Wheat on no-tillage field (Endla Reintam)

No-tillage (Estonia)

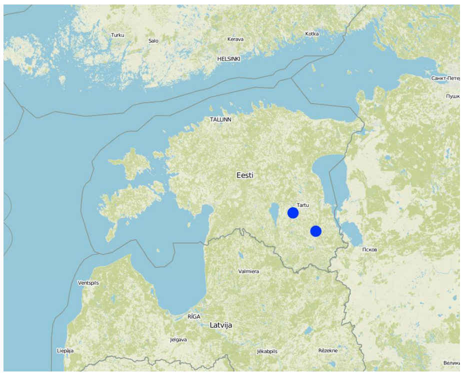
Otsekülv

DESCRIPTION

No-till farming (also called zero tillage or direct drilling) is a way of growing crops or pasture from year to year without disturbing the soil through tillage.

The technology is applied in sub-humid climate with an average of 696 mm of precipitations per year, from which more comes from July to October and less in March and April. Average annual temperature is +4 C, length of the growing period is 180-195 days. The territory is mostly flat, the southern part is hilly with slopes of 6-10%. Average altitude from the sea level is 50 m. About half of the Estonian territory is above 50 m and half is below it. Soils are from very shallow (less than 0.1 m) in the north to very deep (> 120m) in the south. Soil cover is very variable. In the agricultural area the soils are medium textured with low (< 1%) to high (>5%) organic matter in topsoil. Groundwater is near the surface in wet soils and deep in hilly areas. Biodiversity varies from high to low depending on soil and landscape. Market orientation of production system is mixed and off-farm income is less than 10%. Relative level of wealth is average from individual households to cooperatives. Soil management is mechanized. Land belongs to land users, but is leased also in case of bigger farms (over 100 ha).
The purpose of the technology is to reduce soil disturbance and with that to reduce erosion and leaching, increase carbon storage, water infiltration and biological activity. Only 5-10% of the soil surface is disturbed during sowing. The drilling is made by special machinery and thus no-till farming requires specialized seeding equipment designed to plant seeds into undisturbed crop residues and soil. Drilling depth depends on the specific needs of the culture. If the straw remains on the field, it should be chopped to smaller pieces (25-40 mm). For direct seeding it is good if the previous culture was seeded with wider spacing, for example 25 cm and harvest height is 15-20 cm. New sowing will be done between previous crop rows. The highest investment to this technology is the new drilling machine. At the same time there is no need for special tillage machines. In order to help eliminate weed, pest and disease problems, crop rotations and pesticides are used. The system is not suitable for root crops. The no-till system is suitable for cereal based cropping systems as well as for renewing grasslands. The suitable crop rotation, for exampe, is: winter oilseed rape - winter wheat - pea (or bean) - winter wheat - spring barley undersown with red clover - red clover. The main benefit is the reduced working time, fuel costs and with that the lower net-cost of the product, but also the better soil structure. The adoption of the technology may increase weediness and pests and decrease the yield due to the preliminar soil compaction of upper 10-20 cm soil layer. If the soil surface of the field is not enough levelled out, the uniformity of the depth of the seedlings can suffer. There is also increased use of pesticides to control weeds, pests and diseases compared to minimum and conventional tillage. The technology is most suitable for medium-texture soils.

LOCATION



Location: Tartu county, Meeri; Põlva county, Puuri, Tartu county, Põlva county, Estonia

No. of Technology sites analysed: 2-10 sites

Geo-reference of selected sites
- 26.49143, 58.28434
- 27.03776, 58.05095

Spread of the Technology: evenly spread over an area (approx. 1-10 km2)

In a permanently protected area?:

Date of implementation: less than 10 years ago (recently)

Type of introduction
- [x] through land users' innovation
- [ ] as part of a traditional system (> 50 years)
- [ ] during experiments/ research
- [ ] through projects/ external interventions

Sowing into the last year plant residues with CROSS-SLOT seeder (Peeter Viil)

Soil is covered by plant residues (Endla Reintam)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

- [ ] improve production
- [x] reduce, prevent, restore land degradation
- [ ] conserve ecosystem
- [ ] protect a watershed/ downstream areas – in combination with other Technologies
- [ ] preserve/ improve biodiversity
- [ ] reduce risk of disasters
- [ ] adapt to climate change/ extremes and its impacts
- [ ] mitigate climate change and its impacts
- [ ] create beneficial economic impact
- [ ] create beneficial social impact
- [x] reduce tillage cost

Land use

Cropland

- Annual cropping: cereals - barley, cereals - oats, cereals - rye, wheat

Number of growing seasons per year: 1

Water supply

- [x] rainfed
- [ ] mixed rainfed-irrigated
- [ ] full irrigation

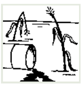
Purpose related to land degradation

- [x] prevent land degradation
- [x] reduce land degradation
- [ ] restore/ rehabilitate severely degraded land
- [ ] adapt to land degradation
- [ ] not applicable

Degradation addressed

soil erosion by water - Wt: loss of topsoil/ surface erosion

soil erosion by wind - Et: loss of topsoil



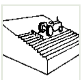
chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)

physical soil deterioration - Pc: compaction

SLM group

- improved ground/ vegetation cover
- minimal soil disturbance

SLM measures

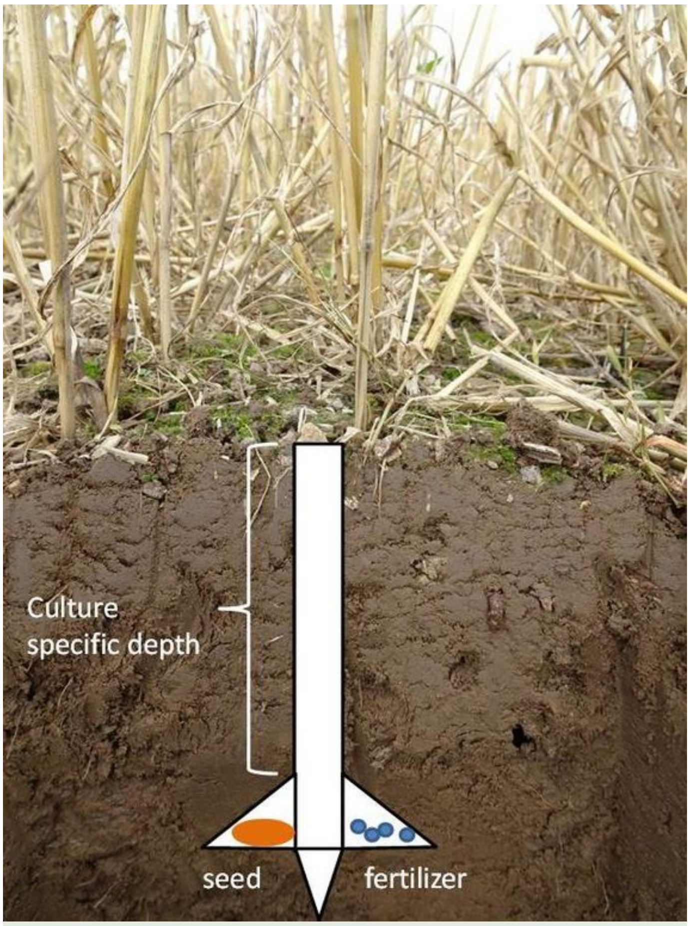


agronomic measures - A3: Soil surface treatment

TECHNICAL DRAWING

Technical specifications

The agrotechnology in case of no-tillage depends on available equipments (drill). If the straw remains on the field, it should be chopped to smaller pieces of 25-40 mm. For direct seeding it is good if the previous culture was seeded with wider spacing, for example 25 cm. Harvest height is 15-20 cm. New seeding will be done between previous crop rows.



Author: Endla Reintam

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated: per Technology unit (unit: **per hectare**)
- Currency used for cost calculation: **EUR**
- Exchange rate (to USD): 1 USD = 1.18 EUR
- Average wage cost of hired labour per day: 36-40 EUR/day + taxes

Most important factors affecting the costs

Fuel price, labour costs.

Establishment activities

1. New direct seeder (Timing/ frequency: None)

Establishment inputs and costs (per per hectare)

Specify input	Unit	Quantity	Costs per Unit (EUR)	Total costs per input (EUR)	% of costs borne by land users
Equipment					
Direct seeder (3m)	piece	1.0	25000.0	25000.0	100.0
Total costs for establishment of the Technology				**25'000.0**	
Total costs for establishment of the Technology in USD				*21'186.44*	

Maintenance activities

1. Sowing together with fertilization (Timing/ frequency: before drilling (spring crops in spring (April), winter crops in autumn (August)))
2. Plant protection (Timing/ frequency: in spring 2 weeks before sowing, herbicides, during growth period depending on the needs ca 3 times)
3. Fertilization during growth period (Timing/ frequency: For winter crops in spring after snowmelt in the beginning of growth, for spring crops in the beginning of intensive growth)
4. Harvest and grain transport (Timing/ frequency: At the end of season (end of July to beginning of September depending of the crop))
5. Drying of grain and soil tillage (Timing/ frequency: after harvest)

Maintenance inputs and costs (per per hectare)

Specify input	Unit	Quantity	Costs per Unit (EUR)	Total costs per input (EUR)	% of costs borne by land users
Equipment					
Sowing with fertilization	times	1.0	55.9	55.9	100.0
Plant protection	times	4.0	11.2	44.8	100.0
Fertilization during growth period	times	1.0	16.2	16.2	100.0
Harvest and grain transport	times	1.0	118.4	118.4	100.0

Drying and after harvest activities	times	1.0	132.1	132.1	100.0
Plant material					
seeds	kg	200.0	0.28	56.0	100.0
Fertilizers and biocides					
Ammonium nitrate (2x per season)	kg	147.0	0.84	123.48	100.0
Complex fertilizer (27 kg N, 40 kg P and 112 kg K per ha) (450 kg of fertilizer per ha)	kg	179.0	0.74	132.46	100.0
Herbicides (2 times)	times	2.0	27.0	54.0	100.0
Fungicides (1 time)	times	1.0	33.2	33.2	100.0
Insecticides (1 time)	times	1.0	3.6	3.6	100.0
Retartants	times	1.0	14.0	14.0	100.0
Total costs for maintenance of the Technology				**784.14**	
Total costs for maintenance of the Technology in USD				*664.53*	

NATURAL ENVIRONMENT

Average annual rainfall
- [ ] < 250 mm
- [ ] 251-500 mm
- [x] 501-750 mm
- [ ] 751-1,000 mm
- [ ] 1,001-1,500 mm
- [ ] 1,501-2,000 mm
- [ ] 2,001-3,000 mm
- [ ] 3,001-4,000 mm
- [ ] > 4,000 mm

Agro-climatic zone
- [ ] humid
- [x] sub-humid
- [ ] semi-arid
- [ ] arid

Specifications on climate
Average annual rainfall in mm: 696.0
Average 696 mm, almost equally spread over the year, more from July to October, less in March and April.
Name of the meteorological station: Tartu Tõravere
LGP 180-195 days

Slope
- [x] flat (0-2%)
- [ ] gentle (3-5%)
- [x] moderate (6-10%)
- [ ] rolling (11-15%)
- [ ] hilly (16-30%)
- [ ] steep (31-60%)
- [ ] very steep (>60%)

Landforms
- [x] plateau/plains
- [x] ridges
- [ ] mountain slopes
- [ ] hill slopes
- [ ] footslopes
- [ ] valley floors

Altitude
- [x] 0-100 m a.s.l.
- [x] 101-500 m a.s.l.
- [ ] 501-1,000 m a.s.l.
- [ ] 1,001-1,500 m a.s.l.
- [ ] 1,501-2,000 m a.s.l.
- [ ] 2,001-2,500 m a.s.l.
- [ ] 2,501-3,000 m a.s.l.
- [ ] 3,001-4,000 m a.s.l.
- [ ] > 4,000 m a.s.l.

Technology is applied in
- [x] convex situations
- [ ] concave situations
- [ ] not relevant

Soil depth
- [ ] very shallow (0-20 cm)
- [ ] shallow (21-50 cm)
- [ ] moderately deep (51-80 cm)
- [ ] deep (81-120 cm)
- [x] very deep (> 120 cm)

Soil texture (topsoil)
- [ ] coarse/ light (sandy)
- [x] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Soil texture (> 20 cm below surface)
- [ ] coarse/ light (sandy)
- [x] medium (loamy, silty)
- [ ] fine/ heavy (clay)

Topsoil organic matter content
- [ ] high (>3%)
- [x] medium (1-3%)
- [ ] low (<1%)

Groundwater table
- [ ] on surface
- [ ] < 5 m
- [x] 5-50 m
- [ ] > 50 m

Availability of surface water
- [ ] excess
- [x] good
- [ ] medium
- [ ] poor/ none

Water quality (untreated)
- [x] good drinking water
- [ ] poor drinking water (treatment required)
- [ ] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to:

Is salinity a problem?
- [ ] Yes
- [x] No

Occurrence of flooding
- [ ] Yes
- [x] No

Species diversity
- [ ] high
- [x] medium
- [ ] low

Habitat diversity
- [ ] high
- [x] medium
- [ ] low

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

Market orientation
- [ ] subsistence (self-supply)
- [x] mixed (subsistence/ commercial)
- [ ] commercial/ market

Off-farm income
- [x] less than 10% of all income
- [ ] 10-50% of all income
- [ ] > 50% of all income

Relative level of wealth
- [ ] very poor
- [ ] poor
- [x] average
- [ ] rich
- [ ] very rich

Level of mechanization
- [ ] manual work
- [ ] animal traction
- [x] mechanized/ motorized

Sedentary or nomadic
- [x] Sedentary
- [ ] Semi-nomadic
- [ ] Nomadic

Individuals or groups
- [x] individual/ household
- [ ] groups/ community
- [x] cooperative
- [ ] employee (company, government)

Gender
- [x] women
- [x] men

Age
- [ ] children
- [x] youth
- [x] middle-aged
- [ ] elderly

Area used per household
- ☐ < 0.5 ha
- ☐ 0.5-1 ha
- ☐ 1-2 ha
- ☐ 2-5 ha
- ☐ 5-15 ha
- ☐ 15-50 ha
- ☐ 50-100 ha
- ☐ 100-500 ha
- ☑ 500-1,000 ha
- ☐ 1,000-10,000 ha
- ☐ > 10,000 ha

Scale
- ☐ small-scale
- ☑ medium-scale
- ☐ large-scale

Land ownership
- ☑ state
- ☐ company
- ☐ communal/ village
- ☐ group
- ☐ individual, not titled
- ☑ individual, titled

Land use rights
- ☐ open access (unorganized)
- ☐ communal (organized)
- ☑ leased
- ☑ individual

Water use rights
- ☑ open access (unorganized)
- ☐ communal (organized)
- ☐ leased
- ☑ individual

Access to services and infrastructure

health	poor	☐	☐	☑	good
education	poor	☐	☐	☑	good
technical assistance	poor	☐	☐	☑	good
employment (e.g. off-farm)	poor	☐	☑	☐	good
markets	poor	☐	☑	☐	good
energy	poor	☐	☑	☐	good
roads and transport	poor	☐	☑	☐	good
drinking water and sanitation	poor	☐	☐	☑	good
financial services	poor	☐	☐	☑	good

IMPACTS

Socio-economic impacts

Crop production

decreased ☐☐☐☐☑☐☐ increased

In different years the crop production may be higher than by ploughing, but another year lower. There has been decrease of spring barley yield by 0.1 t/ha. Winter wheat yield has been ca 1.4 t/ha higher than by ploughing.

crop quality

decreased ☐☐☐☐☑☐☐ increased

No statistically significant difference has been found. However, winter wheat 1000 grain weight was reported 39.6 g by no-tillage and 38.5 g by ploughing.

land management

hindered ☐☐☐☐☑☐☐ simplified

No need for soil tillage. Instead of several machinery to till the soil, one compact sowing machine is needed.

expenses on agricultural inputs

increased ☐☐☐☐☑☐☐ decreased

Less cost for fuel because 50% less fuel is needed compared with ploughing.

farm income

decreased ☐☐☐☐☑☐☐ increased

Even if the yield is a little bit lower or the same as with ploughing, the unit cost to produce barley or winter wheat is 8-11 EUR less than with ploughing.

workload

increased ☐☐☐☐☑☐☐ decreased

No time to be spent for tillage. Even extra spreading of pesticides takes less time than ploughing and other tillage operations.

Socio-cultural impacts

food security/ self-sufficiency

reduced ☐☐☐☐☑☐☐ improved

Unit cost of the production is lower and thus it is possible to sell production cheaper.

SLM/ land degradation knowledge

reduced ☐☐☐☐☐☑☐ improved

If land was eroded before and soil was on the road, everybody can see the differences after establishment of the grasslands. It is not so severe in case of peatlands, however, less tractors will stuck in to the mud on rainy period.

Ecological impacts

harvesting/ collection of water (runoff, dew, snow, etc)

reduced ☐☐☐☐☑☐☐ improved

Residues remaining on the soil surface help to catch more snow during the winter.

surface runoff

increased ☐☐☐☐☐☑☐ decreased

Plant residues protect soil surface structure from raindrop effects, allowing water to infiltrate quicker in the soil.

excess water drainage

Undisturbed soil pore structure allows water quicker to

	reduced	improved	drain in the deeper soil layers. Water permeability of long-term no-till soil is 2 times higher than under conventional management.
evaporation	increased	decreased	Residues on the soil surface do not allow quick evaporation, protecting soil surface.
soil moisture	decreased	increased	Soil moisture content was 3% higher than by ploughing, but not significantly.
soil cover	reduced	improved	Quantity before SLM: 0 Quantity after SLM: 100% The soil is covered by plants or by plant residues during the whole year.
soil loss	increased	decreased	Residues and plant cover stop both wind and water erosion.
soil accumulation	decreased	increased	Reduced decomposition of organic matter increases organic carbon content by 0.1-0.2%.
soil crusting/ sealing	increased	reduced	No crust after applying no-tillage as plant residues protect the soil surface.
soil compaction	increased	reduced	Increased from the top (by 0.04 g/cm3) but decreased deeper in the soil by 0.08 g/cm3) compared to the ploughing. No plough pan. Soil penetration resistance was 1 MPa lower between 20-40 cm under no-tillage compared to ploughing.
nutrient cycling/ recharge	decreased	increased	Due to the decreased decomposition of organic matter and the increase of organic carbon, more nitrogen remains in the soil.
soil organic matter/ below ground C	decreased	increased	It was found that there was slight increase of organic carbon (Corg) by 0.1-0.2% in upper 5 cm of soil compared to ploughing.
vegetation cover	decreased	increased	Plant/residue cover is during the whole year.
biomass/ above ground C	decreased	increased	As there is no tillage, all residues remain on the soil surface.
plant diversity	decreased	increased	Due to the need of changes in crop rotation, more diverse rotations instead of monoculture to suppress weeds. Weeds diversity might increase and change due to the reduced tillage intensity.
animal diversity	decreased	increased	More spiders, beetles, ants compared with ploughing.
beneficial species (predators, earthworms, pollinators)	decreased	increased	Quantity before SLM: 2 species of earthworms Quantity after SLM: 3-4 species of earthworms More earthworm species and higher abundance compared with ploughing.
habitat diversity	decreased	increased	No-till areas create different pattern to the landscape.
pest/ disease control	decreased	increased	Some diseases and pests are surpressed, but there is increase of slugs and snails.
emission of carbon and greenhouse gases	increased	decreased	Due to the reduced use of fuels for tillage, less greenhouse gases will be released. 0.05 kg/ha less greenhouse gases per kg yield is reported by no-tillage compared to ploughing.
fire risk	increased	decreased	Dry plant residues are a high risk in spring.
micro-climate	worsened	improved	Due to the residue cover the soil temperature and water content fluctuations are smaller.

Off-site impacts

buffering/ filtering capacity (by soil, vegetation, wetlands)	reduced	improved	Due to the higher amount of organic matter, the nutrients and water holding capacity is higher.
wind transported sediments	increased	reduced	No wind erosion after applying no-tillage.
damage on neighbours' fields	increased	reduced	No sediments from the field to the neighbours fields.
damage on public/ private infrastructure	increased	reduced	In case of erosion, no soil is carried by water or wind to the ditches and on the roads.
impact of greenhouse gases	increased	reduced	Due to the reduced use of fuels for tillage, less greenhouse gases will be released. 0.05 kg/ha less greenhouse gases per kg yield is reported by no-tillage compared to ploughing.

COST-BENEFIT ANALYSIS

Benefits compared with establishment costs

Short-term returns	very negative	very positive
Long-term returns	very negative	very positive

Benefits compared with maintenance costs

Short-term returns	very negative	very positive
Long-term returns	very negative	very positive

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all	very well	Answer: not known
seasonal temperature increase	not well at all	very well	Season: winter Answer: not known
seasonal temperature increase	not well at all	very well	Season: spring Answer: not known
annual rainfall increase	not well at all	very well	Answer: not known
seasonal rainfall increase	not well at all	very well	Season: winter Answer: not known
seasonal rainfall increase	not well at all	very well	Season: autumn Answer: not known

Climate-related extremes (disasters)

local rainstorm	not well at all	very well	Answer: not known
local thunderstorm	not well at all	very well	Answer: not known
local hailstorm	not well at all	very well	Answer: not known
local snowstorm	not well at all	very well	Answer: not known
local windstorm	not well at all	very well	Answer: not known
cold wave	not well at all	very well	Answer: not known
extreme winter conditions	not well at all	very well	Answer: not known
land fire	not well at all	very well	

ADOPTION AND ADAPTATION

Percentage of land users in the area who have adopted the Technology

- [ ] single cases/ experimental
- [x] 1-10%
- [ ] 11-50%
- [ ] > 50%

Number of households and/ or area covered

7% from agricultural land

Of all those who have adopted the Technology, how many have done so without receiving material incentives?

- [ ] 0-10%
- [ ] 11-50%
- [x] 51-90%
- [ ] 91-100%

Has the Technology been modified recently to adapt to changing conditions?

- [ ] Yes
- [x] No

To which changing conditions?

- [ ] climatic change/ extremes
- [ ] changing markets
- [ ] labour availability (e.g. due to migration)

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Decreases work load and time, also fuel consumption, increases income.
- Increases soil biological activity, soil organic matter content, better structure and infiltration, decreases erosion.

Weaknesses/ disadvantages/ risks: land user's viewhow to overcome

- High preliminary investment (seeder), increase of weediness and pests, Investment support, better crop rotation.

Strengths: compiler’s or other key resource person’s view

- Decrease of soil organic carbon decomposition, decrease of erosion, increase of soil biological activity.

Weaknesses/ disadvantages/ risks: compiler's or other key resource person's viewhow to overcome

- Higher use of pesticides and therefore risk to soil and water pollution. Suggestion of changes in crop rotation, cover crops.

REFERENCES

Compiler
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Editors

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Resource persons
Endla Reintam - Researcher
Toomas Tobreluts - land user
Priit Penu - researcher

Full description in the WOCAT database
https://qcat.wocat.net/en/wocat/technologies/view/technologies_3089/

Linked SLM data
n.a.

Documentation was faciliated by

Institution
- n.a.

Project
- Interactive Soil Quality assessment in Europe and China for Agricultural productivity and Environmental Resilience (EU-iSQAPER)

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