Conservation Tillage Systems – Soil – Nutrient – and Herbicide Loss in Lower Austria and the Mycotoxin Problem

Rosner, J.[1] – Zwatz, E.[1] – Klik, A. – Gyuricza, C.

Office of the Lower Austrian Provincial Government, Frauentorgasse 72, A-3430 Tulln
Tel.: 0043664/4025477, E-mail: josef.rosner@noel.gv.at

1. Abstract

In Austria due to the cultivation of corn, sugar beets, sunflowers, soybeans, potatoes, including wine and fruit, about 450,000 hectares of farmland are at potential risk of erosion. For this reason the cause of soil erosion and the possibilities for reduction and prevention will be investigated.

From 1994 to 2007 eight different tillage systems were tested at three locations in Lower Austria. Five tillage systems were tested in Tulln – located 30 km west from Vienna. The systems included conventional tillage with a plow as well as mulch and direct drilling of cover crops in autumn. No-till and ridge tillage was tested, also. The Institute of Hydraulics and Rural Water Management of the University of Natural Resources and Applied Science Vienna (Prof.A.Klik, Ph.D.) measured surface runoff, soil loss, nitrogen, phosphorus, and herbicide loss. Mycotoxins were analysed in an institute in Tulln. Between 1994 and 2007, the average soil loss at the three locations dropped from 6.1 t/ha/year (conventional tillage) to 1.8 t/ha/year with conservation tillage in cover crops, and to 1.0 t/ha/year with direct drilling systems. Nitrogen and Phosphorus losses showed similar tendencies. Herbicide loss declined by 2.2 % at the application rate in conventional tillage; 1.0 % in conservation tillage and 0.6 % in direct drilling systems.

2. Introduction and Problem Definition

In Austria 450,000 hectares of land are potentially in danger of erosion. This problem and the Austrian program for the promotion of an environmentally just and natural habitat protecting agriculture (OEPUL) led to a change in the way the farmers think. Besides the ecological aspects, economical obligations are becoming more and more important. While soil conservation tillage methods are becoming increasingly accepted, many farmers generally remain sceptical. Reasons for the new cultivation trends are shown below:

Lowering of production costs
Fewer passes - less work time - less soil compaction
Increased productivity - cultivation of larger area possible
Reduction of fuel consumption
Lower machinery use
Prevention of wind - water – tillage erosion
Increased humus content
Improved water retention
Better yields
Lower CO_2 release from the soil (climate - and soil alliance, Kyoto - Agreement)

A reduction in the work time for cultivation from 5–8 hours per hectare to a proven 3-5 hours and less can be achieved, at the same time fully using the ecological advantages. The costs can hardly be reduced through minimizing cultivation, because cover crop management expenditures offset any savings. However, the value of the washed away nutrients plus the better cultivation measures for winter cover crop variations and mulch seeding supplement need to be calculated.

3. Material and methods

Different cultivation systems were examined at three locations in Lower Austria in the dry Hungarian climate (Pannonicum) and in the moderate transition climate. The climate is characterized by an annual precipitation amount of 500 mm in the Hungarian Climate (Pannonicum), 650 mm in the transition climate and by an annual average temperature of 8.5 °C – 10.5 °C.

Besides the conventional seed bed preparation with plow and chisel plow, different cover crops such as yellow mustard, California bluebell (Phacelia tanacetifolia), oil radish, clovers, green rye, buckwheat followed by mulch and direct seed were tested. Two tests of minimal cultivation using only a disk harrow and a No-Till variation were examined for yield achievement and the Mycotoxin content.

The conventional seeding was accomplished with use of a plow and cultivator plus harrow or rotary harrow for seedbed preparation. The mulch seeding was accomplished after two passes with the chisel plow followed with the cover crop. After mulch cultivation with a rotary harrow or seedbed combination implements, the direct drilling with cover crop management was just like the mulch seeding, yet the seedbed preparation was omitted (ZeroTillage). All three aforementioned systems were cultivated with a direct seeding machine.

4. Test results and discussion

4.1. Soil erosion tests

Following in Table 1 are the results of the three locations: Mistelbach (wine quarter, 30 km north of Vienna), Tulln (30 km west of Vienna) and Pyhra around St. Pölten (50 km west of Vienna). Mentioned are the three cover crops and tillage links, which were also tested for soil erosion. Besides the soil loss in t/ha/year the table also refers to the nutrient losses of Nitrogen and Phosphorus separate from the herbicide shift. The calculated grain yields - corn crop rotation (Mistelbach 1 x sugar beets, 1 x sunflowers, and Tulln 1 x sugar beets instead of corn in the crop rotation) are likewise represented in Table 1. No fall cover crop was done with the conventional seeding. The mulch seeding, added in mid-August, consisted of 7.5 kg vetchling, 11 kg winter tares, 3.7 kg buckwheat, 1.1 kg Egyptian clover, 1.1 kg Persian clover, and 0.4 kg yellow mustard as fall cover crops. The direct seed of 3 kg yellow mustard and 7 kg California bluebell were sown at the aforementioned date.

Table 1 Measured yearly erosion and yield 1994 – 2007 Mistelbach, Tulln, Pyhra (Klik 2007)

Cultivation method	Conventional Tillage	Mulch Seeding	Direct Drilling
Soil loss t/ha/Year	6.1	1.8	1.0
Corg loss kg/ha	76.6	27.5	19.2
Nitrogen loss kg/ha/year	9.2	3.7	2.5
Runoff mm/year 2007	23.5	21.1	18.3
Phosphorus loss kg/h/year	4.7	1.3	0.7
Herbicide loss in runoff % sprayed active substance	1.7	0.9	0.17
Herbicide loss in eroded soil % sprayed active substance	3.1	1.2	2.0
Herbicide loss % sprayed active substance	2.2	1.0	0.6
Yield in % Conventional	100	100	101

As shown in Table 1, notable reductions in soil, nutrient, and herbicide erosion are determined. The yields do not differ significantly. Note that detailed results of registered yield reductions of 15-20 % with direct drilling of sugar beets are not represented. All other cultivated plants react to the changed cultivation yield-neutral, as long as the seeding machine slot in the course of the cultivation can be closed. Otherwise this can cause a problem if the soil is too damp or too dry. Implements such as rotary clod breaker or two sloping disks are necessary during planting in order for seeds to be covered with soil.

4.2. Cultivation tests Tulln

Five soil conservation method trials, listed in Table 2, were set-up in two locations around the Tulln area. In addition
to conventional cultivation methods with plow and chisel plow, cultivation using two passes with a disk harrow was tested. One test link was minimal tilling with a single disk harrow. For this method a seed bed was prepared with a rotary harrow or seed bed combination implements, but when the No Till method (zero Tillage) is used the soil will not be cultivated. Here several centimeters of soil were worked by direct drilling with a disk coulter from a seed drill, in the spacing drill there was no soil preparation. Ridge tillage was chosen for the 5th system, similar to potato cultivation. This plot will be worked in the conventional method, drawing ridges out in front of the growing corn, so 1° C higher soil temperature may be obtained.

Next to the yield results in kg/ha 1999-2007 in Table 2, are the analysis of Micotoxin Desoxynivalenol (DON) and Zearalenon (ZON) level in µg per kg grain. The results from cultivated corn in the Tulln area from both trials are combined. Grains were picked for the crop rotation-corn for example- in 2000 soybeans were chosen.

Table 2 Cultivation test results Tulln 1999 – 2007

Tilling method	% yield	ZON		DON		DON		
	conventional	1999	2001	1999	2001	2004	2005	2006
culture		corn	corn	corn	corn	corn	corn	Summer Durum
Conventional Chisel Plow - Plow CT	100	28	79	505	2477	824	2400	600
Chisel Plow 2 x CP	97	12	514	323	2170	1257	5550	1200
Disc Harrow – Reduced Tillage1 x RT	92	12	20	302	1542	1080	730	1800
No Till NT	90	25	nn	600	519	374	850	1200
Conventional – Ridge Tillage corn RiTi	95	24	64	419	3229	387	4100	540

nd… not detectable
The Mycotoxin levels from 2002 and 2003 in the submitted trials were below the detectable level.
Mycotoxin guidelines for Europe:

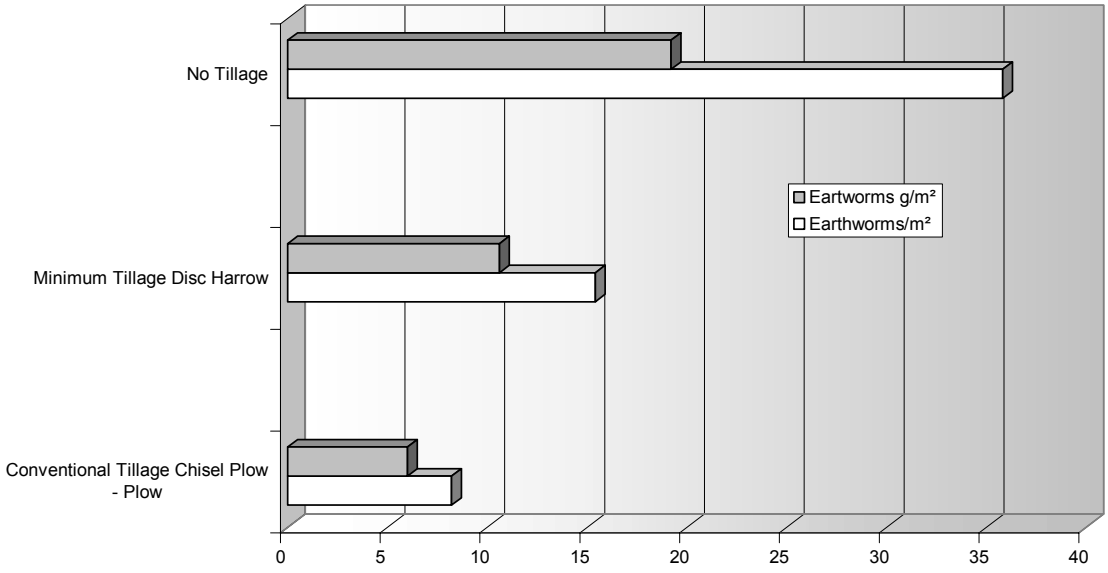
DON: 200 – 1750 µg per kg grain	DON……Deoxynivalenol
ZON: 50 - 100 µg per kg grain	ZON…….Zearalenon

The yields are significantly lower with minimum tilling. This setback is due to the cultivation of sugar beets. Problems arose by the closing of the seed-slots with No-Tilling, which led to a reduced number of sugar beet plants. Moreover, it was not possible to fight the arising field bindweed (Convolvulus arvensis) with the active substance Glyphosate in springtime. Similar difficulties with the locking of the seed-slots can also occur with the cultivation of corn.

Despite the shown problems it seems in practice possible to use these methods if certain principles are paid attention to such as minimum soil cultivation methods and the use of proven ecological advantages. According to practical data, profit losses are only in the first change-over years, reaching a normal level later, whereby the aforementioned advantages can be used.

Cover crop management is also very demanding. Successfully creating a cover crop results in being able to cultivate early, in August. Deep-root cover crops should be selected, in order to move nutrients from the lower-lying soil layers. The use of volunteer cereals should be considered to reduce "Green bridges". These bridges transfer yellow dwarf viruses from aphids to winter barley or soil-born diseases. Particularly with grain, straw residues from corn crop rotations are carefully worked into the ground before the cultivation of the cover crops to prevent the formation of Mycotoxin from Fusarium. If this is not carried out damp conditions must be achieved for the cultivated plant bloom which leaves a very high level of Fusarium risk, which is almost impossible to control chemically. The nuisance of a significant increase in Mycotoxin in the harvested crop is the end result. If the index values are exceeded the harvested crop can not be sold for human or animal consumption, the only application options for the crop are composting or thermal energy.

Figure 1 Number and weight of Earthworms 0-30 cm 2004 - 2006



Notice the influence of soil cultivation on earthworms in Figure 1. When the soil cultivation is more intensive, fewer earthworms survive in the soil crumbs. Intensive soil cultivation generally has a negative effect on the all of the biological activity in the soil, which also affects the antiphytopathogene potential. The rate of decomposition of the organic substance is greater when the soil is more active. Additionally, if this is superficially shallowly trained, the diseases present in the crop residue will transfer less.

5. Conclusion

Reduced tillage lead to significant reduction of soil loss by conservation tillage 70 % and direct drilling 84 %. This tillage system also leads to a positive impact of on aggregate stability, higher organic content in the top layer. For the investigated soils and climate conditions conservational tillage and direct seeding in combination with cover crops during the autumn and winter period are effective soil protection measures to maintain and improve soil quality.

6. References

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