

# Mulch systems and rotational no-till in vegetable farming

Vegetable farming can be very damaging to soil health and soil structure. Reducing tillage in horticulture and particularly organic systems is challenging and no-till is the holy grail. Johannes Storch of Bio-Gemüsehof Dickendorf in Germany is pioneering the use of mulches in field-scale organic vegetable production and has developed machinery to transplant directly through the mulch.



Photos: Phil Stumpflion

Johannes Storch demonstrates soil fertility in the brassicas

Johannes Storch is passionate about soils and soil health: “We have to be honest, even in organic vegetable farming we decrease soil quality and humus content. It is a very intense system. We must look to nature. In nature the soil has permanently active roots with life in the soil and is permanently covered. The exceptions are deserts and in vegetable farming we often imitate these deserts and we wonder why our soil fertility is going down. We need permanent cover and permanent roots in our soil. This is quite a challenge, (our systems) need re-thinking and we need more research, but this is the way we can be sustainable, especially with climate change. This is the way we need to travel.”

*“All measures taken in regard to crop rotation, fertilisation and tillage must aim to increase root production” from Healthy Soils, Sick Soils, Sekera 1984*

Johannes advocates regenerative farming but acknowledges that “in vegetable farming we have the problem of very low density on the ground, we don’t get the intense root systems that you get in pasture or with cereals.”

## Six steps to soil health

They have created a system to use cover crops, grass and silage as mulch and to maintain cover and plant roots in the soil as much as possible for soil health.

**Step 1:** Mechanical loosening of the soil through bed preparation in the autumn to break up compaction and deal with perennial weeds.

**Step 2:** Sow a winter annual cover crop (60% rye/triticale, 20% vetch, 20% peas). They don’t use a frost-killed green manure as it would be dead in January and that would leave a few months without living roots and the soil would become re-compacted. The aim is for permanent root activity and the soil in April is stabilised by the roots. But, how to plant into this?

**Step 3:** Flail mowing the cover crop. They mow very close to the ground leaving a very short stubble. The cover crop can be up to 2.5m high and takes some handling. They have to mow twice to cut all the material.

## BIO-GEMÜSEHOF DICKENDORF

- 4.6ha vegetables, including 1650m<sup>2</sup> protected cropping
- 4ha permanent pasture
- 0.2ha forest
- 1.2ha buildings and infrastructure
- 350-450m above sea level
- Average annual temperature 7.6°C
- Average annual rainfall: 858 mm
- Soil type: loam and pseudogley
- Organic matter: 3.5 to 4.5%
- German soil classification (Ackerzahl): 20-55 (0-100 where 100 is best)
- Farm team: Seven, including an apprentice.
- Direct marketing through markets, farm shop, home delivery (third party) and their own restaurants.

**Step 4:** Harvest mulch material from other fields (grass fields, grass/clover, cover crops), as the in situ crop is not enough to suppress the weeds on its own, especially if the cover crop is not yet flowering as it can re-grow. The material is picked up and is chopped with a loader wagon to 5-10 cm. The shorter the chopped material the denser the mulch and the less the light can get through.

**Step 5:** Spreading transferred mulch on the stubble. Exact spreading and short stubble are crucial for a successful crop. They are looking for 8cm average thickness when spread and around 12t Dry Matter/ha. They must be very efficient when spreading it, as they never have enough material.

**Step 6:** Transplanting. They cut the layer of mulch open, plant the transplant and then press to close it again. They have developed their own machine to do this – the MulchTec planter (see p22)

## Crop rotation for sufficient mulch

They have found that they never have enough material to mulch everything. On average 3ha of grass is needed to mulch 1ha of crops (1ha per cut). So, in order to avoid importing material from outside the farm they have developed a seven year crop rotation with five years of vegetable cropping and two years of biomass (mulch) production.

Rotation		Dry Matter balance (t/ha)		
		In situ	Demand	Balance
Year one	Brassicas	6.7	15.0	-8.3
Year two	Biomass	10.4	0.0	+10.4
Year three	Medium to high N-demanding crops	6.8	11.1	-4.3
Year four	Lettuce and herbs	5.9	12.4	-6.5
Year five	Onions and carrots	3.9	6.7	-2.8
Year six	Carrots	7.0	0.0	+7.0
Year seven	Biomass	17.0	0	+17

### Year One: Brassicas

They start with two cover crop mixtures. For early plantings they use winter rye in the mix as it is earlier flowering and for the later plantings they use triticale. For some crops such as Brussels sprouts that over-winter, it is not possible to sow a cover crop. The very first plantings are done without mulch, as the soil is cold and with mulch there is more frost damage.

### Year Two: Biomass

The brassicas are followed by a biomass production year because a lot of nutrients are available and the roots can cause problems for following crops such as beetroot. After the over-wintered brassicas they sow vetch/peas/oats whole crop silage mix in March undersown with grass/clover. They take a silage cut of 7t DM/ha and a subsequent cut of 3t DM/ha from the grass/clover. Then more cover crops (rye/triticale/vetch) are sown.

### Year Three: Medium and high N-demanding crops

High or medium nitrogen demanding crops like beetroot, squash and sweetcorn are grown. Beetroot is grown without mulch as they haven't found a way of drilling crops into the mulch. Some crops behave differently under the mulch – they have to clean the small roots off the celeriac that grow under the mulch.

### Year Four: Lettuce and herbs

Early plantings are without mulch and later plantings with mulch. They need open soil for plantings in the spring when the soil is still cold, as the soil heats up much faster without mulch. Also heat radiating from the soil keeps frost at bay. The mulch acts as a layer of insulation. Therefore, they only start using mulch from the middle of May onwards. For short-term crops such as lettuce and kohlrabi they flail any crop residues and re-use the mulch, which makes it more economic.

### Year Five: Onions and carrots

Onions are the only crop they plant early into mulch. They use silage as no biomass is available at that time of year (April). In 2018, which as in the UK was a very dry year, the mulch saved the onion crop. They irrigated (17mm), which they don't normally do

and still had a yield of 24t/ha, as compared to 30t/ha in 2017 (with tillage, no mulch).

### Year Six: Carrots.

Carrots are grown without mulch. The cover crop is top-dressed with 30-60kg N/ha (flaxseed press cake) to produce more biomass. "We're like the biogas guys, we see it as a crop" Johannes said. This year on 15th May they harvested the biomass and took it away, and flail mowed very close to the ground. Then on 19th May they rotavated as shallowly as possible undercutting the cover crop to 5-8cm deep. It would be better if we could rotavate at 3 cm. Carrots were then sown on the 4th June. Carrots are undersown in July/August with clovers before the canopy closes to maintain root growth in the soil. Previously they intensely cultivated over a period of six weeks in order to produce a tilth, which is a waste as it is time that could be used to produce biomass. The way they do it now is more efficient and maximises time for biomass production and soil regeneration. After harvest in October a triticale and vetch cover crop is sown.

### Year Seven: Biomass

In the final year of the crop rotation they produce two biomass crops. The first is the over-winter cover crop. The second biomass crop of oats/peas/vetch and sunflowers is conserved as a silage crop in September, as no mulch is needed at that time. Silage is a flexible mulch source that can be used at any time. Silage has the advantage that weed seeds are killed by lactic acid fermentation. However, there can be emission damage to young transplants so you need to wait until there is no smell (1-2 weeks) before planting, or irrigate first.

## Rotational balance

On average last year they used 16.8t/ha of mulch. In the rotation they have a surplus of 144kg N/ha, which Johannes suggests goes into humus formation. Evidence is provided by earthworm counts which, in a trial were highest in the mulch no-till plots (356/m<sup>2</sup>). Counts where they used a roller crimper were 214/m<sup>2</sup> - lower as the long material is not as accessible to the earthworms. The mulch plot after tillage had 272/m<sup>2</sup>.

Trials have shown that some N-demanding crops such as Brussels sprouts need extra fertilisation at the start as they can't utilise the nutrients from the mulch and won't make it to harvest. For this reason, they use under foot dressing when planting. Nutrients are not all available at once and may be used by following crops. Availability depends on the C:N ratio of the mulch material. Grass/clover has a C:N ratio of around 12 and 50% of N is available in about eight weeks. When you have a C:N ratio of 25 nothing is available in this time frame. There is also a much higher N loss from gas emission from grass/clover.

Johannes prefers to use manure and fertilizers on the cover crops than on the vegetables directly and says that "the effect is much nicer on soil fertility". Also, they do not use so much grass/clover in the system as it would produce too much nitrogen and they would over-fertilize the vegetables so there would be a surplus.

## The MulchTec planter

When they started mulching in 2011 they needed to find a way to plant through the mulch by machine. So, they invented one. It has taken a few years to develop to the stage where they are now marketing it, with the first five machines sold last winter.

The most important component, which they had to invent is the cutting unit. That consists of a wheel with blades driven at high speed with electric motors powered by a PTO-driven generator which produces 48 volts and supplies the cutting units with 8 kW of power and also powers the carousel planting machine. Up to six units can be run together.

The mulch is lifted up a bit and cut at speed (adjustable up to 3300 rpm according to mulch thickness).

The height of the cutting unit is dynamically adjusted via a parallelogram to allow blockage-free planting on uneven ground.

The carousel planter has a minimum row spacing of 36cm and intra-row from 10cm. The planting share follows in the slit created. A finger wheel grabs the leaves and keeps them upright so they are not covered by the mulch, followed by the press wheels, which close the slit of the mulch layer. Compressed air can adjust pressure on the press wheels according to soil type and conditions.

A fertilisation system can be added to place fertilizer in the furrow underneath the transplant, allowing easy access to nutrients.

The price is around €4000 per cutting unit and the frame and PTO costs €8000 (€25K for 4-unit planter).



*The cutting unit*



*Brassicas being planted with the MulchTec planter*



Weeds are generally controlled with the mulch but annual weeds such as fat hen can come in when too much soil is moved at planting, or a stubble is mowed too tightly. The previous cover crop e.g. oats can become a weed but has no effect on yield and they are not worried about them seeding. Occasionally they need additional weeding - this year 80 hours/ha were needed to rogue sow thistle in the onions.

Pests are less of a problem under mulch e.g. flea beetle and cabbage root fly, but rodents can be an issue in the tunnels. Slugs are less of an issue than one might imagine, but they do use ferric phosphate pellets. Diseases are less as the mulch reflects light which lowers humidity in the crop.

## Mulching in the tunnels

Some of the surplus of dry matter in the field rotation is used for the beds in the tunnels. The paths are sown to grass, in order to save on mulch and also to keep roots growing.

They use two-stemmed, grafted tomatoes as it makes it much faster when they put the mulch on the beds by hand after planting. They water from above (at 30cm height) in order to wet the mulch so that it is active and decomposes. If they used drip lines under the soil the mulch would not decompose. In the autumn they take out the tomatoes (or other crop), cultivate the whole tunnel and allow it to dry to prevent re-growth of the grass before planting corn salad, lettuce or kohlrabi over-winter.

## Concluding thoughts

The quality of the crops and the soils at Dickendorf shows that the system is working well. Some crops such as fennel and kohlrabi that need constant moisture do particularly well under mulch. Others such as lettuce, which grows flat and close to the ground are more of a challenge. Leeks, which they can't ridge up get less of a white shank, so they choose their varieties carefully, but is less of a problem as they direct market. Direct-drilled crops are presently not possible with mulch.

What is impressive is the thinking behind the system and the constant drive to improve and innovate for the benefit of soil health.

*Phil Sumption*

More information at: [www.mulch-gemusebau.de](http://www.mulch-gemusebau.de)

*A condensed version of this article first appeared in Vegetable Farmer magazine.*