Controlled Traffic Farming “light”- A way to improve soil structure?
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Introduction
An intact soil structure is crucial for crop establishment and plant growth, but field traffic with agricultural machinery, which became larger and heavier over the last decades, increases the risk of soil compaction (Hamza and Anderson, 2005). As a consequence, infiltration rates and water storage capabilities as well as soil ventilation and root growth are reduced, resulting in yield losses and higher risks of water erosion. Traffic induced soil compaction and the associated negative effects on soil structure and soil functions have been shown to be significantly reduced by the use of permanent traffic lanes for all field vehicles, known as Controlled Traffic Farming or CTF (Chamen, 2011).

With regard to a sustainable management of agricultural soils CTF could also be an interesting approach for Switzerland. Adapted to the small-scaled agriculture, a simplified version with permanent lanes only for heavy machines (contact pressure > 0.8 bar) used for crop protection, fertilisation and harvesting should be evaluated. Three-year trials (2015-2017) on 17 fields in the Swiss Central Plateau were used to investigate the practicability of such a “CTF-light”-system with standard machinery and to examine the effects of permanent lanes on soil physical properties and yields under climatic and farming conditions in Switzerland.

Material and methods
Fields selected for this study were located in the cantons Bern, Zurich and Thurgau at an average altitude between 400 m and 600 m asl. Meteorological data show an average annual temperature between 7.5°C and 9.5°C and 900-1200 mm precipitation. The soils are predominantly characterised as fertile Cambisols from sandy loam or loam. With the exception of two conventionally tilled fields all sites have been cultivated by minimum tillage methods (depth max. 10 cm) for many years.

For every field a “CTF-light”-concept with permanent lanes for crop protection, fertilisation and harvesting was developed, based on working and track widths as well as tyre dimensions of the existing machinery. Farming according to this concept was first implemented during the harvest season 2015 and maintained until the end of the project in autumn 2017.

Soil and yield surveys were carried out in four replications within and between harvest lanes. Penetration resistance was determined in spring 2016 and 2017 using the Eijkelkamp penetrologger (Eijkelkamp, Netherlands). Per replication 10 penetrations up to a depth of 80 cm were done. Simultaneously to the penetration measurements the rate of water infiltration was determined as duration of time for lowering the water level in a single-ring infiltrometer (28 cm diameter) by 2 cm. Infiltration rate was measured twice per replication. Soil core samples (100 cm3, 3 per replication at 10-15 cm depth) from three selected sites were taken in spring 2017 to determine bulk density and macropore volume. In addition, field measurements of volumetric soil moisture and water tension were performed at the same three sites between April and June 2017 to determine soil water desorption curves. TensioMark sensors (ecoTech, Germany) and Drill & Drop probes (Sentek, Australia) were used to collect the data at depths of 10 cm and 20 cm. Measurements of soil moisture and water tension were replicated only three times within and between harvest lanes. Yield data were collected every year just before harvesting. Per replication two areas of 1 m² (0.5 x 2.0 m) were sampled.
Statistical analyses were performed using the statistical software R (R Development Core Team, Austria). Data passing Shapiro-Wilk Normality Test were analysed with fixed-effects ANOVA, otherwise Wilcoxon Rank Sum Test was used.

Results and discussion
Harmonisation of wheel tracks was challenging and required intense planning, particularly in case of varying harvesting technology, but “CTF-light” could be realised on all sites. The trafficked area was between 36 % and 61 % depending on crop rotation and machine working widths. A crop sequence with winter barley, winter rapeseed and winter wheat generated the lowest level of trafficking, a two-step sugar beet harvesting process the highest. After three years of controlled trafficking an incipient differentiation of soil physical properties within and between harvest lanes could be observed. More than half of the study sites showed positive effects due to reduced soil compaction, though differences often remained small. In untrafficked areas there was a tendency to decreased penetration resistance in the topsoil (0-30 cm). Infiltration rate was significantly increased (up to 150 %). Laboratory analyses of soil core samples confirmed the results of the field measurements. Without trafficking bulk density was in tendency decreased and macropore volume increased. Soil water desorption curves, obtained by field measurement of water tension from saturated to dry conditions, revealed no obvious results. Measuring errors caused by air-filled pores at the beginning of data logging might be an explanation.

“CTF-light” had a significant positive effect on maize yield (+13 %), which is known to be very sensitive to soil compaction. The observed yield advantage might be attributed to a better root penetration due to reduced soil compaction. In contrast to regular CTF systems no consistent yield differences could yet be determined for other field crops.

Conclusions
“CTF-light” was the approach to adapt CTF benefits to Swiss agricultural conditions. Only heavy machinery was supposed to use permanent traffic lanes. Considering that soil regeneration is a very slow process, results indicate that soil structure and soil functions can be improved by “CTF-light”. However, the technical and organisational effort to realise permanent traffic lanes for heavy standard machines is not to be underestimated. Therefore, this could be a concept to be used by agricultural contractors.

References