The Effect of Cultivation on Soil Conservation

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Numerous scientific reviews dealing with erosional conditions in Hungary have been published in the last decades. FEKETE [1], LÁNG [3], STEFANOVITS [5], LAMMEL [2], TÓTH [6], MATTYASOVSZKY [4], and others have rendered account on degree of erosion and possibilities of its control in various districts and soil types. The consequences of these statements were only partly realized or not carried out at all. This was mainly due to farming on small holdings where the application of soil conservation encountered difficulties. Some of the methods suggested in the meantime became obsolete owing to developments in technics.

Modern large-scale farming enabled to carry out up to date experiments on soil conservation and to apply its results.

The study of this problem is conducted in Keszthely, on the experimental grounds of the College for Agricultural Sciences and in some farmer's cooperatives for the last five years. We are conducting a study of methods increasing soil productivity in various ways with soil conservation in view. The effect of crop rotation and of individual operations (ploughing, sowing etc.) as well as of underground loosening and their joint influence were observed.

Description of the experiments

The soil conservation experiments and observations were carried out on the pseudogleyic brown forest soil in Western Hungary and on the brown forest soil formed on the loess of Kisgörbő. In experiments on crops in rotation, we have regulary observed and examined: the quantity and intensity of precipitation, soil moisture and the quantity of runoff water, and eroded soil. The growth, yield and qualitative development of plants were studied. We propose to give a report on the role of deep-underground loosening by chisel upon which findings the co-operatives and state farms have achieved outstanding results (Városlőd, Kisgörbő, Szentgyörgyvölgy etc.).

Evaluation of the Results

The first experiments were made on brown pseudogleyic forest soils in Western Hungary. Here the water infiltration ability of the soil profile is very bad, because the structure of the top soil is bad and the clay content of the *B* horizon is large. Here an accumulation of stuck water occurs in the B horizont in autumn, which causes marbly gleyic plots in the clay. Table 1. and 2. show the results of these experiments. These Tables compare the data of yields and the percentage of soil erosion. The year 1960 was better for observation on soil conservation in comparison with 1959. There was more than 15 mm. preci-

pitation on 17 occasions and on 5 occasions 15 mm/hour rain intensity in 1959. In the year 1960 precipitation was above 10 mm. on 21 occasions, on 11 occasions ower 15 mm/hour rain intensity. Accordingly the results of these two years showed a considerable difference and made it possible to draw consequences.

The data of Table 1. plainly show the differences in erosion with methods of various cultivation. The soil erosion on maize plot was 9 times higher on a plainly cultivated plot than on deep-loosened fields. In spite of the more frequent and more intensive rains the erosion was only 7 times higher on

Table 1.

The march of yield and soil erosion with various cultivation methods on the pseudogleyic brown forest soils in Western Hungary

(1) Crop	(2) 60 cm deep loosening + disk		(3) Ploughing + underground loosening + disk		(4) Only disk cultivation	
	yield q/kh	erosion m³/kh	yield q/kh	erosion m³/kh	yield q/kh	erosion m³/kh
Maize for silage	147	0,69	124	1,0	82	5,5
Sudan grass	29	1,25	35	4,2	30	8,5

Kh = 1 catastral hold = 0,57 ha.

the Sudan grass plot. Although deep-loosening proved its preventing effect on erosion, pedological investigations and observations have definitely drawn our attention to the processes of water diverting drainage. The data in Table 2 show that higher moisture is present the whole year round when deep-loosening is applied, but in late autumn we can not only observe

Table 2.

The fluctuations of soil moisture with various cultivating methode on pseudogleyic brown-forest soils in Western Hungary

(1) Date and depth of sampledrawing cm		(2) 60 cm deep loosening + disk	(3) Ploughing + loosening + disk	(3) Only disk cultivation
April 30	0—10	18.56	19.24	19.41
	20—30	18.83	18.51	19.57
	40—50	17.91	19.11	19.00
June 8	0—10	17.63	18.00	17.00
	20—30	18.17	17.60	17.00
	40—50	18.00	17.15	16.20
November 24	0—10	26.94	25.85	26.64
	20—30	28.00	24.62	20.17
	40—50	30.80	24.30	20.93

higher soil moisture content, but even water stagnation. This supersaturated state hinders not only soil cultivation and sowing, but even deprives the soil of aeration. On those types of soils, where in the soil profile we find intensive layers of water-isolating accumulation horizon, supplementary drainage should be carried out, deep-loosening in itself is not sufficient.

While in West-Hungarian pseudogleyic slopy brown forest soil cultivation is not fully solved by deep-loosening in the brown forest soil formed on loess of Kisgörbő control is efficient by this single operation in the struggle against erosion. This should be attributed to the different pedological characters (see Tables 3 and 4).

Experiments on rotation combined with cultivation show that the amount of water run-off from the plot is in close connection with the individual treatments (Table 5). Irregular run-off is caused not only by precipitation intensity

Table 3.

The water resistance of the crumbs of the brown forest-soil formed on loess of Kisgörbő

(1) Depth of soil sampling cm	(2) Percentage of the water resistant soil crumbs		
	>1 mm	0.25–1 mm	total
0— 15	31.3	13.5	44.8
15— 20	16.0	22.3	38.3
20— 30	4.8	35.7	40.5
30— 45	9.5	43.8	53.3
45— 73	3.2	35.0	38.2
73— 90	3.4	28.3	31.7
90–100	15,2	15,2	30,4

Table 4.

The water permeability and porosity of the brown forest-soils formed on loess of Kisgörbő

(1) Depth of sampling. in cm	(2) Bulk density	(3) Volume weight	(4) Total porosity P %	(5) Capillar water holding capacyty volume %	(6) Capillar water holding capac.ty P%	(7) Total water capacity volume %	(8) Total water capacity P %	(9) Permeability* ml/min.
5—15	2.63	1.42	46,0	35,2	76,5	41,7	90,7	0,8
20—30	2.65	1.54	42,0	34,3	81,7	37,7	89,8	0,8
35—45	2.68	1.54	42,6	34,7	81,5	36,7	86,2	1,1
55—65	2.68	1.50	44.2	36.7	83.0	37.7	85.3	0.12
90—100	2.70	1.33	50,9	38,5	75,6	41,6	81,7	0,9

*On 18,08 cm² surface

Table 5.

The composition of experimental crop in rotation on the brown forest soils formed on loess of Kisgörbő

I. Clover with grass
Clover with grass
Potatoes
Autumn cereals

III. Autumn cereals
Autumn mixed fodder crops
Rape
Autumn cereals

II. Maize
Spring cereals
Sugar beet
Indian corn for silage

IV. Autumn mixed fodder crops + second crop
Summer cereals with red clover
Red clover
Potatoes

but by the structure, by the covering of the soil and last not least by the mode of cultivation.

The effect of the intensity of precipitation largely depends on the crumble consistence of the thin overlaying soil cover surface structure, the stability of the crumbs mostly showing their effect when the ground is uncovered. When soil sludges soon, deep-loosening does not greatly increase the water capacity (see Table 6, column 3). This fact allows us to conclude that deep underground loosening does not give the desired result, unless the soil structure is improved too. In this case the crumb forming role of perennial plants should be taken into consideration. The differences between the various erosion preventing effects of plants are conspicuous because various degrees of covering include the crumb

Table 6.

Erosional differences between crops in various cultivations on the brown forest soil on loess of Kisgörbő

(1) Mode of cultivation	(2) Clover with grass	(3) Maize	(4) Rape	(5) Cereals
Growing on slopy soil without deep loosening in contour cultivation	100	207	192	286
Growing on slopy soil without deep loosening cultivation down the slope	100	216	188	278
Growing on slopy soil with deep-loosening in contour cultivation	100	186	120	97
Growing on slopy soil deep-loosening with cultivation down the slope	100	164	138	177

Table 7.

Total results of the crop rotation experiment. Eroded water in percentage of the precipitation and percentage of caused erosion

(1) Mode of cultivation	(2) Rotation							
	I		II		III		IV	
	a)	*b)*	*a)*	*b)*	*a)*	*b)*	*a)*	*b)*
Contour cult. with deep loosening	100	100	100	100	100	100	100	100
Contour cult. without deep-loosening	134	117	223	189	103	108	178	164
Cultivation down the slope with deep loosening	163	120	146	135	51	101	98	114
Cultivation down the slope without deep-loosening	170	132	200	161	128	112	217	151

ruining effect of precipitation. So maize suffers more by rain drop erosion than rape or cereals (see Table 6). In generally it can be established that in perennial plants the water run-off is much higher than in row crops, especially at the beginning of rain, but the eroded soil quantity is the highest in uncovered maize. In the relation of crops to each other the effect of the individual operations is not so striking as it is when the rotation system is considered in general (Table 7).

If we take contour farming with deep-loosening cultivation for 100 then water run-off in the rotation as a whole, gives a visible evidence of the efficiency both of the direction in cultivation and deep underground loosening. The effect of deep loosening showed at its best in 1962, during the drought. There was no lack of water on the deep-loosened fields, while on the fields where deep-loosening was not applied the plants suffered by drought. Accordingly to this the yields were different.

Our crop rotation sytems are in this district: 1. After 50 per cent well protecting plants, poorly protecting potatoes and cereals. 2. Only poorly protecting plants. 3. Only autumn plants. 4. The rotation 1 improved for soil conservation.

The effect of the quantity of water run-off, as we can see, was considerably different in the various cultures. This considerable difference was noticable in the framework of crop rotation in percentage of eroded soil. Evaluating results obtained a close connection can be established between the characters of the plants of the crop rotation following each other and the deep loosening cultivation method and direction of cultivation. One would think, that a rotation of which 50 % is clover with grasses should prove to be the best protection against erosion. This is so as a matter of fact if we take contour cultivation into consideration. The growing of row crops (potatoes) may spoil the value of rotation in the case of cultivation down the slope. Considerable soilis erosion may be reckoned with even when deep underground loosening was not applied in contour cultivation. There is a favourable result in soil conservation when autumn crops are grown in rotation year by year. In this case the soil is always covered with plants and this adds considerably to the prevention of drop-erosion developments. Here it seems to be proved, that if rain-drop destroying effect does not arrise, crop rotation without deep-loosening considerably reduces erosion, when plants are sowed in contour row (III. rotation).

The effectiveness of deep-underground loosening can be increased mainly if we apply it at the right time. Deep-loosening is not effective, actually even harmful in rain or mud. It is therefore absolutely necessary to make use of the most favourable weather. This is after the harvest-time, when there are no considerable rains, and the splitting effect of the chisel is the best.

Summary

Soil conservation and cultivation trials were conducted on the pseudo-gleyic brown forest soils in West-Hungary. These soils are characterized by a very poor structure and by the presence of an unpermeable clay with glay patches in the layer B.

The losses of soil through erosion and the yields were assessed for different crops and methods of cultivation. It could be established that the loosening of the soil without turning was a very efficient method for controlling erosion. It could be also established that the loosening of the soil was occasionally without result if not coupled with drainage as the water accumulated in the soil caused anaerob conditions and hindered cultivation.

On brown forest soils with a good structure originated on loess West of the Lake Balaton it was established that the deep loosening without turning was always a successful measure of controlling soil erosion. In the case of cereals, potato and sugarbeet, the deep loosening as well as the tillage at right angles to the slope controlled the erosion, diminishing soil losses. In the case of red clover, deep loosening proved to be successful. Leguminous grass-mixtures and rape both prove to be very successful in controlling erosion without regard to the cultivation method adopted. In the case of widely spaced maize, soil erosion could hardly be controlled even by the best methods of cultivation. Four rotations were examined in the trials. Partly the deep loosening and the tillage at

right angles to the slope, partly the combination of the two methods were successful in controlling erosion. The combined application of both methods of cultivation is recommended as the most effective measure for controlling soil erosion.

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Influence du labourage du sol sur la protection des pentes

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Résumé

Les essais ont été conduits, en Hongrie occidentale, sur un sol pseudo-gley brun forestier à mauvaise structure dont l'horizon B contient de l'argile moins perméable, avec des tâches de gley.

Sur les parcelles des cultures différentes, labourées d'une façon variable, on a mesuré la quantité du sol érodé et les rendements. On a constaté que sur ces sols un labourage sans inversion à une profondeur de 60 cm protège bien le sol contre l'érosion. On a également constaté que cette méthode n'a pas toujours de succès sans drainage, parce que l'humidité accumulée dans le sol évoque des conditions anaérobiques et empêche le labourage.

Sur les sols bruns forestiers à bonne structure, formés au-dessus du loess à l'ouest du lac Balaton, on a constaté qu'un labourage profond sans inversion est toujours efficace contre l'érosion. Chez les céréales, la pomme de terre et la betterave à sucre, le labour profond et horizontal a également diminué l'érosion. Chez le trèfle violet, le labour profond était efficace. Les mélanges de légumineuses avec graminées ainsi que le colza ont bien empêché l'érosion, sans regard à la méthode du labourage. Chez le maïs semé à grandes distances, on a à peine réussi à réduire les effets de l'érosion, même en employant les méthodes convenables du labourage. On a examiné quatre assolements; ici, le labour profond ou le labour horizontal, et enfin, la combinaison de ces deux méthodes assurèrent une protection efficace contre l'érosion. C'est pourquoi le labour profond à 60 cm et le labour horizontal sont également recommendés comme méthodes bien efficaces de la protection du sol.

Tableau 1. Influence des diverses méthodes de cultivation sur les rendements et l'érosion du sol sur un sol brun forestier à pseudogley dans l'ouest de la Hongrie. (1) Plante. (2) Ameubli à 60 cm + hersage. (3) Labour + ameublissement du sous-sol + hersage. (4) Cultivé seulement à la herse.

Tableau 2. Fluctuations de l'humidité du sol sous l'influence des diverses méthodes de culture sur un sol brun à pseudogley dans l'ouest de la Hongrie. (1) Date et profondeur de la prise d'échantillon. (2) Ameubli à 60 cm + hersage. (3) Labour + ameublissement + hersage. (4) Cultivé seulement à la herse.

Tableau 3. Résistance à l'eau des grumeaux dans le sol brun forestier sur loess de Kisgörbő. (1) Profondeur de la prise d'échantillon. (2) Pourcentage des grumeaux résistant à l'eau.

Tableau 4. Perméabilité à l'eau et porosité du sol brun forestier sur loess de Kisgörbő. (1) Profondeur de la prise d'échantillon en cm. (2) Poids spécifique réel. (3) Poids spécifique apparent. (4) Porosité totale P%. (5) Capacité capillaire volume %.

(6) Pouvoir de retention de l'eau P%. (7) Volume capacité de l'eau total %. (8) Total Capacité de l'eau P%. (9) Permeabilité ml/min.

Tableau 5. Composition des plantes cultivées en rotation sur le sol brun forestier sur loess à Kisgörbő.

Tableau 6. Différences de l'érosion entre les cultures cultivées de différentes manières sur le sol brun forestier sur loess de Kisgörbő. (1) Forme de la cultivation. (2) Trèfle et herbes. (3) Maïs. (4) Betterave. (5) Céréales.

Tableau 7. Resultats des experiences de rotation; eaux érosives en pour cent des précipitiatons (a), et degré du pourcentage de l'érosion causée (b). (1) Façon de culture. (2) Rotation.

Der Einfluß der Bodenbearbeitung auf den Bodenschutz vom hügeligen Terrain

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Zusammenfassung

Es wurden Feldversuche an den braunen Pseudo-Gley-Waldböden von West-Ungarn unternommen. Diese Böden sind strukturlos und haben in der B-Schicht einen wasserdichten Ton mit Gley-Flecken.

Auf den Parzellen, die mit verschiedenen Kulturen bestellt und verschiedenartig bearbeitet wurden, wurden Bodenverlust und Erträge gemessen. Es konnte festgestellt werden, daß eine Tieflockerung bis zu 60 cm ohne Wendung einen effektiven Schutz gegen die Bodenerosion gewährleistete. Es konnte aber gleichzeitig festgestellt werden, daß die Tieflockerung allein, das heißt ohne Wasserabführung in einigen Fällen ungenügend wirken kann, da das im Boden angehäufte Wasser anaerobe Verhältnisse verursacht und auch die Bearbeitung hindert.

Bei den an Lößentstandenen braunen Waldböden westlich vom Balaton, die eine gute Struktur haben, konnte es festgestellt werden, daß die Tieflockerung ohne Wendung in jeder Zeit einen guten Schutz gegen die Erosion bietet. Bei Getreide, Kartoffel und Zuckerrübe hat die Tieflockerung ebenso wie die horizontale Bearbeitung den Bodenverlust vermindert. Beim Rotklee bewährte sich die Tieflockerung am besten. Kleegrasgemische und Raps haben sich als effektiver Schutz gegen Bodenverluste bewährt, ohne Hinsicht auf Bodenbearbeitungsmethoden. Beim Anbau von Mais auf größeren Standweiten konnte der Bodenverlust selbst mit den besten Bodenbearbeitungsmethoden kaum verhindert werden. Es wurden auch vier Fruchtfolgen untersucht. Nach den Ergebnissen hat sich teils die Tieflockerung, teils die horizontale Bearbeitung, teils die Kombination der beiden Methoden am besten bewährt. Auf diesem Grunde wird eine Lockerung bis 60 cm mit einer gleichzeitigen horizontalen Bearbeitung als das effektiveste Mittel zur Bekämpfung der Erosion empfohlen.

Tabelle 1. Die Bildung des Ertrages und die Bodenerosion bei verschiedenen Kulturmethoden auf den pseudogleyischen braunen Waldboden Westungarns. (1) Pflanze. (2) 60 cm tiefe Lockerung + Eggen. (3) Ackern + Untergrundlockerung + Eggen. (4) Nur Eggen.

Tabelle 2. Die Schwankungen des Feuchtigkeitsgehaltes des Bodens bei verschiedenen Kulturmethoden auf pseudogleyischem braunem Waldboden in Westungarn. (1) Zeitpunkt und Tiefe der Probeentnahme. (2) 60 cm tiefe Lockerung + Eggen. (3) Ackern + Lockerung + Eggen. (4) Nur Eggen.

Tabelle 3. Die Wasserresistenz der Krümel des braunen Waldbodens auf Löß von Kisgörbő. (1) Tiefe der Probenahme. (2) Prozentualer Anteil der wasserresistenten Bodenkrümel.

Tabelle 4. Wasserdurchlässigkeit und Porosität der braunen Waldböden auf Löß von Kisgörbő. (1) Tiefe der Probenahme in cm. (2) Spez. Gew. (3) Raumgewicht. (4) Gesamt P% Porosität. (5) Kapillarer Wasser Kapacität Volumen %. (6) Wasserhaltungsvermögen P%. (7) Maximale Wasserkapacität Volumen %. (8) Maximale Wasserkapazität P%. (9) Permeabilität ml/min.

Tabelle 5. Die Zusammensetzung der untersuchten Pflanzen in der Fruchtfolge im braunen Waldboden auf Löß von Kisgörbő.

Tabelle 6. Differenzen in der Erosion zwischen Pflanzen verschiedener Kultivation im braunen Waldboden auf Löß bei Kisgörbő. (1) Art der Kultivation. (2) Kleegras. (3) Mais. (4) Raps. (5) Getreide.

Tabelle 7. Gesamtresultate der Fruchtfolge Versuche. Erosionswassers im Perzenten des Niederschlages (a) und der prozentuelle Grad der herbeigeführten Erosion (b). (1) Art der Kultivation. (2) Fruchtfolge

Роль обработки почв в защите склонов от эрозии

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Резюме

В юго-восточной части Венгрии были заложены опыты на псевдоглеевой бурой лесной почве, имеющей плохую структуру и в горизонте «В» водонепроницаемую глину с глеевыми пятнами.

На различных делянках при разных обработках и разных растениях измеряли количество снесенной почвы, а также урожай растений. Установили, что на подобных почвах рыхление на 60 см. без оборота пласта является хорошим мероприятием по защите от эрозии. Установили так же, что упомянутый метод без дренажа не всегда дает положительные результаты т. к. избыток влаги в почве приводит к недостаточной аэрации.

На запада от озера Балатон на бурой лесной почве, образованной на лёссе, имеющей хорошую структуру, установили, что глубокое рыхление без оборота пласта всегда является эффективным мероприятием по борьбе с эрозией. При выращивании зерновых культур, картофеля и сахарной свеклы глубокое рыхление и горизонтальная обработка уменьшала эрозию. При выращивании клевера с травами и рапса, независмо от способа обработки, сами растения препятствовали развитию эрозии. При выращивании кукурузы с широким междурядьем, даже при правильной обработке почвы, эрозия не уменьшалась. Исследовали четыре разных севооборота в которых эффективными оказались в борьбе с эрозией отчасти глубокое рыхление, отчасти обработка по горизонталям, отчасти комбинация этих двух приёмов. Поэтому мы рекомендуем комбинацию этих двух мероприятий, а именно рыхление на 60 см. и обработку по горизоталям, как наиболее эффективные мероприятия по защите от эрозии.

Табл. 1. Урожайные данные и эрозия почв в зависимости от различных методов обработки. Псевдоглеевая бурая лесная почва в западной части Венгрии. (1) Урожай. (2) Рыхление на глубину 60 см + культивация. (3) Вспашка + подпочвенное рыхление + культивация. (4) Только культивация.

Табл. 2. Изменение содержания влажности почвы при разных способах обработки на псевдоглеевой бурой лесной почве восточной части Венгрии. (1) Дата и глубина взятия образца. (2) Рыхление на 60 см + культивация. (3) Вспашка + рыхление + культивация. (4) Только поверхностная обработка.

Табл. 3. Водопрочность почвенной структуры бурой лесной почвы, образованной на лёссе, из Кишгёбё. (1) Глубина взятия образца. (2) Водопрочность почвенных агрегатов в %.

Табл. 4. Водопроницаемость и порозность бурой лесной почвы, образованной на лёссе, из Кишгёбё. (1) Глубина взятия образца в см. (2) Уд. вес (3) Объемный вес. (4) Общая порозность в %. (5) Капиллярная влагоемкость в %. (6) Влагоемкость в % Р. (7) Максимальная влагоемкость в %. (8) Максимальная влагоемкость в % Р. (9) Водопроницаемость в мл/мин.

Табл. 5. Состав растений в ротации севооборота на бурой лесной почве, образованной на лёссе из Кишгёбё.

Табл. 6. Различно выраженная степень эрозии под разными культурами при различных методах обработки почвы. Почва бурая лесная на лессе из Кишгёбё. (1) Различные обработки почв. (2) Клевер с травами. (3) Кукуруза. (4) Рапс. (5) Зерновые.

Табл. 7. Количество воды из осадков в %, которое вызывает эрозию и степень эрозии в %. (1) Обработки. (2) Севообороты.