The challenges of cropping and forestry intensification on grasslands livestock production systems : the Uruguayan case

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Key points :
Livestock production has traditionally prevailed on the grassland ecosystems of the pampas region of South America. However, the global increase in crops prices is having a mayor impact on land use and farming practices. More than 1 million hectares of virgin land per year were taken for cropping, in the last 40 years. Leading by soybean farming the Southern Cone of Latin America was responsible for more than 40% of the increase in world cropping area, The best soils have moved up from livestock production to cropping, leaving the marginal ones to animal production. Uruguay is in the geographic center of the region and additionally has a large growth of forestry plantations which displaced 10% of the livestock production area since 1990. As a result, land price has increased approximately 2.8 times in the last 5 years. Beef prices are increasing and meat demand appears to be strong and high priced in the near future, promoting the increase in production even on marginal and fragile lands. This paper examines the available technology for pastoral production in order to cope the rising demand considering economic competition and impact on natural resources. Accordingly a new research agenda is highlighted.

Introduction

Livestock, grain and forest production will need to increase to meet the world's projected demand (Gregory and Ingram, 2000; Dar and Twomlow, 2007); Uruguay is not an exception. The international market for crops, in particular the case of soybean, is growing associated with the increase in the demand of grains coming mainly from the rapid economical development of Asian countries, which is expected to continue in the near future. Additionally, several countries around the world have made strong capital investments in the long term to develop biofuel as an alternative to petroleum. As a result the prices of grain are significantly high and economic forecast are very positive, at least in the medium term. The international financial and economical fluctuations and uncertainties fostered the investment in lands on South America, where the attractive prices of grains are very encouraging to drive those capitals to cropping. These changes are linked with a great technology revolution augmenting crop productivity particularly in soybean and corn because of: a) better performance of machinery, in particular in the context of the expansion of cropping scale, b) more efficient and cheaper herbicides, c) direct-drilling plantation, and d) transgenic varieties with high yielding potential, resistant or tolerant to herbicides, plant diseases and insect damage.

All these factors have promoted the growth of the cropping land in Brazil, Argentina and Uruguay, as well as favouring the increment in logistic, infrastructure, equipment and industrialization. Additionally, in Uruguay, a forestry growing model" was implemented through subsidies from 1998 until 2005, advancing in planting area and promoting mayor investments in order to add value at the processing phase. This expanding interest and demand for more land for cropping and forestry resulted in substantial land prize and renting raises, which in turn determined a side effect on technology adoption to increase land productivity on animal production systems. On the other hand, some technologies are constrained because of the continuous and important growing costs of key inputs, like petrol, fertilizer, and agrochemicals.

The agricultural frontier in Uruguay could expand 5 and 3.6 million hectares for cropping and forestry respectively considering the agriculture soil capacity and soil conservation regulations. That figure represents about a four times increment in present land use. These changes are predictably leading to higher production records, particularly in countries like Uruguay, where there is still undisturbed land to expand cropping and forestry. They would also increase productivity of livestock farm by planting improved pastures and more intensive use of supplements (concentrates, hay, silage, etc.), either on farm produced or bought to other farmers. The growing potential of cropping and forestry has to be analysed taking into account its influence on livestock production and in particular its effect over production systems sustainability. Within the cropping sector, grain production growth (sorghum, corn, wheat, rice, and with minor magnitude soybean and sunflower) and their by-products could open the following opportunities: 1) an increased productivity (individual and per unit of area) and improved meat quality traits (eg. marbling or tenderness) through the use of supplementation on livestock production, for both-raising and fattening processes, either in the case of supplementation under grazing or feedlot conditions, 2) the growth of cropping in the traditional livestock production regions makes available machinery and know how for promoting: a) grassland improvement, b) local production of grains, c) other by-products for feeding animals, 3) to promote cropping-improved pasture rotation systems for beef and lamb production. An outstanding leading case is the rice-pasture rotation systems on lowlands of Uruguay, 4) to facilitate making hay and silage in traditional livestock regions, 5) to enhance animal production and its stability through irrigation facilities, particularly facing the increase in drought periods, 6) to reduce improved pasture production costs of pastoral phase of the mixed cropping-livestock systems (eg. lowing phosphorous cost for promoting legume production in grain-pasture rotation systems or reducing sowing costs through companion crops), and 7) to increase carcass/meat quality and consistency through reducing slaughtering age.

Approximately 10% of the national territory is forested (4 .6 and 4% of native and improved forests , respectively) . There is an unexplored grazing potential on the 750 ,000 hectares under commercial plantation , because 30 to 35% , is accessible for grazing . Scarce and isolated experiences on agroforestry diversification with animal grazing have demonstrated successful results . There are three main forestry systems that may complement with livestock : a) production of timber saw with added value for part and piece of timber and furniture , b) ply wood mill or/ and c) pulp production for paper . Some forestry practices should be organized in function of both sectors : tree density , the type of tree , sowing improved swards under the trees . The provision of shelter and shadow has positive implications on animal production and welfare . With the agroforestry systems , around of 300 ,000 hectares of unproductive land , could have a potential use for feeding animals . In addition , it is crucial to overcome some political issues and organization constraints , to explore the benefits of the clean development mechanism" of the Kyoto Protocol , by promoting the reduction of the greenhouse effect" in the livestock production systems . Assuming that these changes are not conjectural and they have a structural base of competitiveness , some questions can be raised over the future of the livestock production systems and in particular on the grassland as a main source of the animal's diet : 1) Will the present models of cropping and forestry promote livestock production in the long term ?; 2) Do they will be ecological , economic and socially sustainable ?; and 3) Does the research has answers to these challenges and alternative options for the medium and long term ?.

Uruguay : tivestock producer and exporter

The agriculture sector is the base of the Uruguayan economy , being fundamental to its present growth and social development . In value , more than 70% of the total exports come from agriculture , demonstrating how much prosperity and national population wellbeing depend on it . In this context , the livestock sub-sector (wool , sheep meat , beef and leathers) represents 36% of national exports . The forecast of international meat demand appears to be very encouraging for the next 10 years . The participation of the Uruguayan beef exports in the global market increased more than 100% (from 3 .1 to 6 .6%) , in the last 4 years . Since 1990 , national beef production demonstrated a continuous and accumulated growth of 67% . Historically , this period is considered of the mayor growth and competitiveness of the national livestock production (Montossi and Sañudo , 2007) . The requirements of the international meat market have increased in the last decade : a) of origin product and process certification ; b) care of environment and biodiversity ; c) animal welfare ; d) food safety regulations ; e) new quality features ; f) product differentiation and g) healthy properties (Montossi and Sañudo , 2007) . The last emerging demand refers to some peculiar consumers that are including in their purchasing decisions the concept of social responsibility" . They try to recognize value and pay to those commercial providers , which certify the product and processes from the field to the plate , considering social and environmental quality indicators . The production , industrialization and commercialization of meat can not disregard this new scenario . In the context of an escalating international and regional competitiveness for the red meat market and having into consideration the above requirements and the advantages of Uruguay to achieve them (Figure 1) , the country has the challenge to cope with the unsatisfied demand .

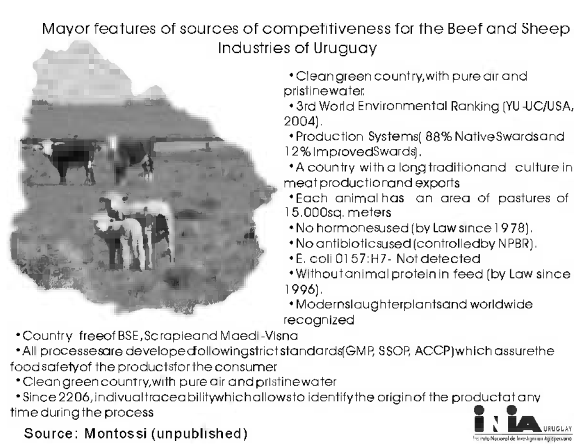

Figure 1 *Main features of the Uruguayan beef and sheep industries* .

Grassland resources

The Uruguayan grassland ecosystem (16 .4 million ha) , is a South American portion of a large area called Bioma Campos" . It has experienced intervention and degradation from the introduction of livestock by early European settlers four centuries ago . An extraordinary growth of intensive livestock production as well as other agricultural products has been reported in the last two decades (Diaz *et al* ., 2006) . The annual report of agricultural statistics (DIEA , 2007) showed that cropping areas increased from 542 ,200 ha in 1999/00 to 929 .100 ha in 2006/07 , mainly by the soybean sector growth . In the same period , forestry expanded from 521.711 ha to 683.878 ha. Cultivated pastures raised in 2007 approximately 2.7 million ha. The result is an alarming menace on biodiversity and genetic erosion on natural germoplasm, aggravated by the perception that the exploitation process will continue this growing trend (Diaz *et al*., 2006). These changes are not being well quantified and mapped at national scale. Millot *et al*. (1987) mentioned degraded areas appearing as a consequence of overgrazing on shallow and fragile soils, where is common a reduced pasture cover, high frequency of weeds and annual grasses. A high demand of land resources promoted by growing and competitive sectors (forestry, summer crops) will concentrate livestock production systems on marginal areas. The development of appropriate forage materials for marginal areas will contribute to improve productivity. *Ornithopus pinnatus* INIA Molles, an annual legume adapted for extensive areas mainly basaltic soils is a clear example of this strategy followed by the breeding programme of the National Institute of Agricultural Research of Uruguay (INIA).

Impacts of different levels of intervention in grasslands ecosystems

Grassland production, composition and stability have been modified by different levels of human intervention. Main impacts are produced by grazing management strategies, nutrient addition and legumes seed introduction to the system. Boggiano and Berretta (2006) reported main effects produced by stocking rate, grazing method and sheep/cattle ratio on species diversity for deep and shallow soils in the basaltic region. The richness species varies over seasons, being higher in deep soils during autumn and winter in shallow soils. Continuous grazing, high stocking rate and high sheep/cattle ratio reduce species number when it is compared with rotational grazing, low stocking or low sheep/cattle ratio respectively. Also, long rest periods and grazing enclosure determined a reduction in the number of different productive grass types. Despite grazing trends to affect negatively biodiversity, it contributes to maintain levels of productivity removing biomass excess. Also, the same authors mentioned that the species richness in natural grasslands can be promoted by increasing the nutrient (nitrogen and phosphorus) levels in the soil.

The inclusion of more productive pastures by adding phosphorus fertilizers and perennial legumes on natural grasslands increases in general pasture productivity three to five times depending on soil types. It also modifies species biodiversity and stability and soil organic carbon levels. Jaurena *et al*. (2008) found that improved pastures showed significantly lower species richness than natural grasslands 10 years after implantation. Perennial C_4 grasses were replaced by annual grasses (*Lolium multiflorum*, *Gaudinia fragilis and Vulpia australis*) in winter and by *Cynodon dactylon* in summer, contributing to a higher vulnerability in drought stress conditions. At the same time, Salvo et al. (2008) found no differences in total soil organic carbon (SOC) in the first 15 cm soil depth, but changes in the distribution showed that SOC in improved pastures was 8% higher and 11% lower than in natural grasslands in the 0-5 cm and 5-15 cm depth respectively. These effects are correlated with the level of biomass production, C-N ratio and changes in the stratification of root systems. More extreme modifications can be introduced either by soil plowing or by the use of systemic herbicides; both can substantially increase productivity but reduce drastically the number (two or three) of predominant species as it was measured in sandy soils (Boggiano and Berretta, 2006). These practices decrease severely the chance to recover the original sward condition.

The impact of plant breeding programs on grassland production systems

Fifteen years ago, the Uruguayan forage seed market, was based on a reduced group of public use cultivars created by public breeding programs managed by INIA. In 1992, the cultivar protection's law was approved, promoting a significant increase in the number of cultivars in the market, mainly introductions from overseas breeding programs (García, 2003). The official evaluation program data showed that, overseas introductions are generally less adapted than locals cultivars but with differences among species (Figure 2). In legumes, genetic progress is mainly a consequence of local breeding programs that actually emphasizes on the development of those species suitable for extensive and marginal environments. In grasses, it is possible to identify potential progress with overseas materials, combined with the development of local or regional breeding programs. In this context, INIA has recently made an agreement with PGG-Wrightson-AgResearch in order to develop *Lolium* and Tall fescue spp. materials for regional markets.

The livestock technology itinerary: beef breeding and fattening

It is very important to conceptualize the different technologies available for the key process in beef production like breeding and fattening, to respond with increasing production to the unsatisfied demand. In order to facilitate the comprehension of the proposed technologies, the presentation of them for breeding and fattening are divided below in the text. It is clear that a common vision with the whole industry has to be imposed to avoid mistakes in the interpretation and explanation of the technology processes. Therefore, the foresight and orientation of the beef industry has to have a consumer to paddock" focus.

It can observe in Figure 3 that increasing production levels can be achieved by applying diverse technologies available in Uruguay. Those permit to explore ranges of weaning rates from 60 to almost 90%, boosting dramatically the historical rates of 60 to 65%. The sequence of using the available technologies and the order of applying them are arbitrary; it can be different to those graphically exposed. They have to be adjusted according to the production system into consideration, given some differential factors like: soil fertility, farm scale, productive orientation, farmer and farm workers skills, age, education level

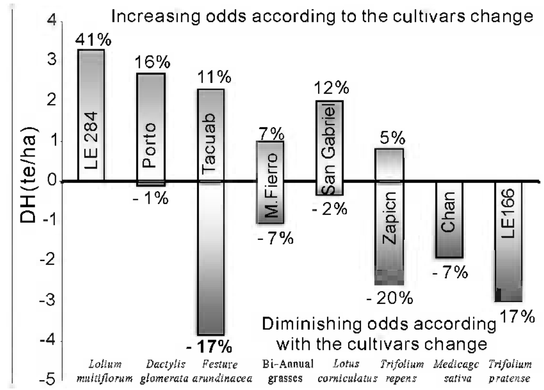

Figure 2 *Herbage production of registered cultivars of different forage species in Uruguay until 2002 showing the increase and reduction of dry matter (% and tt/ha) according to the control cultivars (adapted from García, 2003).*

and motivations, infrastructure and equipments, farmer risk aversion, business opportunities, etc.. There many farmers who achieve consistently 85% of weaning or more. Despite of the importance of market signals and the profit generated by the cow-calf operation business, the main restriction to the adoption of this intensive knowledge" technology is the human factor" (farmer age, education, expectations and motivation, etc.). However, it is very important to highlight that cow-calf operation technology paradigm" is not only determined by the weaning rates achieved by the farmer. The economical return of these enterprises is better explained by other factors, where the total kilos of liveweight produced per hectare became relevant. The number of kilos of liveweight of calves/hectare produced per cow according to its mature weight plus the kilos generated by cull cows and cull heifers are key indicators of the potential profit that could be reached by the cow-calf operation. In mixed grazing systems (beef and sheep), wool (including its bonus by fibre diameter) and sheep meat produced per hectare are also important in explaining the profit of the extensive and traditional farms. The efficient integration of all these products does to the concept of economic and biologic efficiency of the competitive and modern cow-calf farms in pastoral conditions.

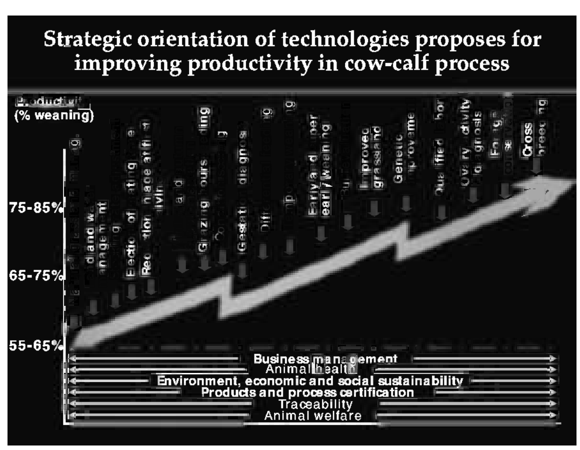

Figure 3 *Main concepts on the technology route for increasing productivity in cow-calf operations in Uruguay.*

In the new context addressed in this paper there are many challenges to face for increasing productivity and efficiency in cow-calf operation, where technology innovation has to plays a fundamental role. Some key areas are mentioned below: 1) to develop new forage species and varieties (in particular legumes) suitable for extensive livestock regions on shallow soils, to allow higher carrying capacity because beef production is moving in. The application of biotechnology to increase resistance to some environmental stresses could significantly contribute to the overall objective. These novel forage options have to reduce the age of heifers to go to bull/insemination, increase pregnancy rates in adult cows, in particular those problematic first calving cows. One special challenge is the summer period, where the use of improved and specialized pastures and crops could encourage early weaning in beef, reducing the cost of using concentrates and increasing stocking rate capacity. These forage could has also a broader for other processes like fattening (cows, heifers and sheep), 2) the strategic use of hay and concentrates for feeding cows and heifers, as a tool to increase and reduce the fluctuations in the stocking rate capacity, during the winter time, 3) to improve the quality of calves (weight and consistency) , in order to accelerate the following processes (raising and fattening) , 4) to increase reproductive efficiency using synthetic breeds and genetic improvement in pure breeds , including the reproductive traits in the selection indexes given therefore an economical dimension in the genetic improvement . It can be considered that the inclusion of the reproductive traits in beef genetic improvement has to consider : a) type of production system and its orientation and c) product generated linked with the final market , 5) to match and improve the traditional animal husbandry processes at farmer level with the international requirement of animal welfare . Local research has to play a key role in producing national animal welfare results and indicators (eg . open rangeland and pastoral systems) to share and discuss codes and rules over scientific bases , with the international research community for local conditions of production , 6) to improve farm management skills in a chain context using advanced technologies of informatics and communication , taking advantage of the implemented individual traceability system , 7) despite of the excellent health status of Uruguay , internationally recognized , there are areas of improvement in the prevention and control in animal health , where it is highlighted the negative effects of internal and external parasites and miasis , particularly when the levels of resistance are increasing in relation to the use of the traditional drugs to control theses parasites . Some promising biotechnologies appear as interesting alternatives to control them in the near future , even promoting natural and organic meat production , 8) considering that overgrazing has historically degraded pasture productivity and biodiversity it could be aggravated with the increment in land use . Marginal and shallow soils will require special attention to prevent and recovery both soil and pasture degradation . These topics are touched in other sections of this paper , 9) to study farmer and their family behaviour and motivation with a holistic approach to understand the logic of the farmer's decision making and the influence of technology change on it . These processes need a better understanding in order to design a proper technology transfer procedure as well as public and private policies which recognize the farmer's diversity , 10) to contemplate and promote educational and training capacities in all the actors of the beef and sheep industries , and 11) to evaluate the economic , social and environmental effects of the technology proposed .

In relation to the technology proposal and orientation in beef fattening (Figure 4) , those concepts and restrictions applied and explained for cow-calf farms are still relevant in this process . The research information generated by Uruguayan investigators show the beef production potentials (1000 kg . of liveweight/hectare) . However , top producers are reaching between 450-500 kg . liveweight/hectare , demonstrating the technology gap between top producers and research stations and the need of identifying possible causes to remove .

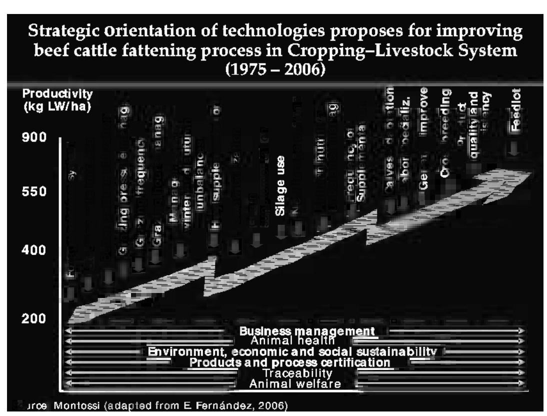

Figura 4 *Main concepts on the technology route for increasing productivity in beef fattenning operations in Uruguay* .

Again , like in case of cow-calf technology route previously analyzed , for beef fattening , it is addressed a series of challenges to improve its competitiveness , which is also associated with those opportunities offered by the technology innovation mentioned below : 1) those items (challenges) numbered 1 , 5 , 6 , 7 , 8 , 9 , 10 , and 11" and developed for cow-calf enterprises are still relevant for fattening farms , 2) there are important opportunities for adjusting and designing new production systems with animal genotype , taking into account the different agro-ecological regions and the demands of products driven by the meat market , 3) the increasing levels of concentrates use in animal diets is generalized and it is necessary the nutritional adjustment for ruminant feeding as well as better animal management husbandry , considering the characteristics of the production systems and the type and quality of products generated , 4) Re-designing the well-known cropping-pasture-livestock systems applied in Uruguay , taking into account the expansion of cropping to new agro ecological regions of the country . The advantages on sustainability of this integrated production system are greater as the soils are more marginal to agriculture , 5) to strength the implementation of good practices for animal welfare and food safety , beginning at the farm , and passing through the transportation phase , and ending at the slaughter house , 6) it is necessary to change the focus of meat farmers to become food" producers who plan with precision the products at farm level to match the quality requirements of meat processors , 7) the challenge of increasing the production during fattening could augment the risk in affecting the sustainability of the grazing production systems . Higher stocking rates in partial o total confinements affects ; a) potential contamination of the surrounded water resources , b) soil chemical and physical properties due to high stocking rate maintained mainly in marginal soils where the livestock production will forced to move . The research has a greater responsibility in giving responses to this new scenario , 8) to speed up the certification procedures for products and processes to differentiate and adding value to meat (eg . natural meat , organic meat , branded meat , grain-fed meat , etc) . This process has to be based on a scientific base and independent criteria , where present production systems has great opportunity for differentiation and building up competitiveness in comparison to other meat exporter countries , 9) the future genetic quantitative improvement will be benefit of applied biotechnology , in particular for identifying quality and health traits , 10) to produce healthy meat (associated with the concentration of polyunsaturated fatty acids particularly of the series omega 3 , vitamin E , minerals like Fe , Zn , etc .) , which is essential to the well-informed consumer with high purchasing capacity . Uruguay has been working with this approach , highlighting the advantages of Uruguayan meat for human health given by the pastoral grazing systems or by adequate and reduced amount of grain in the diet (Montossi , 2007 : Montossi and Sañudo , 2007) , 11) the actual and potential consumer preference and perception studies in the mayor importing markets are basic for programming the production systems , processing procedures , packing , etc . 12) to improve productivity and quality through the implementation of premiums , Uruguayan industry is based on national and individual traceability systems complemented with information gathered with the black boxes available at slaughter houses , 11) to reinforce the marketing and promotion strategies of the Uruguayan meat carried out by the National Meat Institute and the private and public sectors .

Ley-farming : a sustainable option for facing the increasing pressure of cropping

Certainly , the accelerating agricultural intensification in many countries over several decades raises concern about is farming is broadly ecologically sustainable now , and specially whether it could remain so in future , like is the case of New Zealand (MacLeod and Moller , 2006) . Gregory and Ingram (2009) , concluding about future scientific challenges for the near future in agriculture , gave a special attention to adaptation research" , where long-rotation research systems could contribute with responses to global changes . Ley-farming is the system where the integration in time and space of livestock and field crop production through the rotation in land use , achieving the largest potential benefits on sustainability (Diaz , 2007) . According to the Uruguayan large body of research results , Diaz (2007) presented the following main reason for the successful adoption of Ley-farming by local producers :1) recovery of land degradation due to continuous cropping system , 2) average farm size was adequate to develop the mix farming system , and 3) local development of competitive technology .

Figure 5 shows the effect of the benefits of ley-faming system . Farmers in Uruguay started to adopt the system during the early seventies and at the end of the eighties field grain crops were totally in rotation with legume pastures . The soil fertility recovery allowed greater grain yield potentials which justify the adoption of additional farming technologies . As a result , crop yields , like wheat ,increased faster than in Argentina where better agricultural soils allow continuous cropping systems (Díaz ,2006) .

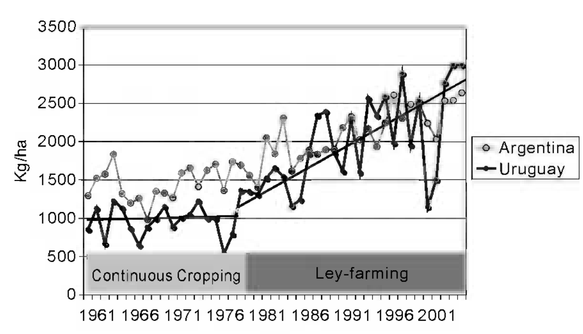

Figure 5 *Average whet yield in Argentina and Uruguay and Dominant Agricultural System in Uruguay from 1961 to 2004 (Diaz , 2006) .*

Since 1963 , the beneficial effects of pastures in recovering soil organic matter , soil physical properties and in improving the dynamics of plant nutrients have been proven by the oldest on-going experiment in Latin America . It was established in La Estanzuela" Experimental Station of INIA-Uruguay (Díaz ,2003) .

Within the 7 production systems evaluated , when System 1 (continuous cropping without use of N and P fertilization) , System 2 (continuous cropping using N and P fertilizer) , System (3 year of cropping plus 3 year pasture rotation) and System 7 (1 year pasture plus 2 years grain field crops) were compared in terms of sustainability and productivity , Morón (2003) showed that : 1) the average loss of soil organic carbon (SOC) of the rotations of continuous crops (S 1) was 421 kg ha-1 yr-1 (1) , accumulating 46% of the original SOC content after 40 years . In comparison , S 5 and 7 , the reductions were minimal , being S 2 in an intermediate position between those and S 1 , 2) as SOC , similar tendencies were found for total nitrogen , even being superior of the original concentration after 40 years for the systems 5 and 7, 3) for S 1, 2 and 5, the total P concentration balance through time was negative, unaffected and positive, respectively, 4) the reduction in soil pH levels were greater for S1 > S 2 > S 5, and 5) after 40 years of cropping, the largest differences in grain productivity were found between S 1 and S2, in favour of S 2. System 5 had 25% greater an annual crop yielding than S 2. System 7 obtained an intermediate productivity between S 2 and S 5.

Hyanes and Francis (1990), in New Zealand conditions, evaluating the effect of mixed cropping farming systems on changes in soil proprieties on the Canterbury plains, showed that these systems are generally too short (rotations of 2-4 years of cash crops plus 2-4 years of clover and grass) to build-up soil organic matter under pasture and its breakdown under arable cropping to occur, but definitively mixed systems perform much better than continuous cropping. In studies evaluating the eco-efficiency of different intensification scenarios for milk production between New Zealand and European countries and using the life cycle assessment methodology, Basses-Mens et al. (2007) shown that intensification of NZ dairy systems (more use of nitrogen fertiliser and maize silage and higher stocking rate) were detrimental to their eco-efficiency in terms of both of milk production and land use functions and could greatly reduce their advantages compared to European systems.

Díaz (2003) documented that the long term stability of the ley-farming systems is highly dependant on the price relationship between grain and livestock products. Usually the grain component represents the main proportion of the income, consequently when the prices gap enlarge, the risk to discard livestock and move to a continuous cropping system increases". Additionally, ley-farming systems of Uruguay are loosing ground in the last 5 years given the high returns of either continuous cropping of soybean or wheat-soybean short rotations, driven mainly by the technologies brought from large scale Argentine companies planting in Uruguay, which mainly rented very important areas of land with 2 or 3 years contracts, They pay a very competitive prize in comparison with other uses of land, like livestock production. The higher incomes of continuous grain production, management complexity of ley-farming systems, and the interesting and advantageous integrated technologies and business management practices and services offered by competitive companies, are resulting in the increase of the cropping land. Díaz (2006) demonstrated in Uruguayan conditions that farm size also determines greater profitability of continuous cropping compared with livestock production systems, when the size of the enterprise is scaling. The present growth model of agriculture in the region reveals a great structural restriction for the integration of agriculture and pastoral livestock production. The impact of scaling is quite different between cropping and livestock production. Whereas cropping increases productivity as the size of operation enlarges, pastoral production decreases its productivity. The reason for this contrasting behaviour is on the nature of the main technology component of both farming operations. While cropping is based on mechanization which benefits performance when increases scale, intensive livestock requires mainly labour and intensive knowledge technology and reaches the highest productivity on much smaller farm sizes than cropping. Consequently the ley farming model persists only in small a medium size farmers. Fernández and LaManna (2003) suggested that the economic performance of ley farming (in spite of high grain prices) is still competitive as a result of the much higher productivity particularly when the long term effects of soil management and conservation are considered.

Final comments: do we have a shared vision and compromise to convert the threats addressed into emerging opportunities into the new very competitive scenario?

This is an historic moment for agriculture worldwide, growing the demands for grains, meat, forest products and by-products, where phenomenal and challenging productive, economic and social changes are operating; livestock production does not escape of this revolutionary situation which seems to determine a new structure. In this context, in the medium and long term, the needs for increasing the volume, efficiency and consistency of meat are very relevant and clear. Even though differentiation and adding value is of primary importance for increasing the competitive advantages of Uruguayan meat in the global market, particularly when its small producing scale is a limiting factor. Additionally, having into consideration the main final destination of Uruguayan meat, the producers, processing plants, and broker and the other agents of the chain have to satisfy the preferences and habits of consumers with high living standards. These preferences include key issues like animal welfare, food safety, palatability, nutritive value, healthiness, respect for environmental care and social ant ethical responsibility in producing, transformation and marketing processes.

There is a great opportunity for national livestock production to respond positively to this new scenario, increasing production and efficiency per unit of area through colonizing new rangeland to be improved and using more supplements in the systems. An important issue has to be addressed, that this growth has to occur with: a) a reducing in grasslands area which will be taken by the highly profits generated by the cropping and forestry alternatives and b) an increase in land prize and rent as well as labor, equipment, infrastructure and input costs.

Accomplishing the high demanding consumer could promote some competing claims among statements of society because the intensification on natural grassland will face the increasing society regulations promoting the conservation of natural resources and biodiversity. Without any doubt, investigation and innovation are called to greatly contribute with responsible proposals to the historic and new challenges aroused. The main challenge to a strategic planning of a research agenda is on, the speed rate of the changes introduced by the aggressive expansion of cropping. It is required more than ever, a proactive and global strategic compromise of the research and development bodies from public and private sectors.

The dilemma for researchers, who come mainly from public institutions, is to meet the objectives of profitability and sustainability of natural resources when develop new technologies. In this sense, Dar and Twomlow (2007), reviewing the environmental effect of managing agriculture intensification and the role of international research on it, were very critic saying that the adoption of various technologies for integrated natural resources management has been poor, for various reasons-technical, socio-economic and institutional. Some of the technology results proposed by the research and development organizations of Uruguay try to balance increasing production maintaining the sustainability of the production systems, but those will not necessary led to the best actual economical return alternative. This was the case of the relatively rapid adoption of ley-farming systems in Uruguay. These systems also demonstrated its sustainability potential in comparison with continuous cropping, but they are under the weakness of the great opportunities of maximizing benefits by farmers using intensive cropping.

Applied biotechnology and quantitative genetics in well structured breeding programs appear to be an excellent response to the present and future abiotic and biotic stresses for increasing the competitiveness of animal and grassland. There are good examples to use as a mirror" in breeding grain, orchard and fruit crops and dairy.

The scientific community has a great responsibility in generating those technological innovations to promote a better world, where the increasing production needs to cope with the rising feeding demand of the world population have to be aligned to the respect of natural recourses. As it has been cited by Bennett (2000), reviewing and analysing the essays of Thomas Malthus (1798) about population needs of feeding, suggest and support the concept that food production would not be able to keep pace with our capacity to produce. This author considers the environmental consequences of increasing production in balance with the rights of individuals, to develop the concept of precautionary principle or quick reaction", with a complementary approach of applying the principle of proportionality".

Finally, policy makers, in an international coordination and cooperation effort, have to promote and facilitate the adoption of environmentally sustainable practices, without restricting necessary productivity, in particular of the undeveloped countries with exporting capacity which appears like an excellent opportunity for social equity in respect to central economies.

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