Successful integration of research and extension combining private and public organizations: lessons from Argentina.

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Abstract
In this paper, we describe an example of integration of research and extension, combining private and public resources and activities in Argentina. This includes the general functioning of an association of farmers composed of 136 groups, Regional Consortiums for Agricultural Experimentation (CREA). CREA is distributed in 17 regions across Argentina, with a total of 1200 farmers and 150 consultants; collectively they are known as the Argentine Association of Consortia for Agricultural Experimentation, AACREA. It began 40 years ago inspired by a similar movement in France. We will discuss the case of one of the regions called Mar y Sierras that has developed particularly strong research and development activities involving public and private organizations. This region is situated in the SE of Buenos Aires (BA) Province between latitude 37 S - 39 S, with 5% of the total crop area (2.5 Mha) in that region under CREA groups and 70 % of this under no till. Wheat yield has shown an increase of 83 kg/ha/yr since 1975, rising to 5 t/ha over 60,000 ha in contrast with 3.5 t/ha for the farmers outside of CREA. Similar upward trends are evident in sunflower (44 kg/ha/yr since 1976), corn (148 kg/ha/yr since 1988) and soybean (58 kg/ha/yr since 1995) with a spectacular increase in area.

We shows how the relationship between farmers, private group consultants, private group scientists and state organizations can function to tackle various research and development issues inspired by questions from the farmers. Also we show how this region obtains funds for research and development and how the annual plan is built. A strong agricultural sector, confronted with weak public sector research, had promoted this effort by farmers to attract private and public scientists to work on agricultural systems. This has also involved strong relationships with the French, and research centers in the USA, Canada, and Australia. Dynamic, highly educated farmers and interest from young farmers is probably one of the most important success factors.

Media Summary
An original partnership between private groups of farmers, and private and public scientists, promoted technical change and drove rapid crop yield increase in a region of the SE of Buenos Aires Province of Argentina.

Key Words
Research and development, partnerships, farmers organization, agronomy, crop yield improvement

Introduction

Argentina over the last hundred years has grown to become a major world grain crop producer (annual production 66 Mt) and exporter (over 33 Mt). The climate is favorable for both rainfed winter (wheat) and summer (maize, soybeans, sunflower) cropping. Agriculture is based on privately owned land, with farm size ranging from medium to large by developing world standards, with widespread adoption of no-till practices, now covering 65% of total crop area. This paper describes the evolution of a unique private-public partnership between an association of farmers, namely AACREA (Asociacion Argentina de Consorcios Regionales de Experimentacion Agricola), and different state organizations, which has arisen in Argentina for the development and supply to farmers of knowledge about new cropping technologies.

AACREA comprises 136 groups (called CREA groups) of farmers distributed in 17 regions across Argentina (Figure 1), with a total of 1200 farmer members and 150 consultants, and involving about 2.5 Mha of primary production and 1.5 Mha of crop production (national primary production area is currently about 140 Mha with 25 Mha of crop production). The aim of AACREA members is to increase the profitability and sustain economic growth of their enterprises sharing their knowledge and experiences. AACREA have three nationals departments in order of importance: Economic Management (studies and

groups support), Institutional (activities of groups and regions), and Production Department (research and development in production systems).

Figure 1. Location of the 17 AACREA regions in Argentina. Location 2 is Mar y Sierras CREA region.

The spirit of this movement, created 40 years ago, was inspired by the French CETAS (Centers of Studies of Agricultural Techniques), with one main difference: in France an important part of the budget of the CETAS movement came from the state, whereas in the AACREA movement there are no funds of the state, but there are strong scientific collaborations with the state, specifically in the production department. Indeed, the recent increase in research and development of AACREA derives partly from the lack of state investment in agricultural R, D and E in Argentina.

Grain production from AACREA farmers represents between 5 to 15 %, depending on crop, of national production (Table 1). The farmer groups obtain superior yields over non-CREA farmers, ranging from 7 to 36 %, depending on crop (Table 1).

In the remainder of the paper I will initially discuss one regional component of AACREA in southeastern Argentina (Figure 1), namely the Mar y Sierras region where I have worked closely for 17 years. I will then discuss how the region interacts with the national CREA operation and highlight its unique features, its constraints, and its future prospects.

Table 1. Area and yield of major grain crops (2002-2003) at a national level and for CREA groups. A comparison is made for yield increase (1997 to 1999) between CREA farmer groups and at the national level (the level of significance from a "t" test is between brackets) (Satorre et al 2001).

Crop	National area (Mha)	National yield (t/ha)	CREA production relative to national production (%)	Increase in yields CREA vs. non CREA yields (%)
Corn	3.08	4.87	+12	36 (P<0.01)
Soybean	12.6	2.76	+5	11 (P<0.1)
Wheat	6.3	1.95	+10	22 (P<0.01)
Sunflower	2.37	1.56	+5	7 (ns)
Rice	0.13	5.3	+15	

Progress in Mar y Sierras CREA Region in SE Buenos Aires Province

Description of region

Twelve CREA groups of 9 farmers each, all located in SE of Buenos Aires (BA) Province, comprises the Mar y Sierras CREA. The region is situated between latitude 37 – 39^{o}S and longitude 57– 61^{o}W at an altitude of 0-200 m above sea level. The climate is temperate with an average of 6^{o}C in July, the coldest month, with no snow, and an average of 20^{o}C in January, the warmest month. The first frosts are around the 20th April and the last frost about 15th November. Annual precipitation is between 800-1000 mm, with peaks in autumn and spring. Soils are Petrocalcic Paleustolls -Typic Argiudolls, with calcareous rock at 0.5 to 2 m depth, 3-7 % organic matter and 70% of soils have little slope.

Total crop area in the province is 2.6 Mha, with the CREA groups occupying 0.14 Mha (5.3%). The number of groups and farmers per group was stable until 2001. In the last 3 years both the number of groups and the area has grown 25% due to better economic conditions for farming as a result of devaluation policies, and we expect 2 more groups this year.

Twenty years ago the common rotation was between pasture grazed by cattle (lucerne, perennial grass) and cropping, with typically 5 years of pasture followed by 5 to 8 years of cropping, using conventional tillage with frequent cultivation. Now, the pastures have almost disappeared. Minimum tillage systems were developed between 1980 and 1990, and since 1990, no till systems have grown to occupy 70% of the area.

Wheat (June to December) and sunflower (October to March) were the main crops, but in the last decade soybean (November to April) has grown rapidly under no till, becoming today the second main crop. In the Mar y Sierras CREA groups, 2003-04 wheat area was 60,000 ha, soybean 24,000 ha and second soybean (meaning soybean planted immediately after wheat harvest; first soybean is planted a little earlier after winter fallow) 12,000 ha, while sunflower had decreased to 15,000 ha, and corn is stable at 9,000 ha. The recent development of second soybean after wheat is unique in this temperate region, and came about due to the new technologies of short cycle varieties with glyphosate resistance, suitable rhizobium inoculants, and good soybean prices. We estimate for this year (2004) that 60% of the wheat area will be seeded with second soybean (36,000 ha)

In the last decade the area managed by each Mar y Sierras CREA farmer had grown from an average of 700 ha to one of 1300 ha, caused especially by the financial crises at the end of the nineties. Most of this growth was based in renting new land. A majority of these contracts are renegotiated each year, depending on crop values, yields expectations, and double crop possibilities.

Progress with wheat

Yield of wheat has increased now to the point where our maximum yields are close to the potential yield estimated by radiation/temperature ratio (Fischer, 1976) for a nationally developed variety (Figure 2). The excellent climatic conditions and the significant adoption of French varieties in the last year (35%), which has given a 20% increase in yield explains the surprising 2003 results (more than 2000 ha had more than 7 t/ha and some fields reached 9 t/ha). The increase in wheat yield in this region (83 kg/ha/yr) is comparable to that achieved for wheat in France (near 100 kg/ha/yr). The average yield of the CREA groups is significantly higher than that of the region, for example 5.0 t/ha for CREA groups last year vs. 3.4 t/ha for the total region. The average wheat yield of the CREA groups from the region is approaching that of the groups with the best results (Otamendi and Azul Group), thus showing an important diminution of the variability between groups. In the first years of the 80's we obtained 5 t/ha as maximum; 24 year latter we have arrived at this value as an average for all the region's groups.

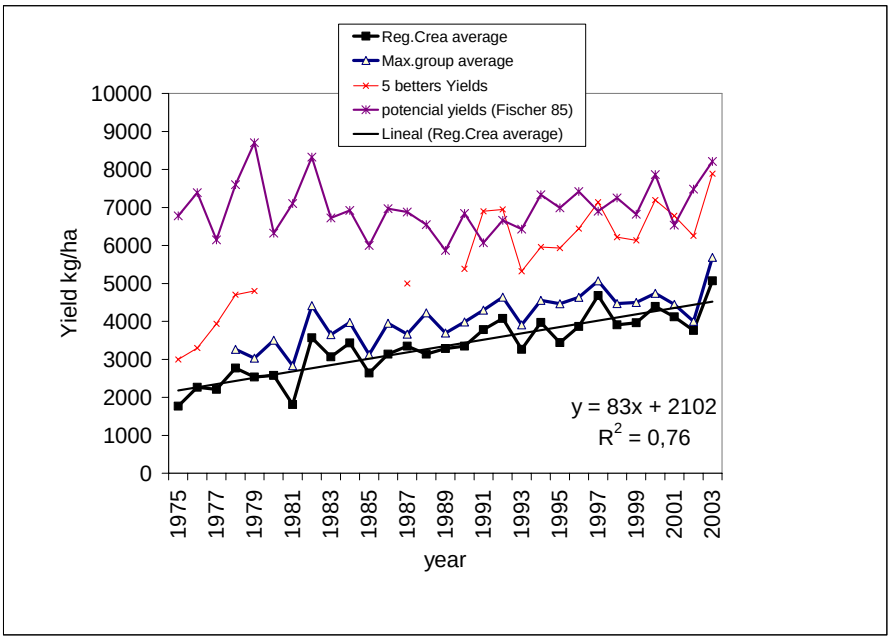

Figure 2: Progress in wheat yield for the Mar y Sierras Region (potential, best 5 CREA fields, best Mar y Sierras CREA group average, and average of all Regional Mar y Sierras CREA groups).

The adoption of new wheat growing technologies can be listed as a consequence of the research conducted by the public sector (Instituto Nacional de Tecnologia Agropecuaria, INTA) and by other bodies mentioned below:

- 1980. New varieties derived from Mexican germplasm. INTA development and several important private breeding companies (Buck, Klein).
- 1982. Phosphorus application introduced with the use of soil testing. INTA development.
- 1985. Advantage of suppression of very early weed competition with wheat.. New residual herbicides developed. Government and CREA regional development (Gonzalez Montaner et al, 1991).
- 1990. First nitrogen models. CREA regional and INRA-INAPG (Institut National Recherche Agronomique – Institut National Agronomique Paris Grignon) development. References for soil N-nitrate testing for maximum economic return was adopted by CREA groups and expanded throughout the region quickly (Gonzalez Montaner el al., 1991).
- 1991. First studies comparing till and no-till systems with wheat. CREA–AAPRESID (Asociacion Argentina de Consorcios de Productores en Siembra Directa).
- 1992. Development with the French of nitrogen application guidelines to improve the efficiency of N use and to reduce pollution using a plant – nitrate indicator. CREA and INRA INAPG development (Gonzalez Montaner at al. 1987).
- 1995. Diseases control models. CREA and private companies development. Changes in the rust susceptibility of high yielding material showed the economic advantages of diseases control models using fungicide. Improved management methods for other diseases like Septoria , Dreschlera and Fusarium were also developed.
- 2000. Regional decision (by CREA farmers and consultants): all the research to be conducted with no till.
- 2002. Introduction of French varieties with high yield potential. Nidera (Seed Company in contract with French Benoist seed company) and CREA development. CREA trials show the environmental conditions under which these varieties were economically superior
- 2003. Control of nutrition in quality wheat and high yielding wheat. CREA and Bahia Blanca Chamber of Cereals Lab, INTA. Amount and splitting of N fertilization based on nitrate-N soil test; plant nitrate and SPAD (Chlorophyll-meter) controls. Also, new diseases models, taking account of genotypic sensitivity, were developed by CREA and companies.
- 2004. Building models for precision agriculture. CREA and The University Buenos Aires (UBA), Remote Sensing Lab. Using remote sensors for vegetation green index to assist the consultant in inter- and intra-field nutrition and pest monitoring.

In these examples for wheat we can see how the region determines what kind of alliance will be the most effective: private, public or mixed. Later we will describe the structure and the functional model of the AACREA and the Mar y Sierras CREA region, where we can see that the farmer groups are frequently the place where the questions first appear, becoming later regional or national projects with public or private partnerships, making this a bottom up or farmer-first system.

Progresses in corn, sunflower and soybeans

Mar y Sierras is the only significant region where we can see rising sunflower yields (45 kg/ha/yr, Figure 3). However the progress is not sufficient to compete with recent soybean results, and consequently the area of sunflower is decreasing. Developments in no till and nutritional models (Gonzalez Montaner and Di Napoli, 2000), and strip till techniques (CREA regional development, Monsanto seed company), earlier seeding dates (Government station results) and canopy structure for maximizing yields (Regional CREA, University of the Center of BA Province (UNICEN) and with A. Hall et al. (2001) at UBA) are revealing some new possibilities. We hope it is not too late to save sunflower. Imidazolinone-resistant varieties have started well, but until now, the potential of hybrids is limited

Corn in this region has the smallest area (Figure 3) because of its high production costs (relative to soybean and sunflower) and sensitivity to water stress in shallow soils. Evolution of no till has favored water supply management in recent years, also new short-season high-potential genotypes, crop structure management (Andrade 1992), and P and N fertilizer application models (INTA and CREA Regional Development) have helped to lift yield (148 kg/ha/yr), and reduce income variability. However the relative prices of corn and soybean mean that farmers only grow corn on the very high potential soils. Popcorn is increasing in area in the lower potential and sandy soils.

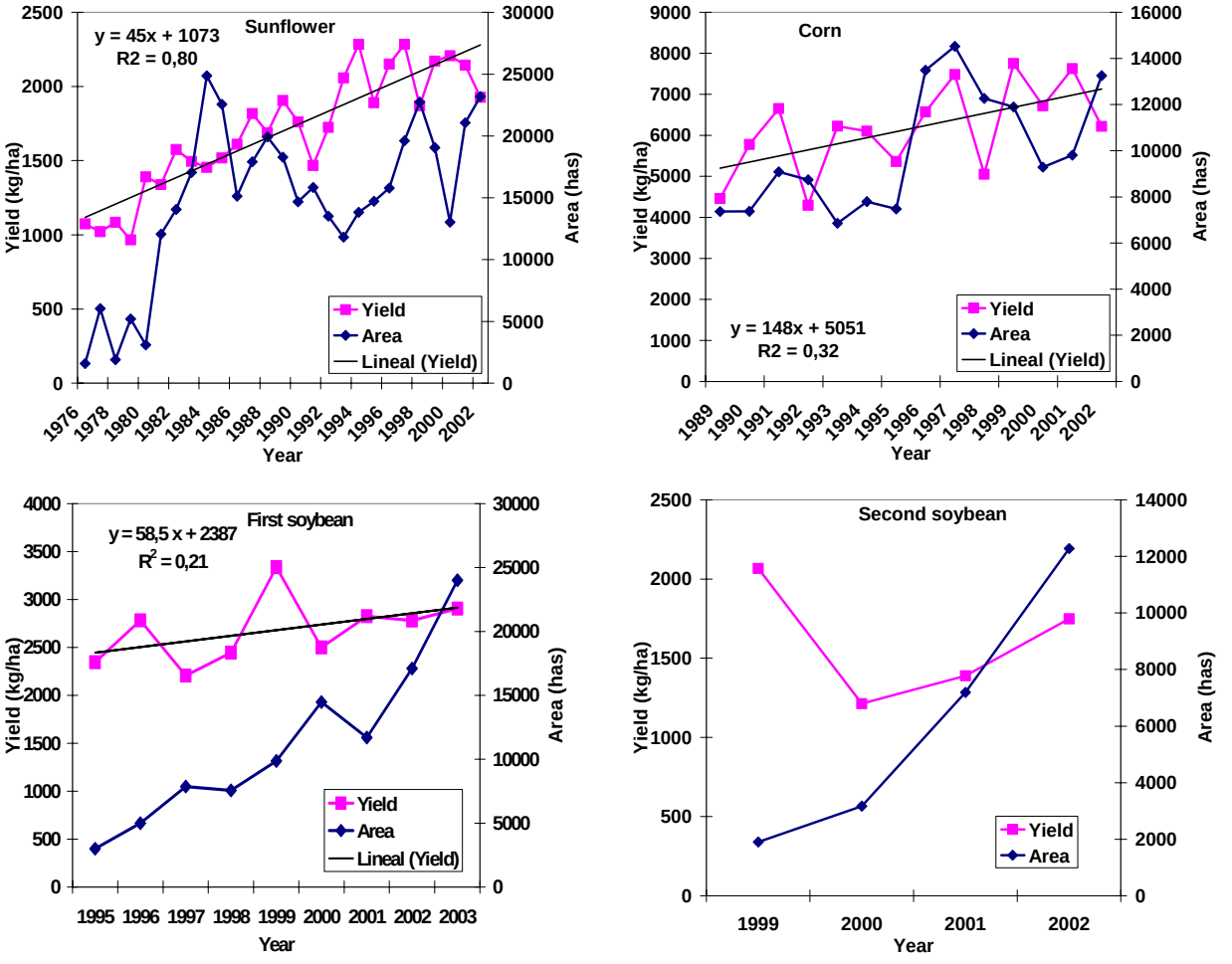

Figure 3: Change of area and yield of sunflower, corn and first and second soybean for Mar y Sierras CREA groups.

This temperate region (with relatively cold nights) was the last to adopt soybean in Argentina (only 3000 ha and 2000-2400 kg/ha in 1990, rising to 35,000 ha and 2800 kg/ha in 2003 in MyS groups). With non-glyphosate tolerant varieties, the common herbicides used caused important reductions to the growth of soybean crops. Varieties of maturity Groups 3 and 4 and new canopy structures were developed for different soil types and seeding dates (Seed companies; Calviño and Sadras 1999, an INTA and CREA development). Also, nodulation was erratic and studies of the CREA with UNICEN and Rhizobium Companies developed new formulations and inoculation techniques. CREA and non-CREA farmers immediately adopted these improvements.

The adoption of first soybean in the region began in the warmest parts, reaching the coldest sub-regions eventually, and over this period the regional yield increased. Roundup-Ready (RR) soybeans were essential for this development in this south, not only for soybean growth but also to facilitate the no-till system because of better cleaning of weeds (for example: *Ammi majus*; *Xanthium* sp.). With non-RR soybean, good control was highly expensive, and not very effective. No-till soybean deals better with cattle compaction than does no-till sunflower, giving another advantage for soybean adoption. Second soybean is only possible with zero-till RR varieties because of the less expensive weed control this involves. The growth of second soybean is affecting sustainability of cattle production because this gap in the cropping was often used in the past for early-sown forage oats. Also second soybean in the virgin soybean regions is a cheap way of introducing rhizobium, thereby assuring the nodulation and good performance of the next first soybean crop.

Structure and operations of the Mar y Sierras CREA regional groups

Farmer groups
The smallest cell of the organization is a group of farmers with 8 -12 members having a part time agronomist/consultant. The group has a rotating farmer president and a budget controller. The consultant makes a one-day visit (or a half-day depending on needs) to each field each month. All the groups have one meeting a month in one of the farms, with the idea of examining the farm operations over the last year. The president of the group and the consultant have two responsibilities: (1) sustainability of the group as reflected in the success of the monthly meeting, which reveals the capacity of the group to work for each farmer, and (2) the annual plan of the group relating to: i) crops or systems research including trials and crops fields evaluations, and ii) farmer training (ranging from economics and commercial ability, to family and social issues). Even though the consultant is principally a group assistant according to the AACREA definition, in practice that person also has a very important role as agro-economic consultant to the farmers.

Regional organization
At a regional level, the presidents of the groups have monthly meetings, chaired by an elected farmer with 2-year responsibilities (regional representative), and aided by an institutional coordinator (regional coordinator). Also, there is an agronomy specialist (regional agronomic coordinator), who is the main source of agronomic information for the region with responsibilities to:

- assist president's meetings and groups
- coordinate technically the consultants' meetings once a month.
- build the annual research and development program of interactions with public organizations like INTA and Universities relate with the national AACREA agriculture commission.

Annual planning for research and development
The groups and their consultants present their information on needs to the regional agronomic specialist who prepares a regional proposal for research. This proposal is discussed at two annual meetings (winter crops in May and summer crops in September) with presidents and consultants together.

The Mar y Sierras region has built over time its own experimental structure with a four sub-region organization. Part-time trained agronomists only constitute the structure. They interact with the public experimental stations for research material. Almost all the experiments are however conducted in farmer's fields.

The monitoring and evaluation of results and publications are done either by:

- the agriculture coordination team, or
- a public teaching organization with students, or
- a consultant (eg conducting postgraduate study) and a public organization.

Typical issues and how they are studied are shown in Table 2. When the subject of the research exceeds the capacities of the regional research team, we look for interactions with organizations such as INTA or the Agronomy Faculties (paying for their services) .

Table 2: Examples of subjects of studies and how had it been developed for MyS region.

Research problems	Who conducts the experimentation	Who publishes the results?	Integrated with other results
Wheat fertilizations models	Region	Regional Team and INRA (France)	UBA
Wheat quality; fungicides models; herbicides	Region	Regional Team	
Soybean adaptation to the region	Region	Consultant doctoral thesis University of Mar del Plata	
Soybean inoculation.	Regional Team and University of Center of BA Province.		
Sunflower needs specials structures for maximizing yields	University of Center of BA Province (1)	(1) With regional team	Physiology Department UBA
Corn fertilization	Regional teams	Regional teams	
Precision agriculture with remote sensing	Remote Sensing Laboratory UBA	Regional teams	

Mar y Sierras CREA funding

Institutional maintenance involves an annual cost per farmer of 1000 ha of approximately $US4 per hectare, giving a total of $4000 which is disbursed as follows: $320 general costs, $600 for AACREA national structure, $280 for regional structure and $2800 for the group consultant.

Research and development funds in Mar y Sierras comes from:

- A tax of 1 peso ($US 0.33) per hectare of crop. This happens only in this region of the AACREA movement. In other regions, farmers can pay for some particular studies, but currently a tax for R&D is not built in.
- Contracts with companies in research subjects of shared interest, such as crop varieties, fertilizers, fungicides, herbicides, inoculants etc.
- Meetings: We present research and production results at three annual meetings (especially for non-CREA farmers) that are organized by the region (on winter crops, summer crops, and a field day on no-till management). There we collect money from sponsors and attendees. 800 farmers per year attend these meetings.

The proportion of funds from each of these sources is 38% from farmers' tax, 42% from contracts and 20% from meetings. Recent positive growth in the number of hectares has permitted an increase in research funds and in the number of research plots (Figure 4). We can see in Figure 5, how soybean research is receiving growing emphasis in Mar y Sierras research.

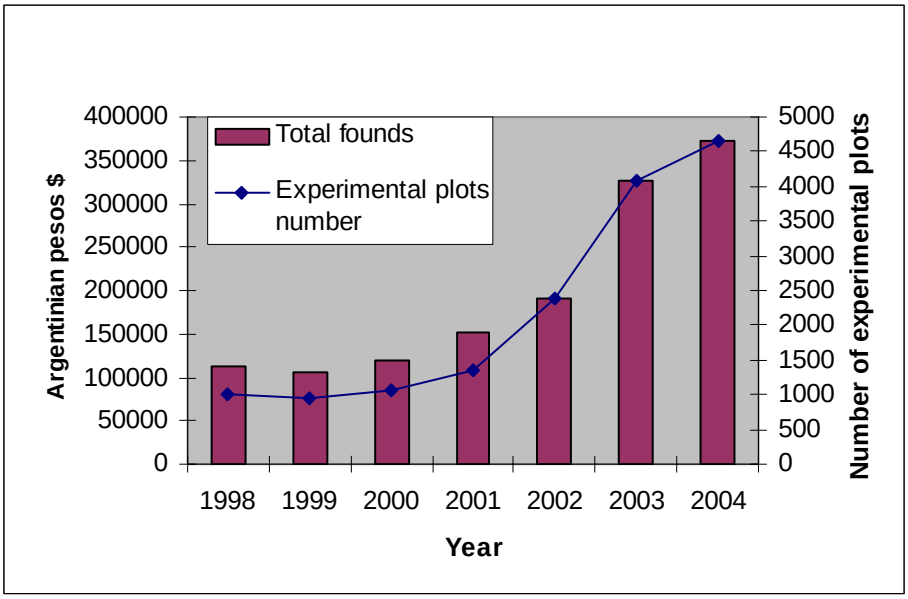

Figure 4: Evolution of funds for research and development in Argentinian pesos (Currently, one peso = 0.33 US$, but was stronger in earlier years) and in number of experimental plots in the Mar y Sierras CREA region.

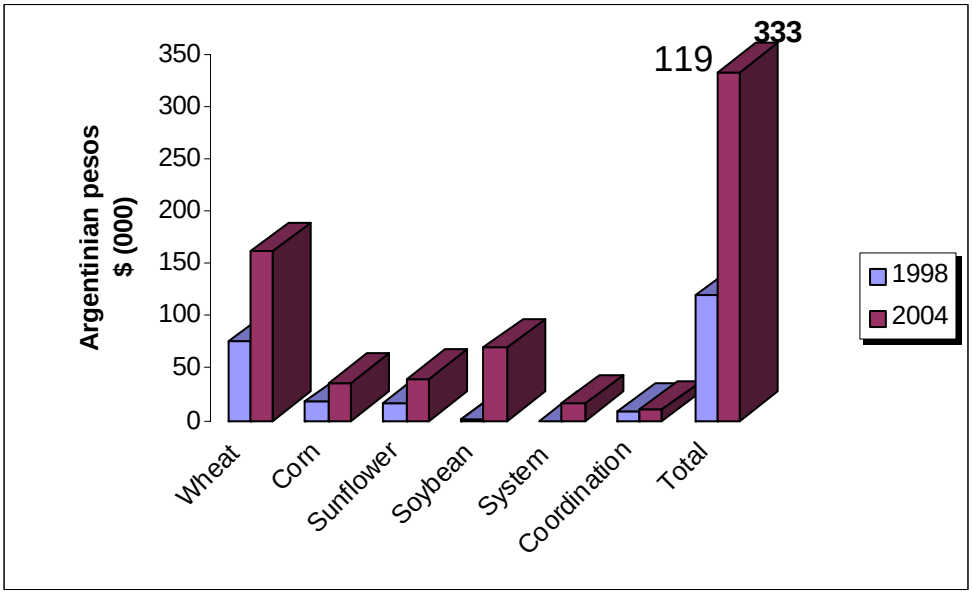

Figure 5: Total funds by crop used in experimentation, CREA Mar y Sierras.

Institutional relationships in ACCREA

Farmer groups and regional groupings, as described for the Mar y Sierras region, are the building blocks of ACCREA nationally. At the national level all the specialists in agriculture from each region coordinate plans in a monthly meeting in Buenos Aires. One specialist in agriculture coordinates the national agriculture commission, helping the regions in research and development and coordinating minimum common protocols between regions and analyzing the major trends. A strong point here is that the professors of the Department of Grain Production at UBA conducted the national and regional coordination. Most of the syntheses and publication at a national level are done with the team at UBA. Also these persons coordinate the postgraduate continuing education of consultants from AACREA, in collaboration with different national and foreign universities and research centers.

What are the keys of the success of CREA groups?

National situation: strong agriculture and weak public research.

The origin of the development of a private research and experimentation was the insufficiency of public research, due to the small and variable budget going from the state to INTA and the Universities dealing

with agriculture. Funds from a tax (20 %) on the exportation of agricultural products had been used for paying the state deficit (and not specifically for helping agriculture). The National Plan of Science and Technology (1998-2000) estimates that the investment in agricultural research in Argentina (public only) was 0.4% of the gross value of the agro-industrial production (Blake et al 2003). This compares with 2.6% in industrialized countries, reaching close to 4% in Australia, and is also less than in similar developing countries like Brazil (0.8 %) and Chile (0.9%).

Our alliance with French R&D.
We have an established collaborative relationship with French researchers: in the beginning with CETA, 1980 with ITCF (now Arvalis) and CETIOM on farmer development and more recently with INRA on scientific issues (N, organic matter, wheat models, etc) and research organization.

The impetus for collaboration came about through complementary interests. For farmers in Argentina, particularly in the pampa region, technology, marketing (commercialization strategies) and scale, are the three keys for survival. Factors such as yield, price of products, area, and costs, income and time per hectare are all relevant for the farmer. In France, in contrast, yield is disappearing as an objective, and farmers' scale of cropping is changing very slowly, and is unlikely to change in the future. Important issues are the role of the European Community rules and an increasing emphasis of the environment.

What are the consequences? In France there is excellent quality research but farmers are lacking in dynamism, an increasing proportion of older farmers, and clever and well trained people abandoning their work. On the other hand, in Argentina we see the opposite: a strong interest from youth in agricultural business, and agriculture seen as an engine of the economy. In CREA groups, for example, more than 30% of the farmers in Mar y Sierras are graduate agronomists and another 20% have commercial training, and this is growing quickly because many of the sons are studying agronomy at a tertiary level.

The stimulated farmer is the catalyst of the AACREA system. Forced by circumstances, we have discovered that a big part of our new technology development has come from trained people looking at the wide variability in field performance arising in response to practices tested and/or varied by farmers. I agree with an agronomist observer in France who points out that there few research people are now monitoring farmers' fields. Systems experimentation is normally done on experimental stations, and later results are proposed for extension to farmers when it is socially, technically and economically ready. The consequence of this is that they:

- only arrive at conclusions about biophysics and processes involved and in a partial way,
- lose the potential of interactions with farmers and companies,
- obtain only partial knowledge about the advantages of farmer practices.

Our scheme in AACREA is to work in partnership (farmers-consultants-research) from the first to the last step in developing new technology. We put the accent on choosing the best people not only in research labs but also for working with the farmer, in order to discover and overcome new challenges. The disciplines: crop physiology, agronomy, plant pathology, microbiology need to be 'on the ground'.

What characteristics are needed for good scientist-farmer collaboration?
The system must stimulate the farmer-consultant–scientist interaction. This is something that I have learned from the famous French agronomist, Professor M. Sebillotte (Professor INAPG and Director of INRA). In our case, for a scientist to participate in this interaction it brings freedom, funds and feedback. The consultant's participation gives them continual learning and the possibility of being recognized by the farmers in order to gain new clients (remember that it is part time work). Participating in this partnership, the farmer increases his competitiveness, for example by becoming bigger but not less efficient.

Effective internal relationships need a group of trained research people working closely with leading farmers who can ask the right questions. And for public organization researchers to be involved in R&D projects, they must have an open mind and be capable of accepting new rules (atypically hours and dates of work, long travel distance, networks of experiments instead of a few highly controlled experiments). Normally this system functions well when the private association provides the funds (then the control) and the regional agricultural coordinator (who in practice may initiate the experimental proposal) is

recognized as a leader also by the public organization. AACREA has a representative on the INTA Board of Directors and in their regional planning committees. They try to emphasize the opportunities for public-private interactions; however this is not the most effective way of getting the right research done.

External relationships are also critical for us, because AACREA specialists like myself are really weak in basic research knowledge. Therefore, for example, we have an ongoing ready exchange with INRA, and with Arvalis Institute (ex Institut des Cereales et Fourrages) also in France, and also with universities in USA, UK, Canada and Australia. Thus we make 2-3 trips per year to different research centers, analyzing new technologies, exchanging and sharing projects, but also identifying researchers that later we invite to give courses in our country. As well, our consultants frequently make trips out of the country and most of them undertake refresher training.

Future Challenges for CREA model and Argentina

The CREA model and Mar y Sierras example represents a structure that we created in a special context: one with poor state investment in agricultural research but a strong agricultural sector, with a culture of growing by sharing. How to sustain the value of sharing, in a more and more competitive sector especially between neighbors (farmer's groups), is a permanent worry for our association.

Future challenges will need a higher state investment especially in biotechnology, but also in eco-physiological research, managing our natural resources in terms of sustainability (for example the expansion of soybean monoculture in cleared subtropical savannas of north western Argentina), and in weather forecasting and climatic change studies. We need strong academic research groups with interdisciplinary scientists for the promotion of strategic long-term research. In the development sphere, effective feedback is needed between farmer organizations and state research organizations. I participated in an expert commission for the rebuilding of INTA many years ago, but very little has been done yet in this area (see also Blake et al 2002).

Finally, the possibilities for adaptation of the cropping sector to new demands of the market and of society depend on what kind of farmer we promote. In this respect, the interests of young people in this sector are an advantage that needs to be supported. How to include more people in social development will be in the focus of discussions this year at the AACREA National Congress entitled "Being Part of a Possible Argentina" (www.aacrea.org.ar). Different sections will try to highlight the idea of how our sector can start a cultural revolution. The first block of the Congress will deal with the Argentinean dream: how to imagine a big rich and serious country with equality and solidarity. The second will deal with education as a national priority, including quality schools for poor people, based on Chilean and national experiences. The third will cover the knowledge society and the agricultural community: how to develop quality of life and generate work from knowledge. The fourth block will develop future possibilities for our enterprises by examining foreign and national examples.

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