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Influence of soil tillage on oats yield in Central Bohemia Region

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Abstract. The paper describes results of the field experiment with two technologies of oats crop stand establishment. First technology is conventional technology and second is no-tillage technology. The article describes an experiment which was conducted in years 2013–2017. The experiments were located in Nesperská Lhota at Central Bohemia region. Altitude of selected field is 460 m. The experimental field is covered by a light cambi-soil. The differences between the two technologies stand establishment are discussed. Statistical evaluation was performed on both methods in the parameter number of tillers per m^2 and yield. Crop yield is the basic indicator of agricultural production and usually affected by quality of soil tillage. One of the parameters affecting the yield is tillage (technology, working tools, depth, turning of soil etc.). Tillage depends mainly on the depth of processing and other quality parameters. An examination of the crop yield is necessary in terms of sensitivity, depending on agro-technical conditions. Among those can be included processing plant soil nutrition and plant protection. It's always necessary commemorate, in these experiments can't be excluded some parameters like locality or meteorological parameter influences. Field trial was conceived as multi-year experiment with minimal changes of agro-technical conditions. During the experiment, the positive effect of conventional technology on crop yields was found. This difference was reflected in the number of tillers and in total yield. The measurement shows the beneficial effect of the loosening of soil on the state of the oat crops. The results of experiment show that, the average yield in 5 years observation was 2.11 t ha^{-1} for no-till technology and 4.22 t ha^{-1} for conventional technology of tillage.

Key words: no till technology, conventional technology, yield evaluation.

INTRODUCTION

The basic result of crop production is yield. Yield is affected and limited by many factors. Limiting factors of yield in field crops can be divided into few basic groups: soil conditions, soil fertility, agro-technics factors and meteorological conditions (Karing et al., 1999). Some of these conditions can be affected by agrotechnology. Of course, meteorological factors cannot be influenced (Zute et al., 2010). The main task of soil cultivation is to prepare optimal conditions for crop growth. Contemporary agriculture is characterized by the transition from conventional soil technology to reduced technologies. Berner et al. (2008) describes the necessary change in the cultivation strategy when changing the soil tillage system. Baumhardt & Jones (2002) also emphasizes the need of good management of plant residues.

The problem of no till technology can also be an extension of persistent weeds. Cereals yield loss increased as weeds density increased but the magnitude of the yield loss diminished with increasing cereals plant density (O'Donovan et al., 1999). The main advantage of reduced systems (including no till) is soil protection. Reduced or no-tillage techniques, together with crop residue management and crop rotation are the pillars of CA (conservation agriculture). The term reduced tillage covers a range of tillage practices but it never involves inverting the soil. In this way, soil disturbance is minimized and crop residues are left on the soil. Studies in many European countries have shown that CA can indeed be very effective in combating soil erosion (Van den Putte et al., 2010).

It is also problematic to grow cereals in monocultures without rotation of crops. López-Bellido (1996) found a connection between crop rotation and soil cultivation. The decline in yield over long-term cultivation is also related to the type of tillage. Berzsenyi et al. (2000) also found a decline in crop yields without rotation. The yields of maize and wheat were lower in all cases in a monoculture than in a crop rotation.

Due to lack of studies targeted on spring cereals yield from different soil tillage systems point of view was established this long term field trail. More over this experiment is focused on sustainability of monoculture plant production of spring cereals.

MATERIALS AND METHODS

The field experiment with two variations of tillage and seeding of oat (*Avena Sativa* L.) was based on loamy cambisol at an altitude of 410 m. Growing slope of the land was uniform in all experimental variants. The average slope was 5.4°. The area of experimental plots for individual variants of the experiment was 300 m^2 – width 6 m and length 50 m (3 repeats of each variant), the orientation of the longer side plots the fall line. First variant was no till technology, and the second was traditional variant with ploughing.

First variant: Conventional technology with ploughing in the fall into depth 0.22 m, during winter soil left in rough furrow, in spring time sowing soil preparation with levelling bars and harrows, oats sowing (each year).

Second variant: No till technology with crushing straw from previous year and it was spreading on soil surface like mulch covering for whole winter time, only oat sowing each spring by Ross seeder.

Primary tillage for the foundation of experiment took place in the fall of 2009. Field trial was established in 2009. First four seasons was as a transition between conventional and no till system. First evaluated season for full no till technology was 2013 (due to exclude influence of previously tillage effect). After harvesting of triticale, the straw was crushed and dispersed. The soil was cultivated in the second half of August by disc tiller BDT 3.5 (only variant with conventional tillage). Driving of the machine proceeded in the direction of the contours, hunk pitch against the slope. On half of October the land was processing by mouldboard plough Ross into depth 0.22 m (only variant with conventional tillage). Tillage and sowing in spring is given for each variant of the experiment.

The field experiment was conceived from the beginning as several years. Vantage Vue weather station is located near the experimental plot. In addition, the rainfall was registered and intensity of rainfall and other meteorological variables. The experiment was established for measuring the quantity of water erosion in particular, but additional parameters were monitored, for example elements of the crop yield, soil physical properties etc. Evaluated parameters of biological yield were the height of the stand, tilers' number of evaluated area.

The height of the stand was measured in ten repetitions three times during vegetation in phonological stage BBCH 30, BBCH 50, BBCH 85. The selection was random. Yield of oats plants was determined by manually harvesting in ten repetitions. Each one area was 1 m^2. Biomass of plants was weighed on digital scales Kern. Samples were trashed on laboratory thrasher unit to achieve grains. Data were processed by the programmes MS Excel (Microsoft Corp., USA) and Statistica 12 (Statsoft Inc.,USA).

RESULTS AND DISCUSSION

Table 1 contains meteorological data from all evaluated seasons. The highest rainfall during the vegetation was in 2014. On the contrary, the 2015 and 2017 seasons were relatively dry. During season 2016, rainfall occurred in the form of heavy rains and much of the water drained in the form of a surface runoff.

Table 1. Precipitations and temperatures at different growth stages by BBCH scale recorded in the experimental field for oat in 2013–2017

Year	Growth stages	Temperature, °C	Precipitation, mm
2013	BBCH 20-29	13.4	86.2
	BBCH 30-59	15.3	101.7
	After BBCH 60	20.5	137.9
	Sum	-	320.4
	Mean	16.4	-
2014	BBCH 20-29	12.3	31.9
	BBCH 30-59	16.5	102.8
	After BBCH 60	21.1	143.5
	Sum	-	278.2
	Mean	16.6	-
2015	BBCH 20-29	13.2	31.9
	BBCH 30-59	19.3	82.8
	After BBCH 60	22.4	43.5
	Sum	-	158.2
	Mean	18.3	-
2016	BBCH 20-29	13.4	46.2
	BBCH 30-59	16.3	101.7
	After BBCH 60	19.1	87,8
	Sum	-	230.3
	Mean	15.6	-
2017	BBCH 20-29	14.1	48.7
	BBCH 30-59	16.5	52.8
	After BBCH 60	22.2	84.2
	Sum	-	184.8
	Mean	17.5	-

The physical properties of the soil are shown in Table 2. Porosity and bulk density were monitored parameters. Table shows relatively small differences between variants. Differences over several year experiment were smaller than we expected. Slightly better soil properties were recorded in the variant with a no-till technology. Changes in soil properties are always long term phenomenon, and are also influenced by many other factors (organic matter, etc.).

Table 2. Soil physical properties between years 2013–2017

Year	Depth (m)	Conventional		No till	
		Bulk density, g cm^{-3}	Porosity, %	Bulk density, g cm^{-3}	Porosity, %
2013	0.05–0.1	1.52	37.5	1.47	42.2
	0.1–0.15	1.50	39.4	1.49	41.7
	0.15–0.2	1.54	40.8	1.50	41.9
2014	0.05–0.1	1.49	36.2	1.44	41.9
	0.1–0.15	1.48	40.2	1.47	40.8
	0.15–0.2	1.54	39.2	1.48	43.5
2015	0.05–0.1	1.47	40.0	1.46	41.9
	0.1–0.15	1.49	41.6	1.54	40.0
	0.15–0.2	1.51	37.4	1.47	43.5
2016	0.05–0.1	1.56	42.9	1.48	44.5
	0.1–0.15	1.52	40.3	1.51	41.1
	0.15–0.2	1.53	44.1	1.50	40.8
2017	0.05–0.1	1.47	39.7	1.40	42.7
	0.1–0.15	1.48	38.7	1.41	42.8
	0.15–0.2	1.50	39.6	1.44	44.2

The graph in Fig. 1 shows the number of tillers of oats in each measurement period (BBCH 50). The figure clearly shows greater tillering of oats using conventional technology. This was proven during all years. The number of tillers is an important element of the yield. This parameter suggests a direct effect on yield. Table 3 shows the average value of the number of tillers in each year for each technology. In the years 2013 and 2014, there were statistical differences at the level of alfa = 0.05 below the threshold of statistical significance. In the years 2015–2017, there was a statistically significant difference over the threshold between these two technologies.

Table 3. Average values of tillers number per 1 m^2

Technology	2013	2014	2015	2016	2017
No-till	357	293	248 (***)	186 (***)	197 (***)
Conventional	399	372	368 (***)	407 (***)	398 (***)

*** statistical significance difference.

Value of total yield confirms the positive impact of conventional technology tillage on plant development oats. Tillering of oat plants increased, as well as the other yield components (total yield), as confirmed by the Fig. 2. Conventional technology resulted in higher total yields during all experimental years in comparison with no-till technology. The smallest difference recorded in the 2013 could be caused by the high amount of rainfall during the main growth of oats (BBCH 10-70).A significant decline in yield for no-till technology is reported in following years.

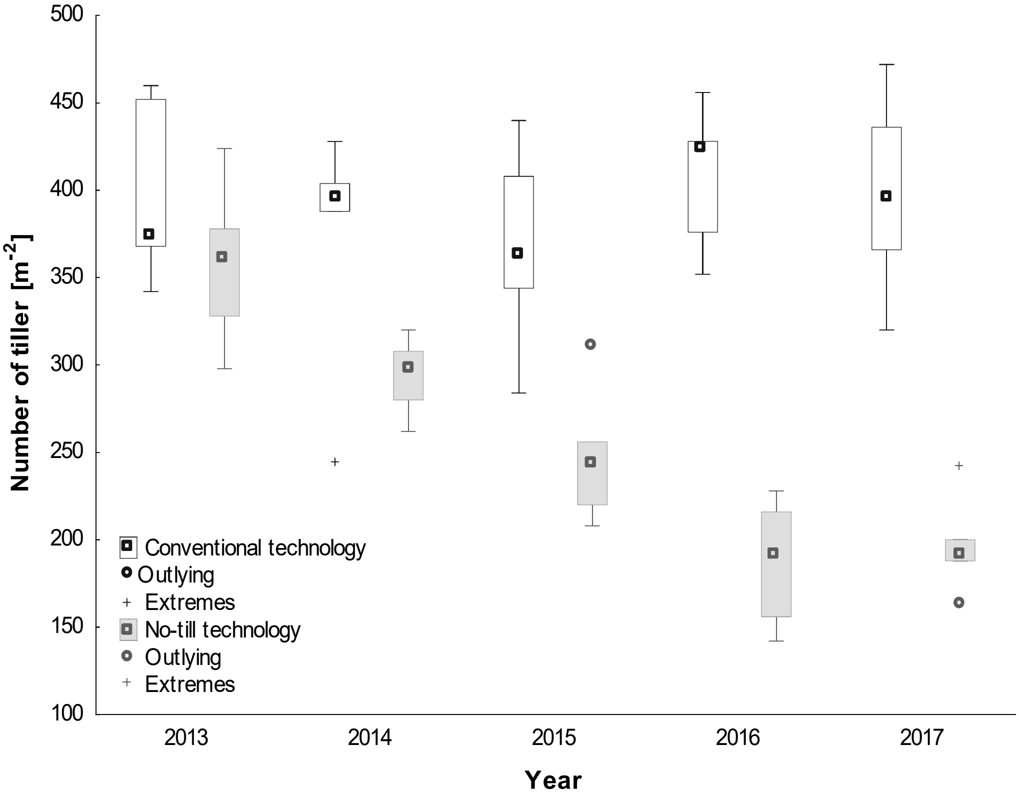

Figure 1. The number of tillers of plants oat in year 2013–2017.

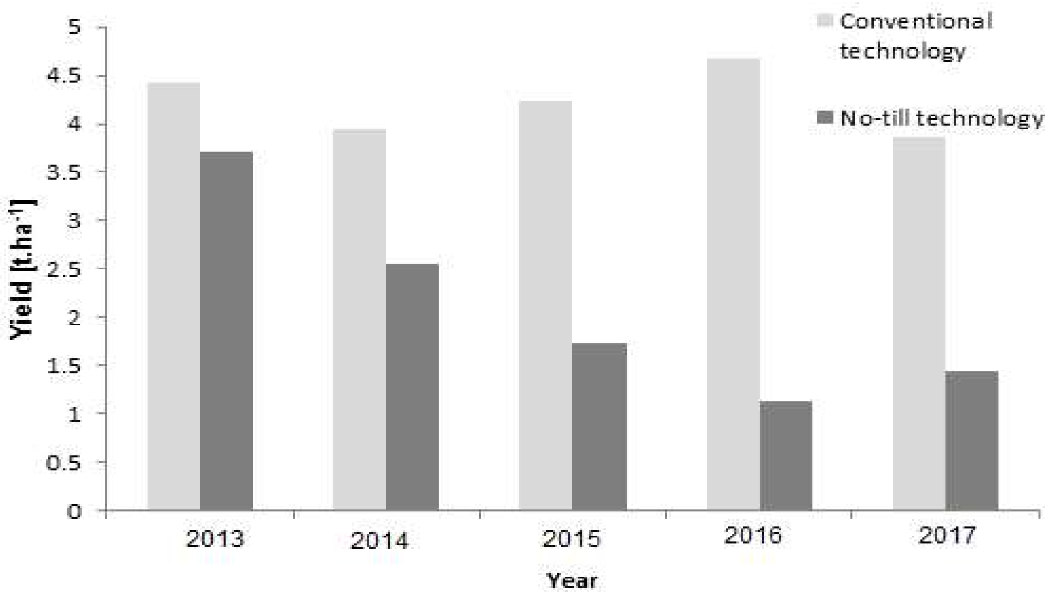

Figure 2. Total yield between 2013–2017.

Fig. 3 shows a comparison of yields for both technologies throughout the given period. It was reported that the conventional technology has more than twice higher yield than no-till technology, suggesting the use of the no-till technology for oats is unsuitable under conditions of central Bohemia region.

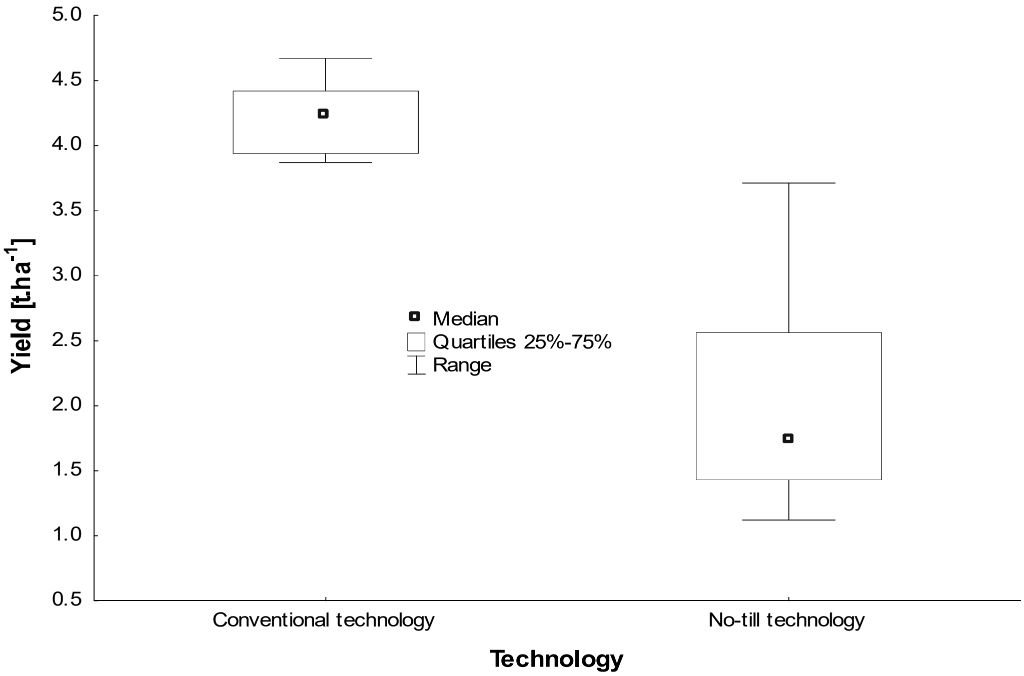

Figure 3. Comparison of each technology in the years 2013–2017.

Tukey test in Table 4 indicates a statistically significant difference between technologies at a significance level alfa = 0.05. Simultaneously shows the average value of each technology.

Table 4. Tukey HSD test- homogeneous group (yield)

Technology	Average yield (t ha^{-1})	1	2
No-till technology	2.11	****	
Conventional technology	4.22		****

The similar results were confirmed by Neumann et al. (2007). They studied effects of crop density and tillage system on grain yield and N uptake from soil and atmosphere of sole and intercropped pea and oat. They also confirmed the beneficial effect of conventional soil cultivation on the yield of oat and the number of tillers. Our results are consistent with results of Riley et al. (2005). They founded that reduced technology (shallow loosening) has a negative impact on total yield compared to conventional technology. Declined yield of oat in no tillage system was confirmed by Seehusen et al. (2017) too. In their work is described reducing the quality of production due to reduced soil tillage for spring cereal production. On the other hand, De Vita et al. (2007) found beneficial effect of no till technology on wheat yields, but only in humid areas. This is confirmed by our research. In the case of higher precipitation during main phonological phases (BBCH 10-60) the difference between technologies was smaller than in the case of lack of rain.

The experiment did not show a decline in yield due to the constant cultivation of one crop using conventional technology. On the other hand, when using no-till technology, decrease of yields was relatively rapid. This is consistent with the study by López-Bellido et al. (1996). It can be stated that for the long-term growing of oats, convection technologies are suitable in these conditions.

CONCLUSIONS

It is evident, that using the conventional technology for oats production has higher yield and more tillers per square meter than using no-tillage technology in this soil conditions. During the research no significant differences were found in the physical properties of the soil. Yield is undoubtedly influenced by other phenomena such as metrological factors and soil properties. The results can't be generalized because the experiment was carried out only in central Bohemia region in one soil type- in this case cambisol. For unambiguous conclusions, it is necessary to test the experiment on multiple sites with different soil conditions.

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