3.2.9. Conservation Agriculture.

3.2.9.1. Description.

Reduction of the soil disturbance during agricultural management is a core concept in conservation agriculture (CA), which is based in three main principles see Table 3.2.9.1., and it is termed conservation tillage. Conservation tillage is part of practically all national agro-environmental schemes worldwide, as for instance in the regulations of the Common Agricultural Policy in the European Union.

This is mainly due to their potential effectiveness in reducing soil erosion and (partially also runoff) for arable land (Hösl et al., 2016; Strauss et al., 2003). This sections deals with different strategies of conservation tillage as applied to annual crops since another major part of CA techniques (e.g. cover crops are dealt for tree crops in section 3.2.4. and in annual crops in section 3.2.10.).

Table 3.2.9.1. Basic principles of conservation agriculture.

#	Principle
1	Minimalize mechanical soil disturbance appropriate to soil type.
2	Maximize permanent organic soil cover.
3	Include diversified crop rotations to minimize the need for external inputs.

When approaching the use of conservation tillage as BMP in annual crops we need to be aware of four major concepts, Table 3.2.9.2.

Table 3.2.9.2. Main concepts to understand conservation agriculture impact.

#	Concept
1	There are a number of different major strategies that are summarized in Table 3.3.9.3. Note that the same technique may be named differently in different countries which can creates confusion.
2	The major strategies have different effectiveness regarding soil protection and surface runoff reduction.
3	Their effectiveness depends on the ability of farmers to keep a sufficient ground cover after seeding.
4	Besides the major strategies for minimum tillage there exist a number of country specific specifications that are established within the particular agri-environmental schemes. These different approaches are also summarized below.

Table 3.2.9.3. Main conservation agriculture strategies.

#	Concept	Definition
1	Direct drill.	Seeding into undisturbed surface fully covered by residues of previous crops.
2	Reduced tillage.	Minimize primary and secondary tillage operations, reduce tillage operation depths and/or concentrate tillage in part of the field.
3	Mulch drill.	Minimized primary and secondary tillage operations, no turning of the soil, and concentrating operations only in the seeding row.
4	Strip tillage.	A variation of mulch drill in which non-inversion soil tillage is performed for the minimum possible area in the seeding row – it can be understood as the mid-point between direct drill and mulch drilling.
5	Ridge Tillage.	A system in which ridges are made and maintained annually with crops seeds on top of the ridges and residues cover permanently the ground in the furrows.

3.2.9.2. Implementation types for conservation tillage practices.

Direct Drill.

The major characteristic of direct drilling is to establish a soil cover before planting of the major cash crop. Seeding of the major cash crop will then be carried out without any further primary or secondary soil management. These techniques involve control of the green soil cover by either pesticide application (this is the normal approach in conventional agriculture) or some other form of biomass destruction, for instance application of a roller-crimper in organic farming systems. In the following season the crop is seeded into the residues of the previous crop, using a seeder that cut through the residues but without any further soil management.

Reduced tillage.

This may involve a large set of alternative primary and secondary tillage operations, but with the aim of using a reduced intensity of tillage. A typical approach to reduced tillage is to use a chiseling rather than a mouldboard plough.

Mulch drill.

Similar to direct drill mulching techniques, it also involves establishment of a soil cover before planting of the major cash crop. However, before seeding some sort of soil tillage is used to prepare seedbed, but without turning the soil. After soil preparation at least 30% of ground cover by either green or dead biomass is achieved. A large variety of management tools are available to prepare the soil surface for seeding, such as chisel plough, rotary hoe or rotary disc. The effectiveness of mulching against soil erosion and prevention of surface runoff largely depends on the number of passes with the tillage implement, the management depth per pass and the management tool that is used. This is because these are the factors that determine the amount of soil cover after this operations, as well as the degree of disturbance of soil structure.

Strip tillage.
Can be envisioned as a mixture of direct drill and mulch drill management in which non-inversion tillage operations are restricted to a strip as narrow as possible in the seeding row and the rest of the field remains under no till conditions.

Ridge tillage.
In this system permanent ridges, 15 to 20 cm high, are made and maintained annually. On these ridges crops are seeded. Residues cover is maintained permanently on the furrows, and residues are regularly deposited on the top of the ridges during ridge formation and harvest.

3.2.9.2. Implementation types for conservation tillage practices.

Table 3.2.9.4. and Table 3.2.9.5. summarize the positive and negative impact of different conservation tillage on the provision of different ecosystem services when compared to conventional tillage.

Table 3.2.9.4. Impact on delivery of soil ecosystem services of different conservation tillage strategies. ++ means high impact, + moderate impact, o means negligible.

Potential Benefit	Direct drill	Reduced tillage	Mulch drill	Strip tillage	Ridge tillage
Increase of soil organic carbon.	++	+	++	++	+
Reduction of soil erosion.	++	+	++	++	++
Reduction of runoff.	+	o	+	+	+
Enhancement of soil quality.	+	o	+	+	+
Enhancement of biodiversity.	++	o	+	+	+
Reduction of off-site contamination.	++	+	++	++	++
Reduction of soil evaporation.	++	+	++	++	++

Table 3.2.9.5. Potential negative impacts of conservation tillage strategies. ++ means high probability, + moderate probability, o means negligible. Note this is an approximation to the probability of appearance of these negative impacts, and that they can only be addressed with studies at specific climate, soil, crop and management conditions.

Potential Benefit	Direct drill	Reduced tillage	Mulching	Strip tillage	Ridge tillage
Soil compaction.	++	o	+	++	+
Herbicide resistant weeds.	++	+	+	+	+
Reduced seedling germination due to slow soil warming.	++	o	+	+	+
Reduced crop yields	+	o	+	+	+
Increased chemical leaching.	+	o	o	+	o

3.2.9.4. Definitions of conservation agriculture in different countries.

A source of confusion is that despite that fact that CA is part of almost every country scheme for agri-environmental measures, the local definition of conservation agriculture operations may differ among countries. This list gives an overview about the requirements to receive subsidies for conservation tillage in three different SHui countries.

Country	Definitions	Subsidy Level
Austria.	* No differentiation between direct drill, mulch drill and strip tillage * farmer qualifies for subsidy when green cover has been established in previous year before 15 October. * Soil management of green cover not before 15 February. * Minimum of two different varieties for green cover * Maximum time between soil management and seeding is 4 weeks * No ploughing	60 €/ha for minimum tillage. 120 – 170 € for establishment of green cover.
Czech Republic.	Direct Payments represent the largest share of payouts determined for subsidies in agricultural sector. They are provided in accordance with rules of the EU Common Agricultural Policy (GAEC). Conservation agriculture is defined by very complex system of variable rules within GAEC, where different soil conservation techniques are recommended for different fields (based on slope, and soil risk assessment), and for different groups of crops. Crops are grouped as: conservative, normal, and risky (concerning soil erosion resistance). Single area payment scheme (SAPS) is major contributor (138 EUR/ha in 2020), and in many fields no conservative approach is needed to reach SAPS. Obligatory: GAEC 4 – over 4° mean field slope: stubble has to be left on field till spring seeding, or strip-till, or cover crop have to be seeded before September 20th and keeping cover crop till October 31st. Exception is manure application and tillage. GAEC 5 – erosion risky soils (SEO) over 2 ha area must apply conservation agriculture via extremely complicated list of measures for variable crops. Here are main techniques: Corn, potatoes, beets, broad beans, soybeans, sunflowers and sorghum prohibited; row crops are permitted when: direct seeded, contour seeded (up to 35 ha), strip-tilled, using permanent cover crops, using protection belts of winter cereals (above 6 ha areas); stone rows are installed during potato seeding (stone removal); under plowed (causing plow pan disturbance) when sugar beet is seeded; seeding winter cereals into 30% mulch cover; putting solid manure into the field during management process of any crop. Winter cereals without additional technique have to be split by protection belts (22 m width) after 220 m slope length. Each above listed measure is described by control parameters to be checked by subsidy provider (date of management, pre-conditions, minimum and maximum field size, surrounding crops, protection belt parameters and density, per-cent of area of the cover crop etc.). The system is complicated and redesigned regularly from year to year.	

Country	Definitions	Subsidy Level
Spain Winter cereals.	Recommended: Introduce where possible, and particularly in areas of especial erosion risk (ZERE) conservation tillage techniques. Recommended: Minimize tillage reducing the number of tillage passes, its depth, and adapting tillage to maintain soil OM content and structure, adapted to soil texture. Obligatory: If conventional tillage is used. a) Do not perform primary tillage on waterlogged or snow covered fields. b) In ZERE (areas of special regulation) areas respect additional restrictions that might impose the administration. c) In rainfed crops do not till between the harvest and the primary tillage date as determined by the regional ministry of agriculture, except when secondary crops are grown, e.g. sunflower. d) In fields with average slope greater than 10% do not perform soil inversion tillage in the direction of the maximum slope unless is authorized by the administration.	

3.2.9.5. Examples of conservation tillage alternatives.

Figure 3.2.9.1. Direct drilling on a cereal rotation in Lower Austria (Photo T. Dostal).

Figure 3.2.9.2. Corn in direct drilling in Austria (Photo Josef Rosner).

Figure 3.2.9.3. Strip tillage in Austria (Photo NÖ LK/Josef Wasner).

Figure 3.2.9.4. Cotton on ridge tillage (Photo J.A. Gómez).

3.2.9.6. Selected References.

Jones, C. et al. 2006. Conservation Agriculture in Europe. An approach to sustainable crop production by protecting soil and water?. SOWAP. Available at https://vtechworks.lib.vt.edu/bitstream/handle/10919/68481/4243_conservationagriculture.pdf?sequence=1

NRCS, 2017. National Resource Conservation Services. Conservation Practice Standard Residue and Tillage Management, No-till. Code 329. Available at https://efotg.sc.egov.usda.gov/references/public/NY/nyps329.pdf

WOCAT 2017. No tillage (Estonia) Available in https://qcat.wocat.net/es/wocat/technologies/view/technologies_3089/ Note that in WOCAT database there are several examples of no and minimum tillage.

Hösl, R. and Strauss, P. 2016: Conservation tillage practices in the alpine forelands of Austria – Are they effective? Catena 137, 44-51. https://www.sciencedirect.com/science/article/pii/S0341816215300916?via%3Dihub.

Strauss P., D. et al. 2003. How effective is mulching and minimum tillage to control runoff and soil loss. Proceedings of 5 Years of Assessment of Erosion, Ghent, 22-26 September 2003, 545-550. https://www.baw.at/service/publikationen.html?q=swoboda&author=&category=%2Fservice%2Fpublikationen.html&releaseYear=&language

Return to Table 3.1.1.