SOIL PRODUCTIVITY FROM THE SANDY PAMPAS REGION UNDER THE PRESENT AGRICULTURAL CONDITIONS

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Abstract

During the last decade, major changes in the organization, extension and intensification of the agricultural systems from the sandy pampas region are observed. Crop production is mostly performed under continuous zero tillage and with the application of fertilizers. In this region, strong relationships between crop yields and soil properties, mostly related to water and nutrient storage, have been described. The purpose of this presentation is to discuss, supported by specific local long-term field trials, about several of the changes in the productivity of the soils of the region under the present management practices. Soil organic matter levels decrease under continuous tillage practices after systems with pastures. But, the application of zero tillage practices contributed to maintain the original soil productivity properties. Production systems established on degraded soils frequently show less water use efficiency, mainly when are cropped with maize (*Zea mays* L.). The establishment of continuous fertilization programs based on the sufficiency for low mobility nutrients (e.g. Phosphorus) shows reduction in the soil extractable levels of the nutrient and lower mean crop production compared with maintenance fertilization programs. The use of winter cover crops in soybean [*Glycine max* (L.) Merrill] monoculture enhances physical soil properties without benefits on crop yields. The crop and soil management practices widely performed during this period have contributed to the soil conservation and to the water use efficiency. However, the application of sufficiency fertilization programs could conduct to the reduction in the levels of soil extractable nutrients and in crop productivity. The present agricultural land use in the region requires to intensify in the use of indexes for the diagnosis of soils productivity independently of the actual relationships with today`s yields. The delimitation of homogeneous areas for the application of efficient soil management practices is needed for the conservation and enhancement of soils productivity capability.

Introduction

The pampas region is an extended plain laying in the central part of Argentina divided in sub-regions depending on the water balance and the soil quality. In the subhumid-semiarid sub-region, towards the central part of the pampas, is the sandy pampas area (1). The weather is temperate with adequate to low rainfalls to support the normal productivity of grain and oil crops. However, during the last decades of the XX century an increase in the rainfalls during the summer is described and consequently, the duration and the frequency of negative water balance is reduced (2). At the same time, changes in the organization of the main agricultural production systems in the central and in the western part of the pampas region are observed.

The traditional agricultural systems considered crop sequences in rotation with pastures for livestock production. It changed to independent production systems with agricultural practices without pastures in rotation isolated from livestock production systems partially under pastures. Today, approximately 85 % of cropland in the sandy pampas region is under annual grain or oil crops production practices and most of the livestock for calves' production is performed in low productivity soils (3). Almost 30 % of the agricultural land is cultivated with the maize (*Zea mays* L.) and the rest of the area is under soybean [*Glycine max* (L.)

Merrill] or sunflower (*Helianthus annus* L.) crops (3). The expansion in the area under agriculture was also accompanied with the increase only in the maximum attainable yields of the crops (Figure 1). The stability in the mean yields is partially explained for the expansion of the cropland towards low productivity soils. These changes in the production systems were described not only in terms of the area under annual crops but also in terms of the intensification of the agricultural practices, mostly under zero tillage and and the increase in the use of fertilizers. For example, in the CREA group "America" the area under zero tillage crops grew from 67 % to 93 % from 2000 to 2010, respectively. In the same period, the use of fertilizers also grew from 17 to 46 % (Duarte, *com. pers.*).

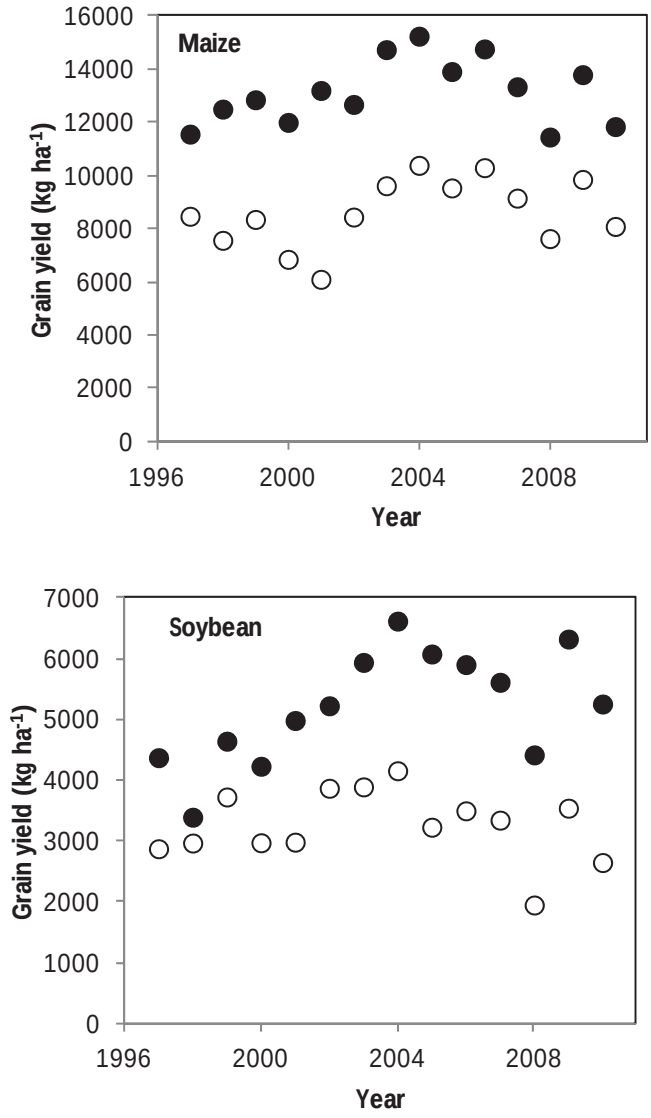

Figure 1: Mean (open circles) and maximum (closed circles) grain yields of maize or soybean in farms from the CREA group "America" in the sandy pampas (Trasmonte, *com. pers.*).

In the sandy pampas, direct and strong relationships between grain yields and soil properties related with the water storage capacity and nutrient availability (ex. soil organic matter) have been described (4). In the semiarid and subhumid regions, abundant studies show that crop management under zero tillage practices contributes to the soil organic matter conservation and it creates its stratification as well as nutrients like phosphorus (5).
The objective of this article is to present and to discuss, based on specific field trials, several of the changes in the productivity of soils from the sandy pampas region under the present agricultural practices in the region.

Tillage effects on soil properties and crop productiviy

Long-term field trials comparing different soil tillage practices applied after pasture show that continuous moldboard tillage operations reduces the soil organic matter levels but the use of zero tillage practices contributes it maintenance (6). The difference in soil organic matter between tilled and no-tilled production systems compared with the original fescue (*Festuca arundinacea* L.) pasture, 12 and 5 % lower respectively was maintained after 10 years of continuous zero tillage practices. However, the soil organic matter stratification indices changed overtime getting similar values to the zero tillage treatments independently of the original soil degradation conditions (Table 1).

Table 1: Mean soil organic matter (SOM), Bray 1 extractable phoshorus (Pe) and water pH levels and SOM stratification indices (OMSI) in a Typic Hapludol (0 to 20 cm depth) under different soil management practices during 12 years [A, from (6)] and after agricultural production under zero tillage (AZT) during 10 years [B, from (7)]. FP = Fescue pasture, AMT = Agriculture under moldboard tillage.

	Moment of evaluation							
	A	B	A	B	A	B	A	B
	---- OMSI ----		---- SOM (g kg^{-1}) ----		---- Pe (mg kg^{-1}) ----		---- pH ----	
FP	2.22	1.93	28	27	11.0	14.8	6.0	5.9
AZT	1.81	1.88	27	25	11.1	14.3	6.0	5.9
AMT	1.41	1.73	25	23	13.1	13.4	6.0	5.9

The agricultural production practices under zero tillage helped to the conservation of the original soil fertility and productivity capability. The production systems established on degraded soils after intensive tillage operations show smaller water use efficiency under favorable rainfall conditions, mainly when are cropped with maize (8).
Actual studies evaluate some of the soil properties that explain these differences in crop yields. For example, the establishment of cropping systems with increasing amounts of soil residue cover base on the cultivation of winter cereals as cover crops in continuous soybean sequences shows greater changes in soil physical properties compared with changes in crop productivity. The effects of changes in the soil management practices (i.e. tillage and fertilization) on the microbial communities and in the mineralization and dissipation of agrochemicals are under evaluation. The purpose of these studies is to support the better soil management practices for the development of sustainable agricultural systems in the fragile semiarid and subhumid environments of the pampas region.

Soil fertility changes and fertilization practices

The frequent application of fertilization practices based on sufficiency models for the recommendation of the application rates for soil low mobile nutrients (ex. Phosphorus) conducts to the reduction in the soil extractable levels and also to a lower soil productivity compared with soil under fertilization practices based on the maintenance approach (9). This behavior was also observed after the analysis of the evolution of soil extractable phosphorus levels during the last 3 decades. From late in the ´70s until almost mid ´90s the apparent reduction in the soil extractable P levels was smaller than

during the following 10 years (Figure 2). The greater reduction in the apparent reduction in soil extractable levels is partially justified to the establishment of almost continuous and intensive agricultural practices without phosphorus fertilization and consequently with a greater extraction than the previous predominant production system based on the crop rotation with pastures for grazing, also almost without phosphorus fertilization. In the present, the increase in the frequency of phosphorus fertilized crops in the sandy pampas region contributes to the apparent maintenance of the soil extractable phosphorus levels.

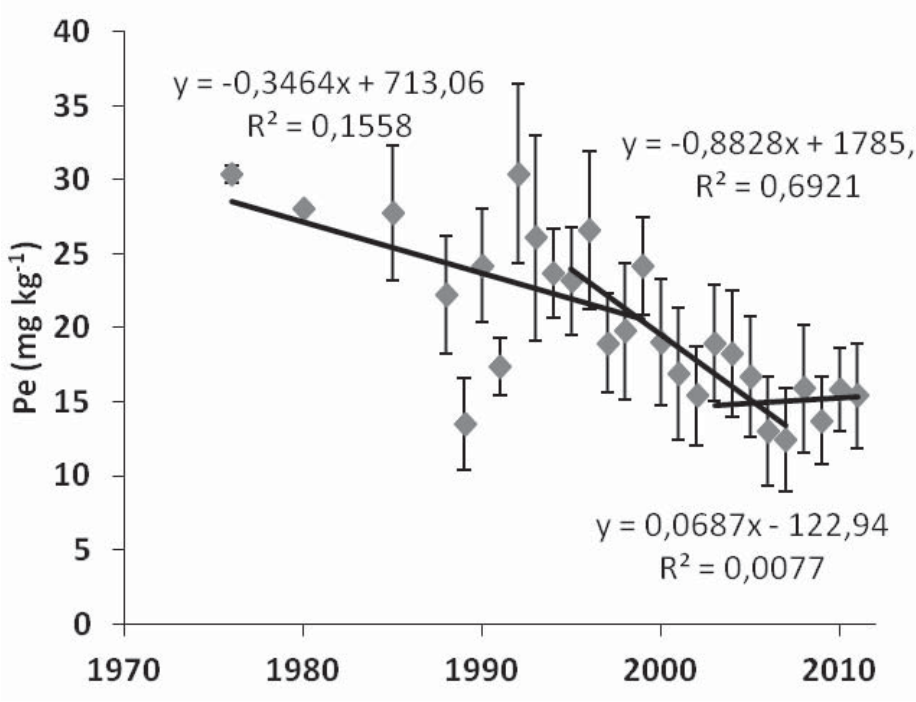

Figure 2: Soil extractable phosphorous levels (Bray Kurtz 1 methodology) in agricultural soils from the sandy pampas region. Based on 6125 soil samples from the 0 to 20 cm layer (DíazZorita *et al.* not published).

Conclusions

In the sandy pampas region, the adopted soil and crop management practices for the development of the present intensive agricultural production systems contributed to the soil conservation, mainly in terms of its water use efficiency. However, the generalized use of fertilization practices based on the sufficiency approach is conducting to the slow but continuous reduction in the levels of several soil nutrients, in crops productivity and the system profitability. The results of these soil management studies suggest that the intensive agricultural use requires the intensification in the use of soil productivity indices and its evolution independently of their present relationship with crop productivity. Also the use of these soil fertility indices is needed for the delimitation of homogeneous areas for the efficient use of better soil management practices and the enhancement of the attainable yields.

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