HYDROLOGICAL BEHAVIOUR OF SEALING UNDER DIFFERENT SOIL MANAGEMENT CONDITIONS IN THE CENTER SOUTH CORDOBA, ARGENTINA.

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The suceptibility of soils to form seals induced by rain depends on a combination of physical, chemical and biological processes, which are, indeed, affected by climatic characteristics and the type of soil.

If we consider the weather factors, the energy of rain, as a function of quantity and intensity, is the most important one. The soil properties that favor the formation of sealing are texture, organic matter content, structural stability and sodium adsorption relationship. Regarding texture, silt is the particle, which is most highly involved.

In central Argentina, specifically in the central southern region of Cordoba Province, the most representative soils show a low content of clays and a high content of silt and fine sand. This land has undergone different production systems, not only agricultural ones but also combined systems, as summer crops, with intense laboring and scarce, even lacking, stubble supply. Therefore these soils have had important losses in organic matter, degradation of the structure of the superficial horizons. This degradation is observed by the high quantity of aggregates presenting a little diameter (Data is available in other speech) as well as the important amount of dust. So that, the impact of rain drops showing certain intensity causes a break of those less stable aggregates which along with the free particles fit together in order to fill the inter-aggregate pore spaces and they also reduce the hydraulic conductivity as well as infiltration in a noticeable way. On the other hand, it is well known that seals have a high dynamism, that is to say that their porosity, thickness and hydraulic properties change as they develop.

It also has to be noticed that in the sub-humid areas, as the one we have studied, the rainfall distribution is related to the weather seasons. Rains begin once the seedling bed is prepared. Or rain start when crops show low height, which favor, the sealing processes.

It became necessary, then, to look for a combination of technologies leading to an energy input throughout conservation tillage systems, soil covering and agro-chemicals which tend to improve soil quality in order to obtain a sustainable production.

One of the researching works has as a main objective to conduct a temporal analysis about the influence of some technological factors on hydraulic conductivity on the superficial part of a Typical Hapludoll showing a very fine sandy loam texture. We have worked in a region located at 32º 57´South latitude and 64º 50´ West longitude. The mean annual temperatures range from 8-23ºC and the mean annual rainfall value is up to 850 mm. 80% of rainfalls take place during spring and summer. The natural vegetation belongs to an open forest, presenting caducous leaves trees, with inner grasslands. The relief is normally weavy, showing slopes of 3 to 4% gradient. The original material is a loessic sediment.

The trial was conducted on a production system. It began in August 1994. The production sequence that the production system followed was corn-corn-sunflower- corn-sunflower, they were planted according to the following factors: a) Two different topographic positions: medium high slope (**I**) and medium low slope (**II**). b) Under three different tillage systems: Conventional with moldboard plow (**CT**), minimum with chisel plow (**MT**) and non-tillage (**NT**). c) The after harvest the stubble were grassed by cattle (**G**) on the other hand, in 50 % of the plot no grassing was allowed during the trial years (**NG**) d) Two different fertilizer doses were studied: zero fertilization (**NF**) and fertilization of crops at the beginning of planting every years (**F**).

The trial was conducted by using a simple at-random design with two repetitions for each treatment. Only *in* **F** The initial saturated hydraulic conductivity (**Ksi**) (non-sealing condition) and the final hydraulic conductivity (**Ksf**) (sealing conditions) were determined in the superficial of soil in 2000, by means of a rain simulator using an intensity up to 50 mm/h for 60 minutes, and a kinetic energy of 0.1336 J.cm^2.
The **Ks** values obtained by applying Darcy´s equation were used to fit the exponential decay function Horton type which describes the **Ks** change as a function of the time of exposure to a simulated rain , this is:

$$Ks = Ksf + (Ksi-Ksf) \exp^{-at}$$

Where
t is time expressed as minutes and *a* was obtained for each of the treatments by solving of a minimum adjustment among the observed Ks values and the simulated till a regression coefficient higher to 70% was obtained.
In order to include the kinetic energy of rain, the exponential term was considered as the product of stability factor S (cm^2 J^{-1}) for the kinetic energy of rain E (Jcm^{-2}), ten, at= SE
The crusting hazard (or risk of sealing), (**R**)(Pieri, 1989 cited by Van der Watt and Valentin 1992) was used to relate the **Ksf** values with susceptibility indicators of sealing depending on soil characteristics. It is calculated as a relation among the following:

$$R(\%) = \frac{OM(\%)}{(\%clay + \%silt)} * 100$$

Where
OM% Is the organic matter content (%). %clay and % silt are the clay and silt contents respectively
The above mentioned author considered a **R** value of 5% to be of high a crusting hazard or sealing risk, while a value over 9% represents a low crusting hazard or sealing risk. They considered 7% to be the threshold value.
The quantity of superficial residues was estimated every year after grassing for each treatment. Results were statistically processed by using the General Lineal model and Kruskal-Walis´ non-parametric test, for a significance level of 95% with the SPSS software.
The studied variables were also evaluated on a site showing a minimum disturbance level at a relict area , which has natural vegetation, presents a relief condition similar to the trial sites and it shows a low use of soil (**MD**, **MDI** and **MDII**).
The following results were obtained:

Table 1

Hydraulic parameters of seals for the studied factors.

Factor	Level	Ksi (cm/h)	Ksf (cm/h)	S ($cm^2 J^{-1}$)
Position	I	1.72	0.78 a	83.63 a
	II	1.72	0.72 a	127.97 a
Grassing	NG	2.03	0.83 a	115.05 a
	G	1.46	0.66 a	96.55 a
Tillage	NT	2.32	0.87 a	157.49 a
	MT	2.28	0.75 ab	99.48 ab
	CT	0.64	0.62 b	60.42 b
Minimum Disturbance	MD	5.02	1.84 c	14.97 c

Interaction pasturing * tillage **at the 5% C.V. 17%
Differing letters are significantly different at the 5 % level

Table Nº 1 shows significant differences between **MD** and the treatments for the three studied parameters. **Ksi** and **Ksf** are the highest values, and S value is lower. This would mean a high stability and permeability of soils under natural condition.
There is also a significant difference between **NT** and **CT** regarding **Ksf** and S.

Table 2
Analysis of grassing* tillage interaction for Ki

Treatments	Ksi ($cm.h^{-1}$)
NT NG	3.24 a
MT G	2.35 b
MT NG	2.21 b
NT G	1.40 c
CT NG	0.66 d
CT G	0.62 d

Differing letters are significantly different at the 5 % level, by LSD.

The interaction effect between tillage and grassing was shown in **NT**, because this system shows a decay of **Ksi** when stubble is removed. This could be caused by a lower input of organic matter and the cattle trampling which produce a higher sealing of the superficial soil. This interaction does not show in **MT** because the minimum laboring would balance the beneficial effects of stubble, that is to say, that the effect of cattle grassing would be compensate by the minimum laboring on this site.

On the other hand, the intense laboring as in conventional tillage, with the total stubble buried presents a marked decreasement of **Ks**.

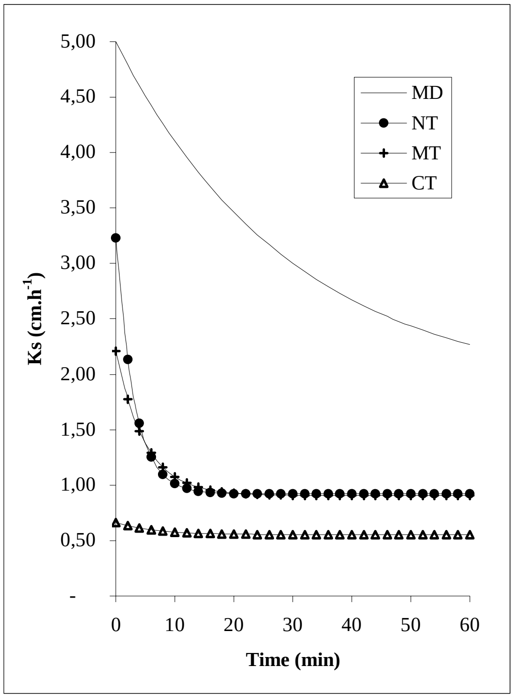

Figure 1: Saturated Hydraulic Conductivity in non grassing

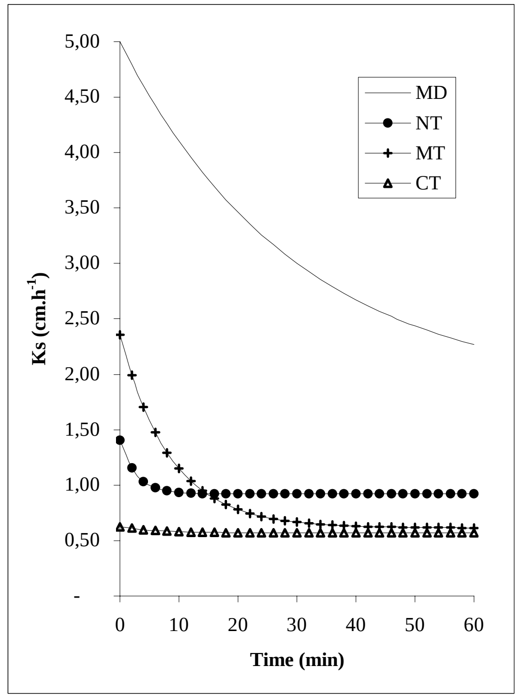

Figure 2: Saturated Hydraulic Conductivity in grassing

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It can be observed in both figures that **Ks** from **MD** is higher from the rest. Besides, its S coefficient is the lowest (See Table Nº 1) , This would state this treatment as one showing resulting in the highest stability. By comparing the resting treatments it can be seen how the **NT** and **MT** non-grassing condition (Fig 1) keep an initial and final conductivity higher than **CT**. This would indicate that even thought a seal is formed, the **Ksf** is higher in the first two treatments. Given S parameter as the one that explain the curve shape , and as it has been considered as an stability factor, those treatments which are likely to be the less stable (**NT** and **MT**) due to their high S value are the ones showing a higher **Ksi** and a higher **Ksf**.

On the other hand, the lowest S value is obtained by the treatment **CT**, whose **Ks** does not change by the effect of simulated rain. this could be attributed to a permanent sealing of soils. For this reason, we consider s to be non-appropriated for the studied condition.

It can be seen in **G** (Fig 2) that even **MT** has the highest **Ksi** it is sealed at a **Ksf** value lower than **NT**, that means a less permeable seal, similar to **CT**.

After analyzing different indicators of stability, the Risk of Sealing (**R**) was selected as the one that best express the soil susceptibility to sealing, due to a higher adjustment (R^2:0.69) between **Ksf** and **R** (Fig. 3).

It should also be noticed that **MD** obtained a 13.5% value which indicates a really low sealing susceptibility, this could be explained by the high content of organic matter, which is up to 7%. The resting treatments had a crusting hazard of 5%.

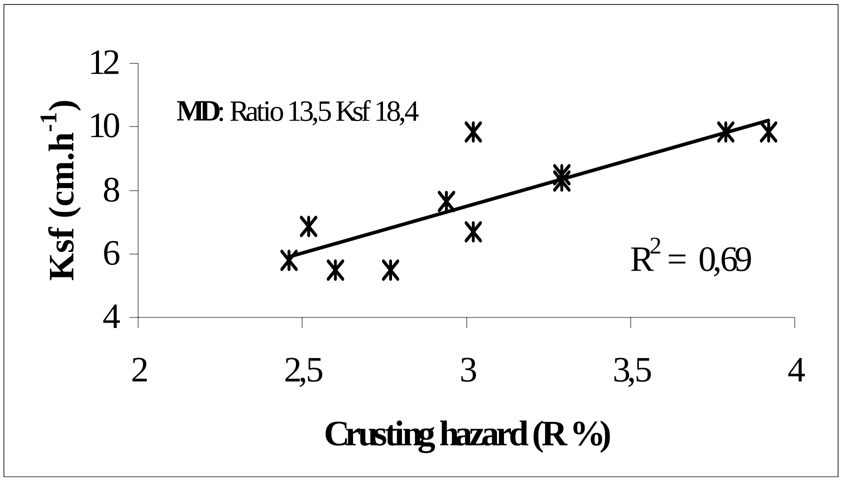

Figure 3: Relation between Ksf and Crusting hazard (R).

It can be concluded that the remotion of natural vegetation and crop systems have produced a decreasement on **Ksi** and **Ksf** up to 87 % and 66 % respectively on soil surface. This means that there is an important amount of water that is not available for crop production. Besides, the erosion processes associated with run-off.

The amount of stubble and conservationist tillages cause an increase on **Ks** of seal which is a 70 % higher than **CT**. However, this conductivity is much further from the conductivity of **MD**.

In the soils that we have studied, which show a high content of skeleton particles, a little increase of organic matter could lead to a re-arrangement of those soil particles with higher porosity. Therefore, a more permeable seal will be formed.

Commentary: There are other variables being analyzed in this production system along the time: Organic matter fraction. Compactibility. Pore distribution according to size and characteristic wetness curve. Simulation on non saturated hydrologic conductivity, and calculations of the continuity index by pore classes. We hope to be able to state change rates through the evolution of the studied indicators. These change rates will help us to obtain a monitoring of soil quality along the time.