European Commission

Natural Water Retention Measures

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Service contract n°07.0330/2013/659147/SER/ENV.C1

Individual NWRM

Low till agriculture

ACTeon environment research & consultancy

Office International de l'Eau

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Environment

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I. NWRM Description

Low till agriculture, also known as conservation or reduced till applies to arable land. It consists of a combination of a crop harvest which leaves at least 30% of crop residue on the soil surface, during the critical soil erosion period and some surface work (low till). This slows water movement, which reduces the amount of soil erosion and potentially leads to greater infiltration.

II. Illustration

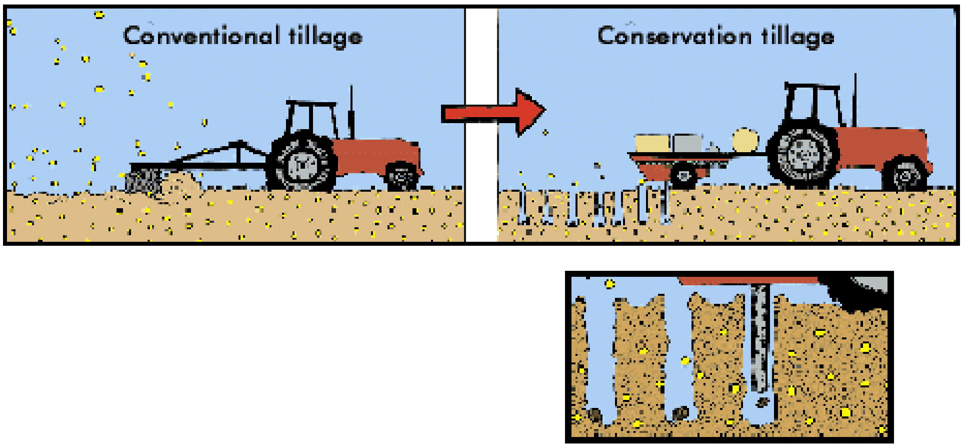

Illustration 1: Example of ridge-till farming system

Source: Why Files, 2011 http://climatetechwiki.org/technology/conservation-tillage

Illustration 2: Example of crop planted in conservation tillage

Source:
http://luirig.altervista.org/naturaitaliana/viewpics.php?title=Contour+farming+and+conservation+tillage+protect+highly+erodi

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	No	Not applicable
Agricultural Areas	Yes	Arable land
Forests and Semi-Natural Areas	No	Not applicable
Wetlands	No	Not applicable

Region	Applicability	Evidence
Western Europe	Yes	Uptake of no-till in selected countries as % of arable in 2010 (Eurostat): Belgium 14.5% Germany 37.7% Ireland 2.6% France 25.1% Luxembourg 25.0% Netherlands 10.1% United Kingdom 24.5%
Mediterranean	Yes	Uptake of no-till in selected countries as % of arable in 2010 (Eurostat): Greece 18.5% Spain 19.7% Croatia 3.2% Italy 4.3% Cyprus 66.0% Malta 0.0% Portugal 13.6% Slovenia 8.7%

Region	**Applicability**	**Evidence**
Baltic Sea	Yes	Uptake of no-till in selected countries as % of arable in 2010 (Eurostat): Denmark 5.4% Estonia 13.3% Latvia 6.4% Poland 4.3% Finland 16.8% Sweden 11.7%
Eastern Europe and Danube	Yes	Uptake of no-till in selected countries as % of arable in 2010 (Eurostat): Bulgaria 55.3% Czech Republic 32.3% Hungary 10.8% Austria 23.8% Romania 2.3% Slovakia 16.9%

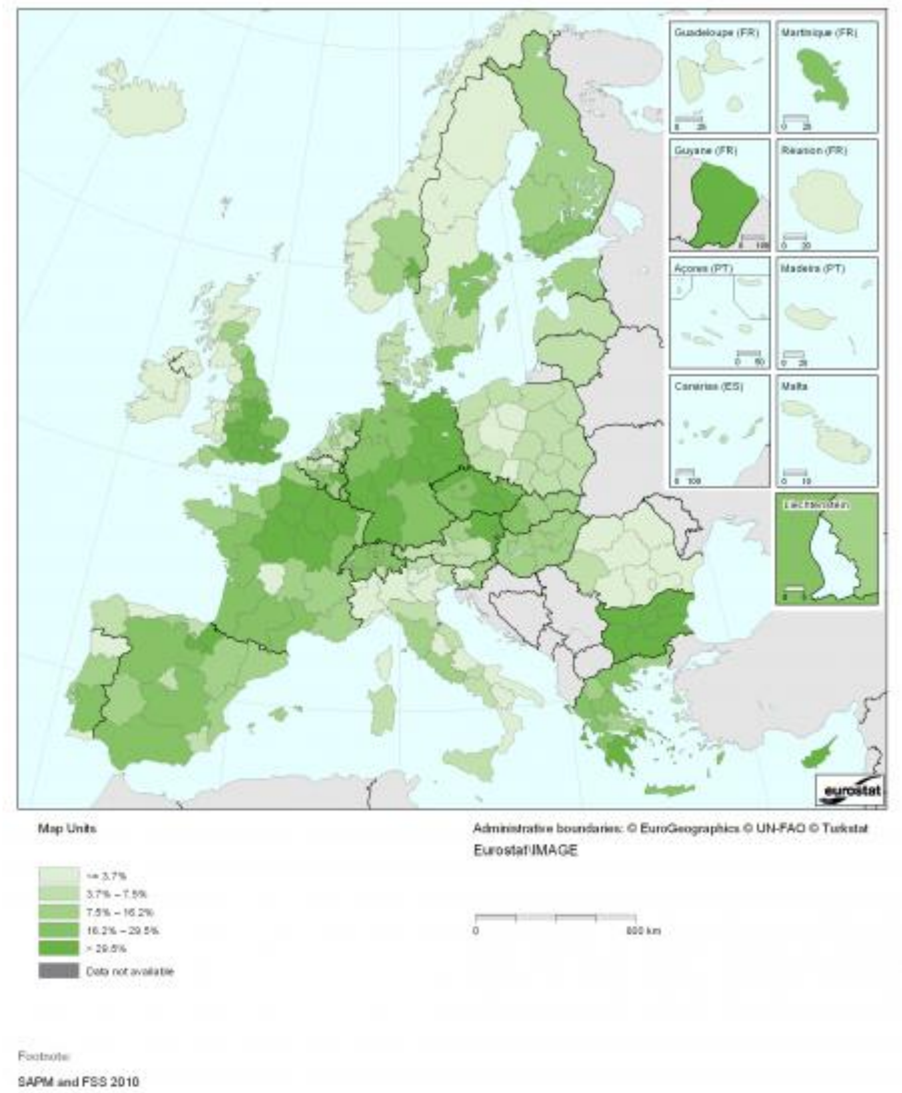

Illustration 3: Share of arable land on which conservation tillage is applied (source: Eurostat, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Agri-environmental_indicator_-_tillage_practices#Database)

IV. Scale

	0-0.1km²	0.1-1.0km²	1-10km²	10-100km²	100-1000km²	>1000km²
Upstream Drainage Area/Catchment Area	✓	✓				
Evidence	This measure acts at field level and operations at larger scales such as whole farms may be constrained by crop rotations where harvesting operations limit potential for reduced tillage in following crops. Implementation over larger areas may require significant coordination and incentive programmes.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	None	
	Slow Runoff	None	
	Store River Water	None	
	Slow River Water	None	
Reducing Runoff	Increase Evapotranspiration	None	
	Increase Infiltration and/or groundwater recharge	None	
	Increase soil water retention	Medium	BIO Intelligence Service (2014) report on a study in Hungary where a 32% runoff reduction was achieved: • Average runoff volumes of 172.6 m^3/ha versus 453.8m^3/ha in conventional plots) • Water storage in the upper 20 cm increased by 8.8%, below 20 cm water content increased by 1.7% However, Bescansa et al. (2006) in a study in Northern Spain found that there is no significant different between reduced tillage and mouldboard tillage. Soil water retention characteristics in the upper soil layer (0-0.15 m) are reported across a range of matric potential of water values: • 0 kPa: 0.435 m^3/m^3 for reduced tillage versus 0.431 m^3/m^3 for mouldboard tillage • -33 kPa: 0.322 versus 0.326 m^3/m^3 • -50 kPa: 0.291 versus 0.287 m^3/m^3 • 1500 kPa: 0.219 versus 0.217 m^3/m^3
Reducing Pollution	Reduce pollutant sources	None	Meyer-Aurich (2005) reports nitrogen balance surpluses for the following systems based on field studies and expert judgement in Bavaria: • Potato: -62 to -25 kg N/ha with reduced tillage and catch crops (conventional: -89 to -2) • Maize: 75 kg N/ha (conventional: 52) • Winter wheat : -25 to -15 kg N/ha in both cases

<table>
<tr><td rowspan="2"></td><td></td><td></td><td>

- Winter barley: 2 to -35 kg N/ha in both cases

For the potato and maize systems there was no difference in nitrogen balance surplus between the conventional and reduced tillage where catch crops are used, this suggests that is these rather than tillage which is driving the nitrogen balance.</td></tr>
<tr><td>Intercept pollution pathways</td><td></td><td></td></tr>
<tr><td rowspan="2">Soil Conservation</td><td>Reduce erosion and/or sediment delivery</td><td>Medium</td><td>

Meyer-Aurich (2005) uses the Universal Soil Loss Equation (USLE) to estimate erosion susceptibility (C factor) for different systems. The estimates for potato and maize are:

<table>
<tr><th>Tillage system</th><th>Potato</th><th>Maize</th></tr>
<tr><td>Conventional tillage</td><td>0.30-0.37</td><td>0.24-0.25</td></tr>
<tr><td>Conventional tillage + catch crop</td><td>0.13-0.17</td><td>0.07-0.08</td></tr>
<tr><td>Reduced tillage + catch crop</td><td>0.02-0.14</td><td>0.01-0.07</td></tr>
</table>

These indicate that the application of reduced tillage and catch crops both reduce soil erosion. However for winter wheat and winter barley where catch crops were not applied there was no difference between the tillage systems.</td></tr>
<tr><td>Improve soils</td><td>Medium</td><td>

Bescana et al. (2006) report the following results for soil physical properties:

Organic matter (g/kg):

- 0-0.15m depth: 18.2 for reduced tillage versus 16.3 for mouldboard tillage
- 0.15-0.30m depth: 16.5 for reduced tillage versus 16.1 for mouldboard tillage

Bulk density (t/m^3):

- 0-0.15m depth: 1.50 for reduced tillage versus 1.52 for mouldboard tillage
- 0.15-0.30m depth: 1.65 for reduced tillage versus 1.51 for mouldboard

The differences between the two systems were significant for organic matter within 0-0.15m depth and for bulk density at 0.15-0.30m depth, indicating that the impacts are variable and occur in different parts of the soil.</td></tr>
</table>

Creating Habitat	Create aquatic habitat	None	
	Create riparian habitat	None	
	Create terrestrial habitat	None	
Climate Alteration	Enhance precipitation	None	
	Reduce peak temperature	None	
	Absorb and/or retain CO_2	None	

VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Food provision	Low	Bescansa et al (2006) report no significant difference in 5-year average barley yields for reduced tillage (4.85 t/ha) versus mouldboard tillage (4.61 t/ha), although the reduced tillage system was more efficient due to lower production costs. Schmid et al (2004) report on the impact of different reduced tillage and cover crop systems on sugar beet in Austria. Yields for the reduced tillage systems were similar with a range of 109.8 to 120.6 dt/ha compared to a range of 118.7 to 121.9 dt/ha for conventional tillage. The yields for both these treatments were below the conventional tillage without cover crop control treatment yield of 130.3 dt/ha.
	Water Storage	None	
	Fish stocks and recruiting	None	
	Natural biomass production	None	
Regulatory and Maintenance	Biodiversity preservation	None	
	Climate change adaptation and mitigation	Low	Meyer-Aurich (2005) reports global warming potentials of reduced versus conventional tillage systems: • Potato: 1.63 tCO_2e with reduced tillage and catch crops versus 1.32 for conventional • Corn: 3.67 versus 3.36

			• Winter wheat: 1.82 versus 1.83 • Winter barley: 1.83 versus 1.84
	Groundwater / aquifer recharge	Medium	Hangen et al. (2002) report that the degree of infiltration potential in a silty (Luvisol) soil was higher under conservation tillage than conventional tillage. Continuous macropores reached a depth of 120cm in conservation tillage plots compared to 50cm under conventional tillage. However, in a sandy loam soil (Podzolluvisol) the presence of mulch residues in the conservation tillage plot prevented water transport beneath 5cm depth compared to a water depth of 20cm under conventional tillage. Capwiez et al (2009) report that tillage practices did not change water infiltration as the increase in macroporosity in reduced tillage soils were offset by a significant increase in soil bulk density (1.49 mg/m^3 versus 1.27 mg/m^3 for reduced and conventional tillage respectively). This was influenced by experimental cropping systems designed to investigate different degrees of soil compaction. A further factor was the abundance and composition of earthworms which were higher in reduced tillage plots but negatively affected by compaction.
	Flood risk reduction	None	
	Erosion / sediment control	None	
	Filtration of pollutants	None	
Cultural	Recreational opportunities	None	
	Aesthetic / cultural value	None	
Abiotic	Navigation	None	
	Geological resources	None	
	Energy production	None	

VII. Policy Objectives

Policy Objective		Rating	Evidence
Water Framework Directive			
Achieve Good Surface Water Status	Improving status of biological quality elements	None	
	Improving status of physico-chemical quality elements	None	
	Improving status of hydromorphological quality elements	Medium	Reduced tillage contributes to this objective through the reductions in soil erosion and consequent sediment delivery.
	Improving chemical status and priority substances	None	
Achieve Good GW	Improved quantitative status	None	
	Improved chemical status	None	
Prevent Deterioration	Prevent surface water status deterioration	Medium	Reduced tillage contributes to this objective through the reductions in soil erosion and consequent sediment delivery.
	Prevent groundwater status deterioration	None	
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		Medium	Catchment level promotion of reduced tillage together with other agricultural measures is likely to be necessary to impact on flood risks
Habitats and Birds Directives			
Protection of Important Habitats		None	
2020 Biodiversity Strategy			
Better protection for ecosystems and more use of Green Infrastructure		High	Reduced tillage contributes to this objective through the reductions in soil erosion and consequent sediment delivery.
More sustainable agriculture and forestry		Low	Reduced tillage offers a number of potential benefits that could contribute to sustainable agriculture; these are often when it used in conjunction with other measures such as cover crops or controlled traffic farming.

		However, these benefits are often not consistent and negative impacts may arise due to conditions such as soil type and climate. Use of the measure may also be constrained by crop types.
Better management of fish stocks	None	
Prevention of biodiversity loss	Low	There is evidence of higher soil biodiversity that may in turn support wider biodiversity. Associated practices such as maintaining winter cover may also be beneficial.

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	
Space required	
Location	
Site and slope stability	
Soils and groundwater	
Pre-treatment requirements	
Synergies with Other Measures	Reduced tillage can be combined with other agricultural measures. Those of particular relevance include green cover/cover crops, mulching, controlled traffic farming. Controlled traffic farming is especially relevant as it can help to avoid problems of soil compaction due to machinery movements, particularly on the wetter soils typical of northern Europe. However, as reported by Hangen et al. (2002) the presence of crop or mulch residues may reduce the effectiveness of reduced tillage for water infiltration.
Design recommendations	

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition	0	Measure is a change in land management practices and does not involve land acquisition
Investigations & Studies	0	Measure does not require pre-implementation studies
Capital Costs	Discing (€/ha): 32 – 67 Rotor-spike/ power horrow (€/ha): 47 - 65 Multi harrowing (€/ha): 30 - 55	Capital costs may involve purchase of new cultivation machinery for practices such as discing and harrowing. The costs here are contractor charges per ha for these activities based on SAC (2013). The costs include a capital element, also included are the labour costs of the driver but not fuel. These costs compare to 50 – 68 €/ha for ploughing.
Maintenance Costs	Non-Inversion: Disc + Cultivator drill (€/ha) 100 - 113 Non-Inversion: Combination Machines (€/ha) 77 Minimum/Shallow Tillage(€/ha) 47 - 86 Direct Drill(€/ha) 47 - 59	Operational costs are derived from ADAS (2001) based on per ha values. These compare to 113 – 143 €/ha for conventional tillage (Plough + power harrow + air drill) The different practices require different labour inputs the following are in minutes per ha: • Plough + power harrow + air drill: 204-254 • Non-Inversion: Disc + Cultivator drill: 52-68 • Non-Inversion: Combination Machines: 47 • Minimum/Shallow Tillage: 44-63 • Direct Drill: 23-38 The exact cost implications will depend on factors such as soil type, slope etc. Biedermann (2013) reports average total cost reduction of €10000 per farm for reduced tillage.
Additional Costs	0	

Values in £ converted at £1 = €1.20

X. Governance and Implementation

Requirement	Evidence
Farm advice and demonstration	Uptake of measures such as conservation tillage involve uncertainty for farmers including potential trade-offs of yield and input costs. The full benefits may not be realised for several years post implementation. Demonstration of the benefits and advice to tailor the techniques to the circumstances of individual farms are important.

XI. Incentives supporting the financing of the NWRM

Type	Evidence
Rural Development payments for associated measures	Low till agriculture can be included as a soil management measure under the Rural Development Regulation. In the 2007-13 RDPs soil management payments across the EU averaged 97 €/ha with a range of 94 to 100 €/ha

XII. References

Reference
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Bescansa P, Imaz MJ, Virto I, Enrique A and Hoogmoed WB (2006) Soil water retention as affected by tillage and residue management in semiarid Spain, Soil & Tillage Research 87(1): 19–27
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BIO Intelligence Service (2014), Soil and water in a changing environment, Final Report prepared for European Commission (DG ENV), with support from HydroLogic http://ec.europa.eu/environment/soil/pdf/Soil%20and%20Water.pdf
Capowiez Y, Cadoux S, Bouchant P, Ruy S, Roger-Estrade J, Richard G and Boizard H (2009) The effect of tillage type and cropping system on earthworm communities, macroporosity and water infiltration, Soil & Tillage Research 105: 209-216
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