Institut für Zuckerrübenforschung

Effect of repeated passes of heavy agricultural machinery on soil structure and sugar beet growth in different soil tillage systems

Henning Heuer, Olga Tomanová and Heinz-Josef Koch

Institute of Sugar Beet Research, Holtenser Landstr. 77, D-37079 Göttingen

Introduction

In mechanized agriculture high wheel loads cause major concern regarding the risk of subsoil compaction. Previous experiments have shown that a single pass of heavy agricultural machinery has only minor effects on subsoil properties under many conditions. The objective of this study was to investigate the cumulative impact of three passes of a present-day sugar beet harvester on the physical properties and subsequent sugar beet growth in different soil tillage systems.

Materials and methods

In 1992, the experimental site (clayey silt soil) was divided into three equally sized fields and sugar beet, wheat and barley were grown in a rotation having each crop in one of the fields every year. On each field, a randomized split-plot design (4 replicates) was established with different soil tillage (Ploughing (P) = 30 cm deep and shallow mixing (S) = 10 cm deep) as main plots. In October 2001 (field 2) and in November 2002 (field 1), sub plots were wheeled once by a self propelled six-row combine sugar beet harvester or left unwheeled as reference. The wheels of harvester ran track by track (Fig. 1).

***Fig. 1**: Sugar beet harvester, hopper half filled*

Front tires	800/65R32
Rear tires	1050/50R32
Wheel load	8-11 Mg
Tyre inflation pressure	200-300 kPa
Average ground contact pressue	112-149 kPa

This wheeling was applied in addition to passes of very light machines for management of sugar beet and cereals. Details for subsequent wheelings and crops are given in Table 1. After the third wheeling undisturbed soil cores were taken to determine soil physical properties in different layers.

***Table 1**: Field management and sampling dates during the study period 2001-2005. *Soil water content, Mg 100 m^{-3}.*

	Field 2	Field 1
1. Wheeling	**14.10.01 (23)***	**27.11.02 (35)**
Barley (field 2), wheat (field 1)	19.10.01-15.08.02	18.03.-11.08.03
2. Wheeling	**27.11.02 (37)**	**14.11.03 (22)**
Barley (field 1, 2)	21.03.-28.07.03	30.03.-04.08.04
3. Wheeling	**14.11.03 (34)**	**10.11.04 (34)**
Ploughing / Shallow mixing	24.11.03	26.11.04
Sowing of sugar beet	03.04.04	04.04.05
Soil sampling	06.05.04	20.04.05
Sugar beet harvest	30.09.04	26.09.05

Results

Soil properties in 18-23 cm depth

Across wheeling treatments air filled pore volume (AFPV) and pneumatic conductivity (PC) were higher in P compared to S on both fields (Fig. 2, A, B). On average of tillage treatments, wheeling substantially decreased AFPV and PC on both fields (Fig. 2, A, B). On field 1, these effects were significant. No interactions between tillage and wheeling occurred.

Soil properties in 40-45 cm depth

On average of wheeling treatments no significant effect of tillage on AFPV was indicated (Fig. 3, A). PC increased significantly in S compared to P tillage on field 1 (Fig. 3, B). Across tillage treatments, wheeling significantly decreased AFPV and PC on both fields. No interactions between tillage and wheeling occurred.

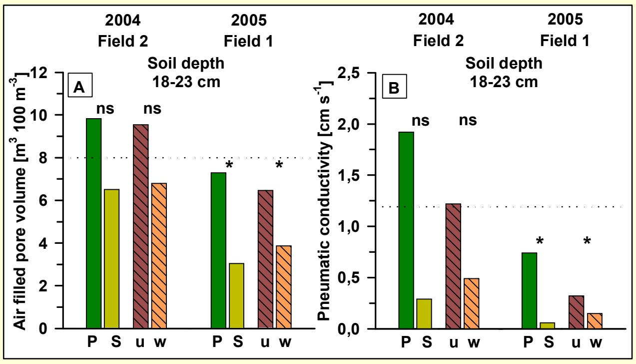


***Fig. 2:** Effect of soil tillage (P = ploughing, S = shallow mixing) and three passes of a sugar beet harvester on air filled pore volume and pneumatic conductivity (-6,2 kPa) in the 18-23 cm soil layer; u = unwheeled, w = wheeled.*

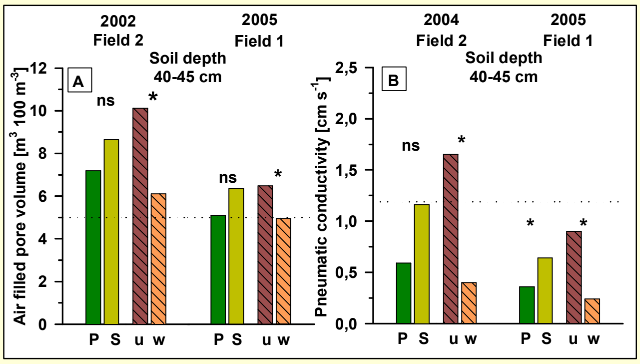
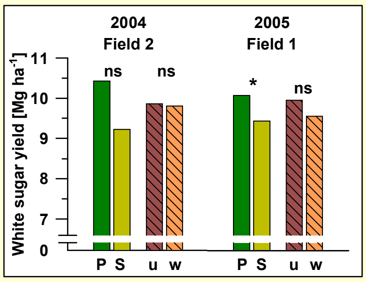


***Fig. 3:** Effect of soil tillage (P = ploughing, S = shallow mixing) and three passes of a sugar beet harvester on air filled pore volume and pneumatic conductivity (-6,2 kPa) in the 40-45 cm soil layer; u = unwheeled, w = wheeled.*

**Differences significant at P<0,05. Dotted lines indicate lower limits for optimum crop growth acc. to Werner & Paul, 1999 (A) and Kmoch, 1966 (B).*



White sugar yield (WSY)

On average of wheeling S tillage treatment decreased WSY compared to P (Fig. 4). This effect was significant on field 1 solely. On average of tillage treatments wheeling had no effect on WSY.

***Fig. 4:** Effect of soil tillage (P = ploughing, S = shallow mixing) and three passes of a sugar beet harvester on White Sugar Yield; u = unwheeled, w = wheeled.*

Conclusions

- **Multiple passes with a present-day sugar beet harvester with high wheel load may cause subsoil compaction**
- **Shallow conservation tillage practices seem not to alleviate the compactive effect of wheeling**
- **Beet growth and yield may not react**