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Joint project „The sugar beet as an energy crop…“

Risk of soil compaction in energy crop rotations with and without sugar beet

Philipp Götze[1*], Jan Rücknagel[1], Anna Jacobs[2], Olaf Christen[1]

[1]Institute of Agricultural and Nutritional Sciences, Department Agronomy and Organic Farming, University of Halle-Wittenberg, Betty-Heimann-Str.5, 06120 Halle

[2]Institute of Sugar Beet Research, Holtenser Landstrasse 77, DE - 37079 Goettingen

*contact via philipp.goetze@landw.uni-halle.de

Introduction

When producing biogas it is beneficial to cultivate crops that achieve the highest methane yields – and thus the highest dry matter yields – across a given area. With this in mind, given the conditions in Central Europe sugar beets represent an alternative to silage maize. However, cultivating these crops to produce biogas must fulfil the criteria of sustainable agricultural production. This article deals with evaluating the risks of soil compaction damage associated with entire crop rotations with and without sugar beet.

Material and Methods

Tab. 1: Crop rotations on field site Aiterhofen (SB – Sugar Beet, SM – Silage Maize, WW – Winter Wheat, Mu - Mustard Breakcrop).

Crop Rotation		2004 2007 2010	2005 2008 2011	2006 2009 2012
1	1	SM	SM	SM
2	1	SB	WW	WW_Mu
	2	WW	WW_Mu	SB
	3	WW_Mu	SB	WW
3	1	SM	WW	WW_Mu
	2	WW	WW_Mu	SM
	3	WW_Mu	SM	WW
4	1	SB	WW_Mu	SM
	2	WW_Mu	SM	SB
	3	SM	SB	WW_Mu

- The cultivation data of crop rotations on field site Aiterhofen is the basis for modeling soil compaction risk.
- Soil compaction risk of different crop rotations distinguished because of varying machinery for crop cultivation and varying soil water content when cultural practice is conducted.
- Since the field trial was established in 2010 and thus data is only available for one crop rotation period, the cultivation data for the years 2010, 2011, 2012 are transferred to the years 2004, 2005, 2006 and 2007, 2008, 2009 respectively. This is necessary to get more valid results.

Tab. 2: Sample of machine data used for modelling (WW – working width, TIP- tyre infiltration pressure).

Operation	WW (m)	Axle Load (kg)	Tyre Size	TIP (bar)
Primary tillage	3	5506	650/65 R 42	0.8
...	...	...	...	...
Seed Sugar Beet	6	3480	420/85 R 34	0.8
...	...	...	...	...
Plant protection | Tractor	21	3316	420/85 R 34	0.8
Plant protection | Trailer	21	3812	420/85 R 38	0.8
...	...	...	...	...
Harvest Sugar Beet	3	26180	1050/50 R 32	2.7
...	...	...	...	...

- The machine data for a 75 ha model farm is the basis to calculate axle load and tyre inflation pressure. For that a bunker filling level of 100% is assumed for harvest machines, trailers and trailed sprayers. The working width is necessary to calculate the proportion of trafficked area.
- The soil water content in the 0-60 cm soil layer is modelled by the German Meteorological Service for all three crops separately (Fig. 1)

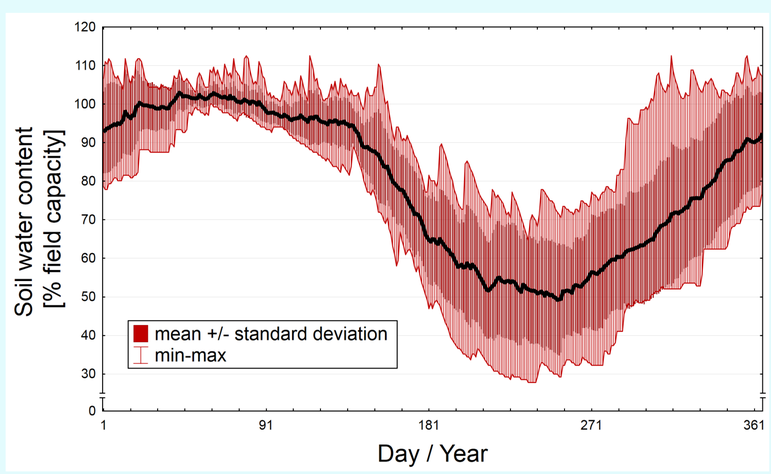

Fig. 1: Regime of soil water content for sugar beet in the 0 - 60 cm soil layer (calculation period 2002-2012).

- For modelling soil compaction risk, soil strength of the lower top soil (20 cm) and subsoil (35 cm) is compared to the soil stress in the current soil depth.
- When soil stress exceeds soil strength a Soil Compaction Index is calculated which indicates the soil compaction risk (Tab. 3).
- Soil strength depends on soil water content, precompression stress (20 cm, 35 cm) and keeps on minimum standards of soil structure (20 cm).
- Soil stress depends on axle load, tyre size, tyre inflation pressure, precompression stress and soil water content (Rücknagel 2007).

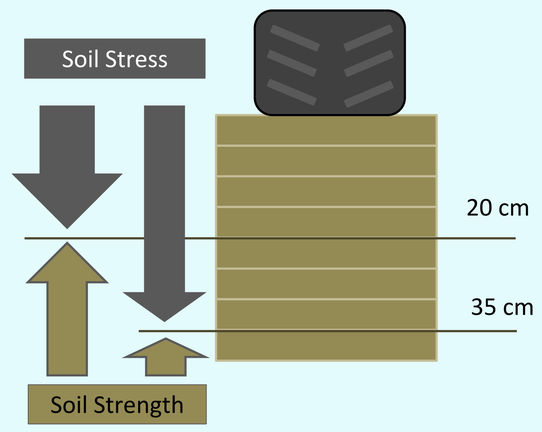

Fig. 2: Model for calculation soil compaction risk.

Tab. 3: Calculation of Soil Compaction Index and classification of soil compaction risk.

Soil compaction index =
Log soil stress (kPa) – Log soil strength (kPa)

Soil Compaction Index	Soil compaction risk
≤0.1	low
0.11 – 0.2	middle
0.21 – 0.3	high
0.31 – 0.4	very high
> 0.4	extremely high

Results and Discussion

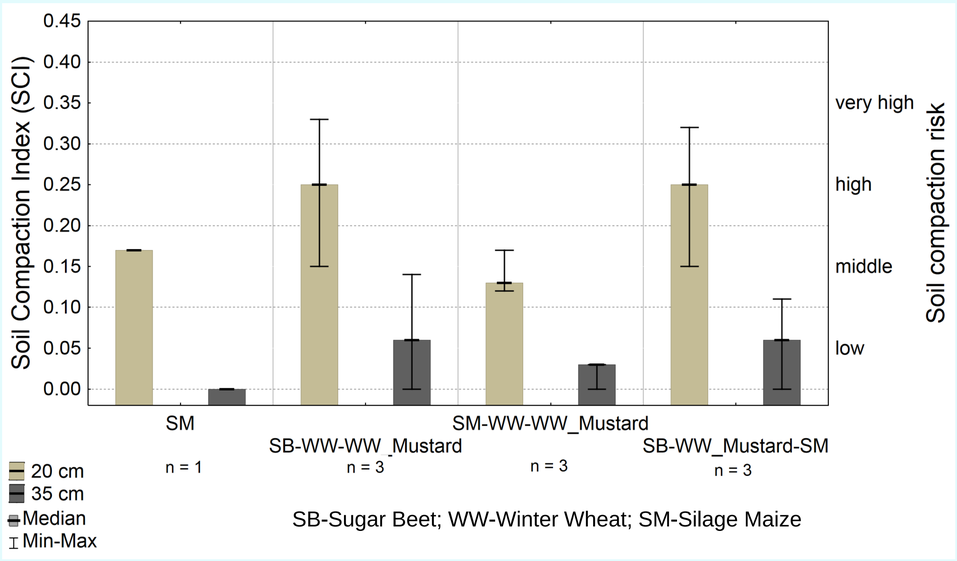

Fig. 3: Soil compaction risk of different crop rotations.

- Figure 3 showes calculated soil compaction indices and soil compaction risks of 4 crop rotations for field site Aiterhofen (75 ha model farm) in the lower topsoil (20 cm soil depth) and subsoil (35 cm soil depth).
- Crop rotations with sugar beet indicates a higher soil compaction risk than crop rotations without sugar beet.
- So soil compaction risk for crop rotation 2 (SB-WW-WW_Mu) and crop rotation 4 (SB-WW_Mu-SM) for the lower topsoil (20 cm) varies from middle up to high and very high. This depends on the crop which is cultivated in years with a high soil water content during harvest. Especially when sugar beet is cultivated in wet years, soil compaction risk increases. By reducing the bunker filling to 50% and adjust of the tyre inflation pressure, the soil compaction risk could be diminished.
- In addition to the sugar beet harvest also the harvest of winter wheat under wet soil conditions has a decisive impact on the soil compaction risk. This explains the lower soil compaction risk for SM-Monoculture compared to SM-WW-WW_Mu for the subsoil (35 cm).

Literature

Rücknagel, J. (2007): Entwicklung eines Modells zur Analyse und Bewertung der Schadverdichtungsgefährdung von Ackerstandorten. Dissertation Universität Halle

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