Role of grass strips in soil erosion control

2013–2016, Final report

(OTKA 104899)

The role of the grass strips in soil protection was examined in three scales during the four years research program Results of this study will be presented separately for each scale.

(1) Plot-scale measurements

The large scale, plot size measurements were carried out at Szentgyörgyvár. The grass strips were examined for two tillage types: Conventional (CV; mouldboard ploughing tillage) and Conservation (CS) tillages (with no inversion, using a reduced number of tillage operations and leaving min. 30% crop residues on the soil surface), and soil erosion was compared for the areas with and without a buffer strip. In the framework of my earlier erosion measurements four plots (2 CV and 2 CS) of 24x50 m size were set up in a two ha experimental area of 9-10% slope at Szentgyörgyvár in 2003 (Fig.1). Normal, mechanized tillage is already possible on plots of this size, but they are small enough to gather and measure runoff water and eroded soil. A special, two channel collection system has been developed to collect the runoff of precipitations of both low and high (of 1% probability) intensity. The runoff collection system enables measurements of great accuracy (Bádonyi et al. 2008; Madarász et al. 2011). In spring 2013, the grass strips were planted on the lower end of one CV and one CS plots.

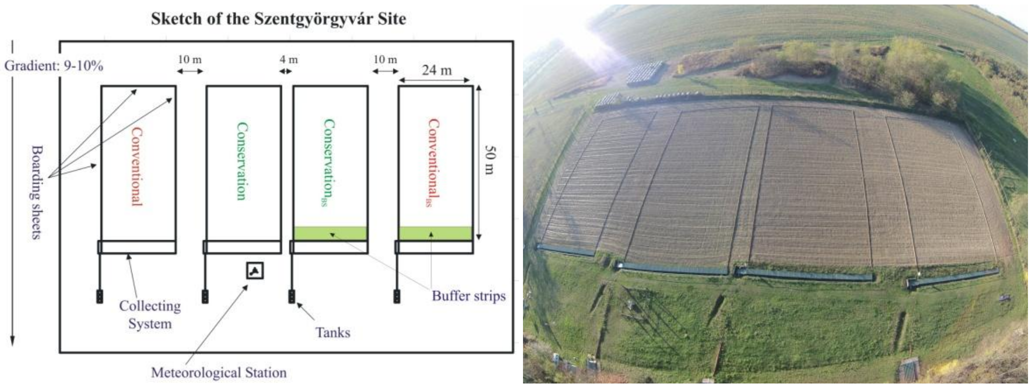

Fig. 1. The soil erosion plots of Stentgyörgyvár.

During the first year the preparations proceeded in accordance with the workplan: maintenance and renovation of the measurement system and the setup of a data recorder in the meteorological station. In the autumn 2012 rape was sowed in both systems. The precipitation distribution was very uneven during this year, which affected the possibilities of sample collection. Each runoff was sampled for laboratory analysis.

For the benefit of the pollinator insects, a special mixture (feeding bees and protecting the environment) was used for the plantation of the grass strips. However, owing to the wet weather conditions, introduction of the grass strips occurred relative late, only in mid-April. In the beginning, despite the wet lower soil, the dried surface layer hindered emergence of the grass, and it hardly grew due to the summer drought. Major development of the grass strips started only after the September rainfalls, but they gained strength during the autumn and became a solid basis for the measurements of the following year (Fig. 2).

Fig. 2. Grass strip at the edge of the plot at Szentgyörgyvár, 2014.

Eight runoff events occurred during 2013 in the study area, five among which happened before the introduction of the grass strips. Unfortunately, due to the slow growth of the grass, the buffer strips could not influence the amount of runoff during the following three runoff events either. Moreover, the volume of these events was small, a few litres only, thus it was not possible to examine the soil protective effect of the grass strips. As a consequence, in the lack of the sufficiently developed grass strips, this year only the difference between the CS and CV tillages could be evidenced (at most) and the amount of runoff water and sediment was small. The average runoff on CV plots was 68.7 m^3/ha, while it was only 0.2 m^3/ha on CS plots, in other words 0.25% of the CV value. Therefore, the soil erosion was also small this year: 0.15 t/ha on the CV and 0.0005 t/ha on the CS, which is not more than 0.32% of the CV (Table 1). This result is well in accordance with results of our previous studies (Kertész et al. 2007; Lane 2007; Bádonyi et al. 2008; Madarász et al. 2011). Nevertheless, data of the first year were not considered for the later analysis of the role of grass strips.

Table 1. Data of soil loss and runoff at Szentgyörgyvár, 2013

	CV	**CS**	**CV**	**CS**
	Soil loss, t/ha		**Runoff, m^3/ha**	
2013.03.30	0.00		1.83	
2013.03.31	0.13	0.00	47.21	0.17
2013.04.04	0.02		20.58	
2013 Total	**0.1509**	**0.0005**	**68.7083**	**0.1667**

The plant records demonstrate that plant height was similar in both tillage types. On the other hand the soil cover on the CS plots was 10-15% more than on the CV plots. This was the result of the plant residues left on the surface on the CS areas, where one of the key issues is to ensure at least 30% soil cover.

In 2014 there was hardly any need for reparations of the well-built plots and collection system and the buffer strips were strong enough to fulfil their role in erosion protection. Both the spring sawn maize and the precipitation distribution favoured soil erosion so that 8 considerable runoff events were successfully trapped. The runoff and soil loss measurements provided significant results. The runoff on the CV plots with a grass strip (CVgs) was reduced by 74% compared to the CV plot with no grass strip. Moreover. runoff on the CS plot with no grass strip decreased by 81% and on the CS plot with grass strip (CSgs) it was 97% (!) lower than on the CV plot. The grass strips appeared to be even more effective with respect to soil loss. The decrease of soil loss was 92% on the CVgs. 87% on the CS and 98% (!) on the CSgs plots. The eroded amount of nutrients and organic carbon is in agreement with the amount of runoff (Fig. 3). These results proved that the grass strips reduced effectively the runoff and soil loss for both CV and CS tillages. Plant survey and estimation of soil cover were carried out eleven times on the plots. results of which showed repeatedly 10-30% higher coverage of the CS plots.

Third year of the experiment was unfavourable for the soil erosion studies. The amount of 617 mm annual precipitation is similar to the mean annual precipitation of the last ten years. However, its distribution and intensity were disadvantageous. Accordingly, only two precipitation events produced runoff big enough for sampling in 2015 (Table 2). This inconvenient year was the major reason for my request of one year enlargement of the project. On the other hand, it is to be emphasized that both sampled runoff events were coming from the CV plot, while there was no runoff and soil loss on either of the other plots. This demonstrates well that even a small intensity rainfall can lead to runoff and soil erosion of the CV plots, which can be circumvented using any method of soil protection. The regular samplings, plant survey, maintenance of the collection system together with the sowing, pest control and harvest etc. were done as normal.

The first three years of my study evidenced that both the CS tillage technology and the grass strips are effective means of protection against soil erosion. On the other hand, considerable investment is necessary for the shift from CV to CS tillage (Madarász et al. 2016), which may dissuade the farmers from the technological change. This is why the buffer strips may be important as a low cost way for reducing soil loss. Moreover, grass strips are able to efficiently reduce runoff and soil erosion also at a lower width (see more at the field-scale experiments).

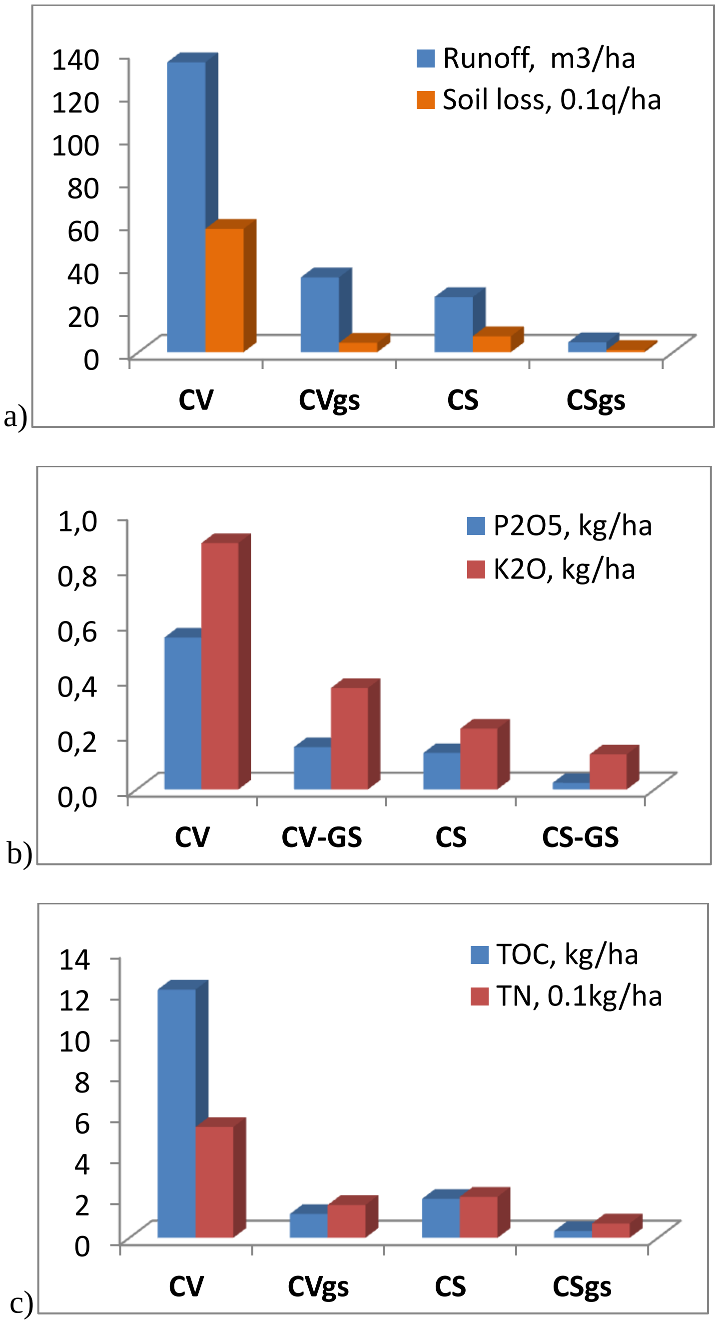

Fig. 3. (a) Runoff and soil loss; (b). phosphorus and potassium; (c) organic carbon and nitrogen loss data of the Szentgyörgyvár station in 2014.

Table 2. Runoff and soil loss data of the Szentgyörgyvár station in 2015.

	CV	**CS**	**CVgs**	**CVgs**		**CV**	**CS**	**CVgs**	**CVgs**
Soil loss, t/ha					**Runoff, m3/ha**				
2015.10.17	0.90					29.21			
2015.10.22	0.38					33.71			
Total	**1.276**	**0**	**0**	**0**	**Total**	**62.917**	**0**	**0**	**0**

Despite the grass strips planted at the bottom of the plots and ploughlands may appear efficient, they mostly provide only a “pseudo”-protection against soil loss. The CS technology enables the major part of the precipitation to be infiltrated, so that water is disponible for the plants within the soil. In other words, only a small portion of the incoming water is lost for the plants, and only this is the amount running downslope. However its reduced amount leads to lower energy and erosivity compared to the CV plots.

On the other hand, when grass strips are applied on a CV tilled area, the amount of runoff water and eroded soil from a plot or ploughland are similar to the CV tilled areas with no grass strip (Fig. 3). The running water and eroded soil are captured by the grass strip is important, as the retained material does not load the surface waters and does not fill up the drainage ditches (see more at the field-scale experiments). However, the precious water and soil, together with the nutrients are stripped from the area, so that these are lost for the plants.

The grass strips are able to capture large amounts of water relative to their width owing to the soil fauna, primarily to the earthworms (Madarász e al 2011). The soil fauna can live and reproduce undisturbedly in the grass strips. Their galleries mesh the soil, which can drain large amount of incoming water. The grass stems and roots themselves serve as physical barriers against running water, reducing its energy and thus forcing the sediment and nutrient particles to settle.

As a conclusion, the buffer strips planted at the downslope end of the plots provide a useful way of the protection of surface waters, drainage ditches. Consequently, grass strips help to prevent flashfloods, which became more frequent during the last years, but are not suitable tools to protect the soil (see more at the field-scale experiments). Accordingly, other ways are to be encountered to prevent the water from leaving the poughlands, to facilitate its infiltration and thus increase the soil humidity and reduce soil erosion.

According to the data (Fig. 3; Madarász et al. 2011, 2017) the CS tillage is the best way to achieve these objectives. A relatively simple and less expensive solution is the application of green manure as winter cover-crop. In the future, the use of winter cover-crop will have an important role in the Agri-Environmental Management Programs (AKG programs) in Hungary, which raises the question on their effect on runoff and soil erosion.

Therefore, in the autumn of 2015 a green manure mixture (Sinapis alba, Fagopyrum esculentum, Raphanus sativus, Trifolium incarnatum, Phacelia tanacetifolia) was spread on the CV and CS plots without grass strip (CV-cc, CS.cc). Despite the late sowing, the plants grew fast in the beginning and developed nicely until the first frosts. By wintertime the plants were 15-24 cm high providing 90-100% surface cover, in contrast with the barren surface of the CVgs. In spring the cover-crops were disked, then the land was prepared for sowing (fertilization, seed bed preparation) and maize was sowed again.

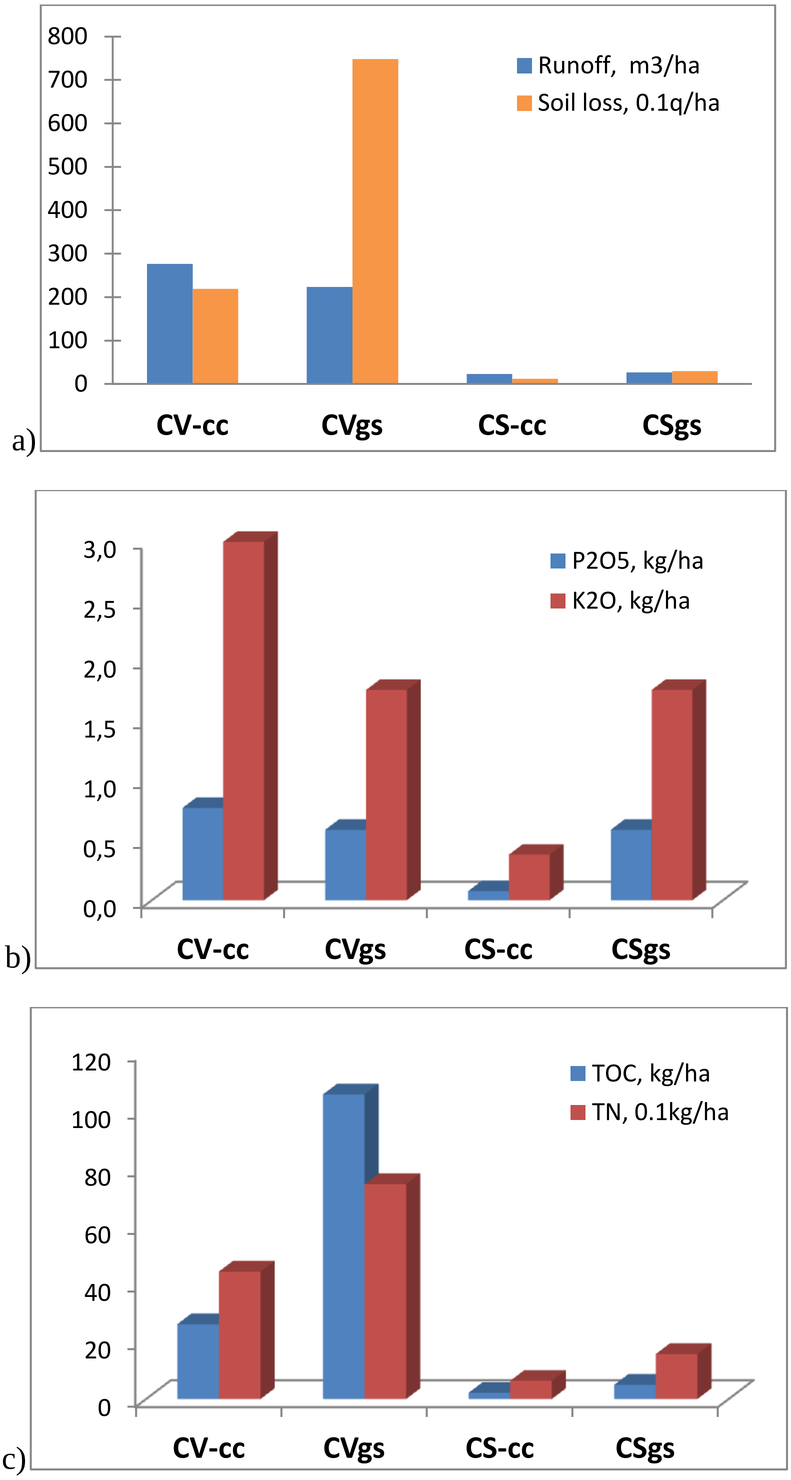

Fig. 4. (a) Runoff and soil loss; (b). phosphorus and potassium; (c) orcanic carbon and nitrogen loss data of the Szentgyörgyvár station in 2016.

In 2016, the more than 750 mm annual precipitation led to 11 runoff events on the CVgs plot, while runoff was detected only 3-5 times on the CS (CS-cc, CSgs) plots. Our data suggest that soil loss was significantly decreased by the application of winter cover-crop. The

CS-cc tillage reduced soil loss by a factor of 2 and the CV-cc tillage by a factor of almost four, compared to the CSgs and CVgs plots, respectively (Fig. 4). It is also well visible, that either with grass strip or with cover-crop, the values measured on the CV plots are an order of magnitude higher than those measured on the CS plots.

I studied the soil organic carbon (SOC) accumulation in the eroded material compared to the upper soil horizon. Our results revealed an inverse relationship between the amount of eroded soil and the concentration of its nutrient- and the SOC content. In other words: the smaller is the amount of eroded material, the bigger is its nutrient and SOC content (Madarász and Kertész 2014; Jakab et al. 2016; Szalai et al. 2016).

Rainfall simulation experiments were also applied to study the effects of the cover-crop. For the simulation the rainfall simulator SP02 developed by the Geographical Research Institute (MTA CSFK) was used.

The chosen plot size of 6 m^2, was big enough to take soil spatial heterogeneity into account therefore no repetitions were needed. The device was set up on a 9% steep slope in each case. The investigated plot was fenced by metal sheets dig into the soil in order to inhibit surface incoming and outgoing surface flow. After the setting up the simulator device, a 40 mm/h intensity rainfall was simulated without runoff measurements. This pre-treatment was followed by runoff measurements of artificial rainfall events of growing intensities. In each measurement the total amount of runoff was collected

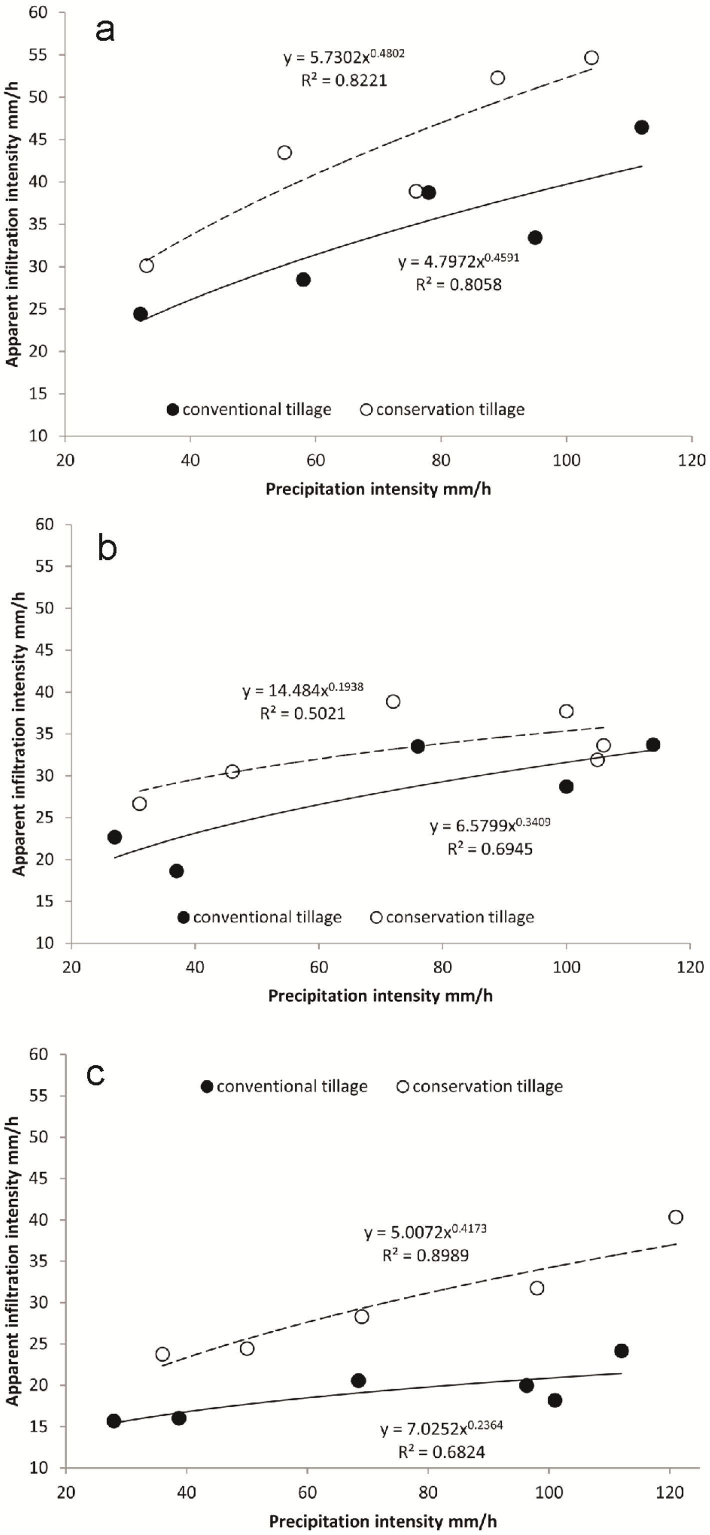

Fig 5. Apparent infiltration intensities as a function of precipitation intensities on various land cover stages under CV and CS tillage, a) cover-crop in April; b) seedbed in May; c)

and measured. Partial runoff and soil losses were measured in separate units with special emphasis on time. This way changes of the infiltration within the precipitation event were recorded. On the basis of runoff dynamics, apparent infiltration intensity was calculated. Both the highest infiltration and the highest increase in infiltration due to precipitation intensity increase were found in the CS plot under cover crop. Comparing the infiltration values of the CS tillage under seedbed and stubble, important changes can be seen: higher infiltration volumes were calculated under seedbed conditions at 80 mm/h rainfall intensity compared to the stubble, as it was expected. On the other hand above that value infiltration under stubble becomes predominant. Concerning the highest rainfall intensity more water infiltrates in the stubble soil than into that of the seedbed. Accordingly soil porosity formed by natural processes can be more effective in drainage than that of a tillage induced, temporary and vulnerable one (Fig. 5; Jakab et al., 2017).

When runoff water is captured after spraying, analysis of pesticide runoff was included in the work plan. The active ingredient in the pesticide used for the maize was Terbutilazin and Metolaklor. Weed control usually takes place in April-May, and runoff waters collected within the following 120 days were taken to pesticide analysis. After 120 days the amount of pesticides is usually under the detection limit. In 2014 and 2016 a total number of 10 runoff events were examined for pesticides. Besides the amount and intensity of the rainfall, the time elapsed since weed control, the tillage type and the applied soil protection techniques influenced the amount of toxic material potentially reaching and damaging the ecosystems of the surface waters. In 2014 the small amount of rainfall led to a limited amount of pesticides leaving the study area, but the proportions are still highlighting the immense role of grass or buffer strips in preventing the transport of the toxic material into the surface waters on both CV and CS tillages (Fig. 6).

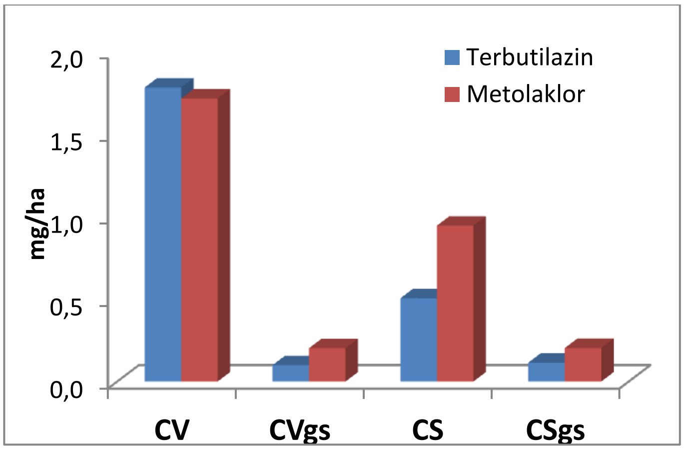

Fig.6. Results of the pesticide analysis per plots at Szentgyörgyvár in 2014

In 2016 as a result of the larger and more intensive rainfall events, the amount of mobilised active ingredients increased. The resulting data set supported the 2014 results, that is the grass strips are of primary importance in the reduction of pesticides leaving the agricultural areas. This is well demonstrated by the 5-6 times higher amount of pesticides leaving the CV-cc areas compared to the CVgs plots (Fig. 7; Dyson et al. 2015).

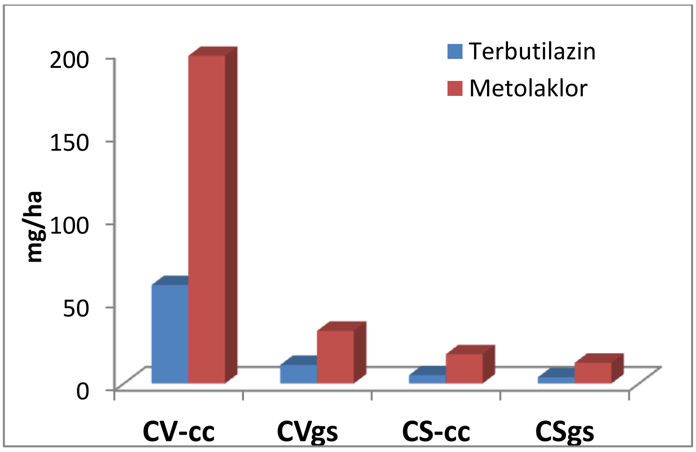

Fig. 7. Results of the pesticide analysis per plots at Szentgyörgyvár in 2016

It also has to be highlighted, that during the four studied years, only one pesticide-erosion event was environmentally significant (06.06.2016; Fig. 8). This event took place 18 days after treatment, resulting in high pesticide amount coupled with high concentrations.

As a conclusion, the period of major risk of pesticide runoff into the surface waters is May-June, when the early summer precipitation maximum coincides with the period when the soil under maize culture is most vulnerable by erosion.

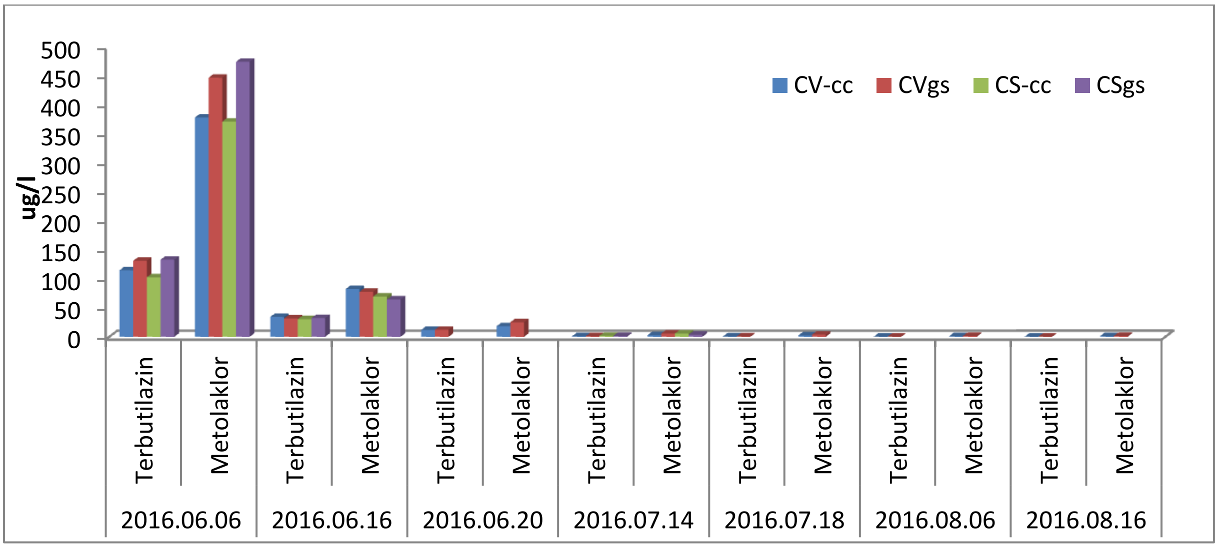

Fig. 8 Results of the pesticide analysis per events at Szentgyörgyvár in 2016

(2) Field-scale measurements

The field-scale measurements were carried out at Bárándpuszta, not far (12 km) from the plot scale measurements. The 20 wide grass strip and the runoff collection system was installed (Fig 9a) in the middle reach of an 8 ha field of 600 m length and 110-150 m width (Fig. 9b). The field was ploughed in slope direction where the crop rotation during the four years study was barley, rape, winter barley and maize. The area outside the grass strip was under continued tillage using the conventional ploughing tillage methods.

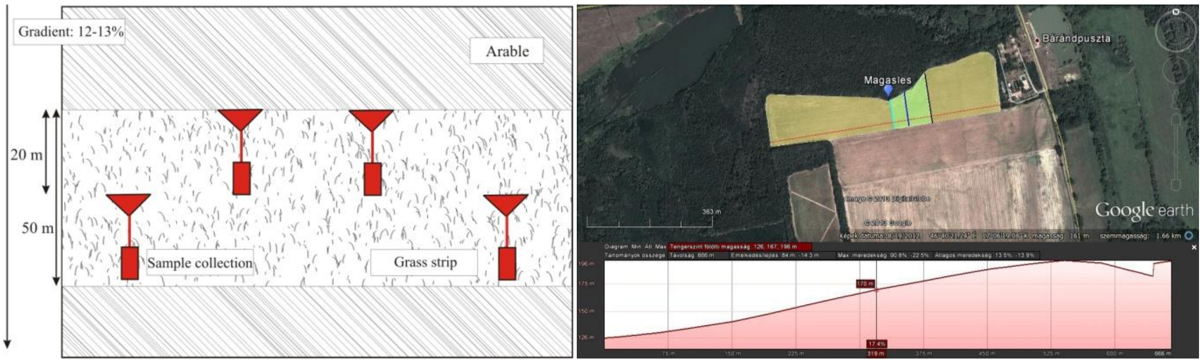

Fig. 9. a) The sample collection system at Bárándpuszta; b) GoogleEarth image of the field-scale experimental site at Bárándpisszta.

After the preparation of the soil (disking, fertilization), sowing of the grass strip occurred in mid-April, 2013. As a result of the dry weather the development of the grass was slow. In the meantime the sample collection tools were planned and manufactured. The water flowing from the field into the grass strip was sampled by two sample collectors (SC). The water flowing out of the grass strip was sampled by two other sample collectors (GC, Figs 9, 10).

The water collected in 4.25 m wide tanks was drained through circular fill dams of 25 cm diameter, where several different levels of the dammed water were sampled (0, 2.5, 5, 10, 15, 20, 24 and 75 cm above the edge of the dam). This sampling method enabled the estimation of the order of magnitude of the water discharge and the determination of the mass of eroded soil. The collecting vessels (of 3 l volume) filled up automatically during the runoff events and were replaced afterwards. The samples were taken to the laboratory for analysis.

To get a precise and detailed record of the timing and intensity of the precipitation at the study site, a pluviometer was set up in the area, which automatically stored the precipitation data integrated hourly with a precision of 0.1 mm.

Installation of the sample collectors occurred by the end of June 2013, and were ready for the measurements at 1st July. By this time the grass strip was strong enough to fulfil its erosion protection role. During the experimental period, almost every extreme but still considered as “normal” weather condition happened, which is considered to be an advantage from the point of view of the soil erosion study.

Fig. 10. a-b) 2x2 sample collectors at Bárándpuszta; c) Samples of the first (07.07.2013) runoff event

At the time of the installation the crop of the study area was spring barley, which was harvested after the first sampling. In the following winter rape was sown. This year the plant registration and cover estimations were carried out four times. At the beginning of the survey (1st July), the soil cover provided by the grass and by the crop was similar (43% and 45%). After the harvest and the following tillage (28th August) this proportion became 62% to 4% and one month after the sowing of the rape (1st October) it was still 75% to 6%. By the 4th of November the difference toned down to 73% to 35%. Accordingly, during the period of the most intensive summer rainstorms the soil surface was practically uncovered and the soil erosion was hold back only by the grass strip.

In the beginning the sampling vessels were loaded evenly. This changed significantly with time due to the tillage operations, to the pressure of the machines on the soil, to the characteristics of the planted crops and also to the fauna having considerable effect on the distribution and main pathways of the runoff. This phenomenon was typical at large runoff events by the end of the experimental period. If the separate measurement of the discharge could not be realised at each sampling vessel, the measured (or estimated) total runoff provided a sum of the runoff coming from the study area. Based on the total runoff and the precipitation data, the infiltration on the study area could be calculated. These calculations suggest that rainfall under 12.5 mm/h maximum intensity are determinative for the infiltration.

On the steep (10-17%) slope of the area runoff was registered 53 times at the SC collectors and 41 times at the GC collectors during the 3.5 years of the study. The total amount of runoff water can only be estimated, as there are no separate plots at this site. Therefore, field-scale erosion processes are evaluated by the quality

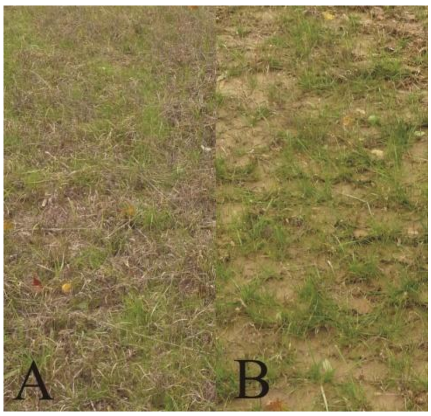

Fig. 11. a) The grass unaffected by the runoff; b) Soil sedimented in the grass strip in Bárándpuszta.

analysis of the runoff waters. The phosphorous, potassium, nitrogen, organic carbon and dry material content of the runoff water were examined. The analysis of 267 samples coming from 36 runoff events suggests that grass strips reduce effectively, nearly by 60%, the dry material content of the runoff water. The grass stems and roots slow down the flowing water, which loses energy leading to sediment deposition (Fig.11). As a consequence, ~20% of the transported potassium, nitrogen and organic carbon are also deposited. However, the amount of phosphorous hardly changed because it is strongly attached to the soil colloids, which remain in suspension (Fig. 12).

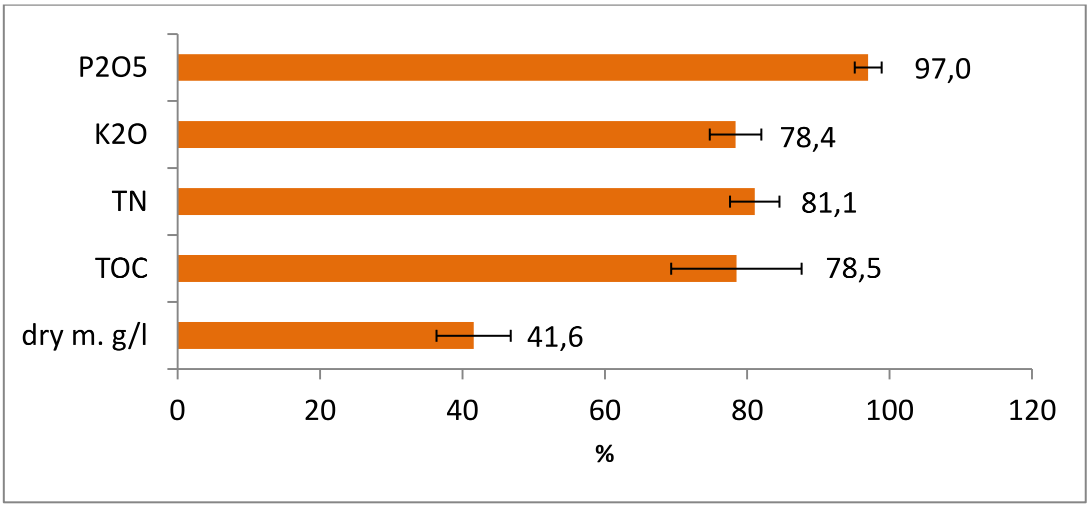

Fig. 12. Composition of the field-scale runoff events in percentage of the tillage without grass strip (2013-2016), Báránd-puszta

It has to be noted that the use of grass strips provides only partial solution for the reduction of soil degradation because the field above the grass strip remains a subject of soil and nutrient loss (see more at the plot-scale measurements). Buffer strips has a beneficial effect on the downslope part of the field by reducing the amount and energy of the incoming runoff water, practically decreasing the length of the erosive slope. Accordingly, the erosional damage may drop considerably on the bottom part of the slope.

Before the grass strips the soil loss was significant in the study area each year. This has been demonstrated by the pedological investigations of the field and also by the sites where the soil forming rock is visible on aerial photos, owing to the soil stripped by erosion. The number of ephemeral gullies has been reduced considerably after the plantation of the grass strips. Only the bigger rainfalls of high intensity were able to create some rills in the area. Nevertheless, the grass strips are unable to restore the eroded soil, but still are useful means of soil protection against erosion.

(3) Micro-catchment-scale experiments

The micro-catchment-scale experiments have been somewhat modified compared to the research plan. The owner of the selected study area at Dióskál participated in the agro-environmental management program (AKG) of the Ministry of Agriculture. Despite it was stated by the Ministry in our correspondence, that the project provides important information and it is also useful for the coming agro-environmental projects, they did not approve of the plantation of grass strips in the area. As a consequence, the earlier measurements from this study area could not be used to show the changes of the yield as a response to the grass strip plantation.

Nevertheless, yields and ephemeral gully formation in springtime were measured in the area, aiming at a comparison of CV and CS tillages only. Details on the yields, which is the question considered to be the most important by the farmers, were published by Madarász et al. (2016). This paper demonstrates the most important advantages of CS under sub-humid continental climate conditions, and provides experiences of the initial period of reduced yields during the adjustment to the new technology. This study shows that the technological change may not be as smooth as expected on the basis of the above studies, and this may result in a considerable decrease in yields. The study also demonstrates that adaptation of the technology to local conditions is essential. The experiences of the 10 years of monitoring the yields on twin CV and CS areas will provide guidelines to regional farmers and agricultural managers to implement CS technology while maintaining high yields. Our technology may be adapted by farmers in sub-humid continental climates where certain factors of production (e.g. slope, precipitation, weeds) are similar to those observed at our experimental site, and may help others to work out their adaptation methodology in other locations with somewhat different environmental conditions.

The ephemeral gully- or rill-erosion could be studied in two years, for wheat and for maize cultures. The survey occurred on two 10 * 120 m size plots, and reflected well the soil protection effect of the CS. The soil loss was 1.0 t/ha on the CS plots and 17.3 t/ha on the CV plots for the winter wheat and 3.8 t/ha and 13.6 t/ha for the maize, respectively (Fig. 13).

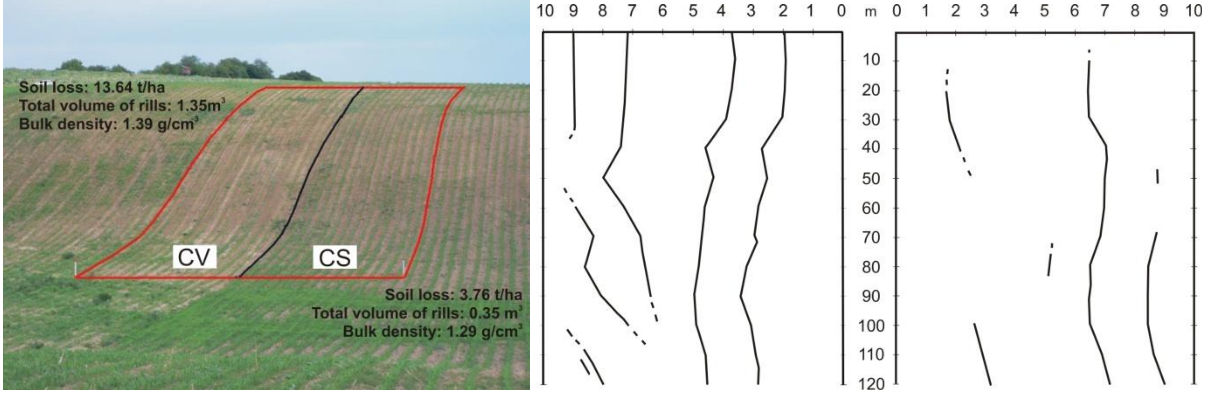

Fig. 13. Rill survey at Dióskál in 2015

A suitable area for the study of grass strips at micro-catchment scale was found at Bárándpuszta, the location of the field-scale survey. The grassing occurred in the autumn of 2014, in the central valley-shaped part of the 30 ha micro-catchment, where grass was planted in a 1 ha area. In the axial zone of the micro-catchment remarkable gullies were formed each year, causing serious damages for the owner and leading to constant debate with the public road operators due to sediment accumulation in the drainage ditches along the road. Moreover, the crops were unable to survive in the area most affected by the rill erosion, therefore the grassing of the area led to negligible loss of yield. In the originally planned study site, it would have been impossible to quantify this effect in the light of the former yields (Fig.14).

Fig. 14. The central, most eroded part of the micro-catchment the year before grassing at Bárándpuszta.

The early summer rill survey in 2014 showed 232 t/ha (!) soil erosion in this area. The survey was repeated in 2015 and in 2016 after the grassing, but no rill was observed in the grass strip pointing to 0 t/ha soil loss. The running water is slowed down when arriving at the grass strip, its sediment is deposited and the water is infiltrated (Fig. 14). Accordingly, the runoff is unable to reach the central valley of the micro-catchment, where the discharge and energy of the incoming water could sum up culminating in high erosion potential.

Fig. 15. a) Maintenance of the grass strip of the micro-catchment; b) sediment of the major runoff spread over the grass strip at Bárándpuszta, 2015

Conclusions

Our results show that it is possible to reduce soil erosion considerably by the application of CVgs, Cv-cc and CS. The decrease of the total amount of runoff and soil loss leads to a reduced amount of nutrient and SOC loss (Jakab et al. 2016), even though higher concentrations are measured in the runoff water and sediment (Madarász et al 2017). Under the present climate conditions, the intensive rainstorms at the end of the summer lead to the highest erosion during the year. Therefore, special attention must be paid to this period of time if the soil cover is already absent after the harvest (winter wheat, oilseed rape). As a consequence of the predicted climate change, the winter periods of increased precipitation will pose a danger as well. To protect the soil, it will be important to plant winter crops as soon as possible so that a dense soil cover is obtained early. In addition to the application of winter cover crops or/and buffer strips may also be useful. The growing frequency of summer droughts, leads to an increasing importance of water retention. The flash floods triggered by sudden summer rainstorms may also damage the soils and the built environment. Therefore, the retention of the maximum possible amount of water from these precipitation events within the soil must be a high-priority objective. Retained water both aids the survival of the plants during the dry periods, reduces erosion and the probability of flash floods. The preservation of humidity is also important for the soil fauna (earthworms) (Emmerling 2001; Birkás et al. 2004; Madarász et al. 2011), which maintain the soil structure by creating macro-pores that promote water-infiltration. But the use of grass strips provides only partial solution for the reduction of soil degradation because the field above the grass strip remains a subject of soil and nutrient loss. Buffer strips has a beneficial effect on the downslope part of the field by reducing the amount and energy of the incoming runoff water, practically decreasing the length of the erosive slope. Accordingly, the erosional damage may drop considerably on the bottom part of the slope. Effectiveness of CS tillage in soil protection is justified by our results and its effect may be increased by planting buffer strips that capture the water that would otherwise transport soil and nutrients away from the plots (Madarász et al. 2016, 2017).

Conferences and presentations

I presented the results of the project by 15 presentations on 10 conferences.

In 2014 I organised the "1st Soil conservation tillage systems in Hungary" workshop. Main objective of the workshop was to bring together the people studying and applying CS tillage methods in Hungary and to give a chance to show and discuss their results (http://ktm2014.mtafki.hu). Results presented at the conference were published in a conference special issue edited by me.

Motivated by the success of this workshop, in 2016 together I organised the "International Conference on Conservation Agriculture and Sustainable Land Use" together with a colleague (http://caslu2016.mtafki.hu. Outstanding researchers were invited speakers, and a councillor of the FAO was also present. 102 researchers from 35 countries participated at the conference. In the framework of the conference fieldtrip, the study site at

Szentgyörgyvár was visited, and the results of the plot-scale measurements were presented on site (Madarász and Tóth 2016; Tóth and Madarász 2016).

During the four years of the study 39 field presentations took place at the plot- and field-scale experimental sites, including several international groups. Presentations were held for conferences, for farmers, for the authorities and for policy makers.

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