PROPOSALS FOR FIELD WORK RIDES AND THEIR OPTIMIZATION ACCORDING TO SHAPE OF LAND

Jan Chyba, Milan Kroulik, Patrik Vitek, Frantisek Kumhala
Czech University of Life Sciences Prague
chyba@tf.czu.cz

Abstract. In this research were compared different irregular shapes of the land. Each of these shapes was evaluated based on the driving direction in the scale distributed by 5°. Then the optimal guidance lines were planned. In the case of optimal guidance lines it was found that using the inverted loops decreases the percentage working rides and thus increases turning of agricultural machinery on the field. These differences in percentage working rides with/without using inverted loops are in the scale from 0.72 % to 44.50 % depending on the shape and area of the land. The values of the driving distances showed similar results. In the case of using inverted loops the values of the driving distances are higher in the order of hundreds of meters. Furthermore, it was found that even the slightest deviation from the optimal direction line can lead to a significant increase in the proportion of non-working rides and crossings. Also these optimizations may lead to reduction in load of soil and risk factors.

Keywords: GPS navigation passes, passes organization, shape of the land.

Introduction

The development of precision agriculture in the nineties of the last century opened up new ways in the attitude to mechanization for plant production. A new range of terms in agriculture were added, many of them were not brand new and unfamiliar, but practically meant a change in farming and in the view of the land. GPS navigation has become a synonym for precision farming and modern agricultural technology. On the other hand, the introduction of precision farming expected, to some extent, a high degree of expertise and technical skills of the users. However, most farmers see this approach as too complicated. As also studies from the USA, Great Britain, Denmark and Germany have shown it is one of the reasons why precision farming is used less than was expected [1].

With expansion of satellite navigation it is possible to see renewed interest in the precision farming technology. Application of the technology of precision farming is often based on difficult and expensive monitoring of land. As some of our results and studies show, the mere knowledge of the position of the machines together with deployment of navigation devices can help minimize the negative impacts of intensive agricultural activities, mainly on the soil environment.

An example of the impact of agricultural activities on soil environment is soil compaction. Soil compaction is an important factor that influences the water infiltration rate. Soil compaction is mainly caused by the crossings of the agricultural machinery. This compaction reduces the porosity and increases the density of the soil, thus reducing the water infiltration rate in comparison with non-compacted soil [2; 3]. Soil compaction caused by machinery traffic in agriculture is a well-recognised problem in many parts of the world [4; 5]. Subsoil compaction has been acknowledged by the European Union as a serious form of soil degradation, which is estimated to be responsible for degradation of an area of 33 million ha in Europe [6].

Merging of tracks is shown as a suitable way how to reduce the load of the soil by traversing mechanisms. At present, the merging of tracks is based especially on the experience of the drivers or usual habits of the farmers. On the other hand, Bochtisa [7] presented that introduction of controlled traffic farming instead of uncontrolled traffic farming increases the traffic distances during slurry applications. Briefly, there are many factors that affect the efficiency of machine sets. The shape of the land, its size [8], slope, obstacles and working widths of machines play a significant role in this case [8; 9].

Materials and methods

For this work the data were used obtained from six different fields which have different irregular shapes. These fields are shown in Fig. 1. The borders of these fields were converted into the SHP file and then, with cooperation with the corporation Leading Farmers, were processed by software

OptiTrail. Each field was evaluated based on the driving direction in the scale distributed by 5º and then the optimal guidance lines were planned.

For all proposals a sprayer with the working width of 18 m was used.

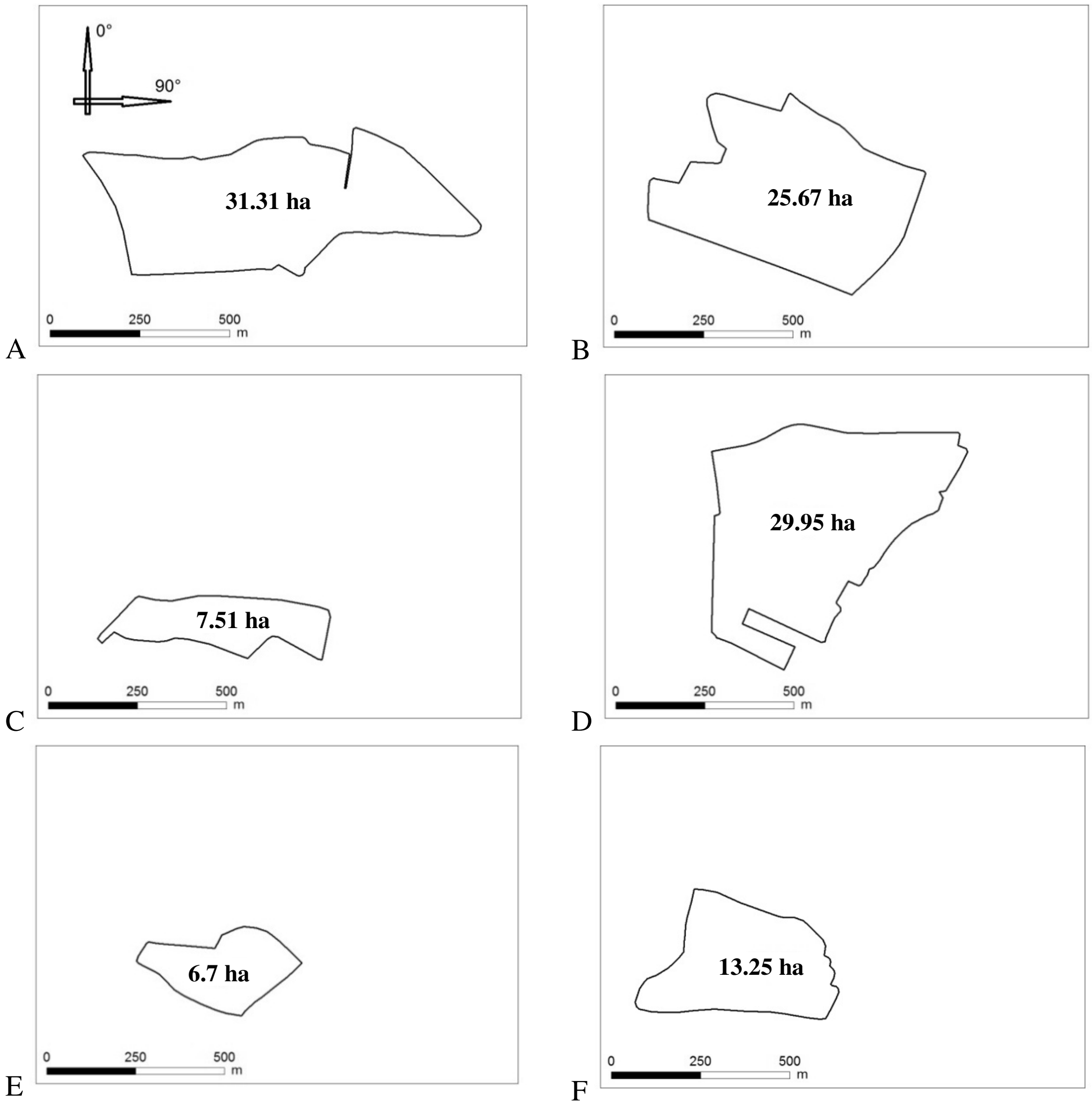

Fig. 1. **Examined field shapes and areas**

Results and discussion

An example of the optimal trajectory of the guidance line is shown in Fig. 2, the figure also shows in which parts of the field C the inverted loops have been used.

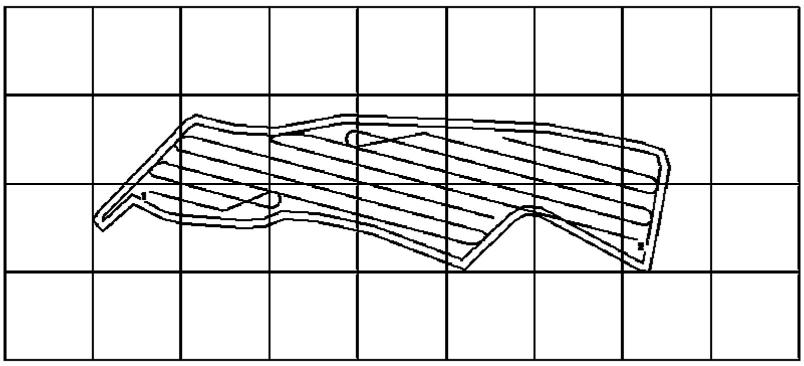

Fig. 2. **Example of optimal trajectory of guidance with inverted loops on the field C**

The influence of the direction of movement at a known shape of the field A on the working efficiency of machine sets is shown in Fig. 3. Fig. 3 also shows the differences between use and non-use of inverted loops. The ratio between the turning and working ride helped us specify the optimal direction of the ride. For proposal of the field A without inverted loops the value of the direction was designed 95º and for the same field with inverted loops the value was 100º

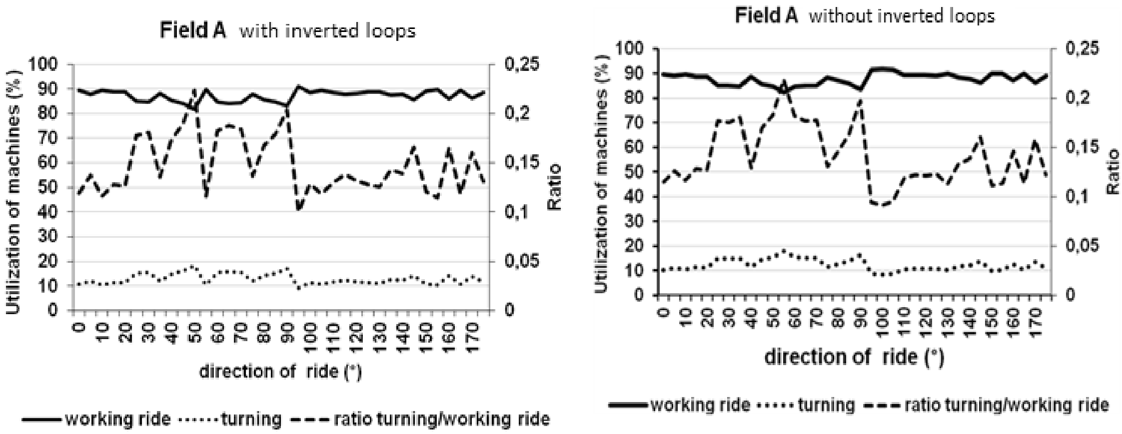

Fig. 3. **Influence of the direction of movement at a known shape of land on the working efficiency of machine sets for the field A**

The design of optimum ride is shown in Table 1. From the table it is obvious that usage of inverted loops increases the total length of rides, number of turnings and thus the ratio between the turning and working rides. From the above mentioned values it is obvious that inverted loops reduce the length of the working rides in the order of percent. The only exception is the field F where the use of inverted loops is better than in the case of the proposal where the inverted loops were not used. The highest difference of the optimized rides, between using and not using inverted loops, occurred in the case of the field A, where the difference was 2.78 %, while the lowest difference occurred in the case of the field D (0.47 %). A similar result was found for the ratio between the turning and working ride, where the field A has the highest value (0.04) and the fields D and F the lowest values (0.01).

Table 1

Design of optimum ride

Field	Acreage, ha	Inverted loops	Direction of ride, degrees	Total, m	Working Ride, %	Turning, %	Ratio turning/working ride
A	31.31	no	95	17553.21	91.36	8.64	0.09
		yes	100	18050.15	88.58	11.42	0.13
B	25.67	no	105	15090.54	94.89	5.11	0.05
		yes	110	15526.77	92.75	7.25	0.08
C	7.51	no	115	4802.71	87.35	12.65	0.14
		yes	105	5054.39	86.02	13.98	0.16
D	29.9	no	110	18091.60	92.46	7.54	0.08
		yes	110	18184.66	91.99	8.01	0.09
E	6.7	no	105	783.32	47.49	52.51	1.11
F	13.25	no	90	8116.08	92.13	7.87	0.09
		yes	90	8053.11	92.85	7.15	0.08

Conclusion

In overall terms, we can say that in most cases of using the inverted loops the efficiency of agricultural activities decreases (as in cases of the fields A, B, C, D). As shown in Table 1, the inverted loops could increase the total travel length of agricultural machinery and thus the fuel consumption and working time. For example, using inverted loops on lands increases the total path of agricultural machinery in the range of 93 m (field D) to 497 m (field A). On the other hand, in some cases the inverted loops could decrease the total travel length of agricultural machinery (from the value of 8116.08 m to 8053.11 m in the case of the field F). Thus, the result is to determine the optimal route for a given shape of the land, adjust the optimal direction of the ride and determine whether it is suitable to use inverted loops. The mentioned comments are not the only part which should be taken into account. For example, the proposed algorithm might be able to take into account not only the size and shape of the land, but also its slope conditions, soil conditions, the entry point for agricultural machinery and other limiting conditions. Future research should be focused to assess the suitability of land for the application of controlled traffic of agricultural sets and to study the benefits of controlled traffic based on the trajectory model.

Acknowledgments

Project is supported by the Ministry of Industry and trade of the Czech Republic, Project No FR-TI3/069

References

1. Reichardt M., Jürgens C., Klöble U., Hüter J., Moser K. Dissemination of precision farming in Germany: acceptance, adoption, obstacles, knowledge transfer and training activities. Precision Agriculture, vol. 10, 2009, pp. 525-545.
2. Liebig M. A., Jones A. J., Mielke L. N., Doran J. W. Controlled Wheel Traffic Effects on Soil Properties in Ridge Tillage. Soil Science Society of America Journal, vol. 57, 1993, pp. 1061-1066.
3. Yuxia L., Tullberg J. N., Freebairn D. M. Traffic and residue cover effects on infiltration. Australian Journal of Soil Research, vol. 39, 2001, pp. 239-247.
4. Chan K. Y., Oates A., Swan A. D., Hayes R. C., Dear B. S., Peoples M.B. Agronomic consequences of tractor wheel compaction on a clay soil. Soil & Tillage Research, vol. 89, 2006, pp. 13-21.
5. Gysi M. Compaction of a Eutric Cambisol under heavy wheel traffic in Switzerland: field data and a critical state soil mechanics model approach. Soil & Tillage Research, vol. 61 (3-4), 2001, pp. 133-142.
6. Akker, J.J.H., Canarache, A. Two European concerted actions on subsoil compaction. Landnutzung und Landentwicklung, vol. 42, 2001, pp. 15–22.
7. Bochtisa D.D., Sørensena C.G., Greena O., Moshoub D., Olesena J. Effect of controlled traffic on field efficiency. Biosystems Engineering, vol. 106 (1), 2010, pp. 14-25.
8. Landers A. Farm machinery, selection, investment and management. Farming press, United Kingdom, 2000, 152 p. ISBN 0-85236-540-3.
9. Jílek L., Podpěra V. The effect of the land shape on the energy intensity of operation steps. Research in Agricultural Engineering, vol. 51 (4), 2005, pp. 134-139.