European Commission

Natural Water Retention Measures

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Individual NWRM

Controlled traffic farming

ACTeon environment research & consultancy

Office International de l'Eau

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Environment

This report was prepared by the NWRM project, led by Office International de l'Eau (OIEau), in consortium with Actéon Environment (France), AMEC Foster Wheeler (United Kingdom), BEF (Baltic States), ENVECO (Sweden), IACO (Cyprus/Greece), IMDEA Water (Spain), REC (Hungary/Central & Eastern Europe), REKK inc. (Hungary), SLU (Sweden) and SRUC (UK) under contract 07.0330/2013/659147/SER/ENV.C1 for the Directorate-General for Environment of the European Commission.

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I. NWRM Description

Controlled traffic farming (CTF) is a system which confines all machinery loads to the least possible area of permanent traffic lanes. Current farming systems allow machines to run at random over the land, compacting around 75% of the area within one season and at least the whole area by the second season. Soils don't recover quickly, taking as much as a few years. A proper CTF system on the other hand can reduce tracking to just 15% and this is always in the same place. CTF is a tool; it does not include a prescription for tillage although most growers adopting CTF use little or none because soil structure does not need to be repaired. The permanent traffic lanes are normally parallel to each other and this is the most efficient way of achieving CTF, but the definition does not preclude tracking at an angle. The permanent traffic lanes may be cropped or non-cropped depending on a wide range of variables and local constraints.

II. Illustration

Illustration1: Tractor applying the principle of CTF

Source: http://www.abc.net.au/landline/stories/s652276.htm

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	No	
Agricultural Areas	Yes	Controlled traffic farming can be applied to all agricultural areas in particular arable and intensively managed grassland.
Forests and Semi-Natural Areas	No	
Wetlands	No	

Region	Applicability	Evidence
Western Europe	Yes	
Mediterranean	Yes	
Baltic Sea	Yes	
Eastern Europe and Danube	Yes	

IV. Scale

	0-0.1km^2	0.1-1.0km^2	1-10km^2	10-100km^2	100-1000km^2	>1000km^2
Upstream Drainage Area/Catchment Area	✓	✓				
Evidence	Controlled traffic farming is implemented at the farm scale and at each field scale. In terms of drainage, the concerned area is the field itself. In Europe, field size can vary a lot across states and agriculture types in each state; in France (Latruffe, 2013) and Denmark (Levin, 2006) for instance, mean field size is a bit more than 4ha.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	None	
	Slow Runoff	High	Controlled traffic farming reduces the area of permanent traffic lanes where machinery compact soil and vegetation. US Department of Agriculture (1997) explains that clear-tilled areas have lower hydraulic resistance than areas where the vegetation is more developed and not flattened, which contributes to fasten runoff on clear-tilled areas. Thus, decreasing compacted areas through controlled traffic farming leads to slow runoff.
	Store River Water	None	
	Slow River Water	None	
Reducing Runoff	Increase Evapotranspiration	None	
	Increase Infiltration and/or groundwater recharge	Low	According to Douglas (1998), soil compaction enhances waterlogging. Chamen (2011) reviewed different literature sources and concluded that infiltration could increase by 84 to 400% in the absence of wheel compaction. Controlled traffic farming, by decreasing soil compaction, has so an effect on increasing infiltration.
	Increase soil water retention	Medium	According to Whitmore et al (2010), compaction decreases soil water storage through the loss of soil porosity. Da Silva and Kay (1996) also wrote that soil compaction decreased water storage in the soil. Controlled traffic farming, by decreasing soil compaction, has so an effect on increasing soil water retention.
Reducing Pollution	Reduce pollutant sources	Medium	Compaction enhances nutrient losses through inhibiting uptake by crops and facilitating leaching and denitrification. Thus, control traffic farming can decrease nutrient losses (The James Hutton Institue and CTF Europe Ttd, 2012). Chamen (1993) showed that controlled traffic farming could avoid nutrient losses by: - 1.5 (sand) to 15.55 (clay and peat) kg/ha for N, of which 0.53 (sand) to 5.28 (clay and peat) kg/ha is not leached and 0.06 (sand) to 0.62 (clay and peat) is not lost as NO2

			- 0.42 (sand) to 4.20 (clay and peat) kg/ha for P - 0.38 (sand) to 3.78 (clay and peat) kg/ha for K
	Intercept pollution pathways	None	
Soil Conservation	Reduce erosion and/or sediment delivery	Medium	Controlled traffic farming contributes to reduce and slow runoff; thus, it has a positive effect on reducing erosion and sediment delivery.
	Improve soils	None	
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	Medium	Controlled traffic farming leads to diesel use reduction; Chamen (1993) calculated that diesel reduction was between 4.70 and 16.30 L/ha depending on soil types compared to conventional farming. The net impact on CO2 emissions is assessed between 31.96 (sand) and 236.71 (clay) kg/ha.

VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Food provision	Medium	Yield can be lower on compacted soils of increased mechanical impedance of roots, decreased aeration and decrease water storage in the soil. According to (The James Hutton Institue and CTF Europe Ttd, 2012) crop income will depend upon: • yield from the non-trafficked beds; • yield from the cropped traffic lanes. Since controlled traffic farming cannot be implemented progressively but needs to adapt machinery and practices in one time, the effect on yields is difficult to estimate. A modeling work led by Kingwell & Fuchsbichler (2011) on a Australian 2000ha dryland farm assessed crop yield increase under controlled traffic farming by 6 to 9%

			depending on the soil type:

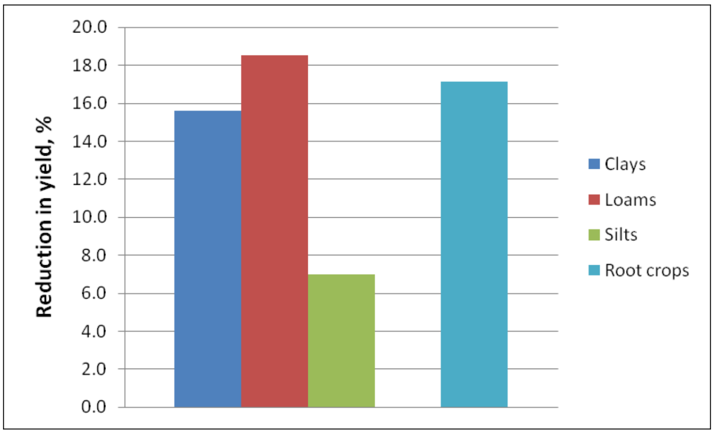


Figure 1. Percentage reduction in crop yields due to conventional traffic on different soil types (left columns, combinable crop responses, right column, root crop responses on loam soils) **(Kingwell, 2011)**

A study led in 25 farms in UK (12000ha) intended to asses crop yield change with controlled traffic farming for different types of culture, which happens to be difficult given that converting all fields prevent from doing any comparison. The results are shown below:

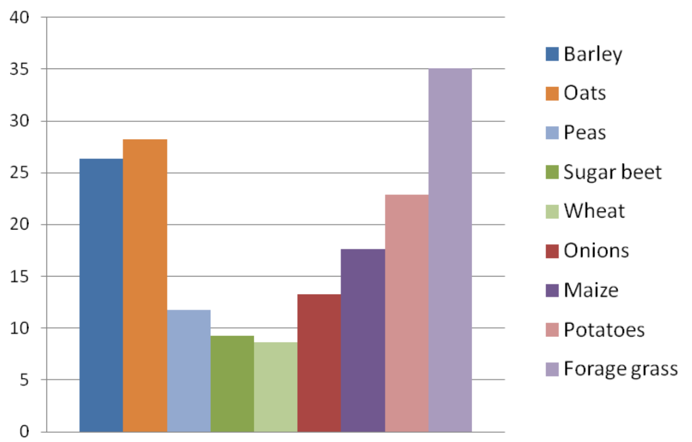
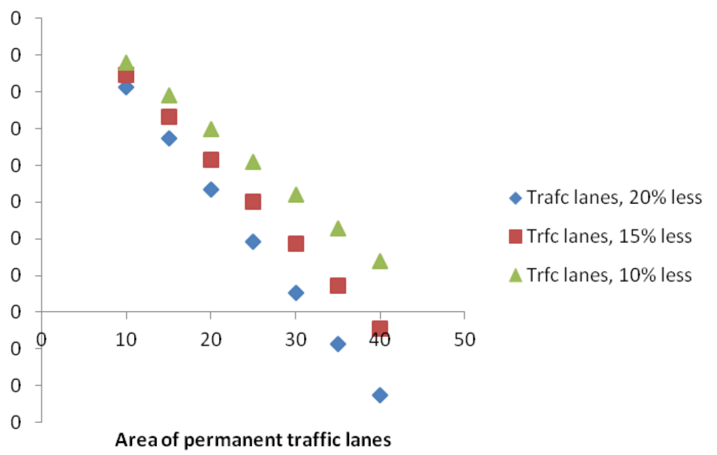


Figure 2. Percent increase in crop yield of different crops grown on non-trafficked compared with randomly trafficked soil (Chamen, 2011).

Taking into account crop yield reduction in the cropped permanent traffic lanes (and an 8% increase of wheat yields on non-trafficked beds) gives a net increase of about 4%.

			 Figure 3. Predicted net field yield of wheat for different trafficked areas within a controlled traffic system. Prediction based on chemical application tramlines at 24 m and different levels of yield reduction in the cropped traffic lanes compared with conventional practice.
	Water Storage	None	
	Fish stocks and recruiting	None	
	Natural biomass production	None	
Regulatory and Maintenance	Biodiversity preservation	None	
	Climate change adaptation and mitigation	None	
	Groundwater / aquifer recharge	Low	By increasing infiltration and reducing runoff, controlled traffic farming has a positive effect on groundwater recharge.
	Flood risk reduction	Medium	According to Chamen (2011), compaction mitigation permitted by controlled traffic farming can decrease the risk of flooding through enhanced infiltration.
	Erosion / sediment control	Medium	Controlled traffic farming contributes to reduce and slow runoff; thus, it has a positive effect on reducing erosion and sediment delivery.
	Filtration of pollutants	Medium	Controlled traffic farming enhances nutrient uptake by crops by improving soil structure and increasing water infiltration. Thus, it has a positive impact on pollutants filtration (The James Hutton Institue and CTF Europe Ttd, 2012).
Cult ural	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	None	
	Improving chemical status and priority substances	None	
Achieve Good GW Status	Improved quantitative status	None	
	Improved chemical status	None	
Prevent Deterioration	Prevent surface water status deterioration	Low	By decreasing nutrient losses and erosion, controlled traffic farming contributes to prevent surface water deterioration.
	Prevent groundwater status deterioration	None	
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		High	Controlled traffic farming can be one of the measures taken in rural areas in order to reduce flood risks. Indeed, by slowing down runoff and enhancing infiltration, it contributes to flood risk reduction.

Habitats and Birds Directives		
Protection of Important Habitats	None	
2020 Biodiversity Strategy		
Better protection for ecosystems and more use of Green Infrastructure	None	
More sustainable agriculture and forestry	Low	Controlled traffic farming is part of the measures increasing agriculture sustainability, through maintaining good conditions for further cropping, mostly through soil conservation.
Better management of fish stocks	None	
Prevention of biodiversity loss	None	

VIII. Design Guidance

Design Parameters	**Evidence**
Dimensions	Controlled traffic farming is applied at field scale. Traffic lanes correspond to 15% of the field area is the system is properly designed. Bare tramlines' width varies from one missing 18cm row to two missing 30cm rows (GRDC and Govermnement of Western Australia, 2004).
Space required	The required space corresponds to the dimension of the measure.
Location	Controlled traffic farming can be implemented on any field where conventional farming is already done.
Site and slope stability	Slope constraints impact mostly on possibilities for mechanized agriculture. If conventional mechanized farming is already done, controlled traffic farming can also be implemented. The design of the lanes can be impacted by slope characteristics.
Soils and groundwater	Soil characteristics do not impact on the possibility to convert to controlled traffic farming but impacts on yield benefits, erosion and sediment loss control (GRDC and Govermnement of Western Australia, 2004).
Pre-treatment requirements	
Synergies with Other Measures	Controlled traffic farming can be combined with other soil conservation practices in order to maintain soil characteristics; it can also be combined with measures reducing flood risks, such as buffer strips.

<table>
<tr><th>Design Parameters</th><th>Evidence</th></tr>
<tr><td>Design recommendations</td><td>

GRDC and Government of Western Australia (2004) elaborated a tree decision to help choosing an appropriate tramline farming system:

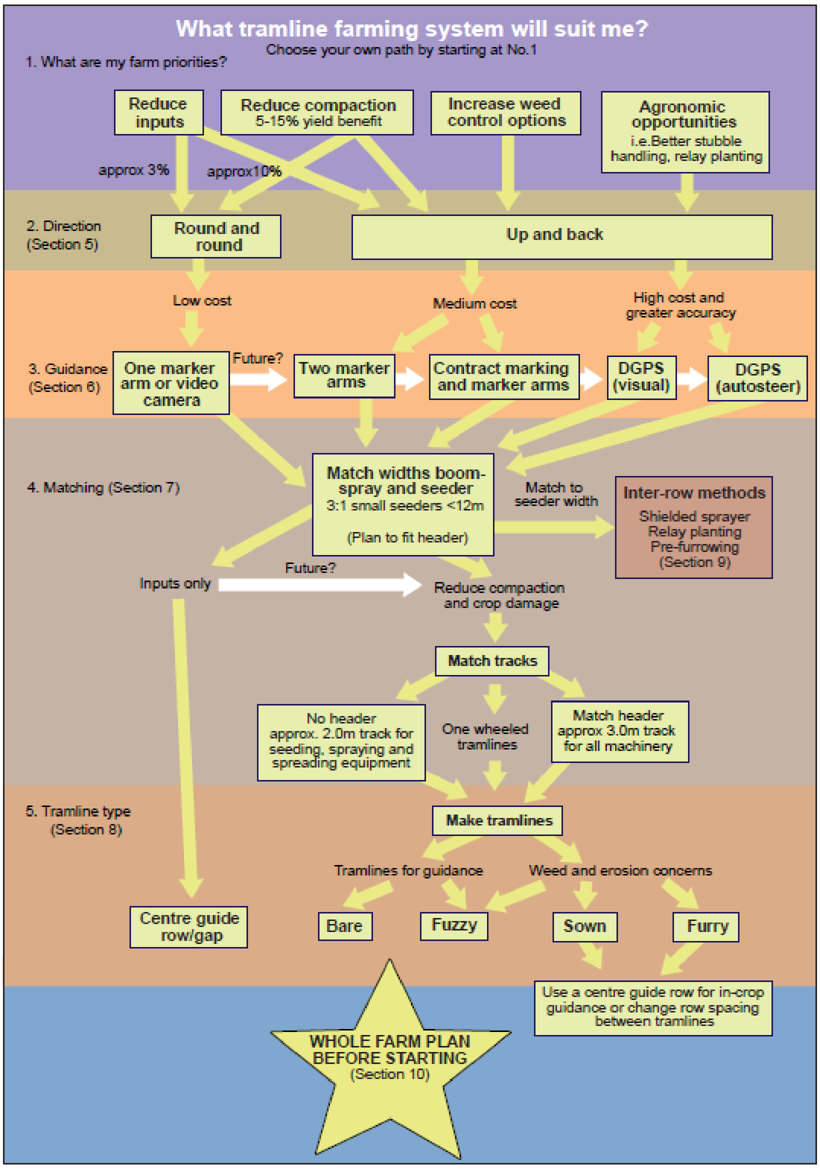


Figure 4. Tramline farming decision tree. Source: (GRDC and Govermnement of Western Australia, 2004)

- bare tramline: their width varies from one missing 18cm row to two missing 30cm rows

- fuzzy tramline can be used when weed competition is a concern

- sown tramlines are a useful substitute to bare tramlines when soil throw is needed for herbicide incorporation

GRDC and Government of Western Australia (2004) recommend to choose the most efficient direction for the in-paddock operation and water movement, to decide on the most convenient access for loading and unloading, to take care with areas prone to being wet and to set up the whole system with unripped tramlines when an initial deep ripping is employed.

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Photo 8.1 Bare tramline *Photo 8.2 Fuzzy tramline* *Photo 8.3 Sown tramline*

Figure 5. Different types of lanes. Source: (GRDC and Govermnement of Western Australia, 2004)

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition		
Investigations & Studies		
Capital Costs	-213€/ha	A study led in the UK on 25 farms (12 000ha) assessed machinery cost savings at 213.6€/ha (The James Hutton Institue and CTF Europe Ttd, 2012).
Maintenance Costs		
Additional Costs		
Net benefits	22.8€/ha	Gaffney and Wilson (2013) calculated long-term average costs and returns for four systems based on a five-year rotation in Australia. They included implementation costs, inputs savings, yield effects and reduction in field efficiency. They estimated the cost of changing to control traffic farming based on a 3m track gauge for all equipment was about 22.8€/ha. Another study (Chamen, 1993) calculated the net benefit of controlled traffic farming compared to conventional practices. Taking into account the rates of work, timeliness

Cost Category	Cost Range	Evidence
		of operations, energy inputs and the transmission efficiencies of machinery, they estimated that 6m tractor-based non plough controlled traffic farming system was : - less profitable than conventional plough based practice on medium soil (21.6€/ha) - more profitable on heavy soil (30€/ha) A study led in UK on 25 farms (12 000ha) assessed overall reduction costs at 51.60€/ha (The James Hutton Institute and CTF Europe Ttd, 2012). On these farms, profit margin was increased by 8% without any potential crop yield increase and by 17% considering crop yield increase. A modelling performed at a wheat farm scale in UK gave results on gross margin change by adopting controlled traffic farming, on different types of soil (The James Hutton Institue and CTF Europe Ttd, 2012):

€/ha	Clay	Silt	Sand	Peat
Option cost	0.00	0.00	0.00	0.00
Input saving	28.68	17.0	5.45	18.94
Output gain	108.3	89.2	76.32	79.30
GM change	137.0	106.	81.77	98.23

X. Governance and Implementation

Requirement	Evidence
Farmers involvement	Controlled traffic farming cannot be implemented alongside conventional practice without a complete conversion (The James Hutton Institute and CTF Europe Ttd, 2012) which can act as a barrier for farmers.
Farmers involvement	Controlled traffic farming is implemented on private areas (fields). Thus, farmers' involvement is necessary to guarantee positive biophysical impacts.
Technical support and communication	Controlled traffic farming appears to have positive effects on yields, which consist in a good reason for farmers to adopt it. However, communication and demonstration are needed to let farmers know about that and see the benefits they could get from this measure. Field tests and demonstration, communication of the results of some studies through technical medias, exchanges between farmers can be efficient ways to disseminate the adoption of the measure. Technical support is also necessary to accompany conversion projects.

A11: Controlled traffic farming

Requirement	Evidence
Coordination and animation	So as to be efficient on reaching some policy objectives, controlled traffic farming should be part of a wider program of measure and be considered at a sufficient scale. If implemented only on individual will and at field scale, the measure will not be sufficient to impact on water quality or flood risk. Coordination of measures and animation at a relevant scale (watershed) can make the implementation of the measure more efficient and relevant. Local authorities, local water or agricultural stakeholders (consular chambers, watershed agencies...) have a role to play.

XI. Incentives supporting the financing of the NWRM

Type	Evidence
Rural Development payments for associated measures.	CTF is not directly supported as a measure in the 2007-13 Rural Development Programme. However, it could be considered as soil management practice that might be included in Agri-Environment-Climate measures in the 2014-20 RDP. Across the EU, payments for soil management actions in the 2007-13 RDP averaged 128 €/ha with a range of 11 to 390 €/ha

XII. References

Reference
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