"Influence of no tillage on soil carbon storage and the erosion risks in southern Latin America"

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Abstract

No tillage (NT) practices can improve soil aggregation and change the distribution and retention of soil organic matter; on the other hand, the increase in surface cover can prevent soil erosion processes and decrease the amount of sediment in runnoff. In Southern Latin America, a sustained increase in NT practices in a extended region were observed last years; the expectations with regard to their impact on several aspects of the soil conservation begin to be responded.

The information contributed by different sources from Brazil, Chile, Uruguay and Argentina was analyzed, in order to clarify the effects of the NT on the soil organic carbon content, the soil loss and needs for future research.

In general, it was observed that in NT, the content of organic carbon increase in surface, especially in the range of 0 to 5 centimeters. Despite of the high differences from textures, environmental conditions and crop rotations, the total contents of carbon under NT were up to 40 g kg^{-1} in Brasil, from 20g kg^{-1} to 32 g kg^{-1} in Argentina, and from 13,3 to 28,6 g kg^{-1} in Uruguay. Some reports informs values from 112 to 158 g kg^{-1} in Chile, probably due to the vulcanic soils origen, the lower temperature and higher humidity than the others.

The NT influence on soil water storage seems agree with the general idea; the infiltration rate in NT is greater than in conventional tillage (CT), but some reports found that the chisel plow was the most effective treatment. The increases are variable from 12 percent up to 60 percent and in some cases, researchers have been observed that the increase in soil compaction caused by NT, conditioned the efficiency of this practice.

Soil losses by water erosion were reduced with NT in all cases; the reports confirm decreases from 23 to 5.6 Mg ha^{-1} yr in Brasil, from 37 to 5.7 Mg ha^{-1} yr or from 3,9

to 0,6 Mg ha^{-1} yr^{-1} in Uruguay, and from 22 Mg ha^{-1} yr^{-1} to 6 Mg ha^{-1} yr^{-1} or from 1,8 to 0.5 Mg ha^{-1} yr^{-1} in Argentina; the diferences were due to crop sequences or crop meadows rotation and soil characteristics in the countries.

The interactions between slopes and cover degree could produce uncertainty in model response; in Brasil, with rain simulators, the reports mentioned soil losses of 7 $Mg.ha^{-1}$ in CT, and 2,4 $Mg.ha^{-1}$ in NT, with slopes of 10 % . However, with slopes of 3% others researchers found that the soil losses were 6,2 $Mg.ha^{-1}$ in CT and 0,78 $Mg.ha^{-1}$ in NT. In Chile, with slopes of 12%, the soil losses were 6,6 to 4,9 $Mg.ha^{-1}$ in CT and 1,1 to 0,7 $Mg.ha^{-1}$for NT.

Similar results were observed in Uruguay , with 9,9 $Mg.ha^{-1}$ in CT and 0,6 $Mg.ha^{-1}$for NT with slopes of 2 at 4%, and in Argentina, with slopes of 1,25 to 2,5 % , the soil losses were 6,7 $Mg.ha^{-1}$ for CT and 0,8 $Mg.ha^{-1}$ in NT .

In spite of the diverse treatments and soils involved, the enrichment rate in organic carbon content that was measured in Uruguay, changed of 1,9 to 0,94 and in Argentina it was of 2 to 0,5. The situation is not clear about the sediment delivery and their enrichment rate due to shortage of data, and there are discrepancies with regard to the efficacy in the control of colloidal particles.

Influence du non travail du sol sur l'accumulation du carbone dans le sol, et le risque d'erosion dans la region sud de l'Amerique du Sud

Les pratiques de non travail du sol (NT) peuvent améliorer l'agrégation de sol et changent la distribution et la rétention de la matière organique, en plus, la coverture superficiel peut contrôler l'érosion de sol et diminuer la quantité des sédiments et le ruissellement.

On observe une augmentation des pratiques de NT, dans les derniers ans. Dans ce travail on analyse l'information de la recherche au Brésil, au Chili, en Uruguay et en Argentine,Les objectifs sont d'observer l'effet de NT sur le carbone organique, les pertes de sol dans la région et aussi déterminer la nécessité de futures recherches.

En général on a observé une augmentation du carbone organique dans les surfaces des sols avec NT, jusque 40 g kg^{-1} au Brésil, entre 20 g kg^{-1} et 32 g kg^{-1} en Argentine, et entre 13,3 g kg^{-1} et 28,6 g kg^{-1} en Uruguay. Au Chili quelques études donnent des quantités de 112 g kg^{-1} à 158 g kg^{-1} .Ceci peut s'expliquer par l'origine volcanique de ces sols, la température basse et l'humidité plus grande.

L'infiltration de l'eau dans les sols montre une tendance similaire avec l'idée générale l'infiltration est plus grande dans NT qu'avec un travail conventionel (TC), mais l'utilization du chisel produit un meilleur effet; l'augmentation de l'infiltration avec le chisel est variable, de 60% à 12%. En plus, dans quelques sols les chercheurs ont vu une compactation et une diminution de l'efficacité en raison des pratiques de NT.

Le NT diminue les pertes de sol produit pour l'érosion de l'eau dans tous les cas. On a vu, dans 1 an, diminutions de 23 Mg ha^{-1} à 5.6 Mg ha^{-1} au Brésil, de 37 Mg ha^{-1} à 5.7 Mg ha^{-1} ou bien de 3.9 Mg ha^{-1} à 0.6 Mg ha^{-1} en Uruguay et de 22 Mg ha^{-1} à 6 Mg ha^{-1} et de 1.8 Mg ha^{-1} à 0.5 Mg ha^{-1} en Argentine. Les différences proviennent des rotations des cultures avec prairies et les caractéristiques des sols dans les pays.

L'interaction entre la pente et la couverture peut produire une incertitude dans la réponse du modèle. Au Brésil, sous pluie simulée, les chercheurs trouvent des pertes de sol de 7 Mg ha^{-1} dans TC, et 2,4 $Mg.ha^{-1}$ dans NT avec pentes de 10 %.

Cependant avec pentes de 3 %, autres chercheurs informent pertes de sol de 6.2 Mg ha^{-1} dans TC et 0.78 Mg ha^{-1} dans NT. Au Chili avec pentes de 12 % les pertes de sol ont varié de 6.6 Mg ha^{-1} à 4.9 Mg ha^{-1} dans TC et de 1.1 Mg ha^{-1} à 0.7 Mg ha^{-1} dans NT. On a trouvé similaire résultat au Uruguay: pertes de 9.9 Mg ha^{-1} dans TC et de 0.6 Mg ha^{-1} dans NT avec pentes de 2 à 4 %. Et en Argentine avec pentes de 1.25 à 2.5 %, les pertes sont 6.7 Mg ha^{-1} dans TC et 0.8 Mg ha^{-1} dans NT

Quoique les tratements et sols sont divers l'EROC en Uruguay a changé de 1.9 à 0.94 et en Argentine de 2 á 0.5. La situation n'est pas claire avec le transport du sédiment et le taux d'enrichissement, à cause de l'absence de données régionales, et les divergences avec l'efficacité de NT sur le contrôl du mouvement du colloides

1. Introduction

Many reports has found No Tillage produce increase in soil organic carbon (SOC) and others important advantages in soil functioning, such as water holding, infiltration rate, porous system, water stable aggregates, and so on. However, other reports has mentioned that in some cases, the advantages are not higher than other conservation tillage systems.

In this present review, papers from different sources were consulted in order to obtain results related with the effect of No tillage (NT) comparing with Conventional Tillage (CT) and other conservation tillage, when they are available.

2. Influence on soil organic carbon

SOC is the most common soil parameter measured when the tillage systems had been compared; in order to permit the analysis between diverse situations in different countries, the data were displayed at respect to the soil texture, and data from each country were drawing in separated form.

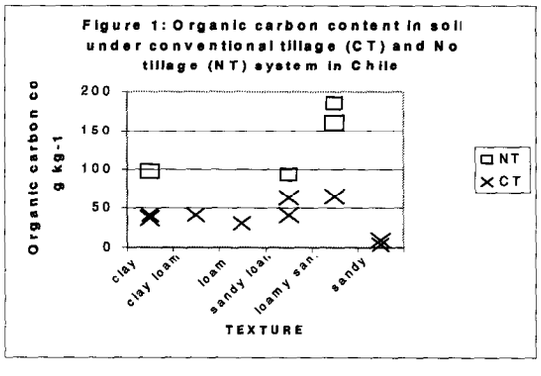
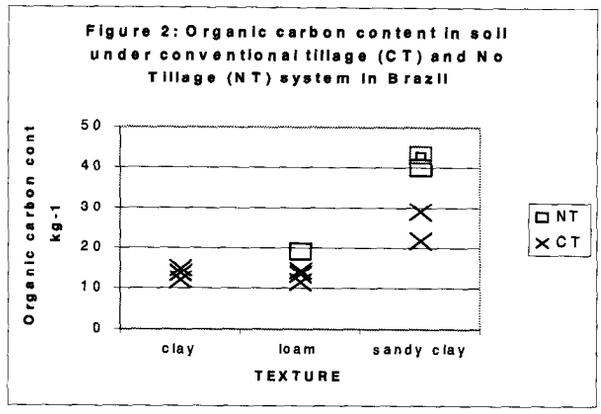
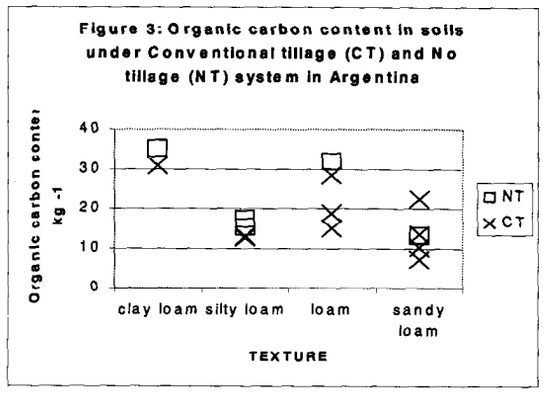


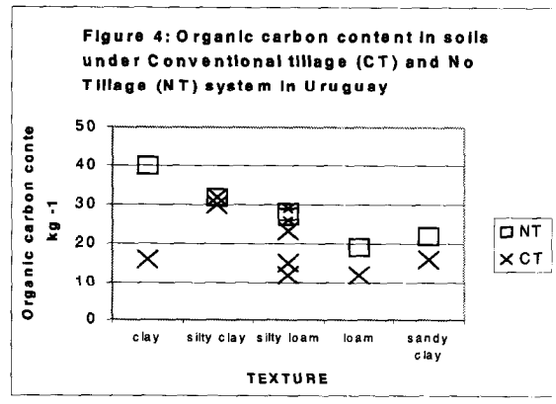
Figure 1 shows the results of SOC content in two tillage systems, from data of Chile researchers (Aguilera, et al., 1996; Aguilera et al., 1999; Alvear et al, 1999; Echeverría et al, 1999; Koch et al., 1999; Valenzuela, et al., 1999). The trend seems agree with the situation mentionated formerly, and Soils under NT have more OC than under CT. Nevertheless, by comparing data among different soil textures we can observe that the increases produced by NT are very different from each other and we could not ignore this interaction .

When we observed the data from Brazil (Figure 2), NT system has produced more SOC than CT (Andrioli et al.,1996; Beutler et al., 1996; D´Andrea et al., 1999; Martins y Nunes Gonçalves, 1996; Neto et al., 1996; Naves Silva, 2002; Neves et al., 2002; Venzke Filho et al., 1999; Venzke Filho, 2002) but the variability between data is very high, maybe because the SOC can be influenced by rotation, crops, residue kind and other interactions.



Data from Argentina and Uruguay (Figure 3 and 4, respectively) confirm the mentionated effect of NT on SOC in soil surface, but again, a variability in SOC content within textures is remarked (Arzeno y Corvalán, 2000;Bergh, 2001; Bergh et al., 2002; Bricchi et al., 2002; Corbella et al ., 2000; Cosentino et al ., 1999; Fontanetto y Vivas, 2001; García et al, 1999; Michelena et al., 1996; Quiroga et al., 2001; Sánchez, et al., 2001; Taboada y Micucci, 2002)



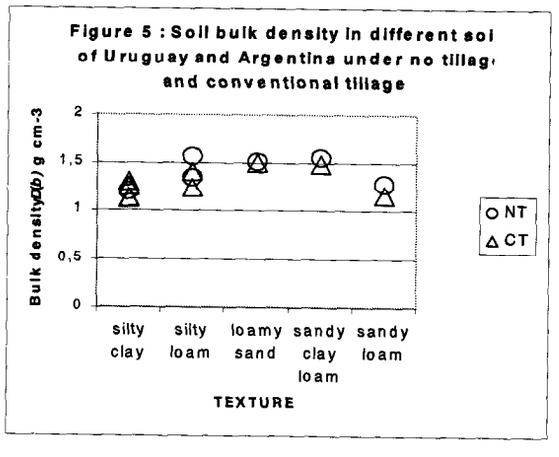


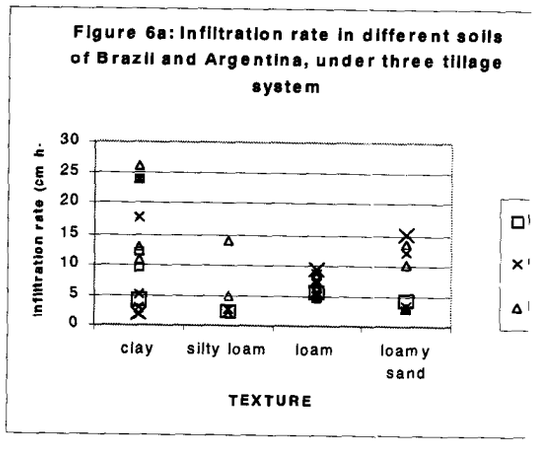
In addition, Figure 3 shows an inverse tendency between SOC content and sand content in soils; apparently in Uruguay soils the same situation could occur.

1.2 Influence on soil bulk density, infiltration rate and water storage

Figure 5 includes data from all countries with respect to the effect on soil bulk density (Arzeno et al., 2000; Beutler et al.,1996; Bricchi et al., 2000; Da Cunha Medeiros, et al., 1999; Gesumaría et al., 1999; Fontanetto y Vivas, 2001; García et al., 1999; Quiroga et al., 2001; Mestelan et al., 2002; Sanzano et al., 1999; Sánchez et al., 2001; Taboada y Micucci, 2002; Urchei et al., 1999; Valenzuela y Wilson, 2002). We can observe that NT tends to increase soil surface bulk density; a interesting observation is the lack of relationship with soil texture. No more data are available about it, and the razon for this behavior is not clear.

Infiltration rate data from Brazil and Argentina (Barcelos et al., 1996; Becker et al 2002; Bricchi et al., 1999; De Freitas et al., 1996; Fontanetto y Vivas, 2001; Formia et al, 1999; Gesumaría et al., 1999; Lucarelli, et al., 1999; Marelli, 2001; Roloff et al., 1996; Urchei et al., 1999) are shown in Figure 6a and the dissimilarity in values could explain why a dissagrement subsist at respect to the influence on different tillages system on infiltration rate.





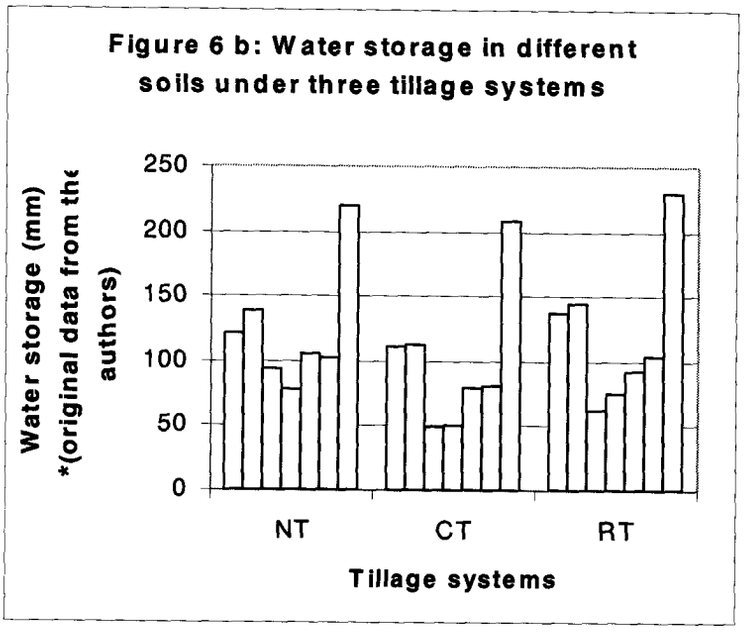
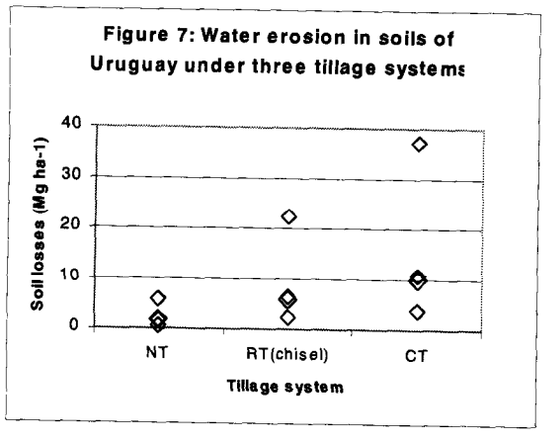
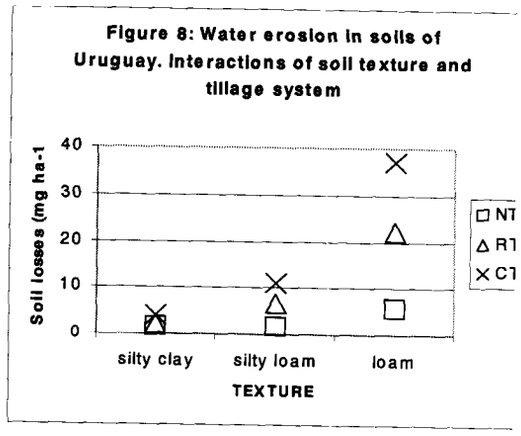


Figure 6 b includes water storage, and shows a little increase in this parameter in NT with respect to CT and when we observe Chisel plow tillage (RT), this seems to be more effective than the others (Bricchi et al ., 1999; Gesumaría et al ., 1999; Barcelos et al., 1996; Fontanetto y Vivas, 2001; De Freitas et al ., 1996; Marelli, 2001; Bergh, 2001). The higher water storage in NT than in CT could be due to both, the posible enhancement porous system maintenance and the protective effect of the residue cover.
Nevertheless, the high increase in SOC from NT systems do not seems to be translate enterely through the soil in order to enhance it better funtionality.

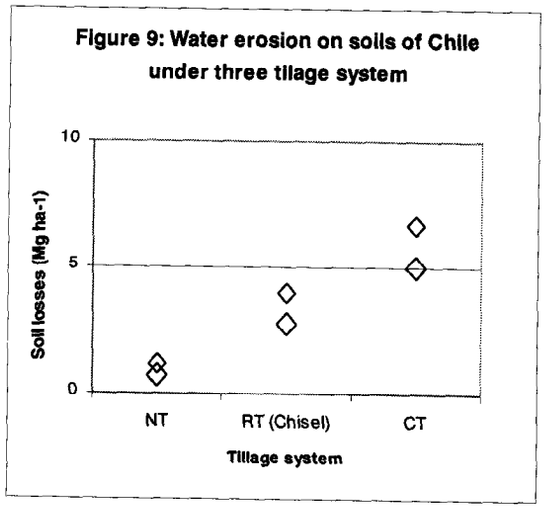
1.3 Influence on soil losses by erosion, sediment concentration and enrichment rate

In Figure 7 we can observe the decreasing in soil losses produced by NT by comparison with CT (Garcia Préchac et al.,1999, Clerici y Del Pino, 1999 , Celana y Martino 1999; Victora et al., 1999); in spite of in water erosion, we would expect the production of more losses when the silt percentage increase, NT system reduce the losses at the same level in all cases; by comparing Figure 7 and Figure 8, the data show that in Uruguay soils, the interactions between tillage and soil texture can avoid the efficiency of tillage practices.





The same analysis shows that in Chile (Figure 9 and 10) the losses are more associated with slope, but NT can reduced them (Gaete et al., 1999; Sepúlveda et al., 1999; Etcheverría et al., 1999). It is important to observe that this slope degree is not common in the rest of the countries, and for that, we cannot compare them.



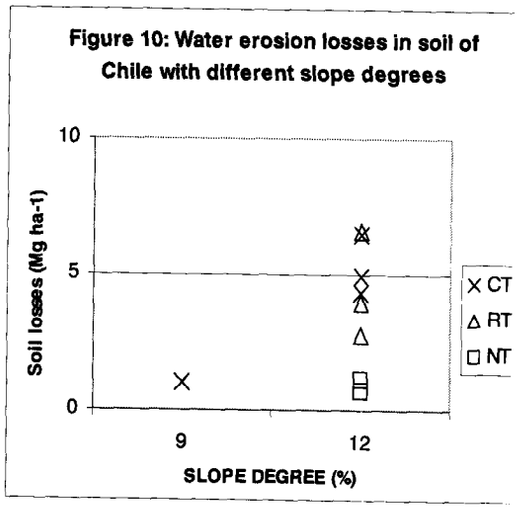
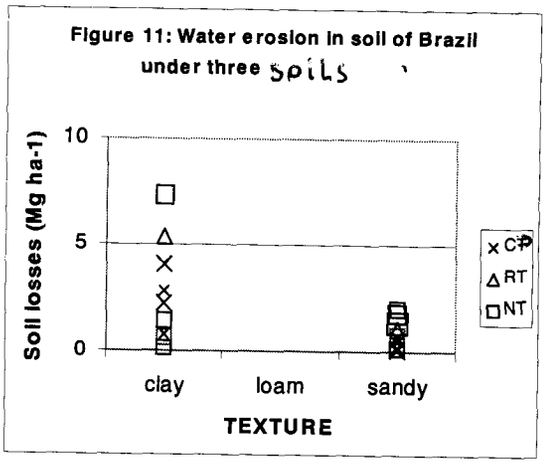
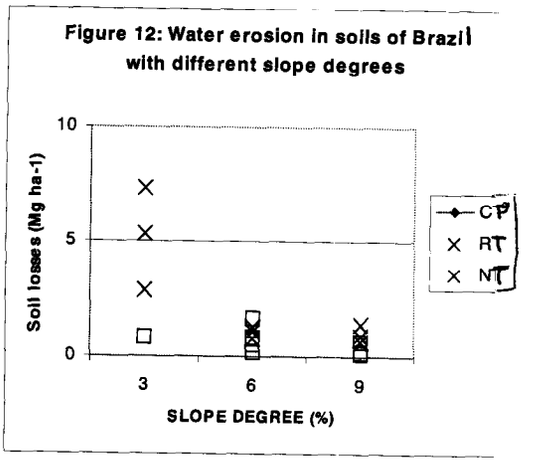


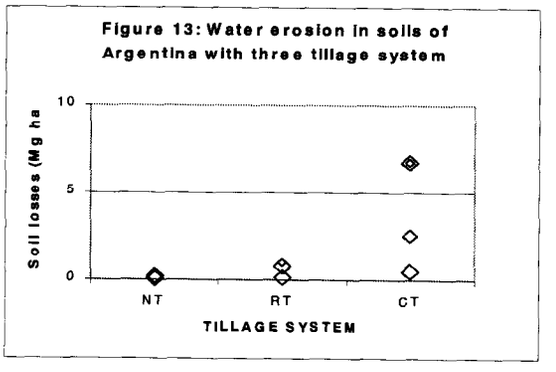
Figure 11 and 12 support the formerly observation relative to the NT decrease soil water erosion, but at the same level of losses, aproximately between 0,2 to 1 ton ha^{-1} (Hernani, et al., 1999; Fiorin et al., 1996; Barcelos et al., 1996; Beutler, et al.,1996) Figure 12 confirms that soil losses apparently do not depend on slope degree.

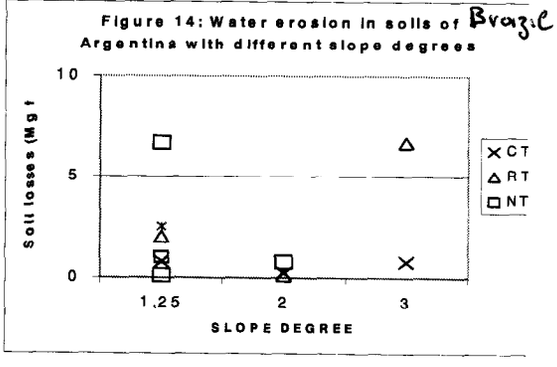




Data from Argentina (Figura 13) (Marelli, 2002; Marelli y Arce, 2001; Marelli, 2001; Rienzi y Kvuolek; Rienzi y Sanzano, 2002 ; Fontanetto y Vivas, 2001; Becker, 2002 Bricchi, et al., 1999; Michelena et al., 2002) shows that other systems such as chisel plow can reduce soil erosion too, and soil losses in NT tend to stabilize at similar values than in other countries in this region. In Figure 13 we do not see a trend between soil losses and slope degree, maybe due to the analysis only included similar slopes degrees, and not higher than 4 %. Probably in this situation, soil losses could be more influenced by aggregate stability and crops sequence.

The environmental consequences of sediments concentration in the runoff are other important aspects of soil erosion (Rienzi, Kvuolek, 2001; Rienzi y Sanzano, 2002); Figure 14 combine data for Brazil and Argentina, (Marelli, 2001; Becker et al 2002; Beutler et al 1999) and in spite of different climate conditions, crops sequences, slopes degree and soil characteristics, the sediments concentration are similar. This observations could





imply the similarity about mechanism of soil erosion in all places. That situation can be utilized in order to avoid lack of data and to ajust prediction models.

Moreover, figure 15 shows that the enrichment rates in sediment organic carbon from Uruguay and Argentina (Clerici y Del Pino, 1999; Victora et al., 1999; Marelli y Arce 2002; Marelli, 2002; Rienzi y Kvuolek, 2001; Rienzi y Sanzano, 2002) are very closed too, which support the idea that NT could have similar consequences on soil erosion, and this relationship (EROC) apparently is not influenced by soil texture.

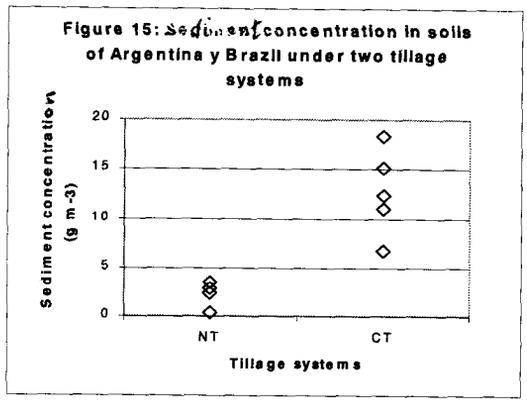


Figure 15: Sediment concentration in soils of Argentina y Brazil under two tillage systems

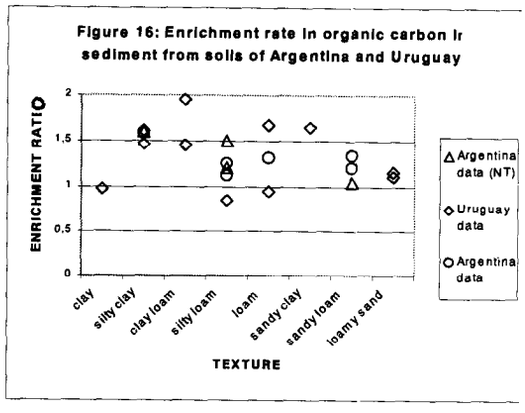


Figure 16: Enrichment rate in organic carbon ir sediment from soils of Argentina and Uruguay

Cover influence seems to maintain EROC higher than 1 and sediments concentration lower than 5 g L^{-1} If the selectivity mechanism observed in different reports (Rienzi y Kvuolek, 2001; Rienzi y Sanzano, 2002), changes the soil erosion process to high quantity of colloidal particles, the qualitative change for the use of NT could arise environmental consequences.

The research should focus on the movement of colloidal particles, not only by the possible losses of organic carbon in the sediment, but for their capacity in order to carry on nocive sustances.

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