Tillage in Pesnica valley, Slovenia (Gregor Kramberger)

Mulch-till (Slovenia)

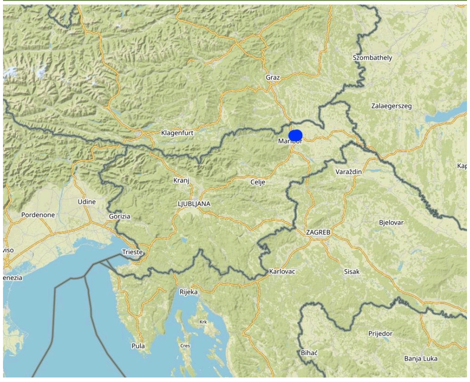
Konzervirajoča obdelava tal (mulch-till)

DESCRIPTION

Mulch-till is a method of farming that does not utilise a plough, and thus the soil is not turned over. Furthermore, at least 30% of the cultivated area remains covered with organic residues left over from the previous crop. There are multiple benefits to the soil and carbon dioxide emissions are reduced.

Mulch-till (also called "conservation agriculture" or "minimum tillage") is a method of land management with modified, less intensive tillage, where land is covered with plant residues year-round (at least 30% cover) or grass, energy consumption is reduced, and there is less trampling/ compaction of the soil because of fewer machine passes and the protected surface. Under mulch-till, special agricultural machinery and attachments are required. Disc harrows and chisel ploughs are used to loosen the soil, and direct drills are employed for seeding. Ploughs are not used and the soil is not inverted. This method of tillage is intended to maintain soil structure, build up humus, improve nutrient supply and soil moisture, increase soil microbiological activity and also to prevent soil erosion. Mulch-till reduces the number of work operations on the cultivated area. Because the soil is disturbed less, this minimises the exposure of soil organic matter to the air, and therefore decreases the formation and release of CO2 to the atmosphere.
The debate over whether ploughing is still necessary has been going on for quite some time. Both mulch-till and ploughing have their advantages as well as disadvantages. Research shows that mulch-till reduces soil erosion and compaction, and this has a significant impact on soil fertility. On the other hand, ploughing better inhibits the spread of weeds and certain types of diseases and pests.
Mulch-till requires complete replacement of machines/tools, and this is a considerable initial investment. Regular annual maintenance of the equipment is needed also. Mulch-till provides full benefits after a number of years, through making sure that minimal soil inversion and organic soil coverage is guaranteed. It also requires good planning of crop rotation, the use of a special seed drill and employment of herbicides after emergence (or surface hoeing). Users mention one advantage being the low costs for tillage, which is less expensive than ploughing, and the reduction of soil erosion on sloping terrain. However, they do not like the high investment for equipment, possible lost of yields and increase in weeds: all tend to arise at the beginning of implementation. Knowledge and experience are required, as the technology is quite demanding, so there are chances of failure.

LOCATION



Location: Vosek, Jareninski dol, Pernica, Slovenia

No. of Technology sites analysed: 2-10 sites

Geo-reference of selected sites
- 15.725, 46.6
- 15.72331, 46.60397
- 15.68969, 46.59931

Spread of the Technology: evenly spread over an area (approx. < 0.1 km2 (10 ha))

In a permanently protected area?: Nee

Date of implementation: 2020

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

Tillage with a disk harrow after mulching maize residues left on surface. Preparation for sowing with a combined seeder. (Andrej Ropič)

Residues left over the surface of the field before sowing next crop (maize). (Andrej Ropič)

CLASSIFICATION OF THE TECHNOLOGY

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

Land use
Land use mixed within the same land unit: Nee

Cropland
- Annual cropping: cereals - barley, cereals - maize, cereals - wheat (winter), fodder crops - clover, fodder crops - other, legumes and pulses - other, legumes and pulses - soya

Number of growing seasons per year: 1
Is intercropping practiced? Nee
Is crop rotation practiced? Ja

create beneficial social impact

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, Wg: gully erosion/ gullying

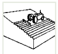

chemical soil deterioration - Cn: fertility decline and reduced organic matter content (not caused by erosion)


physical soil deterioration - Pc: compaction


biological degradation - Bc: reduction of vegetation cover, Bq: quantity/ biomass decline, Bl: loss of soil life

SLM group
- improved ground/ vegetation cover
- minimal soil disturbance
- integrated soil fertility management

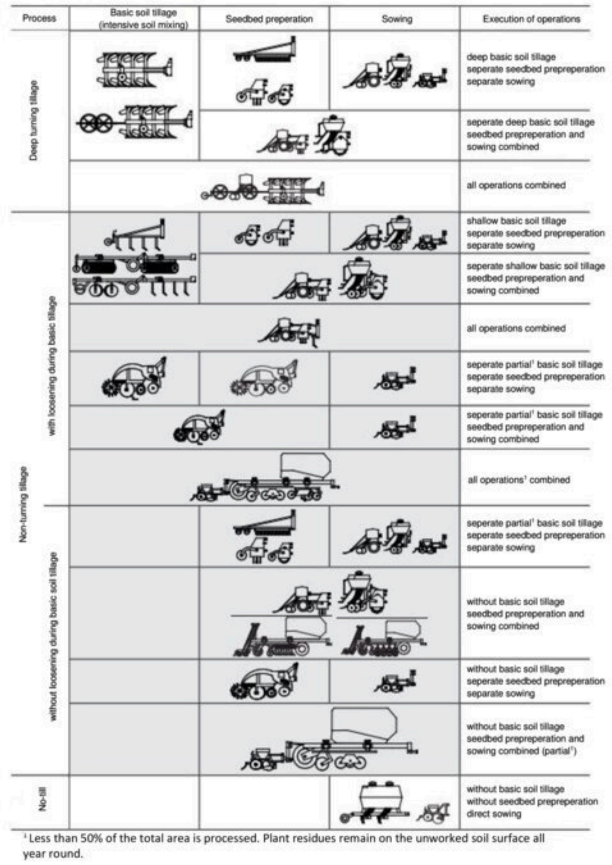
SLM measures


agronomic measures - A1: Vegetation/ soil cover, A2: Organic matter/ soil fertility, A3: Soil surface treatment (A 3.2: Reduced tillage (> 30% soil cover)), A6: Residue management (A 6.4: retained)

TECHNICAL DRAWING

Technical specifications

Whether it is low-till or conventional tillage depends on the tool use during soil tillage and how we use it. There are many implementation variants of conservation tillage that go by different professional names and definitions. Low-till is defined according to the depth of tillage, the intensity of soil layer mixing, the coverage of soil surface with harvest (organic) residues or intermediate tillage residues, according to the way tools move on the soil and the number of machine operations that are performed individually or combined (basic tillage, soil loosening seedbed preparation, pre-sowing tillage, sowing, ...). We focus on one version of low-till that we estimate has the greatest chances of being established in a short time in the case study area, which is so called »mulch-till«. We will concentrate on the term »mulch-till« which we define as a medium deep (10 cm) conservation tillage technique using chisel plow in combination with disk harrow. The coverage of the soil surface with residues must be at least 30% or higher. In addition, a special seeder is required to carry out "mulch" sowing (with moving parts). The success of mulch-till also depends on the combination with other implemented measures like crop rotation, cover crops, etc.



Author: Bodenbear beitung und Bestellung

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs
- Costs are calculated: per Technology area (size and area unit: **1 ha**; conversion factor to one hectare: **1 ha = 1 ha = 10,000 m2**)
- Currency used for cost calculation: **EUR**
- Exchange rate (to USD): 1 USD = 0.97 EUR
- Average wage cost of hired labour per day: 90.90

Most important factors affecting the costs
It very much depends on the type of soil, what is the structure of the soil. In addition, the planning of the crop rotation and cover crops also affect the costs. As a result, weed development and subsequent herbicide use may be different.

Establishment activities
1. Purchase of 2-row disc harrow (Timing/ frequency: 1st year)
2. Purchase deep chisel plow (Timing/ frequency: 1st year)
3. Purchase pneumatic seed drill combined with rotary harrow (Timing/ frequency: 1st year)
4. Purchase pneumatic precision planter with rotating elements (Timing/ frequency: 1st year)
5. Purchase cover crop seed drill (Timing/ frequency: 1st year)

Establishment inputs and costs (per 1 ha)

Specify input	Unit	Quantity	Costs per Unit (EUR)	Total costs per input (EUR)	% of costs borne by land users
Equipment					
Purchase of 2-row disc harrow	piece	29.7	404.0404	12000.0	100.0
Purchase deep chisel plow	piece	29.7	101.0101	3000.0	100.0
Pneumatic seed drill combined with rotary harrow	piece	29.7	909.0909	27000.0	100.0
Pneumatic precision planter with rotating elements	piece	29.7	572.3905	17000.0	100.0
Cover crop seed drill	piece	29.7	151.5151	4500.0	100.0
Total costs for establishment of the Technology				**63'500.0**	
Total costs for establishment of the Technology in USD				*65'463.92*	

Maintenance activities

1. Tractor operation and maintanance (Timing/ frequency: It is used for all operations related to the technology (without cover crop seed drill operation)..)
2. Deep chisel plow operation and maintanance (Timing/ frequency: 1 time per 5 years, on all cultivated field surfaces (29,7 ha), 1.0 h/ha.)
3. 2-row disc harrow operation and maintanance (Timing/ frequency: 2 time per year, on all cultivated field surfaces (29,7 ha), 0.8 h/ha.)
4. Pneumatic precision planter with rotating elements operation and maintanance (Timing/ frequency: 1 times per year, on 50 % of all cultivated field surfaces (14.85 ha), 1.3 h/ha.)
5. Cover crop seed drill operation and maintanance (Timing/ frequency: 1 time per year, on all cultivated field surfaces (29,7 ha), 0.8 h/ha (combined with harrow).)
6. Pneumatic seed drill combined with rotary harrow operation and maintanance (Timing/ frequency: 1 times per year, on 50 % of all cultivated field surfaces (14,85 ha), 1.4 h/ha.)
7. Purchase cover crop seed mixture Fruh (Timing/ frequency: 1 time per year, on all cultivated field surfaces (29,7 ha).)

Maintenance inputs and costs (per 1 ha)

Specify input	Unit	Quantity	Costs per Unit (EUR)	Total costs per input (EUR)	% of costs borne by land users
Labour					
Tractor operation	EUR/ha	29.7	18.144	538.88	100.0
Machine maintenance	EUR/ha	29.7	2.88	85.54	100.0
Equipment					
Machine avarage total costs of tractor operation and maintanance	EUR/ha	29.7	122.598	3641.16	100.0
Machine avarage total costs of deep chisel plow operation and maintanance	EUR/ha	29.7	4.36	129.49	100.0
Machine avarage total costs of 2-row disc harrow operation and maintanance	EUR/ha	29.7	30.432	903.83	100.0
Machine avarage total costs of pneumatic precision planter with rotating elements operation and maintanance	EUR/ha	14.85	29.744	441.7	100.0
Machine avarage total costs of cover crop seed drill operation and maintanance	EUR/ha	29.7	2.872	85.3	100.0
Machine avarage total costs of Pneumatic seed drill combined with rotary harrow operation and maintanance	EUR/ha	14.85	52.416	778.38	100.0
Plant material					
Cover crop mixture Fruh	EUR/ha	29.7	66.768	1983.01	100.0
Total costs for maintenance of the Technology				**8'587.29**	
Total costs for maintenance of the Technology in USD				*8'852.88*	

NATURAL ENVIRONMENT

Average annual rainfall
- [ ] < 250 mm
- [ ] 251-500 mm
- [ ] 501-750 mm
- [x] 751-1,000 mm
- [x] 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: 1015.0
The most precipitation falls in summer, the months with the highest average precipitation are June and August, the least precipitation falls in winter, in January and February at least, and in principle more precipitation falls in autumn than in spring.
Name of the meteorological station: Jareninski vrh (1981 – 2010)
Mean annual temperature in year 2014 Jareninski vrh is 11,9°C.

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

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

Altitude
- [ ] 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
- [ ] convex situations
- [x] concave situations
- [ ] not relevant

Soil depth
- [ ] very shallow (0-20 cm)
- [ ] shallow (21-50 cm)
- [x] moderately deep (51-80 cm)
- [ ] deep (81-120 cm)
- [ ] 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)
- [ ] good drinking water
- [ ] poor drinking water (treatment required)
- [x] for agricultural use only (irrigation)
- [ ] unusable

Water quality refers to: surface water

Is salinity a problem?
- [ ] Ja
- [x] Nee

Occurrence of flooding
- [x] Ja
- [ ] Nee

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

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

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

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

Off-farm income
- [ ] less than 10% of all income
- [x] 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
- [ ] cooperative
- [ ] employee (company, government)

Gender
- [ ] women
- [x] men

Age
- [ ] children
- [ ] 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
- [x] 15-50 ha
- [ ] 50-100 ha
- [ ] 100-500 ha
- [ ] 500-1,000 ha
- [ ] 1,000-10,000 ha
- [ ] > 10,000 ha

Scale
- [ ] small-scale
- [x] medium-scale
- [ ] large-scale

Land ownership
- [ ] state
- [ ] company
- [ ] communal/ village
- [ ] group
- [ ] individual, not titled
- [x] individual, titled

Land use rights
- [ ] open access (unorganized)
- [ ] communal (organized)
- [x] leased
- [x] individual

Water use rights
- [ ] open access (unorganized)
- [x] 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	Some farmers report a slight drop in yield in first years after the implementation of the measure, but the farmer in the case study location didn't notice any difference in yield.
risk of production failure	increased	decreased	Reduced risk, but with the wrong approach it can increase. For example, reduced risk due to unfavorable weather conditions, increased risk due to the possibility of weed development.
land management	hindered	simplified	Simplified soil tillage technology.
expenses on agricultural inputs	increased	decreased	Reduced costs due to lower energy (fuel) consumption.
workload	increased	decreased	Fewer hours dedicated for tillage.

Socio-cultural impacts

food security/ self-sufficiency	reduced	improved	Facilitated production with lower costs, motivation to do business in agriculture.
SLM/ land degradation knowledge	reduced	improved	With positive effects more interest of the farmer in sustainable production.

Ecological impacts

surface runoff	increased	decreased	
evaporation	increased	decreased	
soil moisture	decreased	increased	
soil cover	reduced	improved	
soil loss	increased	decreased	
soil accumulation	decreased	increased	
soil crusting/ sealing	increased	reduced	
soil compaction	increased	reduced	
nutrient cycling/ recharge	decreased	increased	
soil organic matter/ below ground C	decreased	increased	
vegetation cover	decreased	increased	
biomass/ above ground C	decreased	increased	
plant diversity	decreased	increased	
invasive alien species	increased	reduced	
animal diversity	decreased	increased	Cover crops act as hiding places for various animals.
beneficial species (predators, earthworms, pollinators)	decreased	increased	Plants attract pollinators.
habitat diversity	decreased	increased	
drought impacts	increased	decreased	
emission of carbon and greenhouse gases	increased	decreased	

Off-site impacts

buffering/ filtering capacity (by soil, vegetation, wetlands)	reduced	improved	Surface cover with plants.
damage on public/ private infrastructure	increased	reduced	The soil is not carried into ditches and ponds.

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

The initial establishment and investment costs for implementing the technology are high, and in the short term, the benefits may not be very noticeable or even negative compared to conservative technology. However, the long-term benefits are more significant and positive. While there are recurring costs involved, such as maintenance expenses, they are considerably lower compared to the initial investment costs. The technology requires substantial upfront investment in equipment, which can initially outweigh the immediate returns. It takes time for the technology to mature and for the full benefits to be realized. As the system becomes established and optimized, the positive outcomes become more apparent over the long run. Additionally, the lower costs mentioned refer to the ongoing maintenance and operational expenses required to sustain the technology (machines), which are generally lower than the initial investment costs. These costs are often outweighed by the benefits gained from improved efficiency, reduced resource consumption, and other long-term advantages. Therefore, while the short-term returns may not be overwhelmingly positive, the investment in the technology pays off over time, with greater benefits and lower operational costs.

CLIMATE CHANGE

Gradual climate change

annual rainfall decrease	not well at all	very well

Climate-related extremes (disasters)

local rainstorm	not well at all	very well
heatwave	not well at all	very well
drought	not well at all	very well
landslide	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%

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

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

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

- [x] Ja
- [ ] Nee

Added cover crop seed drill. more emphasis on cover crop.

To which changing conditions?

- [ ] climatic change/ extremes
- [ ] changing markets
- [ ] labour availability (e.g. due to migration)
- [x] added equipment/mechanization attachments to facilitate technology implementation, improved technology implementation with knowledge and experience

CONCLUSIONS AND LESSONS LEARNT

Strengths: land user's view

- Less depression, erosion and soil leaching.
- Cost and time (fewer passes, machine hours, less machine power required).
- Care for nature, sustain natural resources.

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

- A big investment in machinery. It is possible to start gradually with cheaper and simpler machines (also home-made).
- Adaptation of crop protection. Implementing integrated pest management (IPM).

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

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

- In the long term it enables the achievement of better soil conditions, in terms of appropriate ratios of water, air, nutrients, organic matter, microbial activity, pH, microbial activity, pH and other factors of soil fertility.
- Compaction and drying of the top layer of the soil is significantly less frequent and as a result losses of young plants are therefore smaller.
- It reduces the potential for soil erosion. A major threat to soil fertility is erosion processes (wind, water and other erosion), where the most fertile surface layers of the soil are carried away to other parts of the ecosystem that are not intended for food production.
- It brings advantages in terms of energy consumption and the possibility of carrying out production tasks in a shorter time and in difficult weather conditions. Conservation tillage tools typically operate in a shallower soil layer and mix less soil mass, it enables the use of tools with larger working widths and thus less unproductive driving in the field.
- Benefits in terms of reduced transfer of phytopharmaceuticals and nutrients excess from the cultivation area to water and other ecosystems.
- Reduced tillage improves soil quality, reduces nutrient leaching and lowers greenhouse gas emissions.
- Benefits in terms of bioavailability and nutrient uptake efficiency.
- Benefits in terms of greater adaptability of crops to extreme weather events.
- Benefits in terms of maintaining the overall biological diversity of the agricultural landscape and soil.

- An increase in the occurrence of certain types of weeds and a high dependence on certain types of herbicides. Some studies show that the introduction of conservation tillage slightly increases losses from certain diseases and pests. For successful weed control, it is important to have a varied crop rotation, frequent sowing of cover crops and intercrops, and that the weeds never leave uncontrolled development on the stubble. The variegated crop rotation is meant as an obstacle that interrupts the development cycle of diseases and pests. How we handle harvest residues is also important. The more finely they are chopped by combines, mulchers or tools for vertical tillage before sowing, the faster they decompose and the worse the chances of harmful organisms developing on them. An evenly distributed mulch of harvest residues should remain, which prevents the emergence of new waves of weeds. These additional measures, together with mechanical weed control with new types of tools, allow limiting the weed population to a level that can be controlled with a limited range of herbicides.
- Investment costs in machines designed for the method of soil cultivation can be very high. An important obstacle in the introduction of conservation tillage is the large investments in new machinery... The value of purchasing these tools can well exceed the amount of 100,000 euros for an individual farm, which is a practically unfeasible investment for small farms. Small farms can take the transition to conservation farming only with the help of hired machinery services from neighbouring large farms that have been able to invest in new equipment. The subsidization of the purchase of machinery and also the economic legal status of the farm in terms of VAT calculation play an important role.
- It is necessary to replace all the tools used by farmers according to the old methods of tillage. It is necessary to purchase adapted cultivators, harrows, looseners and especially seeder drills. Increase in the supply of relatively inexpensive machines from manufacturers from Eastern Europe and Turkey, which can increase the availability of this equipment to smaller farms.
- In the first years of the transition period, there may be a significant reduction in yields and poor financial results. There is a yield reduction and financial stress during the transition period to the new system. The transition from conventional cultivation to conservation tillage is usually difficult and risky. Growers must be financially strong in order to make the transition, and the areas under alternative cultivation systems must increase gradually when they really master the new cultivation technique. Good financial support during the transition period is very important for small farms with weak investment assets. Targeted education and training is necessary, as technological errors due to lack of knowledge regarding the implementation of conservation cultivation in different soil types can be economically very fatal.
- A small increase in the seeding rate (10 to 15 %) is often recommended to compensate for losses caused by diseases and pests at the time of plant emergence. A necessary cost that must be accepted (higher sowing rate for the main crops and additional crops – cover crops) for the successful implementation of the measure.

REFERENCES

Compiler
Gregor Kramberger

Editors
Matjaz Glavan

Reviewer
William Critchley
Rima Mekdaschi Studer

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Resource persons
Gregor Kramberger - SLM specialist
Matjaz Glavan - SLM specialist
Miha Curk - SLM specialist
Rozalija Cvejic - SLM specialist
Andrej Ropič - land user

Full description in the WOCAT database
https://qcat.wocat.net/af/wocat/technologies/view/technologies_6241/

Linked SLM data
n.a.

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- Mimalna obdelava tal – praktični primeri na naših kmetijah (žipo, ropic, horvat): https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiZ6smRpuD8AhWrsaQKHcRSBoMQFnoECAkQAQ&url=https%3A%2F%2Fwww.kmetijski-zavod.si%2FPortals%2F0%2Flombergarjevi%2FMinimalna%2520obdelava%2520tal%2520%25E2%2580%2593%2520prakti%25C4%258Dni%2520primeri%2520na%2520na%25C5%25A1ih%2520kmetijah%2520%5BSamodej 12-13-094249-623&usg=AOvVaw1jtWGuL4ovgrvC0rvqm1iS