



# Controlled Traffic Farming

in regenerative mosaic agriculture

# CTF

”Controlled Traffic Farming”  
*Automatic steering systems*

**Instead of driving randomly** across the field, the vehicle is driven along **defined, permanent lanes with the help of GPS and an automated steering system**



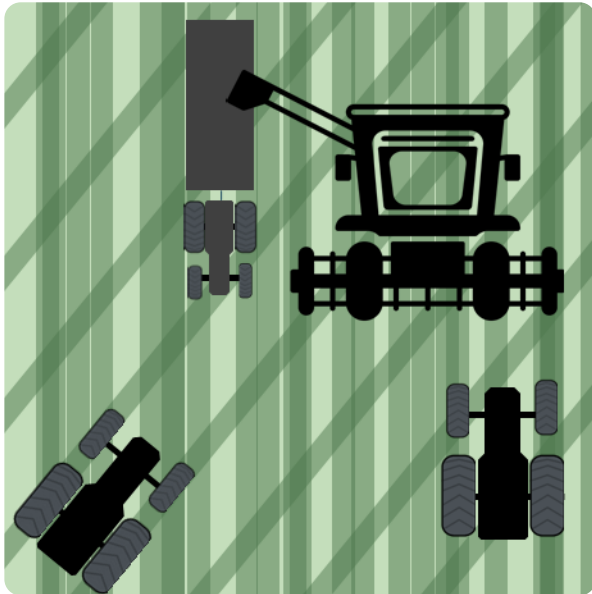
- ↓ Soil compaction
- ↑ More efficient cultivation
- ↑ Soil quality & yield



# CTF enormously reduces the area driven on

## RTF

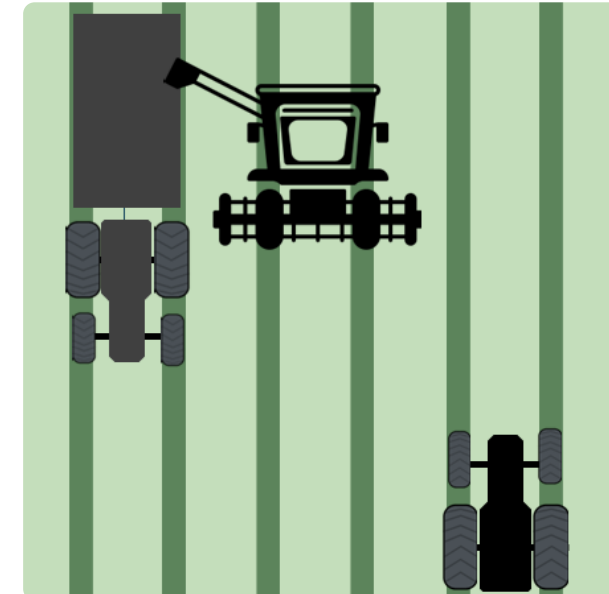
Random Traffic Farming



VS

## CTF

Controlled Traffic Farming



"Normal" cultivation on random tracks

**85%** of the area is driven on **every year**<sup>1</sup> Each pass compacts the soil, but the **first pass** compacts the **most**.

Driving exclusively on permanent lanes

Only **30%** of the area is driven on<sup>2</sup>  
i.e. **70%** are **NEVER** travelled on.

[1] (2015). The potential of controlled traffic farming to mitigate greenhouse gas emissions and enhance carbon sequestration in arable land: a critical review. Transactions of the ASABE, 707-731. <https://doi.org/10.13031/trans.58.11049>

[2] Berechnung mit unserer Spurbreite von 1.77 m und 50 cm Bereifung.

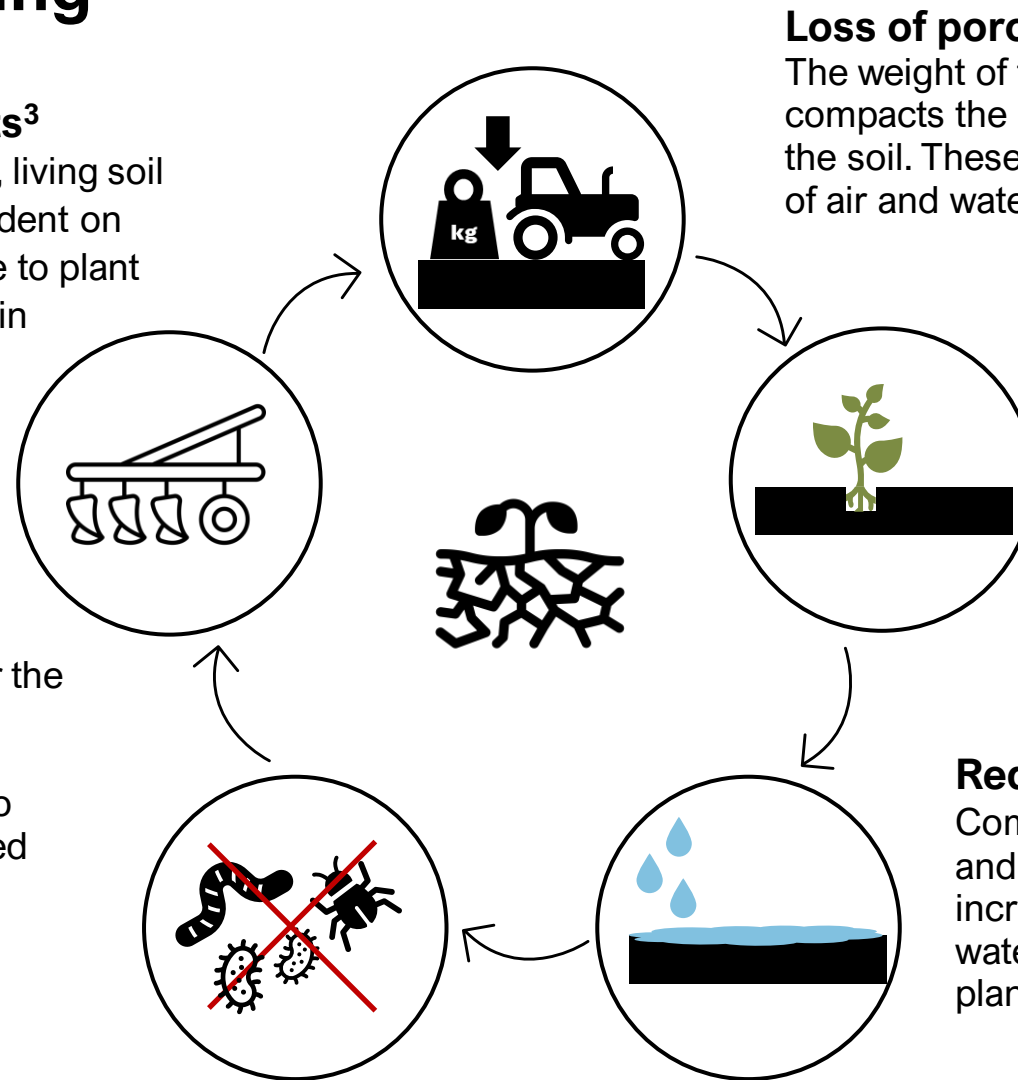
# Das häufige Befahren führt zu einer konstanten Bodenverschlechterung

## Heavier machinery and higher costs<sup>3</sup>

The valuable production factors of porous, living soil are no longer available, and we are dependent on fertilisers and irrigation. In order to be able to plant new crops in hard soil, heavy tillage is again required on the field.

## Lower soil fertility<sup>2</sup>

The natural balance and activity of soil microorganisms, which are responsible for the nutrient cycle, humus formation and soil structure, are disturbed by the anaerobic ("without oxygen") conditions. This leads to nitrogen losses (denitrification), deteriorated soil structure and reduced availability of nutrients for the plants.



## Loss of porosity (soil compaction)<sup>1</sup>

The weight of the machines compresses and compacts the soil - reducing the number of pores in the soil. These pores are important for the absorption of air and water, which are crucial for plant growth.

## Impaired root growth<sup>1</sup>

The soil becomes denser and harder, making it difficult for plant roots to penetrate. The roots are prevented from reaching water and nutrients deeper in the soil.

## Reduced water infiltration and drainage<sup>1</sup>

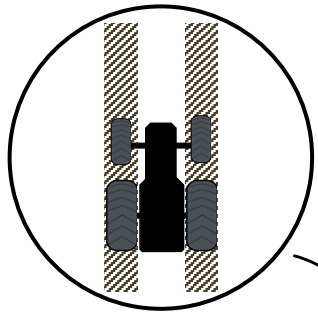
Compaction reduces the soil's ability to absorb and drain water. Increased surface runoff increases nutrient loss and erosion. If waterlogging occurs, this is harmful to many plants.

[1] Agroscope (2020). *Permanente Fahrspuren reduzieren Bodenverdichtung*. Agroscope Transfer | Nr. 336 / 2020. <https://doi.org/10.34776/at336g>

[2] Longepierre, M., Widmer, F., Keller, T. et al. *Limited resilience of the soil microbiome to mechanical compaction within four growing seasons of agricultural management*. ISME COMMUN. 1, 44 (2021). <https://doi.org/10.1038/s43705-021-00046-8>

[3] Hamza, M. and Anderson, W. K. (2005). *Soil compaction in cropping systems*. Soil and Tillage Research, 82(2), 121-145. <https://doi.org/10.1016/j.still.2004.08.009>

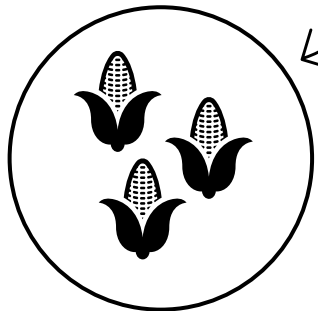
# Grossflächige Versuche zeigen die positiven Effekte von CTF



Minimisation of soil compaction through permanent tracks



Improving soil health & environmental impact<sup>1</sup>



And thus yield & quality improvements<sup>2</sup>

RTF  
**85%** of the area is driven on **every year**

vs. CTF  
**70%** of the area is **NEVER** driven on

$\frac{1}{4}$  up to less

- Fertiliser
- Pesticides
- Seeds
- Fuels

$\frac{1}{3}$  approx. less

- **Water loss** (runoff)
- **Nitrous oxide fluxes** in the soil
- **Methane flows** (2100% less)

on average  
25% more barley  
8% more wheat  
20% more potatoes  
18% more onions

- Improved **time management** (lanes are load-bearing earlier)<sup>3</sup>
- **Earlier sowing/planting options**<sup>3</sup>
- **More even stocks**

[1] Gasso, V., Sørensen, C. A. G., Oudshoorn, F. W., & Green, O. (2013). Controlled traffic farming: A review of the environmental impacts. *European Journal of Agronomy*, 48, 66–73. <https://doi.org/10.1016/J.EJA.2013.02.002>

[2] Godwin, R. J., White, D. R., Dickin, E. T., Kaczorowska-Dolowy, M., Millington, W. A. J., Pope, E. K., & Misiewicz, P. A. (2022). The effects of traffic management systems on the yield and economics of crops grown in deep, shallow and zero tilled sandy loam soil over eight years. *Soil and Tillage Research*, 223, 105465. <https://doi.org/10.1016/J.STILL.2022.105465>

[3] Hamza, M. and Anderson, W. K. (2005). Soil compaction in cropping systems. *Soil and Tillage Research*, 82(2), 121-145. <https://doi.org/10.1016/j.still.2004.08.009>

[4] (2015). The potential of controlled traffic farming to mitigate greenhouse gas emissions and enhance carbon sequestration in arable land: a critical review. *Transactions of the ASABE*, 707-731. <https://doi.org/10.13031/trans.58.11049>

# Weitere Vorteile aus unserer Praxiserfahrung



## Practical for field work

- **Faster turning**; you don't have to drive "on connection"
- Much **less** driver **fatigue**
- Better quality of work, as full **attention is focussed on the machines**
- GPS **shows** you **the bearing track** when the track is no longer visible, e.g. in green manure or grain
- System **ready for future technologies**; small, lightweight machines are easier to electrify or replace them with robots



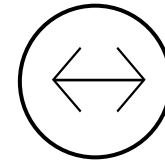
## Good for the soil

- Sigbathtubs (also thanks to strips in thnificantly **better water balance & infiltration**; also thanks to strips in slope line)
- **Soil infrastructure**, earthworm burrows and habitat for fungi and other **soil organisms are preserved**
- **Grain stocks** are **more even**
- We see **clear differences** in the spade sample between **path** (hard, compacted) **and bed** (loose, crumbly)



## Labour-saving

- **No need to repair soil damage** from previous crops; soil structure is ready for fine vegetables after the cereals. Plough, roundabout harrow, bed tiller must normally be used
- Generally: **less effort** because **less damage**
- **No blanket treatment of the entire field**; individual treatment of individual strips is possible
- **More flexible cultivation planning** and **faster bed preparation**



## "Lost space" is functional

- Typical objection: paths are lost space.
- We see the advantages: more root space, more light, more aeration → **less fungal infestation** (similar structure to hare wheat)
- And: due to the negative effects of compaction, **compacted areas** in the RTF are also **"lost"**
- **Yield increases** in the CTF are **higher than** yield losses due to **loss of area**



## Steering system



**RTK GPS signal:** an RTK signal is required in addition to the freely available GPS.



**Software:** We use a free open source solution on a tablet computer in the tractor.



**Steering hardware:** Antennas for signals, steering angle sensor, control mechanics and electronics for signal processing



## Direction of travel & track width

**1.77m:** We have opted for 1.77m - a standard track width for Swiss agriculture

### Along the fall line:

- For **more precision**, we drive along the slope line
- **Drifting** of the machine is **minimised**
- We observe **better water infiltration**; fewer "bathtubs" and therefore more sustainable for the soil structure

# Zusätzlich zum GPS Signal wird ein RTK Signal benötigt



## Steering system



RTK GPS Signal



Software



Steering hardware

- For a **driving accuracy** of **+/- 2cm**, an **RTK signal** is required in addition to the **freely available GPS signal**. necessary (Real Time Kinematic positioning)
- The signal comes via the **Internet** or via a specially installed **antenna**. There are **low-cost** services, **some of which are free of charge**.



Examples of signal providers (as of January 2024)



Swipos



SAPOS



onocoy



RTK2Go

Eigene  
Basisstation



# Die Software verarbeitet die Signale und ermöglicht die autonome Lenkung



## Steering system



RTK GPS Signal

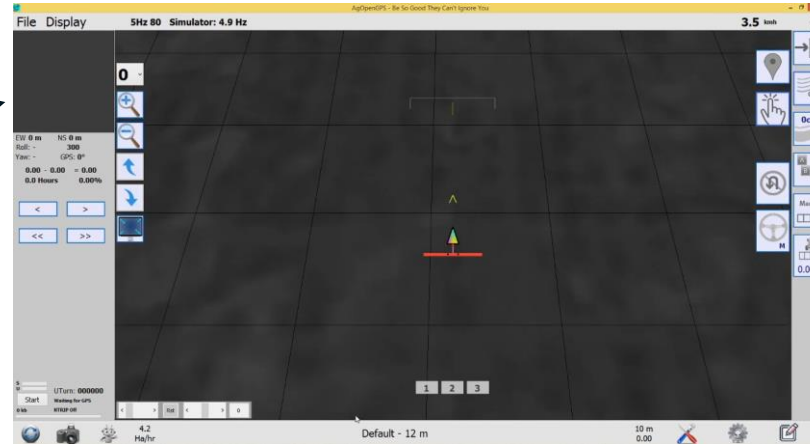


Software



Steering hardware

- Software is required to **process** the GPS and RTK **signals** and transmit them to the steering mechanism.
- We use the **free** open source solution "**AgOpenGPS**" on an **additional tablet computer** in the tractor.



AgOpenGPS Infos



AgOpenGPS Download

# Die Steuerungshardware ermöglicht die autonome Lenkung des Traktors



## Steuerungssystem



RTK GPS Signal



Software



Steering hardware

- The steering hardware **transmits the signals** from the software to the **tractor steering system**.
- Steering is therefore automatic - **manual steering is no longer necessary\***
- Suitable for **all tractors** with **power steering**
- Folding steering wheel motor is an advantage: **easy to retrofit** & does not require approval from the road traffic authorities

**Costs:** approx. CHF 3000

**Where to buy:** Our "**Retrofit Kit**" was developed by Andreas Pfister and can be obtained from **Fink + Frosch GmbH**. We will be happy to connect you.

### Building blocks:



Steering wheel motor



Steering angle sensor



GPS antennas



Electronic Signal processing



\*Rules for autonomous driving: The type of steering system described is "dual mode"; the tractor can therefore be operated both autonomously and manually. Autonomous driving is only permitted on private fields if these are fenced off (withdrawal of public accessibility). If this is not the case, someone must always be in the cab by law, even when driving autonomously.



# Alle Maschinen sollten auf der gleichen Spurbreite arbeiten



## Spurbreite

**1.77m** is a track width that makes sense for us:

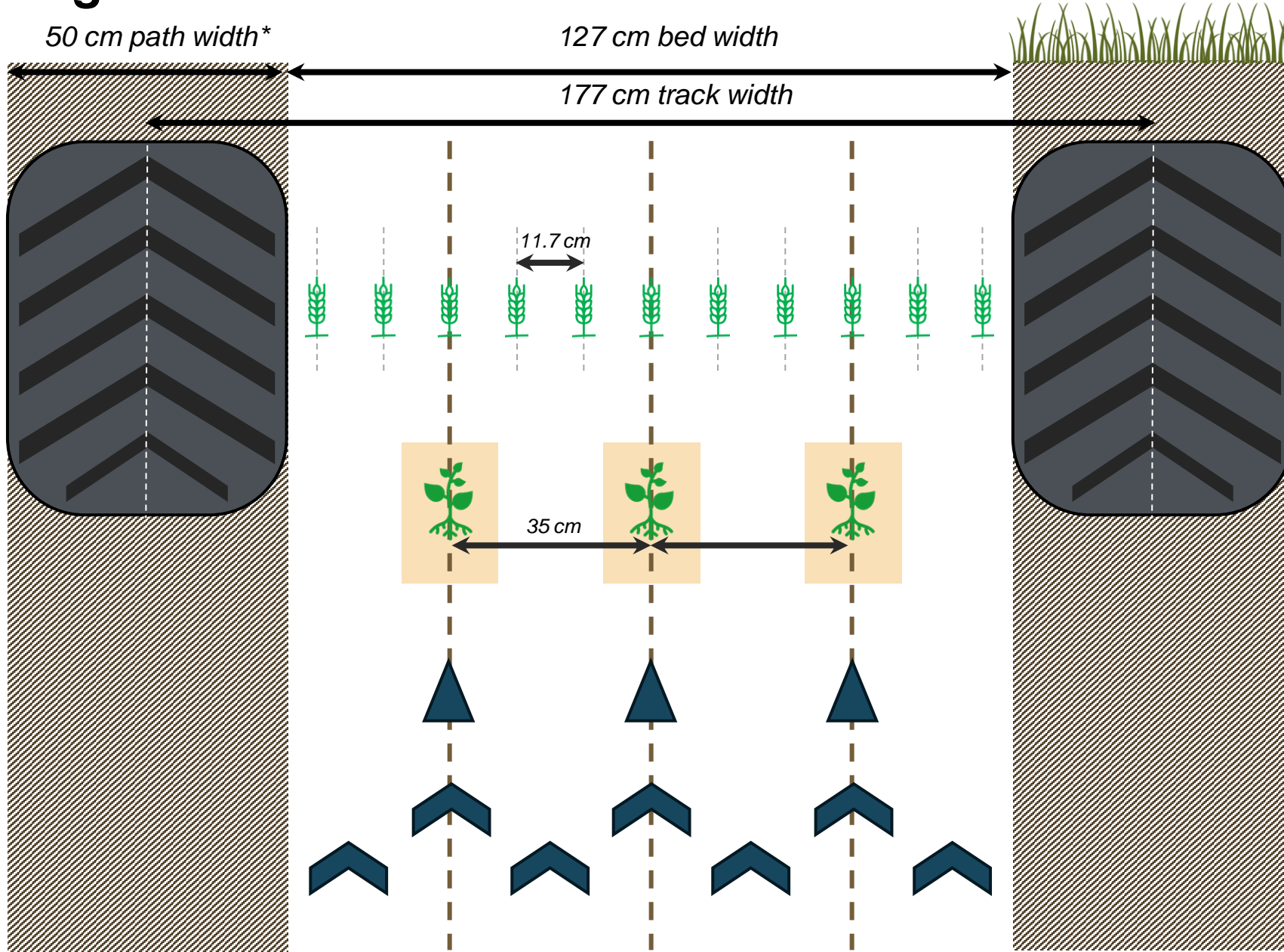
- This is a **common width** in Swiss **forage and arable farming** for tractors, rakes, tedders, mowers, mulchers, etc.
- **Wide machines for 3 beds** (e.g. roller harrows) can also move in the mosaic.
- **Planting beds** is **common** practice in **vegetable growing** anyway and many **vegetable growing machines fit well** on this width.
- It is ultimately dependent on **existing & available** machines, but also **future new acquisitions**
- In **Holland** there are also examples with **3m** track widths. This is possible thanks to rounded farms<sup>1</sup>

! It is important that all machines work consistently on the selected track width.

- Harvesters are the most difficult  
Threshers, potato harvesters etc.
- **We have purchased our own plot combine harvester and a sieve chain harvester for this purpose - both can also be hired from us**

[1] <https://vooruitboeren.com/>

# Pflanz-, Sämaschine und Bodenbearbeitung sind aufeinander abgestimmt



## Green paths

Currently being tested with clover  
\*Can also be driven on with maintenance tyres & narrower track

## 11 rows seed

for cereals & green manures. 2 seed hoppers allow different variants, e.g. sowing of 3-row crop + 8-row undersowing

## 1-3 rows planting/seeding

1-row crops are planted in the centre, 2-rows (incl. potatoes) outside

## 3 rows deep loosening

in the planting track

## 3 or 4 rows row rotary tiller

# All machines run on 1.77 track width - Tractors & tillage



Tractors with RTK GPS  
(own kit)



Rotary tiller bed  
(Celli) (phase out)



Rotary tiller bed & path (Breviglieri)  
(phase out)



Row rotary tiller  
(Badalini) (new since 2023)



Rotary harrows 1.4 m for  
beds (as a combo with seed)



Rotary harrows 2.35 (for  
bed + path or bed/path only)



Cultivator



Potato hiller

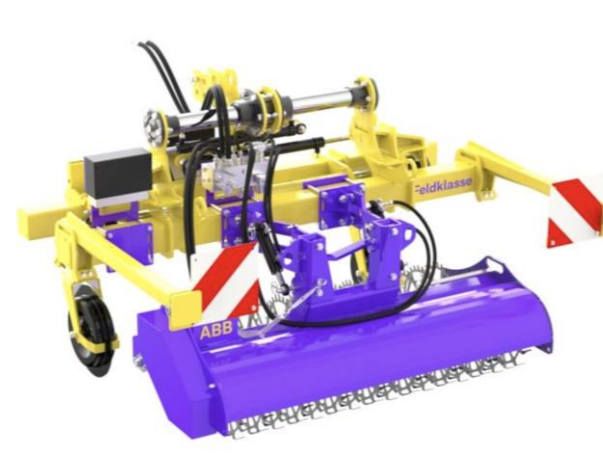
# Mulching, mowing and maintenance



Flail mulcher 2.3 m  
(standard)



Path mower & inter-row mulcher  
(test from 2024)



Rotating chopping (Feldklasse.de)  
(Test from 2024)



RapTrac - Multitool  
(development co-operation)



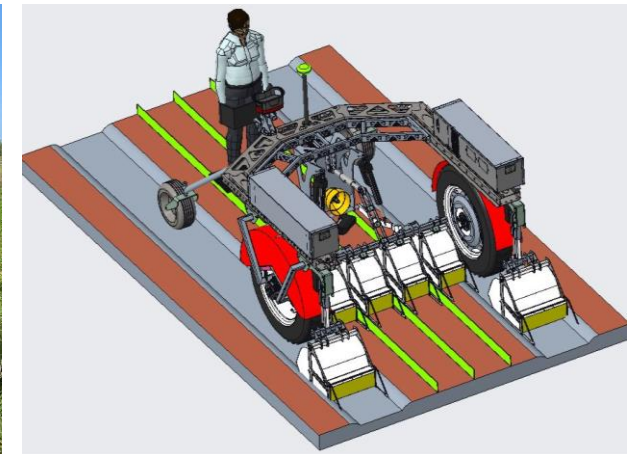
Rolling harrow with broad  
sowing 3 beds (standard)



Rake (standard)



Mower (standard)



RapTrac - Multitool  
(development co-operation)

# Sowing, planting and harvesting



Metering loader wagon for mulch spreading



Mulch planter (Mulchtec Planter)



Bed sieve chain harvester (track extension ex works)



Bed sieve chain harvester (track extension ex works)



Modular & direct sowing seed drill



Plot combine harvester



Harvest trailers and co. (standard)

# Swiss Agroscope study tested "CTF Light". Conclusion: if CTF, then do it right.



- Swiss study by Agroscope tested "**CTF light**"
- **Heavy machines** (wheel loads over 2.5 tonnes and average contact surface pressures over 0.8 bar) travel in **defined lanes**
- Tillage, sowing and other **light work are not** subject to **any driving restrictions**.

## Conclusion:

- **Soil improvements** were observed
- **Increased yield** only observed in maize
- **Implementation** was rated as **complicated**

Our conclusion: **If CTF, then do it right!** (also the "**supposedly**" light work)



Agroscope study



# It's worth implementing CTF consistently - the soil regenerates and becomes functional again

## Summary

- The following is required
  - **RTK GPS signal**
  - **Software on tractor computer/tablet**
  - **Steering hardware**
- Costs approx. CHF 3000.-
- We recommend **1.77m track width, driving direction along the slope line**
- The CTF is one of the **most important cornerstones** for rebuilding and maintaining **soil functionality**;
  - Improved **water & nutrient balance**
  - **Lower input costs**, fewer emissions
  - **Higher yields & quality**

## Summary

- **Considerations** for current and future (and existing) **machines** and **definition of the track width**
- Considerations regarding the **alignment of the stripes** and direction of travel - **Definition of the 0-line**
- Install **retrofit kit** for tractor
  
- It is important that all machines run on the same track width in the long term.

We are happy to help with any questions!

[hoflabor@mosaikdesign.earth](mailto:hoflabor@mosaikdesign.earth)



**Wir freuen uns über Feedback!**

**HofLabor**

Matthias Hollenstein & Petrisa Eckle, PhD

Im Eichhof 1

8617 Mönchaltorf

✉ [hoflabor@mosaikdesign.earth](mailto:hoflabor@mosaikdesign.earth)

**[www.hoflabor.ch](http://www.hoflabor.ch)**



CTF	Controlled Traffic Farming
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (most prevalent GNSS)
RTK	Real Time Kinematic positioning
RTF	Random Traffic Farming