XVII[th] World Congress of the International Commission of Agricultural and Biosystems Engineering (CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Québec City, Canada June 13-17, 2010

CONTROLLED TRAFFIC FARMING AND MINIMUM TILLAGE: RESULTS OF INITIAL EXPERIMENTS AND A LAYOUT OF A LONG TERM EXPERIMENT

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CSBE101106 – Presented at Section III: Equipment Engineering for Plant Production Conference

ABSTRACT Controlled traffic farming is technology that minimizes the compacted area of the field. Hence, applications are mainly combined with no-till technology. There is no existing evidence about the effects of CTF in combination with conventional or minimum tillage. This paper presents: A) the layout of along term experiment aimed at assessing the CTF combined with tillage practices used in Slovakia. B) The results of initial measurements conducted on a 16 ha field (using controlled traffic) and a 17 ha control field (using random traffic), both growing spring barley. The CTF system designed uses a 6 m basic module providing minimum tillage practices. CTF system was introduced during drilling operation. The first operation was conducted in a different direction when compared to traditional practice that was stubble tillage; this had an impact on the quality of the operation. Field surface unevenness together with distribution of crop residue (using image analyses) was assessed. Based on the obtained results it can be concluded that there was no significant difference between the quality of stubble tillage operation conducted under control and random traffic systems. However, these are the results obtained after one growing season of the CTF adoption and further investigation is needed.

Keywords: Controlled traffic farming, tillage, soil compaction

INTRODUCTION Soil compaction is one of the most important factors which influence the aeration of the soil, nutrient uptake efficiency and also the emission of green house gases as CO2 and NOx. In traditional farming there is more then 80 % of the field trafficked (Kroulik, 2009). Controlled traffic farming is technology which minimizes compacted area of the field. All operations over years are conducted in one direction using permanent tramlines. Up to date, applications are combined with no-till technology mainly (Chamen, 2006). There is no evidence about effects of CTF in combination with conventional or minimum tillage.

Despite of many advantages (Yule, 2006 and others), CTF has still not been widely used in Europe. There are still barriers of CTF implementation in Eastern Europe. These can be summarized as following:

- high precision of satellite guidance (RTK) is required, used with integrated autopilots, there is not many of them in usage yet,
- in order to avoid soil surface unevenness, there is a very strictly used practice to conduct some field operations angle wise to previous one (especially the stubble tillage after the harvest),
- a lot of farmers still use traditional tillage with plough.

Therefore, there is need to establish a long term experiment looking at possibilities of using CTF to avoid soil compaction and assess its perspectives in Slovakia.

MATERIAL AND METHODS a) Experiment will be conducted at University farm Kolinany. A 16 ha field "Pri Jeleneckej ceste" was selected as the experimental field, one part of the field "Spicerka" (17ha) was chosen as control field. The long term experiment is planned for years 2010 to 2012, with following aims:
- to find the most effective way of soil compaction reduction, comparing the control and random traffic farming and also other possibilities of soil compaction reduction,
- to find the best tillage technology for CTF in Slovakian condition for growing the most common crops.

The effect will be assessed based on following factors: soil structure, yield, green house gasses emissions (CO_2 and NO_x). The layout of the long term experiment will be designed in two steps: 1. Selection of the crop rotation and growing technology used. 2. Selection of machinery and permanent tramlines design.

B) Aim of the initial measurements was to asses the performance of disc harrows during the stubble tillage in the CTF system. This was carried out at 31 monitoring points of the experimental field and 20 monitoring point of the control field. Quality of the operation was evaluated based on two factors: soil surface unevenness and distribution of crop residuals on the surface.

Distance from a horizontal level panel to the soil surface was measured 57 times at each monitoring point. Data were statistically analyzed. Image analysis was used to assess the crop residuals distribution. Five pictures were taken at each monitoring point. Camera was attached at a construction comprises of metal frame and a boom to ensure the vertical direction. The evaluated area was specified with this metal frame. This area was shadowed during the image taking. The area was later selected in Adobe Photoshop. The software IrfanView 3.51 was used to turn the image in black and white version. The calculation of surface covered with crop residuals was done with the software Impor Basic 4.0 as percentage.

All data obtained at a monitoring point were averaged and then statistically analyzed. The data sets were tested for homogeneity of variances with F-test. T-test was used to compare the two fields.

RESULTS

Layout of a long term experiment

The crop rotation for the long time experiment was selected so it reflects the most grown crop in the region. Grown crops will be: spring barley, oil seed rape, winter wheat. The minimum tillage technology will be used at both fields. The machinery and layout of

machinery movement was selected based on existing conditions at the University farm. The basic 6 m module was selected. Spraying and fertilizer distribution will be realized with 24 m machinery width. Machinery used for this experiment is presented in Table 1. Movement of selected machinery during the field operations at the experimental field is given in Figure 1. Track widths are given in Figure A- 1 of Appendix A.

It is necessary to use a high precision (RTK) satellite guidance for the CTF system. The experiment is planned with existing tractors. However, a new tractor with RTK satellite guidance is planned to buy. The GPRS technology for transfer of RTK signal will be used. RTK signal will be received from reference stations of the "SK POS" service (http://www.skpos.gku.sk/).

Main problem is matching track widths of combine harvesters with other machinery. The out track system will be used, where the tyres of combine harvester will be at the out side of the tractors tracks. Providing 9 m wide cutter bar and exact guidance of the harvester, its movement will be as given in Figure A -2 of Appendix A.

Table 1.Machinery selection for the CTF system.

No.	Machinery	operation	Implement width
1	John Deere 8230 John Deere 8100 with dual tyres (other tractor with RTK precision*) + Lemken Solitaire 9	drilling	6 m
2	New Holland T 6070 + sprayer Agrio NAPA	spraying	24 m
3	Claas Lexion 480	harvesting	9m
4	John Deere 8230 + discs Lemken Rubin 9	stubble tillage	6m
5	Johne Deere 8230 + Lemken Sy-Kompaktor	seedbed preparation	6m

* there is intention to buy tractor with RTK autopilot

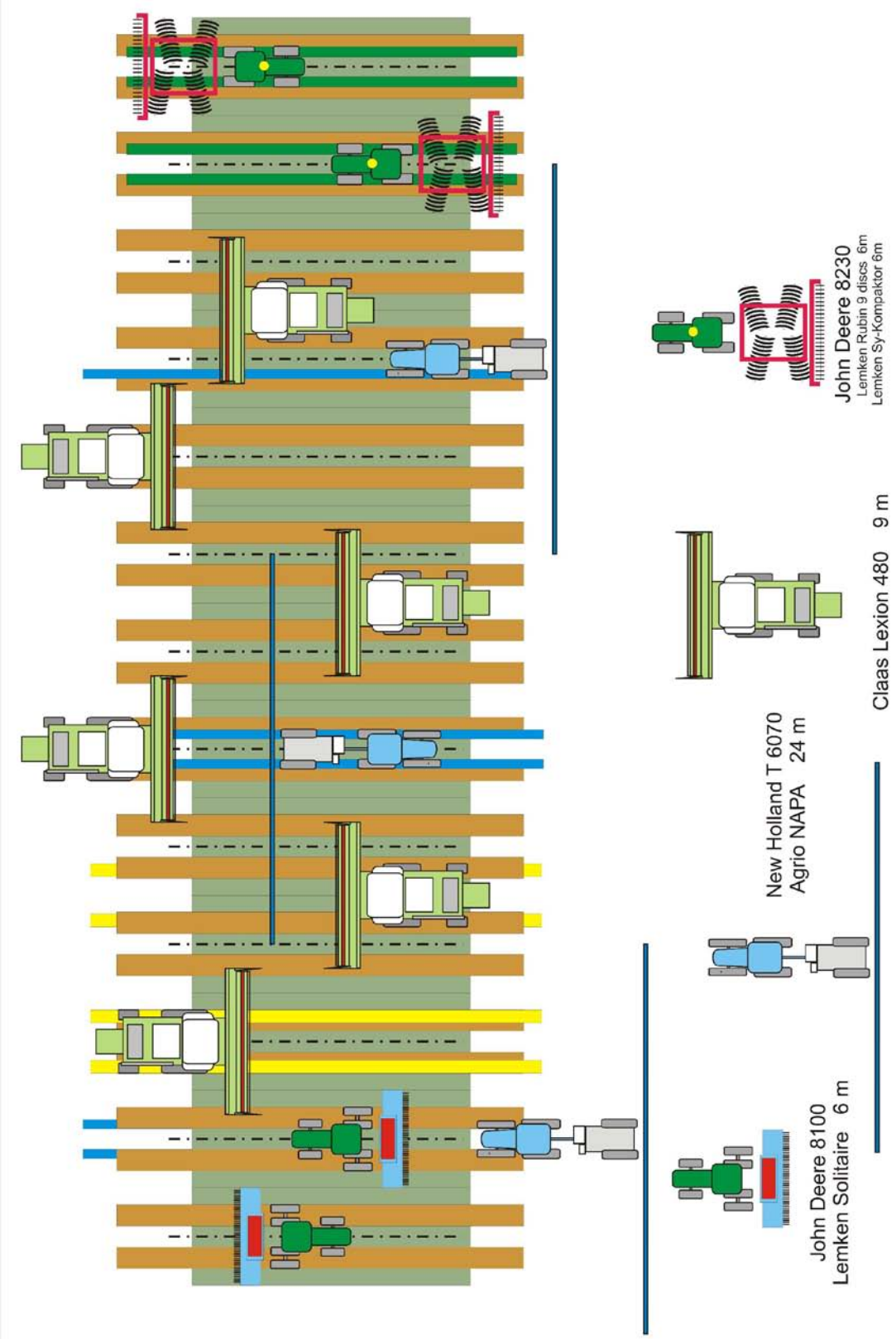

Figure 1 Layout of the machinery movement during the long term experiment

Results of initial measurements

Controlled traffic farming technology was introduced during drilling the spring barley at 16 ha field „Pri Jeleneckej ceste“. As the RTK precision of the satellite guidance was not available at the farm at that time, the SF 2 signal was used. The absolute positioning was solved by using the permanent physical marks to offset the GPS absolute position error. The relative positioning error of the signal can be considered as adequate.

Field was harvested with Claas Lexion 480 with 9 m cutterbar. Because of the breakdown of the combine during the harvest, the field was finished with John Deere 1188 with 5.3 cutter bar in two phases (See appendix A Figure 2). Claas Lexion 480 was guided with Laser pilot; the JD 1188 was navigated base on Trimble EZ Guide and physical marks.

The initial measurements were aimed at quality of stubble tillage as the first difference among the control and random traffic farming comes with this operation. The field was tilled with disc harrows. The stubble tillage was performed in the same direction as all the previous ones at the field (Figure 2). At the control field, this operation was done in the angle wise direction.

Figure 2 Machinery used for stubble tillage and measurements conducted after this field operation

Soil uneveneses Soil unevenness were measured in each monitoring point approximately at 57 times (Figure 2). Basic statistics of the measurements is given in table 2.

Table 2 Basic statistic of the surface unevenness

Parameter	*Pri Jeleneckej ceste CTF field*	*Špicerka Control field*
Mean	8.43	8.25
Standard deviation	0.54	0.39
Minimum	7.39	7.48
Maximum	9.68	8.78
Cunt	31	20

The difference between the two fields was evaluated through the t-test with homogenous variance. Based on the results (t_{stat} = 1.33, t_{krit}= 2.00, $t_{sta<}$ $t_{krit,}$ α=0.05), there is no significant difference between the means of the two datasets. It can be concluded that the direction of disc harrows movement during the field operation stubble tillage did not have significant effect on the soil surface unevenness after the first CTF growing season.

Crop residues distribution

Crop residues were assessed through image analyses (Figures 3 and 4). Five pictures were taken at different places of each monitoring point. Surface, covered by crop residuals, was expressed as percentage.

Figure 3. Image taken at a monitoring point and its processing in Adobe Photoshop

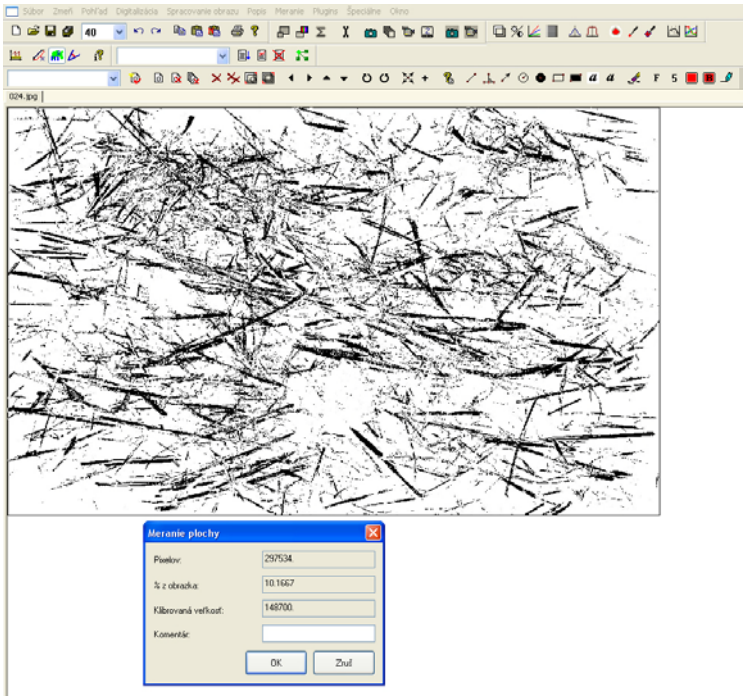

Figure 4. Image processed in Impor Basic 4.0

Data were analyzed with basic statistics (Table 3). The difference between the two fields was evaluated through the t-test with non homogenous variance. Based on the results ($|t_{stat}| = 1.37$, $t_{krit} = 2.02$, $t_{sta<} t_{krit,} \alpha=0.05$), there is no significant difference between the means of the two datasets, the differences in the distribution of crop residuals are not statistically significant.

Table 3 Basic statistic of the crop residuals distribution

Parameter	*Pri Jeleneckej ceste CTF field*	*Špicerka Control field*
Mean	21.56	25.16
Standard deviation	8.89	9.33
Minimum	13.41	14.74
Maximum	38.46	40.20
Cunt	31	20

Obtained results showed that the direction of disc harrows moving did not affect the quality of crop residuals distribution.

CONCLUSION A long term experiment was designed to assess the possibilities of controlled traffic farming (CTF) systems in conditions of Slovakia. Six meter base module was chosen, based on possibilities of University farm. CTF system was introduced by drilling operation in spring 2009. After the first growing season, the quality of stubble tillage was assessed. There was no statistically significant difference in the soil surface unevenness and crop residual distribution between the controlled and random traffic farming fields.

Acknowledgements This paper was prepared in the frame of research project funded from the European Union under the title: ITEPAg: Application of information technologies to increase the environmental and economical efficiency of production agro-system.

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APPENDIX A

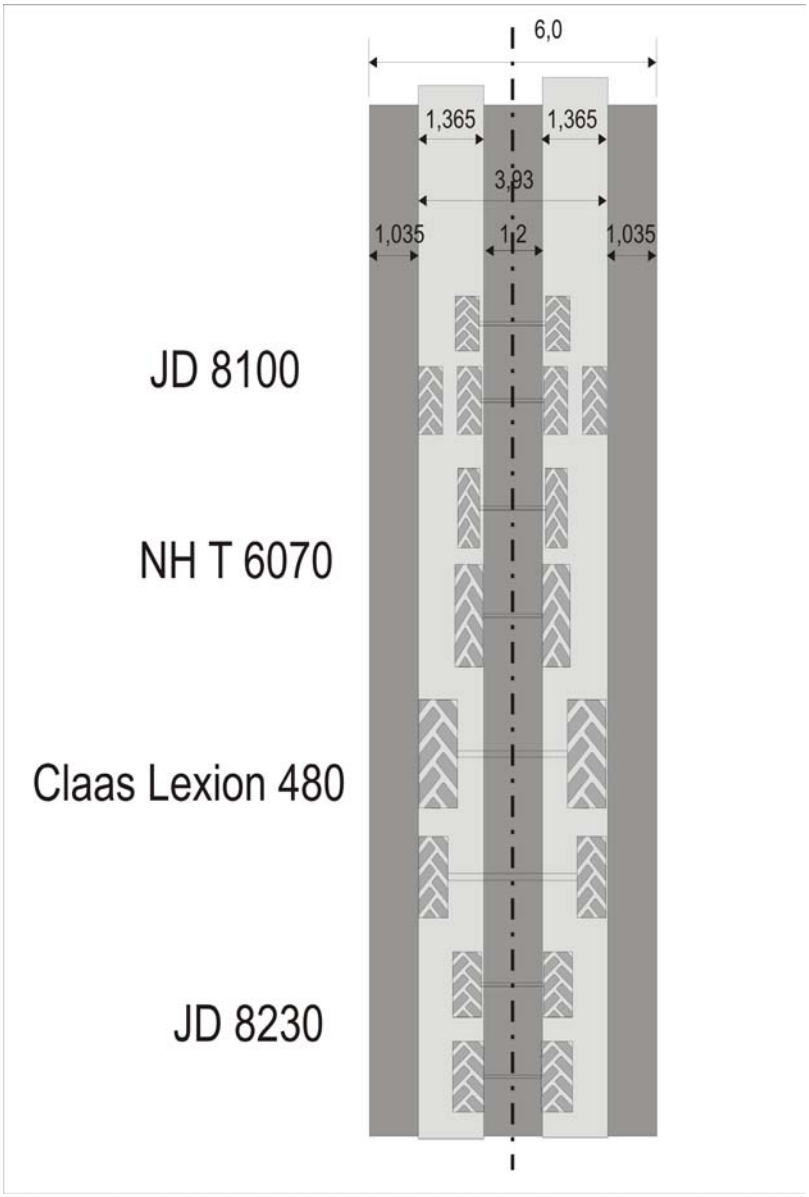

Figure A - 1 Track widths of used machinery (dimensions in meters)

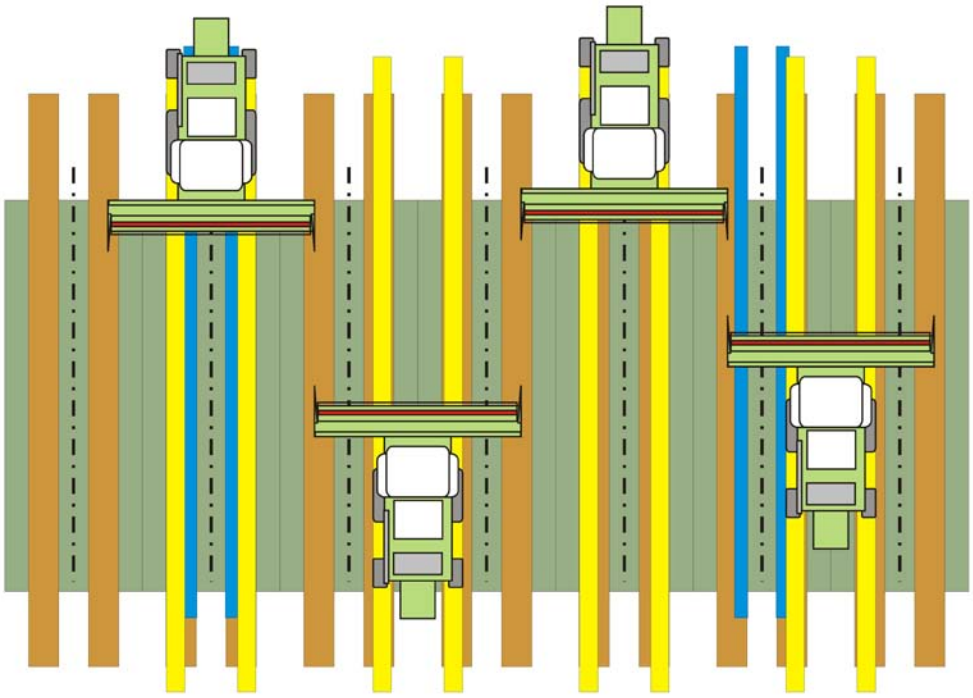

Figure A -2 Movement of combine harvester during the long term experiment