with the reduced-tillage technology, namely by 5.1 %. From that, machinery costs were lower by 11.9 %, material costs by merely 1.3 %. Together with the slightly higher rape yield, the reduced-tillage technology costs per ton of production were by 232 $CZK.t^{-1}$, i.e. by 4.1 %, lower than using conventional technology. The potatoes production area demonstrated the lowest unit costs per ton of production, mainly thanks to its highest average rape yield. Evaluation of the results according to the other criteria, such as organic fertilizer application etc., is only informative due to uneven distribution of cases in individual categories.

Tab. 2. – Average duration of vegetative period, fuel and labour consumption, averages of individual cost components, and average costs per ton of oilseed rape production according to the tillage technology and other criteria over the whole monitored period

	Veget. period (days)	Consumption		Average costs			
		Fuel ($l.ha^{-1}$)	Labour ($hrs.ha^{-1}$)	Machinery ($Kč.ha^{-1}$)	Material ($Kč.ha^{-1}$)	Total ($Kč.ha^{-1}$)	Unit. ($Kč.t^{-1}$)
Tillage Technology							
Reduced	345	71.58	3.70	6 052.25	12 713.45	18 900.81	5 401.98
Conventional	343	90.11	4.89	6 872.26	12 879.57	19 918.94	5 633.59
Production Area							
Forage	359	90.21	5.40	6 419.52	12 513.23	19 214.57	5 686.99
Potato	351	89.67	5.06	6 798.45	12 743.63	19 735.59	5 229.29
Cereal	348	75.88	3.88	6 174.94	11 522.29	17 781.05	5 346.03
Beet	338	77.62	3.97	6 455.41	13 519.77	20 129.89	5 583.55
Maize	334	68.99	3.63	6 043.58	13 787.19	19 880.77	6 526.41
Variety							
Conventional	345	77.06	3.98	6 231.17	11 731.87	18 109.54	5 360.00
Hybrid	344	81.38	4.38	6 545.96	13 508.28	20 203.06	5 593.47
Mixed	332	87.89	4.57	6 261.10	12 476.24	18 957.34	5 765.54
Organic Fertilisers							
No	343	69.97	3.58	5 998.56	11 957.51	18 150.97	5 223.28
Yes	347	98.79	5.48	7 222.41	14 388.94	21 672.62	6 048.22
Fertilizers at Sowing							
No	343	83.11	4.46	6 588.50	12 851.77	19 590.79	5 579.84
Yes	348	69.25	3.47	5 866.39	12 581.09	18 592.94	5 265.28
Aggregate	**344**	**79.80**	**4.23**	**6 416.16**	**12 787.17**	**19 352.64**	**5 504.77**

The fuel and labour consumption as well as the value of costs were influenced by organic fertilizer application. With respect to similar average yields, the unit cost per ton of production exceeded by 15.8 % the average of the cases where no organic fertilizers were applied. Average length of vegetative period did not vary much except for production areas. It was longer with production areas located at higher altitudes.

With respect to the costs per unit of production (Fig. 1), the best results were reached in potato production area with reduced-tillage followed by conventional tillage there, and in cereal production area with both conventional and reduced-tillage technologies. Beet production area with reduced-tillage showed also very good results, namely in recent years.

Concerning average yields, statistical analysis showed no significant differences with regard to the tillage technology, organic fertilizer application, or fertilizer application at sowing, and to rape variety. Production area was the only exception where significant differences were demonstrated between the average rape yields of cereal and beet (Turkey HSD; p = 0.0097) and cereal and potatoes production areas (Turkey HSD; p = 0.0382). The trials thus correspond only partly with what MADARÁSZ ET.AL (2016) proved, i.e. by 12.6 % significantly higher rape yield of conservation compared to ploughing technology over ten-year period. One reason might be the monitoring and operational character of the trials, another one the differences in local climatic and other conditions.

Concerning technological and economic indicators from the viewpoint of tillage technology and organic fertilizer application, fuel and labour consumptions, and machinery costs proved statistically significant differences. Material, total, and unit costs differed significantly only with respect to organic fertilizer application. The conclusion of SANCHEZ-GIRON ET AL. (2004, 2007) on higher herbicide costs of reduced-tillage was thus not confirmed, as was the one on lower machinery costs. Decrease in fuel and labour consumption (BONCIARELLI AND ARCHETTI, 2000; GEMTOS ET AL., 1998; TEBRÜGGE, 2000) was validated entirely.

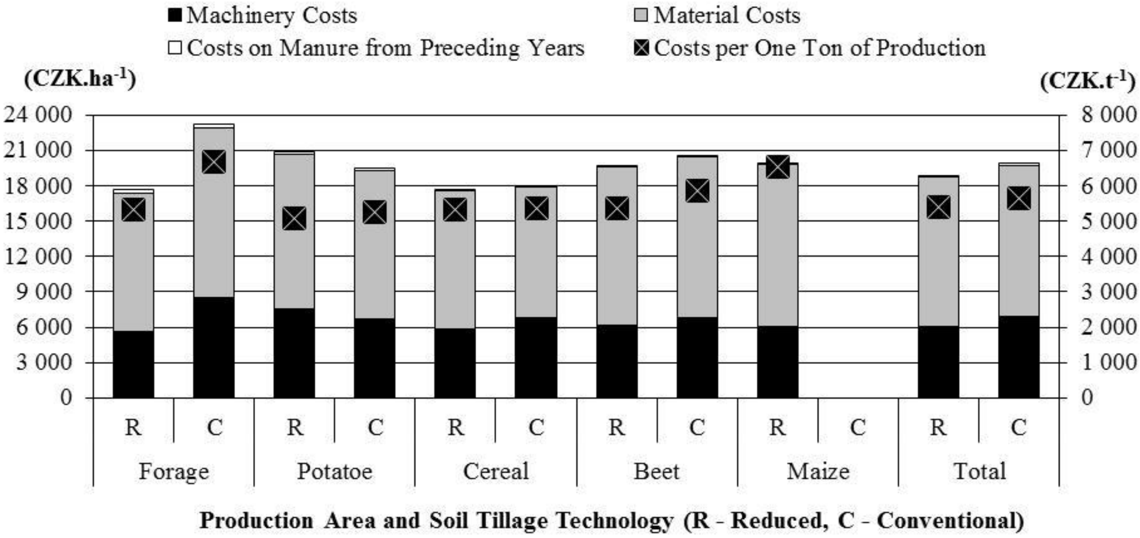

Fig. 1. – Raph of average machinery, material and total costs, and costs per one ton of produced rapeseed with respect to the production area and soil tillage technology over the period of fourteen production years from 2001/02 to 2014/15

CONCLUSIONS

The average fuel consumption of the reduced-tillage technology was by 20.6% lower than that of the conventional technology, the overall labour consumption again lower by 24.3 %. The total costs were again lower by 5.1 %. Yields reached by reduced-tillage were slightly higher, i.e. by 0.6 %, and thus the unit costs lower by 4.1 %. The potatoes production area proved to be the most favourable in terms of oilseed rape yields. Beet production area demonstrated also good results, namely over the recent years.

From the point of view of rape yield, of economics as well as of labour and fuel consumption, the reduced-tillage technology proved to be an adequate alternative to the conventional technology.

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