The International Seed Industry

Samuel Contreras[1]

Introduction

One of the most fundamental goals of agriculture is the production of food, feed and fiber for an increasing number of people in the world, which today is over six billion. With this objective in mind, the different areas of production management have been greatly developed, such as breeding, establishment techniques, irrigation, nutrient supply, pests control and postharvest. Among these areas, breeding of cultivated plants has been especially relevant, being estimated that it represent about 50% of the total increase in yield of most cultivated species, during the last 50 to 60 years (Duvick, 1996).

In addition to this noble goal, the economic development experienced by a portion of the society, has originated new necessities. For instance, in the last time there have been an increasing demand for vegetables because they have been associated with heath benefits or properties. The demand for ornamentals species is also increasing, influenced by the moving of people from rural areas to the cities. It is estimated that, in United States, vegetables and ornamentals represent about a 20% and 10%, respectively, of total agricultural value (McDonald, 1998).

Research has provided new technologies in order to do both, a more efficient food production and production of goods that respond to new and more specific demands. In the last two decades, the achievements in these areas have been extraordinary, with a special relevance of genetic engineering, essential component of biotechnology. In this context, seeds have become more than a fundamental input of the agriculture, nowadays seeds are valuable organisms, able to transport some of the most recent technologies. Therefore, seeds must have high quality and flawless performance.

The changes in orientation of production and other ancillary changes have affected the seed industry as a whole, creating a new global industry, which is guided by large multinational companies. This article analyzes the reasons that have led toward the globalization of the seed industry, how technological advances have affected it, and the roles that nowadays the industry has had to assume.

Globalization of the Seed Industry

The global market for seeds is not easy to apprise. The first obstacle for the analysis is that the definition of "seed" varies from country to country; obviously seeds also vary in value and level of

[1] Departamento de Ciencias Vegetales, Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile. Casilla 306, Santiago 22, Chile. scontree@puc.cl

renewal among countries (Le Buanec, 1996). In spite of these difficulties, the International Seed Federation (ISF) estimates that the total value of annual seed consumption in the world is close US$ 50 billion, with approximately US$ 30 billion being actually involved in commercial transactions.

In terms of the internal markets for seeds in different countries, United States is leader, with an estimated value of US$ 5,700 millions, followed by China and Japan (Table 1). However, if the European Union is considered as one market, it would place second, with about US$ 5.23 billion. For each country, the value of their domestic markets vary quite strongly according to size, agricultural activities and the level of development. Among South Americans countries, Chile is in third position, with US$ 120 million, preceded by Brazil and Argentina (ISF, 2002).

Figure 1 shows the steadily increasing international exchange of seeds experienced in the last three decades, multiplying by 4 the world trade value. It is estimated that during this year in the world will be trade seed by almost US$ 4.1 billions, and that in the 2010 the value will be close to US$ 20 billion. Table 2 shows the 10 most important seed exporting countries in the world.

Globally, the most important products are vegetable, flower, herbage and beet seeds; 'regional' products are maize and potatoes, while 'local' products are cereals and large seed legumes (Le Buanec, 1996). Table 3 shows the magnitude of exports of different species ad gives a glimpse of worldwide values of the globalization process experienced by the seed industry. A general explanation for globalization is based on political, economic and technical changes which have conducted to a true global market. Some examples of these changes are the existence of the Mercosur, NAFTA and the consolidation of the European Community. In the technology area, the development of telecommunications and transport have advanced dramatically, breaking down national barriers, thus allowing a true global market (Le Buanec, 1996).

In addition to general reasons such as the ones stated, there are others more specifics reasons for the internationalization of the seed industry. Le Buanec (1996) presented the followings:

- In order to ensure regular supply, it is necessary to organize production in different countries so that climatic accidents be avoided. Counter-season growing allows the acceleration of breeding cycles as well as prevention from seasonal hazards in either of the hemispheres.
- Some agro-climatic zones are particularly favorable to the production of seeds of specifics crops, and also some countries have available manpower with an interesting quality/ price ratio.
- During last century some regional and international organizations concerned with the existence of adequate regulations related with seed trade were created, watching over the interests of breeders, producers and consumers. Some examples are the ISF, which is the result of the merger of the International Seed Trade Federation (FIS) and the International Association of Plant Breeders (ASSINSEL); the International Seed Testing Association (ISTA), which is in charge of the international seed analysis certification; the International Union for the Protection of New Varieties of Plants (UPOV); etc.
- The creation of multinational companies which facilitates and enhances international seed trade and the globalization of the market.

In spite of the described reasons, there are also some restrictions to a more intense internationalization of the market, which can be grouped in technical or commercial and regulatory limitations (Le Buanec, 1996):

Technical commercial limitations: Contrary to commodity products, which can be sold globally without major modifications, plant varieties must be especially adapted to their geographical markets, so there is a geographical specialization preventing movement from one region to another. There are also some reasons that limit exports of some kind of seeds; for example in many cereals the fragmented structure of the industry, a smaller commercial margin and the high seed volume per hectare.

Regulatory limitations. As a result of the commercial agreements, tariff barriers are decreasing more and more, however another kind of barriers have been appearing. This is the case of:

- phytosanitary regulations. For some diseases, no identification tests have been developed and legislation implemented is often inappropriate and/or impossible to practice;
- in various countries there are prohibitions to the trade of varieties which are not registered in an official catalogue;
- problems to the trade of seed treated with products which are not registered in some countries;
- prohibition to the commerce of genetically modified organisms (GMO) products, maybe the most important in recent time, due to the increment of transgenics crops production.

Also, there is one aspect that should be either limiting or accounting for the internationalization of the commerce: the protection of intellectual property. In one hand, breeders will be reluctant to produce and commercialize their varieties in countries where there is weak or no protection of the intellectual property. Whereas, in the other hand, they will be encouraged to do it in UPOV member countries, where theirs rights are well protected. Also, as will be discussed later, new methods to protect intellectual property are being worked out.

Impact of new technologies

During the last decade the advances in genetic engineering, the central component of the biotechnology, have resulted in revolutionary changes in the plant breeding area. Those changes have affected the production and seed technology, as well as the market and its economic value.

Breeding and creation of new varieties

Recent technologies which have led to the study of the genome structure and function, have made possible to increase the precision of the process that generate variability and, at the same time, a better use of this variability (Bradford, 1999; Campos, 1999). In addition, by virtue of recombinant DNA technology, today the breeders dispose of all the genes of nature and also of artificial genes created in the laboratory (Campos, 1999). Thus, the breeding of new varieties has had important advances, manifested by reduction of the time required and a better precision in obtaining target characteristics, such as larger yields, resistances to diseases and insects, better adaptation to stress conditions, herbicide resistance, better compositional traits of the products, improved post-harvest performance, etc.

Production and seed technology

The mentioned advances could also carry some problems, for instance, the modification of a specific trait could affect either seed quality or the performance of the variety, or both. For example, there are evidences that modifications in compositional characteristics of the kernel are related with problems of seed viability and vigor in maize. Something similar happens in tomato; in this case genes which are associated with production of lycopene enriched fruits have deleterious effects on seed quality and plant development. Thus, alternative methods for the production and use of these seed should be developed.

Another example of the influence of new technologies on seed production, is the generation of new techniques to control fertility in species in which natural sterility is not know or is useless. This aspect is specially important on the efficiency of hybrid seed production. Some techniques that the genetic engineers implemented are: attainment of self-incompatibility by inclusion of some specific genes which control it; flower morphology manipulation; ad use of specific promoters which cause the tapetum destruction, interfering in the pollen production (Bradford, 1999).

Also new techniques have been developed to control germination of second generation of seeds. Some examples are programmed male-sterility, modifications in the seeds compositional traits to diminish viability, and programmed expression of characters on time (Bradford, 1999). These methods prevent farmers from using second generation seeds, helping to protection of intellectual property. Other benefit of these traits is the prevention of dispersion of GMOs in the environment, avoiding the undesirable cross between transgenic and non transgenic plants (Brancroft, 2000).

It is easy to understand the high value that the seeds represent nowadays; they are more that a basic input of production, they have transformed into the delivery and trade unit of new varieties and all the technology developments that they represent. In this way, seed technology rises as an important discipline, including selection, conditioning and treatments of seeds to improve their performance as a propagation unit (Bradford, 1999). An example is the different techniques of seed coating, from use of film coatings to seed pellet. The first is a thin film which does not obscure the shape of the seed, improving the adherence of chemicals and appearance of the seed. Pellets are produced by encasing the seeds in an inert material, such as montmorillonite clay, which affects the shape and volume of the seed, allowing free flowing during mechanical precision planting (McDonald and Copeland, 1997). These techniques also permit the addition of fungicides, insecticides, microorganisms, growth regulators, micronutrients or any compound which improve the seed performance. Another technique of increasing relevant in last years is priming, which is a process of controlled seed hydration, after which seeds are directly planted or redried and handled using normal practices. Priming allows the seeds to override thermodormancy and improve field stands, even under some stressful condition. The technologies described are an opportunity for seed companies to give an extra value to their product, or to share or transfer this value with others specialized companies.

Impact in the seed market

Since the introduction of the first commercial transgenic crop in United States, in 1996, production of transgenic crops has increased steadily, and during 2001 represented more than 52 million of hectares in the world (Figure 2). Table 4 shows which species and traits are predominant in transgenic crops and, also, the portion of the total area grown for each specie represented by GMO's varieties. It is possible to appreciate that the number of species is limited, and that the modified traits, benefit just the growers. However, it is expected that in the future the breeding will be done in a wider number of species and that it will be more focused in traits which will benefit also the consumers, for example, improving compositional traits of products.

In the analysis of the evolution of transgenic products, it is necessary to state the fact that this kind of technology is in its infancy. In fact the acreage is constituted basically by four species and, in spite of transgenic crops being cultivated commercially in 16 countries, just four countries represent 99% of the total acreage (Uauy, 2002). It is well known the reticence that GMO's produce in some groups around the world. However, the introduction of new traits more attractive to consumers, the introduction of new crops, and the establishment of clears policies related with the production and commerce of GMO's, should result in larger increases in GMO's. The importance of these tendencies in the seed market is obvious; it is estimated that in 2001, the value of the transgenic seed market was almost U$3.5 billion, which is about 12% of the total seed market.

Function and structure of the seed industry

The seed industry is responsible of supplying a basic and valued input of agricultural production. Among the diverse functions of the industry, according to Desai, Kotecha y Salunkhe (1997) are the following ones:

- Plant breeding, including genetic research and cultivar assessment,
- Multiplication and seed production, either in companies own dependences or by producers,
- Processing, including drying, storage, packaging and seed treatments,
- Marketing
- Legislative control, seed certification and testing,
- Extension activities.

The Industry is organized in public and private entities, which assume these different functions, with the objective of accomplishing the general roles of research, production, quality control, and marketing.

Universities and others public entities carry out research of different aspects of interest for the industry. Recently, research also have been assumed by companies, they are investing increasing amounts of resources in it, which obviously have affected the divulgation of the knowledge. One obvious target of research is breeding, which include from genetics studies to cultivar assessment. However, research is not just limited to obtaining new cultivars, but concerns each one of the many activities of the industry. For example, research is essential to the optimization of the seed production process, and it generates the information and techniques for efficient seed production of different crops under different environmental conditions. Research also is concerned with seed technologies and testing.

Another aspect of research carry out by public entities, which has a not so obvious relation with the seed industry, is the development and extension of better growing techniques. It is known that the use of improved varieties and seed of high quality is important for successful growing, but it is not the unique requirement. To achieve the potential of an improved variety, it is necessary certain technological level; developing that level among growers will be essential to increase seed demand.

Other public entities that participate in the seed industry, are the global, regional and national organizations, which contribute in the regulation of seed market. These organizations guarantee the rights of breeders, producers and consumers, and also contribute to the training and operation of seed analysts. Examples are ISF, ISTA, UPOV, International Society of Seed Technologists (ISST) and others.

Nowadays the seed industry is characterized by the presence of huge multinational companies, most of them North American, European and Japanese. They have integrated vertically and participate in all the functions of the industry. Maybe one of the most important fact of recent years, perhaps as consequence of advances in genetic engineering, is the several merges that have been occurring. The underlying reason may be that the companies which enter the race for identification and patenting of potentially useful genes, realize that those genes have value only if they are included in superior varieties. Therefore, the interest to buy or merger with companies who have the superior varieties become crucial and has created a new concept of companies, known as "Life Science Companies". This companies, based in genomics (study of genome function and structures), biotechnology and chemistry, will generate agricultural, pharmaceutical and agrochemicals products, which will be introduced to the production process by the seed (Bradford, 1999).

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Table 1. Estimated value of the internal trade of seeds in the world's largest markets (ISF, 2002).

Country	Internal trade (US$ x 10^6)	Country	Internal trade (US$ x 10^6)
1-USA	5,700	11-United Kingdom	570
2-China	3,000	12-Canada	550
3-Japan	2,500	13-Poland	400
4-Russian Federation	2,000	14-Mexico	350
5-France	1,370	15-Spain	300
6-Brazil	1,200	16-Netherlands	300
7-Germany	1,000	17-Australia	280
8-Argentina	930	18-Hungary	200
9-Italy	650	19-Denmark	200
10-India	600	20-Sweden	200

Table 2. Seed exports of the largest exporting countries (ISF, 2002).

Country	Agricultural seeds	Horticultural seeds	**Total**
USA	550	249	**799**
Netherlands	420	200	**620**
France	373	125	**498**
Denmark	150	40	**190**
Germany	150	35	**185**
Chile	84	60	**144**
Canada	104	18	**122**
Belgium	111	n.a. [(1)]	**n.a.**
Italy	70	41	**111**
Japan	5	100	**105**

[1] Not available.

Table 3. Seed exchange by crops (ISF, 2002).

Crops	Value of seed exports (US$ x 10^6)
Vegetables and flowers	1,150
Maize	530
Herbage crops [(1)]	427
Potato	400
Beet	308
Wheat	75
Other agricultural crops [(2)]	750
Total	**3,640**

[1] Grasses and legumes for both forage and turf purposes.
[2] Soybean, sunflower, rapeseed, cotton, etc.

Table 4. Dominant transgenic crop/ trait combination in 2001 (James, 2001).

Crop	**Trait**	**Million hectares**	**Transgenic area as % of global area of each crop**
Soybean	Herbicide tolerant	33.3	46
Maize	Insect resistant (Bt)	5.9	7
	Herbicide tolerant	2.1	
	Bt + herbicide tolerant	1.8	
Cotton	Herbicide tolerant	2.5	20
	Bt + herbicide tolerant	2.4	
	Bt	1.9	
Canola	Herbicide tolerant	2.7	11
Total		**52.6**	

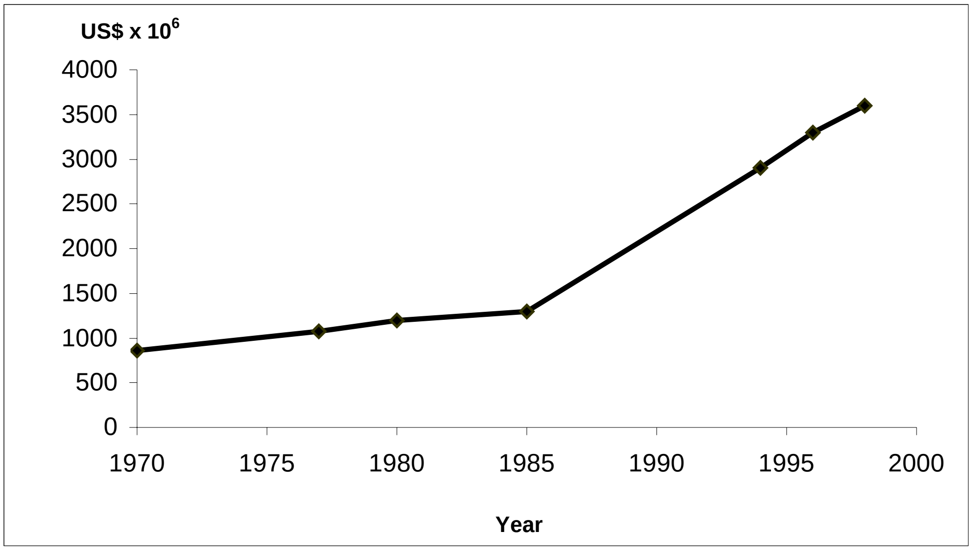

Figure 1. Evolution of the value of seed exchange in the world during the last 30 years (ISF, 2002).

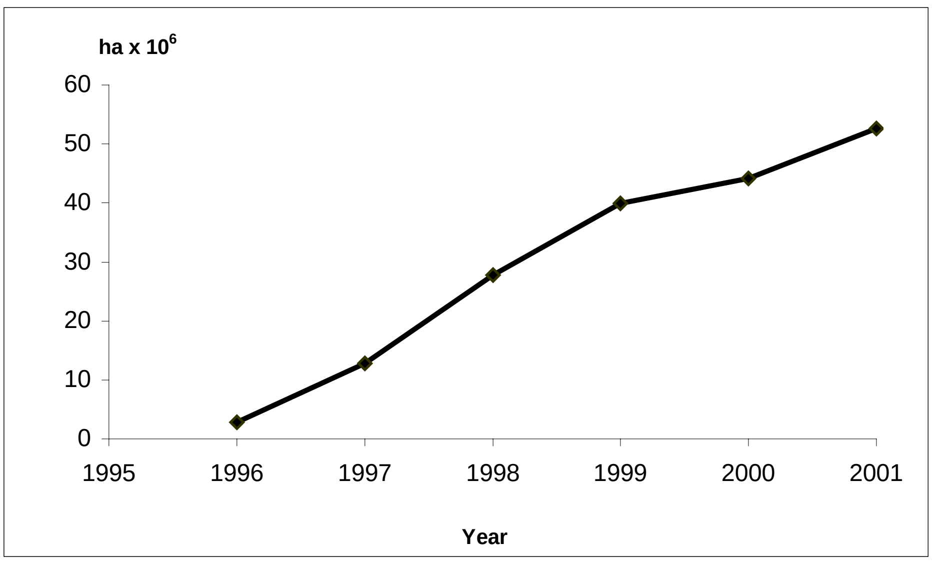

Figure 2. Evolution of global area cultivated with transgenic crops (ISF, 2002).