Left: Cereal field in April. Right: Crop residue in August of cereals that were harvested around May/June. This field remains like this until March/April next year when it will be ploughed for seeding in autumn. (Joris de Vente (Murcia, Spain))

Reduced contour tillage of cereals in semi-arid environments (Spain)

Labranza reducida de cereal en contra de la pendiente en ambientes semi-áridos (ES)

DESCRIPTION

Reduced contour tillage in a rotational system of winter cereals and fallow land.

This technology is a type of conservation tillage with minimal economic effort and is adapted to semi-arid conditions. Tillage is reduced to a maximum of three times surface tillage (20-30cm) in two years with a disc- or a chisel-plough. The disc-plough is only used where there is a dense weed or crop residue cover. The disc-plough breaks-up the soil top layer better than the chisel-plough, while the chisel tends to plough slightly deeper (~30cm) than the disc-plough (~20cm). The advantage of the chisel-plough is that it leaves a higher surface roughness and is less destructive to soil aggregates. Under conventional tillage, fields are ploughed up to five times every two years, once with a mouldboard plough. In both systems, cereals are cropped in a rotational system with fallow land. Cereals are sown in autumn (October) and harvested in June followed by a fallow year. Under reduced tillage the crop residues are left on the field throughout the autumn and winter periods. This provides increased protection against soil erosion. Tillage is performed on fallow land in early spring (March-April) to prepare the land for sowing in October. With conventional tillage, fields are ploughed with a mouldboard plough in autumn. Traditional sowing machinery can be used so no investments are needed in specialised equipment. Tillage is performed parallel to the contour lines to prevent rill and gully formation. No herbicides are required since annual weeds are mixed with the upper soil layer during ploughing. Owing to increased organic matter content and a better infiltration capacity, soil water retention capacity, soil humidity and crop yields will increase within 3-5 years after implementation.
The aim of this technology is to increase the soil organic matter content by retaining it in soil aggregates and to reduce soil erosion by water and tillage. The higher infiltration capacity and better surface cover with crop residues in autumn and winter protects the soil against water erosion, reducing soil erosion by over 50% and runoff by 30%. In addition, the better organic matter content increases overall soil quality in terms of soil structure and water holding capacity. Compared to traditional multiple tillage operations with a mouldboard plough, under reduced tillage, tillage erosion is reduced by having fewer tillage operations, but also through tillage of fallow land resulting in lower tillage erosion rates than secondary tillage operations of already loosened soil. Fuel use by tractors is decreased, leading to a reduction of 40% in production costs and reduced CO_2 emissions. Some studies showed that in first 2-3 years after implementation, the soil can be denser and have a lower infiltration capacity than under traditional tillage regimes. Yet, when the organic matter content and soil structure have increased, infiltration rates are higher than under traditional ploughing and result in increased soil water content and crop yields.
The technology is applied on loamy soils with a calcareous substrate, of shallow to medium depth, and slopes are gentle to moderate (5-15%). The climate is semi-arid with a mean annual rainfall of around 300 mm. Droughts, centred in summer commonly last for more than 4-5 months. Annual potential evapotranspiration rates greater than 1000 mm are common. The production system is highly mechanised and market oriented but depends strongly on agricultural subsidies.

LOCATION

Location: Guadalentin catchment, Murcia, Spain

No. of Technology sites analysed:

Geo-reference of selected sites
- -1.7076, 37.7931

Spread of the Technology: evenly spread over an area (approx. 10-100 km2)

In a permanently protected area?:

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

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

Crop residue in August of cereals that were harvested around May/June. This field will remain like this until March/April next year when it will be ploughed for sowing in autumn (Joris de Vente)

Cereal harvest in June. (Joris de Vente)

CLASSIFICATION OF THE TECHNOLOGY

Main purpose

☐ improve production
✓ 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

Land use

Cropland

- Annual cropping

Number of growing seasons per year: 1

Water supply

✓ rainfed
☐ mixed rainfed-irrigated
☐ full irrigation

Purpose related to land degradation

✓ prevent land degradation
✓ 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

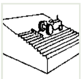
physical soil deterioration - Pk: slaking and crusting

water degradation - Ha: aridification

SLM group

- minimal soil disturbance

SLM measures



agronomic measures - A1: Vegetation/ soil cover, A3: Soil surface treatment, A4: Subsurface treatment

TECHNICAL DRAWING

Technical specifications

Photo of the disc-plough used for superficial ploughing (~20cm depth) where there is a large amount of crop residue and/or perennial vegetation. Bottom: Chisel-plough

Technical knowledge required for field staff / advisors: moderate.
Technical knowledge required for land users: moderate.

Main technical functions: control of raindrop splash, control of dispersed runoff: retain / trap, control of dispersed runoff: impede / retard, control of concentrated runoff: impede / retard, improvement of ground cover, improvement of surface structure (crusting, sealing), improvement of topsoil structure (compaction), improvement of subsoil structure (hardpan), increase in organic matter, increase of infiltration, increase / maintain water stored in soil. Secondary technical functions: increase of surface roughness, increase in nutrient availability (supply, recycling,…)

Rotations / fallows: cereals are followed by 1-2 years of fallow

Breaking crust / sealed surface / compacted topsoi: Disc-plough or chisel-plough

Minimum tillage: Disc-plough or chisel-plough

Non-inversion tillage: Disc-plough or chisel-plough

Contour tillage: Disc-plough or chisel-plough

Author: Joris de Vente

ESTABLISHMENT AND MAINTENANCE: ACTIVITIES, INPUTS AND COSTS

Calculation of inputs and costs

- Costs are calculated:
- Currency used for cost calculation: **Euro**
- Exchange rate (to USD): 1 USD = 0.63 Euro
- Average wage cost of hired labour per day: 79.00

Most important factors affecting the costs

Fuel price is the most determinate factor affecting the costs.

Establishment activities

n.a.

Establishment inputs and costs

Specify input	**Unit**	**Quantity**	**Costs per Unit (Euro)**	**Total costs per input (Euro)**	**% of costs borne by land users**
Labour					
Disc plough	piece	1.0	397.0	397.0	100.0
Total costs for establishment of the Technology				**397.0**	
Total costs for establishment of the Technology in USD				*630.16*	

Maintenance activities

1. Tillage with disc-plough (Timing/ frequency: Before seeding once every 2 years in a rotational fallow system)

Maintenance inputs and costs

Specify input	**Unit**	**Quantity**	**Costs per Unit (Euro)**	**Total costs per input (Euro)**	**% of costs borne by land users**
Labour					
Labour		1.0	12.0	12.0	100.0
Equipment					
Machine hours		1.0	50.0	50.0	99.0
Total costs for maintenance of the Technology				**62.0**	
Total costs for maintenance of the Technology in USD				*98.41*	

NATURAL ENVIRONMENT

Average annual rainfall **Agro-climatic zone** **Specifications on climate**

- [ ] < 250 mm
- [x] 251-500 mm
- [ ] 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

- [ ] humid
- [ ] sub-humid
- [x] semi-arid
- [ ] arid

Dry period in summer during 3-4 months (June – August/September)
Thermal climate class: subtropics. The higher parts are generally somewhat colder

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

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

Altitude
- [ ] 0-100 m a.s.l.
- [x] 101-500 m a.s.l.
- [x] 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
- [ ] concave situations
- [x] not relevant

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

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

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

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

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

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

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

Water quality refers to:

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

Occurrence of flooding
- [ ] Yes
- [ ] No

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

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

CHARACTERISTICS OF LAND USERS APPLYING THE TECHNOLOGY

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

Off-farm income
- [ ] less than 10% of all income
- [ ] 10-50% of all income
- [x] > 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
- [ ] Sedentary
- [ ] Semi-nomadic
- [ ] Nomadic

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

Gender
- [ ] women
- [x] men

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

Scale
- [x] small-scale
- [ ] 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)
- [ ] leased
- [x] individual

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

Access to services and infrastructure

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	Depending on local conditions yield may be the same or increase slightly. Sometimes in first year of implementation crop production is slightly reduced.
expenses on agricultural inputs	increased	□□✓□□□□	decreased	Possible investment in a Disc-plough during first years
farm income	decreased	□□□□✓□□	increased	Depends on crop yield. Gasoline use is decreasing.
workload	increased	□□□□✓□□	decreased	Reduced labour: Less ploughing required.

Socio-cultural impacts

conflict mitigation	worsened	□□□□□✓□	improved	

Ecological impacts

harvesting/ collection of water (runoff, dew, snow, etc)	reduced	□□□□✓□□	improved	On the long term higher infiltration capacity of the soil
surface runoff	increased	□□□□□✓□	decreased	about 10% reduction
soil moisture	decreased	□□□□✓□□	increased	
soil cover	reduced	□□□□□✓□	improved	
soil loss	increased	□□□□□□✓	decreased	reduction by about 45%
soil crusting/ sealing	increased	□□□□✓□□	reduced	
nutrient cycling/ recharge	decreased	□□□□✓□□	increased	
emission of carbon and greenhouse gases	increased	□□□□✓□□	decreased	Less tractor use

Off-site impacts

downstream flooding (undesired)	increased	□□□□✓□□	reduced
downstream siltation	increased	□□□□✓□□	decreased
wind transported sediments	increased	□□□□✓□□	reduced
damage on neighbours' fields	increased	□□□□□✓□	reduced
damage on public/ private infrastructure	increased	□□□□✓□□	reduced

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

When a disc-plough was not already used in normal farming operations, this implies a slightly negative influence on farm income during establishment.

CLIMATE CHANGE

Gradual climate change

annual temperature increase	not well at all	□✓□□□	very well

Climate-related extremes (disasters)

local rainstorm	not well at all	□□□✓□	very well
local windstorm	not well at all	□□□✓□	very well
drought	not well at all	□✓□□□	very well
general (river) flood	not well at all	□□□✓□	very well

Other climate-related consequences

reduced growing period	not well at all	□□□✓□	very well

ADOPTION AND ADAPTATION

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

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

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

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

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

- [ ] Yes
- [ ] 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

- The technology is low cost and even generates more farm income due to lower fuel use. The increased soil cover through winter and the contour ploughing have a notable positive effect on rill and gully formation in the fields. (How to sustain: The tillage between two fallow periods might be avoided to further reduce fuel use and maintain surface cover intact. However, in order to apply for subsidies for agricultural extensification, farmers are obliged to plough fallow land once a year in order to eliminate weeds.)

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

- This is a low-cost technology that requires limited initial investments in equipment and potentially results in a slightly increased farm income, as well as a decrease in land degradation and an increase in soil quality and water-holding capacity. (How to sustain: In some higher areas with sufficient rainfall, the technology might be adapted to conservation tillage with direct sowing, reducing the tillage operations even more. However, this implies an important investment in machinery and a high level of organisation at the agricultural cooperation level.)
- An increased soil surface cover throughout autumn and winter provides a good protection against soil erosion reducing rill and gully formation. (How to sustain: Sometimes a field is left fallow for two consecutive years, but it is still ploughed between them. This ploughing might be avoided as well.)

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

- In order to apply for subsidies for cereal cultivation in a rotation system with fallow, farmers are obliged to plough after each fallow period to control weeds, even when two consecutive years of fallow are applied. This is considered unnecessary It might be worthwhile to test the need for this and look for alternatives without ploughing.

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

- The most important weakness of this technology is that it does not significantly improve farm income and so may not be stimulating enough for farmers to apply Provide information on all the advantages of good soil management that include many costs for society (including floods, reservoir siltation, etc.) and stress the fact that reduced tillage will lead to less work for the same or slightly higher profit.

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Compiler
Joris De Vente

Editors

Reviewer
Deborah Niggli
Alexandra Gavilano

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Resource persons

Joris De Vente - SLM specialist
Ascensión Ibáñez Torres - None
Antonio Escamez - land user

Full description in the WOCAT database

https://qcat.wocat.net/en/wocat/technologies/view/technologies_939/

Linked SLM data

Approaches: Regional rural development programme https://qcat.wocat.net/en/wocat/approaches/view/approaches_2419/

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