28/2005 – UHE/UAB – 24.01.2005

Environment Conditions and Biological Innovations in theEuropean Agrarian Growth, 1819-1939.

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1. Introduction.

The circumstances that were the driving forces behind Europe's economic growth beginning in the 19th century are diverse, and not easily prioritized. Until the 1970's, specifically, in Economy and Economic History, attention was focused on different institutional and technological variables, and various regularities were proposed (e.g. Hobsbawm (1968), Pollard (1981), Landes (1969), Cipolla (1972/76), Maddison (1991)). Nevertheless, new studies also underlined that the evolution of economic activity could not be understood considering only the new production possibilities offered by market economies. As a result, today it is also accepted that those processes can not be explained without considering two additional circumstances: the energy flows that sustained them, and the changes undergone in their transformation(e.g. Wrigley (1990), Debeir, Deleage et Hemery (1986), Sieferle (2001) y Naredo y Valero (1999)).

In this context, a question arises that takes on special importance. Which was the influence of the biological change in the economic growth?. A part of the flows of energy must be made into food, and this transformation can only happen with the participation of plants and animals. As Soddy emphasized in 1921, “The plant world continues to be the only one that can transform the original flow of inanimate energy into vital energy” (Martínez Alier (1995)). Also, in recent years there has been research in this direction, the results of which should be considered.

This research stands out are, for example, 1) the long tradition of biological innovations in the agricultural food sector; (2) their important implications; and (3) the final configuration of a new business sector of great importance around these processes. (Heiser (1990), Friedland et al.(1991), Goodman, Sorj and Wilkinson (1987), Goodman and Redclift (1991), Busch (1997), Busch et al. (1991), Perkins (1997)). It is also shown that the orientation of this type of innovations and their institutional organization have become more complex with market expansion, and that their contribution has played a decisive role in the configuration of contemporary economic growth. From this research, in synthesis, an issue can be raised as a working hypothesis. In the study of economic growth, we should consider three processes together: (1) the flows of energy and materials used and the technical bases of their transformation, (2) the biological conditions under which the production of food is carried out, and (3) the changes undergone in the organization of society.

In this context, nevertheless, some clarification is required with respect to the situation of our knowledge about the previous issues. On one hand, we know the processes undergone after World War II better, and this circumstance has propitiated unrealistic perceptions about the true possibilities of agrarian change at different times. On the other hand, the handling of the previous issues has advanced notably since the 1980's, but the studies performed have focused especially on the agricultures of the United States. With respect to this country, we have excellent analyses of the importance of biological changes in agrarian growth since the 19th century, about its institutional characteristics, and about its relationships with other aspects of technical change (e.g. Kloppenburg (1988), Dalrymple (1988), Busch, Lacy (1983), Dandom (1986), Huffman and Evenson (1993) Olmstead and Rhode (2003)). In the European area, these contributions have been less numerous. Various circumstances have been involved in this imbalance. For example, (1) the different significance of the biological problems in both areas; (2) the traditional interest of the governments of the United States in transforming the biological bases of its agriculture; and (3) the hegemony acquired on an international scale by that country's food and biotechnological industries. In any case, for European agriculture, one must remember the excellent studies that have been performed about the wheat sector and different species of livestock, or, about the relations between biological innovations and agrarian change (p.e Martin (2000)). But we also must remember two other issues. In the first place, the nonexistence of a general framework in the Economic History for interpreting biological and economic changes over time. Secondly, the need to dispose of more sector studies on a national and regional scale, especially with respect to the impact of those innovations on the levels of productivity.

In the following pages I will develop these directions, by analyzing the biological changes in the Atlantic Europe and the Mediterranean till the 1930s. The text is organized as follows. Section 2 places those changes in the general framework of the environmental conditions of production. Section 3 indicates some of their main characteristics in the wheat and livestock sectors. Section 4 puts forward some explanations for their differing evolution in different places. Finally, section 5 relates these changes to other innovations and underlines their importance in order to understand them better.

Just one word of caution. In this paper, the institutional variables involved in the processes that will be dealt with are not considered. Not because they are not considered important, but rather because I prefer to focus on certain aspects that are still relatively unexplored in Economic History. As we will see, when biological variables and environmental conditions are considered, some characteristics of the processes of change undergone by European agriculture up until the middle of the 20th century can be better understood.

2. Biological Innovations and Environmental Conditions

I understand biological innovation to be all activities performed consciously for increasing the production capacity of the agrarian sector, whether this be by introducing new varieties of plants or animals, or by altering their constitution through different techniques (selection, crossing, etc.). Therefore, from this perspective biological innovations have been one of the main lines of the participation of human societies in the environmental conditions of production, and, more specifically, one of those most used for increasing agrarian production.

I this sense, an important issue to underline is the development of these innovations from the second half of the 18th century, as a result of three circumstances. Firstly, the knowledge accumulated on the physiology of plants and animals, the progressive improvements undergone in selection and crossing techniques and the rediscovery of Mendel's Laws in 1900 (Stubbe (1972), Corcos, Monaghan and Mendel (1990)).

Secondly, the ever-closer contacts fostered by the expansion of trade between areas with different natural resources. Thirdly, especially beginning in the second half of the 19th century, the growing availability of new means of production, both chemical and mechanical, the use of which appeared ever more linked to the availability of new biological varieties (Heiser (1990), Walton (1999), Grantham (1984)).

Another issue to emphasize is more related to the different orientations and possibilities that these innovations could have. As the biological conditions of production depend on the climatic, hydraulic, and edaphic characteristics of each area, these innovations were also conditioned by another variable. That variable is the degree to which these innovations were complementary to the overall environmental circumstances under which the agrarian systems operated. The importance of these circumstances with respect to the two large areas that we will be dealing with is well known. While in the agriculture of Central and Northern Europe there were high levels of water, deep soil, and very mild climatic conditions in the spring and summer, in Mediterranean Europe, these conditions could be very different. The rainfall was lower, especially when it was needed the most, temperatures tended to be very high from the end of the spring on, and agricultural soil was poorer in organic material. These differences are not very dissimilar nowadays, although technical changes have mitigated them (Papadakis (1966)).

As a result, when demographic pressure, institutional changes, and the intensification of exchanges accentuated the expansion of cultivated areas and the processes of specialization, these processes tended to take shape

differently from one part of the continent to the other. The first area tended towards very intensive growing systems and increasing integration between agricultural and livestock activities (Tracy (1982), Grigg (1992), Van Bavel and Thoën (1999)). In the second, the expansion of crops was combined with the maintenance of very extensive systems in the grain-growing areas, and growing specialization in vineyards, olive groves, and fruit trees. Where climatic conditions allowed, and the irrigated surface area could be increased, other orientations must also be underlined. The expansion of vegetable crops, rice, and fresh fruit trees took place where there was more intensive irrigation, and new grain rotations were used in the more irregularly irrigated areas with fewer resources. Anyway, broadly speaking, the most important thing in Mediterranean systems was the articulation of an agrarian sector, characterised by (1) few resources of fodder, livestock, and fertilizers;
(2) the presence of fallow land in grain areas; and (3) a high presence of vineyards, olives and tree crops in most parts of the territory. On the other hand, livestock farming continued with grazing, and the development of livestock producing milk and meat took place later and was more limited (Simpson (1995), Bevilacqua (1992), Garrabou y Sanz Fernández (1985)).

But the influence of environmental conditions on both areas is not only reflected in the different productive orientations that accompanied agrarian growth. Their impact also stands out when we consider the different evolution undergone in two important sectors: wheat production and livestock. The evolution of these sectors has often been used to evaluate the ability of European agriculture to adapt to the expansion of markets, and consequently, its study has played an important role in agrarian history research. Wheat, meat, and milk were also three basic foods for the population, although their importance in this sense tended to vary over the course of time (Teuteberg (1992), Collins (1993), Kiple and Ornelas (2000, pp.1193-1247)).

3. Biological Innovations During the 19th Century and theFirst Third of the 20th Century.

The first issue observed when we consider biological innovations in the wheat sector, is its different evolution according to place. Various research projects have emphasised its growing importance in the British wheat sector since the 1770's, and its quick spread to other countries of Western Atlantic Europe, especially from the second half of the 19th century on (Walton (1999), Lupton (1987), Zeven (1990), Doussinault (1995)). In Mediterranean Europe, however, this kind of innovations were not begun until the 1880's, their development was slower, and had fewer repercussions. As a result, while wheat seeds were transformed relatively quickly in Atlantic Europe, this process was later and more limited in Mediterranean Europe, particularly where the dry land conditions were more extreme (Pujol (1998a)).

At the beginning, these innovations were based on the introduction of new varieties from Eastern Europe, and on the intensification of traditional methods of mass selection. Later, already in the 19th century, three types of initiatives took on growing importance: (1) the spreading of English and Scottish seeds to the continent;
(2) the intensification of biological exchanges inside this area; and (3) the progressive substitution of mass selection with individual, along with the growing use of different

types of crossing (Lupton (1987), Percival (1934), Zeven (1990)). Consequently, although the new techniques of improvement were still not very precise, and on many occasions were not able to stabilize the desired characteristics in the new seeds, by the middle of the 19th century, the quick spreading of new types of wheat in many areas of Atlantic Europe was also observable. Two circumstances favoured this process: the autogamous nature of that grain (which limited spontaneous mutations and hybridization) and the fact that farmers could continue to obtain the seeds for planting from their own productions, once a new variety was accepted.

The fact that the innovations could not be appropriated meant that improvement activities tended to be very decentralized, and only in special cases were they performed in a new type of company of some size. Even in these cases, it was common that their activities were very diversified, and companies also included the production of other seeds for vegetable or fodder crops among their activities. Two companies of these characteristics were: Vilmorin, and Denaiffe, Colle & Sidorot. This situation changed partially between the 1880's and the 1930's. On the one hand, the intensification of competition and exchanges stimulated the demand for seeds that were more productive and resistant to diseases. On the other hand, improvement techniques became more complex and expensive, and their development tended to be concentrated in a new type of institutions, totally or partially financed by the State (Sala Roca (1945), Walton (1999), Grantham (1984), Kamps (1989), Maat (2001)). In tables 1 and 2 of the appendix, some of them are listed.

In this context, nevertheless, various issues should be emphasized. While British economic policies tended to limit these innovations until the 1920's, protectionism and/or direct promotion by the State were a driving force behind them in other countries of the continent (Palladino (1996)). The economic and social structures of each area and their different foreign relations probably influenced these options (Offer (1989, Ch.5), Tracy (1989), Koning (1994)). In any case, while these innovations tended to be delayed in British agriculture, in France, Holland, Belgium, or Germany, they accelerated; and the spread of new wheat and the biological exchange between these countries increased (Simon (1999), Bonjean and Angus (2001)). Additionally, the sources consulted also show that the processes of innovation tended to spread towards the Mediterranean area. Nonetheless, the effects of such processes in this area did not begin to be evident until well into the 20th century. In Italy, particularly in the northern part, towards the end of the 1920's. In Spain, about 20 or 25 years later (Pujol (2002b)). In graph 1 and tables 3 and 4, some characteristics of these processes and some of the new types of wheat that tended to be spread are indicated.

With respect to the livestock sector, if we limit ourselves to cattle, horses, mules, and pigs, the information and studies consulted also show three issues. Firstly, the biological exchanges and different activities of selection and crossing existed already from the end of the 18th century. Secondly, this innovations were already important results in Western Europe in the middle of the 19th century. Finally, the spreading of these activities in Mediterranean Europe had greater repercussions than with respect to wheat, but their impact was again very limited and concentrated in few regions. Let us see some examples.

Innovations in cattle are probably the best known. Different studies have shown that the owners of Swiss and Dutch livestock had already achieved at the end of the 1800's the consolidation of different milk-giving breeds that were very improved. For example, the Friesian and the Holstein in the case of the Dutch, and the Brown Swiss and the Simmental in the case of the Swiss. Soon, with the purpose of reinforcing the uniformity of the new varieties, and focusing their improvement more precisely, they established the Dutch herdbook in 1873 and the Friesian herdbook in 1875. Somewhat later, the Red and White Spotted Simmental Cattle Association were settled in 1890; and the herdbook for the Brown Swiss in 1911. Other varieties improved for the production of meat were the Charolais and the Limousin from France, and the Durham and the Hereford from the United Kingdom, for which their respective Herdbooks were also established. For example, the English herdbook, published in 1822, two herdbooks for Charolais livestock, in 1864 and 1882, and another one for Limousin in 1887 (Briggs and Briggs (1980), Felius (1985), Porter (1991), Bieleman (2002)).

In reference to pigs, two important events are to be mention: (1) the successive improvements undergone in different English varieties since the 1770's, and (2) the foundation in 1884 of the National Pig Breeder’s Association. As a result of these activities, varieties such as the Large White or Yorkshire, the Large Black, and the Berkshire were established, and the new pigs spread quickly to the continent to give rise to other ones. Another important selection was the Craon, from French (Hall and Clutton-Brock (1989), Briggs (1983)).

Regarding horses and mules, the changes are more difficult to follow. Despite this problem, the information available also shows that their constitution tended to improve, gaining in height and strength, and that the Percheron, Ardannes, Belgian and Suffolk varieties got notable prestige. Also, in all these cases biological exchanges were very intense, both to directly exploit the new varieties and to generate other ones with successive selections and crossing (Hendricks (1995), Mason (1996)). In clear contrast with these processes, those observed in the Mediterranean areas again show important differences. In fact, leaving out the more northern areas with a greater livestock tradition, the information available again underlines the long survival of traditional varieties. The evaluations and comments of different Spanish agronomists and engineers of the end of the 19th century are very illustrative. In the 1880's and the 1890's, these technicians still underline two circumstances: (1) the scarce integration of agricultural activities with livestock farming, and (2) the existence of varieties that were not very productive. With respect to pigs, the hegemony of the varieties with dark skin and long snouts, with scarce aptitude for fattening, and slow growth was remarkable. Regarding cattle, it was evident that they were apt for working, but with low productivity for the production of meat and milk. In reference to horse and mule species, these engineers pointed out their short stature and light weight and their limited capacity in the operations of cultivation and transport.

This situation changed partially during the first third of the 20th century with the introduction of improved European varieties. In Catalonia, for example, in the 1930's, a new livestock population replaced that traditionally used in the region almost completely, and new varieties of mixed breeds from different places tended to predominate in their composition. Particularly, the characteristics of Yorkshire and Craon pigs, the Swiss and Dutch breeds in cattle, and Percheron, Norfolk and Norfolkbreton in horses and mules spread. These processes are also observed in other agricultural areas of the northern half and the Mediterranean coast, but not so much in the central and southern parts of the territory (Domínguez (1996), Pujol (2002a), Castell (2002)).

4. Biological Innovations and Environmental Conditions.

What circumstances allow the explanation of these differences? The processes that we have just synthesized cannot be explained without considering economic and institutional changes that occurred on a European scale between the second half of the 18th century and the 1930's. Nonetheless, the geografical differences that we saw in the previous paragraphs cannot be explained solely in terms of that type of variables.

In reference to the wheat sector, for example, we must remember one important issue. This sector was not only important as a producer of grain, but also of straw, and the varieties of wheat had to be long-stalked for this reason. Straw was necessary for the keeping and caring of livestock, especially where fodder was lacking, and also for the preparation of manure prior to its use as fertilizer. Consequently, although greater fertilization could increase yield in grain and allow more intensive rotations, also facilitating the appearance of lodging. When this happened, it made harvesting operations more expensive, and it could even make mechanical harvesting impossible. With lodging, a part of the production was also lost, and the attack of various diseases was facilitated. In synthesis, to increase grain production and simultaneously mechanise harvesting, it was necessary to have more productive new varieties, resistant to lodging, so that these characteristics became two of the main objectives of biological innovations (McNeill (2000, pp. 219-225) and Walton (1999, pp.34-39)). In Nordic countries, increasing the resistance of plants to low temperatures also occupied an important place. In contrast, in Mediterranean countries obtaining of earlierripening varieties was necessary (Sala Roca (1948)).

The initial interest of european breeders for British wheat is thus not difficult to understand. With the expansion of mixed farming from the middle of the 18th century, british wheat had evolved towards varieties with low gluten content, but which were very productive of grain and straw, and resistant to lodging. This trend accelerated later with the liberalization of imports and the change to high farming. But, while the institutional framework discouraged these innovations in the British case, in Western Europe it encouraged them, and the wheat varieties of Great Britain were used in a wide range of crossings and selections. Three objectives were persued:
(1) to maintain or improve the protein richness of the wheat varieties planted, (2) to increase their yield per seed or surface area unit, and (3) to make their stalks sturdier. In table 4 of the appendix, some of the main hybridization performed are indicated.

Nevertheless, at the end of the 19th century the French breeders still indicated the great difficulties met when trying to improve wheat seeds in the southern and eastern parts of France, because of climatic conditions. For Spain, the information is even more explicit. Despite various experimental centers created in the 1890's, and the numerous tests performed with the new wheat seeds spread throughout Europe, the results obtained were very poor. The new wheat varieties degenerated quickly if they came from Atlantic Europe, or they did not surpass the results of indigenous ones if they came from other grain-growing areas with similar environmental conditions. Only at times a bit of success was attained, e.g., at the end of the 19th century, with the Italian Rieti and Richella Blanca wheat from Naples, and, already in the 1920's, with some of the new seeds obtained in Italy by N. Strampelli. In reference to these last varieties, we also have to remember two issues. First, that those varieties were obtained from a new type of crossing, in which the Japanese variety Akagomushi was used. Second, that their dissemination was concentrated in the central and northern parts of the country. In Spain, on the other hand, the improvement of indigenous wheat began in the 1920's, often using new Italian wheat varieties, but their results did not become relevant until after twenty years. It was not until the 1950's that new varieties such as the Aragón 03 spread further, and only again, in the grain-growing provinces of the northern half of the country (Nagore (1935), Pujol (2002b)). In table 5 are listed the main experimental centers that carried out these activities.

In synthesis, two results arise from these experiences: (1) the use of Atlantic wheat was not viable in Mediterranean Europe, because of different environmental conditions in the two areas; (2) the improvement of the seeds themselves was more difficult to achieve in the Mediterranean areas than in the Atlantic ones.

The problems faced by biological improvements in the livestock sector were different. In this sector, the processes of selection and crossing were easier to perform and to evaluate, and hence their early results in Atlantic Europe during the 19th century. This does not mean that environmental conditions lacked importance. High temperatures throughout a large part of the year, and scarce water also limited the processes of improvement in cattle and pigs in many areas. Also, while the resources of meadows and pastures in Central and Northern Europe were great, in many areas of Mediterranean Europe it was the opposite. This circumstance was aggravated in a large part of the territory by the scarce orientation towards livestock production in the agrarian sector.

This is once again particularly clear in the case of Spain (Santiago Enriquez (1922), García Bengoa (1923), Arán (c1933)). As we have indicated, both high levels of specialization in vineyard, olive and other tree crops, and the impossibility of using the crop rotations that were used in the damper parts of Europe, limited the development of livestock in this country. This situation was also fomented by the need to resort to grazing and the scarce resources obtained with this type of farming. With the change of century, various circumstances made the greater development of that sector possible. The changes in agrarian markets, and the expansion of urbanization were undoubtedly two of them, as they stimulated the expansion of meat and milk consumption in large cities (Simpson (1997, pp.249-261), Langreo (1995)).

But the development of new sectors can not be entirely understood without considering two other variables. First, the new production possibilities provided by mineral and chemical fertilizers from the end of the 19th century. Second, the great expansion of irrigated areas undergone at the same time. As a consequence of these innovations, grain rotations were made more intensive, and the offer of fodder resources was more abundant. In a more thorough analysis, nevertheless, it also stands out that the impact of those processes tended to be concentrated in the Mediterranean coast, and in other regions of the north-eastern third of the territory, and much less in the central and southern parts of the country (González de Molina (2001), Fernández Prieto (2001)).

5. Biological Innovations and Agrarian Growth.

The biological changes that we have just synthesised are not the only ones that we could consider. Others affected Mediterranean agriculture very directly, and their impact, in some cases, was also outstanding. The spreading of new seeds is well-documented in the rice sector since the end of the 19th century, often in order to tackle lodging and to make more intensive fertilizing possible (Calatayud (2002)). Parallel to this, destruction of vineyards by phylloxera led to the transformation of biological bases in this sector, and the spreading, as we know, of American vines grafted onto European varieties of *Vitis Vinifera* (Pan-Montojo (1994, Garrier (1989)). With regard to other fruit trees, we also have varied information about the spreading of new varieties of plants with three objectives: (1) to improve the quality of final productions and increase yields; (2) to develop new productions; and (3) to better control harvesting operations (Abad (1984)).

Based on these considerations, there are certain questions that should perhaps be raised more clearly in future research. For example: what specific importance did biological innovations have in the different growth processes that took place during the 19th century and the first third of the 20th? Or, what was their role in the expansion of agrarian yields and levels of productivity? These questions are not easily answered. Firstly, because we cannot quantify the biological changes that we have described, and we must limit ourselves to very indirect estimates of their impact and dissemination. Secondly, because biological innovations tended to advance in many cases complementary to other innovations, and it is not easy to isolate their specific effects. Probably, we could advance in solving these problems by analysing the experiments undertaken in the different research centers that were created during those years more carefully (Moule (1994)). Now, I would only like to stress that the impact of biological innovations may be greater than we usually consider it to be, and that it is not a good thing to minimise it.

In reference to the wheat sector of the United States of America, the expansion of which was usually associated with an increase in planted surface areas and mechanisation, recent research has estimated that approximately 50% of the increase in its productivity levels between 1839 and 1909 was caused by the spreading of new seeds of that grain (Olmstead and Rhode (2003)). We still don't have studies of these characteristics for European agriculture. On the one hand, we do not have statistical information on the evolution of planted areas, such as those existing for the USA since 1919. On the other hand, biological innovations

advanced along with the use of more intensive fertilizations and the expansion of irrigated surface area, so it is more difficult to isolate its effects on the levels of productivity. Nevertheless, in recent studies it has also been suggested that environmental conditions might exercise a greater influence over the dissemination of new means of production, and that among these conditions we should consider two variables:
(1) the initial biological bases, and (2) the possibility of altering them.

Various research projects allow us to know a fair amount about the dissemination processes undergone by mineral and chemical fertilizers and harvesters. Three issues stand out: (1) the initial spreading of these means of production in British agriculture, especially in the case of harvesters; (2) the intense spreading of the use of these inputs in Continental Atlantic Europe, approximately from the 1880's; and (3) its later and more limited spreading in Mediterranean Europe. In table 6 some of these aspects with regard to the spreading of new fertilizers are shown. In reference to the spreading of harvesters, let us remember the following issues. At the end of the 19th century, 80% of the British wheat areas were harvested with machines. In France, on the other hand, this percentage dropped to just under 15%, and in Germany, to little more than 5% (Grigg (1992, pp.52-55)). In the rest of the continent these percentages were even lower, and in the cases of Spain and Italy, they were practically negligible. Soon after, the studies performed show that the use of harvesters intensified in countries such as Belgium, France, and Germany, but in the case of Spain and Italy, they did not begin to be significant until the 1920's (Van Zanden

(1991), Gallego (1986)). Besides, the implementation of harvesters ended up being high in the grain-growing areas of the northern part Spain, but very little in the central and southern parts, and along the Mediterranean coast. Additinally, the spreading of the new fertilizers ended up being quite remarkable in this last area, and other inner regions in the north. On the contrary, they lacked relevance in the central and southern parts of the country. In fact, the use of those materials in a wide part of this area did not even reach 5 kg/ha in the 1930's, when it was often greater than 30 kg/ha in the coast and in the Ebro basin (Simpson (1987), Pujol (1998c), Fernández Prieto (2001)). See table 7.

How do we explain these processes and differences? The sustained expansion of exchanges and the intensification of the processes of industrialization tended to favor the spreading of new means of production in two ways. One, by improving the conditions of its offering in terms of price, facility of access, and greater adaptation to local needs. The other, by reinforcing successive salary increases, due to the changes caused in the labor markets by these processes. The sustained reduction in the relative prices of new fertilizers (Pezzati (1994)), and the improvements that were introduced into the design of harvesters illustrate the first issue very well. The tendency of agrarian salaries to rise from the last decades of the 19th century, and especially after World War I, is also welldocumented (Scholliers (1989), Martínez Carrión (2002)). These processes are also well-known for the Spanish case, and they are illustrated in graph 2. As a consequence of these changes, we can confirm that the threshold of use of these means of production tended to widen over time, and that this circumstance reinforced its spreading in a sustained way. But the previous information also shows significant differences in the rhythms and intensity with which the new techniques of production spread, which can not always be explained by the evolution of their offer or by wage pressures.

Evidently, another variable that we must consider is the institutional framework, due to their great influence on the farmers´ demand for new production techniques. Numerous studies have analysed these issues and have dealt with the influence of three groups of variables on those processes: (1) the structure of land owning and its changes over time, (2) the size of the farm and the social systems of production, and (3) the agrarian and tax policies. Thanks to this research, today we can better explain, for example, the early spreading of new production techniques in the British agricultural sector during the 19th century, or its intense spreading, between the 1880's and the 1930's, in countries such as France, Belgium, Holland, or Germany (ie. Koning (1994), Van Zanden (1994)). In these studies, interesting explanations have also been provided for the decline of British agriculture since the 1880's (Offer (1989, Chap. 5)) and on the different orientation of biological innovations in the wheat sector in Atlantic Western Europe (Walton (1999)).

But even if we also consider institutional variables, the processes observed in Mediterranean agricultures are not easy to explain, especially considering the intense regional differences between the middle of the 19th century and the 1930's. For this reason, the need to include environmental factors in analysis has been mentioned on various occasions, and these proposals have often favoured controversial findings (O'Brien and Toniolo (1991)). In the case of Spanish historiography, they are still being hotly debated (Pujol et al. (2001), Historia Agraria, 28, p.p. 179-230; 29, forthcoming)).

Recent research on this country sustain what follows. The environmental conditions defined very distinct constellations of available techniques in Mediterranean and Atlantic agricultures, and the demand for new means of production also was for this reason, very different. This consideration does not minimise the importance of the other variables. The institutional framework doubtlessly delayed the beginning of agrarian changes and contributed to slowing them down, as it realised late and slowly the transformations that the sector needed. At the same time, the late development of a new industrial sector, producing fertilizers and mechanical means of production, was another factor that we should not forget. From our perspective, nonetheless, these circumstances can't satisfactorily explain two issues: the low levels of use of the new agrarian inputs during the 1930's and their unequal spreading in different places. Moreover, when those agrarian innovations are analysed more carefully, different relations are perceived that should be investigated more precisely. In table 7 the clearest cases are indicated.

Firstly, the close relationship existing between the spreading of new fertilizers and the availability of water. These relationships are shown, for example, in two situations observed in the 1930's: (1) the high consumption of fertilizers in the irrigated areas of the territory and in various northern provinces; and (2) the negligible consumption of these same products in wide areas of the center and southern parts of the country, i.e., where precipitation was very little and irrigation was not significant. Secondly, the studies performed also show another issue. Altough the surface areas to harvest could be very large, mechanised harvesting tended to be not very significant where the surface areas of vineyards and olive groves were also great, or where both surface areas were relatively near each other. There are certainly exceptions, but the relationsip between the spreading of harvesters and cultivation structures is difficult to question and must not be ignored. One of the reasons that has been suggested to explain this relationship is the discontinuity that could be generated by grape and olivegrowing specializations in grain-growing lands. Other reason are the different problems that the work processes of those crops could generate in the different graingrowing areas. Let us recall that the harvesting of grains had to be performed during a short period of time, between June and July, also coinciding with the reaping of the alfalfa fields and the like, and that the gathering of grapes and olives was done later and successively. The grape gathering in September, and olives from November till February or **March**. These operations also required a great deal of work and could not be mechanized. Therefore, it is not risky to suggest that the pressures to mechanize the harvesting of grains had to be very different according to the structures of crops, and lower in the Mediterranean coast, and in the central and southern parts of the country. Finally, both with respect to new fertilizers and harvesters, in this analytical framework there is another issue. Its lesser spread in many areas was also conditioned by the existing varieties of seeds and the difficulty to improve them (Gonzálex de Molina (2001), Fernández Prieto (2001)).

Conclusions.

In syntesis, the transformation of European agriculture during the 19th century and the first third of the 20th should be explained as a result of two large groups of variables. On one hand, the successive pressures generated by economic and institutional changes undergone during that period, promoted the development of new types of activities, new means of production, and higher levels of productivity. On the other hand, the environmental and biological environments of the different areas, conditioned the productive orientations that could be developed and the available techniques.

In this paper I have tried to show that the biological characteristics of plants and animals occupied a strategic place in the development of the processes of production, hence the interest in transforming them. In some cases, to mitigate the impact of certain diseases or accidents. In others, to improve the quality of the final production, but broadly to increase the levels of productivity and improve agrarian incomes.

Analyzing the case of wheat and different livestock species, nevertheless, we have also seen another issue. Biological and environmental conditions influenced the spreading of other innovations, such as those related to the fertilization of the soil and the harvesting of grains, and consequently the different patterns of the spreading of technical change. Therefore, these circumstances should also be taken into consideration to explain the different courses followed by those sectors in the different areas of the continent.

Finally, based on the previous considerations two working hypotheses could be maintained. First, that the possibilities of agrarian growth until World War II were always fewer in Mediterranean agricultures than in Atlantic ones, although the new offers of means of production and the expansion of irrigation tended to increase them. Second, that these differences did not begin to decrease significantly until the 1960's, and then as a consequence of two groups of innovations: those related to the use of fossil fuel in cultivation, harvesting and threshing; and those related to the use of new seeds and chemical products for the fertilization of the land and the treatment of plants. That is, when a whole group of new technical possibilities allowed the mitigation of the impact of environmental variables and increased the dependence of agriculture with respect to the industrial sector.

STATISTICAL APPENDIX

Table 1: European Experimental Centers, Members of theInternational Association of Seed Testing (1931)[a].

	Nº		Nº		Nº
Germany	19	U. Kingdom	3	Finland	1
Sweden	8	Spain	2	France	1
Italy	5	Latvia	2	Hungary	1
Poland	5	Switzerland	2	Rumania	1
Czechoslovakia	4	Belgium	1	Netherlands	1
Ukraine	4	Bulgaria	1	Denmark	1
Norway	3	Ireland	1	Estonia	1

(a) All seeds, not only wheat.

Source: Boletín Mensual de Información Técnica, InstitutoIntenacional de Agricultura, 1933, p.p. 114.

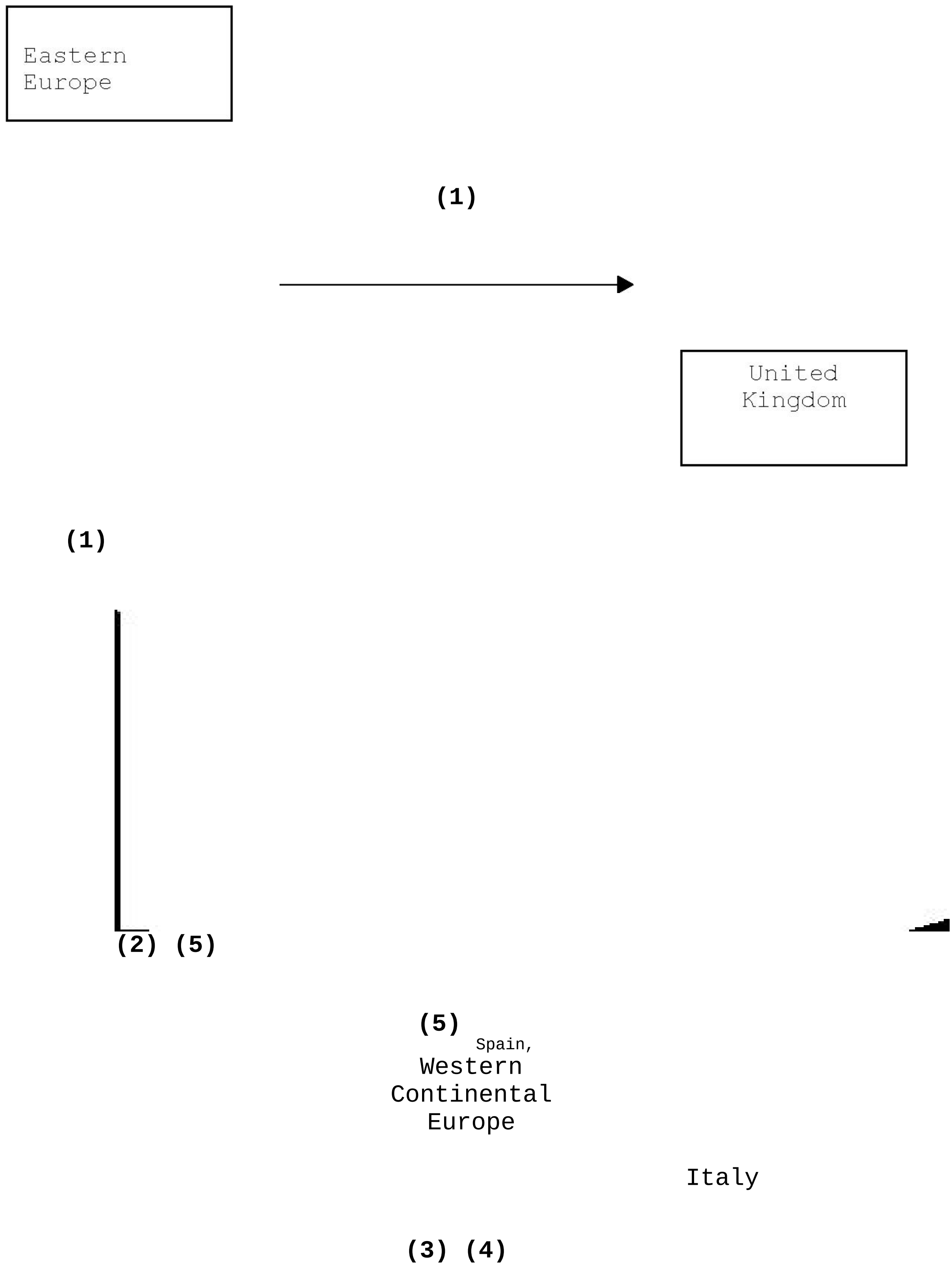
Table 2: Institutions of wheat improvement in Europe, 1880-1938[(a)].

(1)(b)	(2)	(3)	(4)	(5)(c)
Maison Vilmorin-Andrieux (Verriéres)	(II)	FRA	1815	M.H. and Ph. Vilmorin
Institut de Recherches Agronomiques	(I)	FRA	1921	
C. de Recherches Agronomiques (Versailles)	(I)	FRA	1923	
Plant Breeding Station at Gembloux	(I)	BEL	1872	
Station de Selection du Boerenbond Belge (Héverlé)	(II)	BEL	1925	A.G. Dumont
Plant Breeding Institute at Wageningen	(I)	NET	1886	L.Broekema
Station de Recherches Agronomiques (Groningue)	(I)	NET	1889	
Plant Breeding Institut (Munich)	(I)	GER	1872	
Plant Breeding Institut (Breslau)	(I)	GER	1872	
Plant Breeding Institut (Halle)	(I)	GER	1863	
Plant Breeding Institut (Hohenheim)	(I)	GER	1905	
Plant Breeding Institut (Magyarovar)	(I)	HUN	1909	
Plant Breeding Station (Viena)	(I)	AUS	?	E.Von Tschermak
Svalöf Plant Breeding Station	(III)	SWE	1886	N.H. Nilsson-Ehle
Weibullsholm's Plant Breeding Station (Landskrona)	(III)	SWE	1904	
Plant Breeding Institut (Cambridge)	(I)	UK	1912	R.H. Biffen, F. Engledow
I. di Genetica per la Cerealicoltura (Roma)	(I)	ITA	1919	N.Strampelli
Stazione Sperimentale di Granicoltura (Rieti)	(I)	ITA	1907	N. Strampelli
I. di Allevamento per la Cerealicoltura (Bolonia)	(III)	ITA	1920	F. Todaro

(1) Institution; (2) Type of financing: public (I), private(II), and mixed (III); (3) Country; (4) Breeder.
(a) Institutions and breeders most cited in the source; (b)Other important institutions were: Plant Breeding Station (PBS)al Krizevci (SER), Kaiser Wilhelm Institut of Breeding (GER)(c)Other important breeders were: M. Blondeau (FRA), C. Benoist(FRA), R. Carsten (GER), C. Krafft (GER), F. Vettel (GER), F.Heine (GER), W. Rimpau (GER), F. Strube (GER) and P.J. Hylkema(NET).

Source: From Lupton (1987), Zeven (1990), Institut Internationald'Agriculture (1933).

Graph 1: Main flows of wheat seeds between 1830 and 1914.


Eastern Europe
(1)
United Kingdom
(1)
(2) (5)
(5)
Spain,
Western Continental Europe
Italy
(3) (4)

(1): Polish, Odessa, Noé, Chaff Dantzick, Bonte Poolse
(2): Hallet, Hickling, Munsgowell, Goldendrop, Wittington, Hunter, Essex, Chiddam, Prince Albert, Essex, Trump, Spalding, Victoria, Shirreff, Tunsall, Squarehead, Prolific, Standup, Master.
(3): Hatif Rimpau, Perle N. Barbú, Sta. Helène, Gelderse, Japhet, Wilhelmina, Grenadier.
(4): Richelle Bl.Nápoles, Rieti.
(5): Only for testing.

Source : From Lupton (1987), Bonjean and Angus (2001), Zeven(1990), Percival (1934), Debaiffe & Colle, Sidorot (C1920's),Vilmorin-Andrieux (1880).

Table 3: New varieties of wheat between 1880 and 1938.

United Kingdom	**Western Continental Europe**	**Italy**
	1880-1914	
Sh. Squarehead,Orice Prilific,Ambrose Standup,Starting II, LittleJoss.	Lamed, Dattel,Bordier, Strubes,Spijk, RimpauFrüth, Wilhelmina,Japhet, Champlan,Duivendaal, BonFermier, Fletum,Hatif Inversable,Briquet Jaune, DeMassy, Gross Tete,Grenadier,Montilleul,Krafft's, Cuiras I,II, Emma, Algebra,Juliana,Concurrent, Jacobs,Géant Rouge, GéantBlanc, Cartens V,Travenant, MilionI, Hylkema, Ceres,Robusta, Kronen	Carlota Strampelli,Undici.
	1915-1938	

Yeoman I and II,Holdfast, A1,Premier, Wilma,Steadfa st, Quota,Redman, Warden.	Prins Hendrik,Blanka, Des Aliées,Addens, Van Hoek,Extra Kolben II,Mansholt, Invicta,Skandia II, Carma,Ideal, Vilmorin 23,27, 29, Wilobo,Bersée, H. 40,Crown, Jubilée,Mendel, Alba,Astra, Staring,Lovink, Strube 56,Elisabeth, Atle.	Senatore Capelli,Ardito, Mentana,Villa Glori,Sestini, Damiano,Fandull a,

Source: From Lupton (1987), Bonjean and Angus (2001), Zeven(1990), Percival (1934), Debaiffe & Colle, Sidorot (C1920's),Vilmorin-Andrieux (1880)..
27/2005 – UHE/UAB – 24.01.2005

Table 4: Main pedigrees of wheat hybrids obtained between 1880 and 1938.

	From			
	(1)	(2)	(3)	
France				
Chiddam epi rouge	Chiddam			
Chiddam epi blanc	Chiddam			
Gros Téte	Prince Albert			*Chidd*
Massy	Shirreff	Noé		
Bordier	Prince Albert	Noé		
Gros Bleu		Noé		
Bon Fermier	Blé Siegle			*G*
Trésor	Shirreff			*G*
Dattel	Prince Albert			*Chidd*
Alliés		Noé		*Massy*
H. Inversable	Chiddam			*Gross Bl*
Vilmorin 23		Noé		*Alliés, P*
Vilmorin 27				*Dattel, Alliés, Fermier*

Belgium				
Jubilée			*Vilmorin 23* (Fra) *Iron III*(Swe)	
Alba	Essex		*Tresor (Fra)*	*W*
Netherlands				
Spijk	Squarehead			
Wihelmina	Red Squarehead			
Emma	Essex			*W*
Juliana				*Wihe*
Hylkema	Squarehead		Shonen (Swe)	*W*
Staring				*Juliana*

GermanyCarstens V				
	Squarehead	(?)		***C***
Model	Squarehead			L
Braun Rimpau				*Model*
Strube 56	Squarehead	Noé		
Sweden				
Grenadier	Squarehead			
Iron				*Gren*
Kronen				*Ir*
Extra Kolben			*Saumur* (Fra), Emma (Net)	
UK				
Little Joss	Squarehead	Ghirka		
Yeoman	Browick		*Red Fife (Can)(a)*	
Steadfast	Squarehead			*Little*
Holdfast			*Red fife*	
Italy Villa Glori				
			Akagomughi (Jap),*Wihelmina*(Net)	
Ardito			*Akagomughi* (Jap),*Wihelmina*(Net)	
Damiano			*Akagomughi* (Jap),*Wihelmina*(Net)	
Mentana			*Akagomughi (Jap),Wihelmina*(Net)	

(1) From UK (Squarehead also include its selections); (2) From East Europe (Noé was a selection andinclude other selections of

it); (3): From other countries (italics means wheat hybrids **or selections** previously obtained); (4): From the same country (italics means wheat hybrids **or selections** previouslyobtained).Notes: (a) Originally from Danzig (Poland).

Source: From Lupton (1987), Bonjean and Angus (2001), Zeven (1990), Percival (1934), Debaiffe & Colle,Sidorot (C1920's), Vilmorin-Andrieux (1880).

Table 5: Wheat improvement activities in Spain, 1880-1935.

(1)(a)

(2) Granja Experimental del Jardín del Real de Valencia 1885 Granja Escuela Experimental de Valencia 1888 Granja Experimental de Barcelona 1894 Granja Experimental de Zaragoza 1885 Granja Experimental de La Coruña 1896 Granja Escuela Práctica de Agricultura de Palencia 1908 Campos de Demostración y Experiencias de Segovia 1898 Estación Agronómica del Instituto Agrícola de Alfonso XII 1905 Estación de Ensayo de Semillas de La Moncloa 1908 Escuela Práctica de Agricultura de Jerez de la Frontera 1906 Granja Escuela Práctica de Agricultura de Navarra 1908 Granja Agrícola de Pamplona 1908 Granja Experimental. Badajoz 1906 Granja Experimental. Jaén 1906 Granja Agrícola de Palencia 1909 Estación de Agricultura de Zamora 1919 Granja Regional de Castilla la Vieja 1923 Granja Experimental de Zalla ? Sección Agronómica de Alava ? Servei de Terra Campa (Cataluña) 1923/1932

(1) Public experimentation centers; (2) Date of constitution.
(a) The activities of the Sindicato Agrícola de Guissonabeginning in 1932 must also be emphasized.

Source: From Cartañà (2000) and Pujol (2002b).

Table 6: Consumption of N, P_2O_5, and K_2O from mineral and chemical fertilizers between 1880-1936 (Kg/ha).

	1911-1913(a)	**1931-1937**(a)
Netherlands	163.7	299.2
Belgium	68.4	160.9
Germany	49.9	143.9
UK	28.2	60.1
Denmark	17.9	54.8
France	10.7	40.6
Italy	13.3	26.0
Spain	5.8	16.8
Mediterranean Coast		*32.3*
Northeast		*28.8*

Northwest(b)		*12.9*
Center and South		*9.49*

(a): Different years; (b): Without Cantabrian coast and Galicia. Source: Pezzati (1994), Gallego (1986) and Pujol (1998).

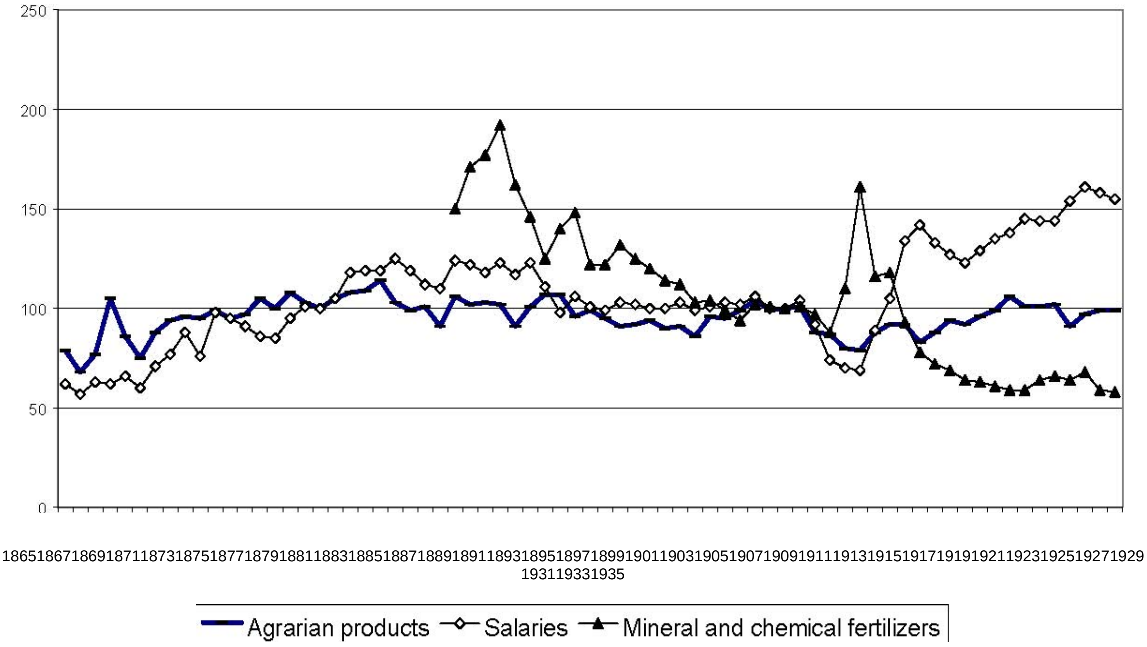
Table 7: Agronomic conditioning factors and technicalchange.

Mineral and chemical fertilizers Grain harvesters
PROVINCES (*) (1) (2) PROVINCES(*) (1) (2)
Areas witht higher use VALENCIA 32,26 75,88 ALICANTE 24,49 28,16 ALMERIA 22,98 27,67 LERIDA 29,18 22,00 ZARAGOZA 21,08 34,16 CASTELLON 17,29 33,82 TARRAGONA 15,10 39,46 BURGOS 8,7 39 PALENCIA 5,6 34 LEON 15,9 70 HUESCA 16,6 32 TERUEL 24,1 36 ZARAGOZA 24,6 27 GERONA 26,4 31
Areas witht lower use JAEN 5,44 1,41 CIUDAD REAL 3,78 4,78 GUADALAJARA 3,03 7,49 CACERES 1,64 7,18 BADAJOZ 0,24 7,16 CORDOBA 0,65 7,06 CUENCA 0,92 7,92 BADAJOZ 23,6 250 TOLEDO 27,7 2.119 CIUDAD REAL 37,7 832 MALAGA 43,7 228 CORDOBA 53,1 365 BARCELONA 64,3 637 TARRAGONA 67,9 574

(*) Provinces with little precipitation and hightemperatures in spring and summer.
(1) Relative importance of irrigated surface areas in 1922.
(2) Kg/ha of mineral and chemical fertilizers around 1933.
(3) Relative importance of surface areas of vineyards andolive groves in the total occupied by these crops, thesurface areas sown with grains, and the surface areas ofartificial pastures, around 1932.
(4) Hectares sown with grains by harvester, around 1932.

Source: From Pujol (1998b; 1998c)

Graph 2: Price indexes in Barcelona (Spain) in constant



pesetas (1913=100).

Source: Pujol (1998b) and Garrabou et altri (1991).

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