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TRACKING THE TREND TOWARDS MARKET CONCENTRATION: THE CASE OF THE AGRICULTURAL INPUT INDUSTRY

Study prepared by the UNCTAD secretariat

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FOREWORD

Paragraph 64 of the São Paulo consensus states, *inter alia*, that *"the added value retained by many developing countries' producers of commodities is decreasing in some sectors, and their participation in domestic and international value chains is a major challenge. This situation may be further complicated by concentrated market structures at the international and national level*". This paragraph comes in addition to paragraph 100 which mentions, *inter alia*, that *"UNCTAD should continue to monitor developments in commodity markets"* (…) and that "*it should analyze and promote exchange of information on commodity markets and experiences with factors, policy issues and responses influencing the competitiveness of the commodity sector".*

These decisions adopted at UNCTAD XI complement the mandate given to UNCTAD at its tenth session and particularly paragraph 65 of Bangkok Plan of Action which recognized that (...) *"rather than diversification of commodity patterns of trade, in several countries concentration has increased over the past decade; only a few countries have made tangible progress in diversification, primarily based on agro-business"* , as well as paragraph 144 which urged UNCTAD to identify *(…) "the changes that are taking place in the dynamics and structure of international commodity markets, in order to make commodity-dependent countries more able to formulate policy responses to critical new developments".*

Accurate and timely information as well as analytical appraisal of the degree of market concentration is often lacking and no systematic approach exists for dealing with the different stages of the commodity chain. This report is by no means an exception but is seen as an attempt to first define a methodology and construct a measure of concentration of, and explore emerging patterns in, agricultural input industries. Subsequent investigations to monitor industry consolidation in commodity trading, processing and distribution would be desirable to capture the full picture along the commodity chain. This contribution is part of a broader initiative to improve market transparency and information in the commodities area and to monitor developments in commodity sectors.

EXECUTIVE SUMMARY

There is clear evidence suggesting a trend towards greater concentration at several stages in various commodity sectors. Focusing on the agricultural input segment, there has been a process of consolidation in the global agribusiness in recent years (by means of divestitures, mergers and acquisitions), the outcome of which is a few major integrated companies, each controlling proprietary lines of agricultural chemicals, seeds, and biotech traits. A significant increase in the concentration of agrochemical industry has been observed with three leading companies accounting for roughly half of total market. An upsurge in seed industry takeovers and changes in rankings (with the acquisition of Seminis in 2005, Monsanto surpassed DuPont in the global seed market) occurred between 2004 and 2005. Some of the largest agrochemical companies have branched out forcefully into plant biotechnology and the seed business, heralding a move towards unprecedented convergence between the key segments of the agriculture market (agrochemicals, seeds and agricultural biotechnology).

Besides mergers and acquisitions, another aspect of structural change of interest in this area is increased "coordination", which typically refers to contractual arrangements, alliances and tacit collusive practices. At the horizontal level, evidence suggests a trend towards heightened strategic cooperation among the largest competitors in the agricultural biotechnology sector. It is also interesting to note vertical coordination upward and downward along the food chain, with the establishment of food chain clusters that combine agricultural inputs (agrochemicals, seeds and traits) with extensive handling, processing and marketing facilities.

On the one hand, the need to consolidate patent portfolios and thus ensure freedom to operate appears to have created incentives for the extensive mergers and acquisitions that have occurred between agricultural biotechnology and seed businesses, and for other cooperative responses short of full integration (such as cross-licensing). On the other hand, because of the breadth of protection accorded to the patent holder (the seed or biotech company), concentration in agricultural biotechnology is giving the largest corporations unprecedented power vis-à-vis growers and other stakeholders. In particular, the privatization and patenting of agricultural innovation (gene traits, transformation technologies, and seed germplasm) have supplanted the traditional agricultural understandings on seed and farmers' rights, such as the right to save and replant seeds harvested from the former crop. In some jurisdictions, the privatization and patenting of agricultural innovation has resulted in a drastic erosion of these traditional farmers' rights, and the assertion of proprietary lines on seed technologies and genetic contents has changed farmers from "seed owners" to mere "licencees" of a patented product.

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INTRODUCTION

There has been a process of consolidation in the global agribusiness in recent years, the outcome of which is a few major integrated companies, each controlling proprietary lines of agricultural chemicals, seeds and biotech traits.

Concentration in the agrochemical industry has been increasing substantially since the late 1990s. The three leading corporate groups (Bayer, Syngenta and BASF) would account for approximately half the global market (by 2004 reported sales).

The largest agrochemical companies branched out into plant biotechnology and the seed business, heralding a move towards unprecedented convergence between the key segments of the agriculture market (agrochemicals, seeds, and agricultural biotechnology).

The agricultural biotechnology industry remains one of the most concentrated in the world, with much of the intellectual property in agricultural biotechnology aggregated by a few very large IP portfolios held by the agrochemical giants. Concentration in agricultural biotechnology has far-reaching implications for global food security, as the privatization and patenting of agricultural innovation (gene traits, transformation technologies and seed germplasm) has been supplanting traditional agricultural understandings of seed, farmers' rights, and breeders' rights. The leading agricultural biotechnology firms have proprietary entitlements that eventually encroach on the farmers' disposal of his/her commodity. Also, the environment in which the companies within the seed industry compete is increasingly affected by patent positions and the status of various intellectual property rights. Ownership of, and access to intellectual property (IP) rights, particularly those relating to biotechnology, can have significant structural impact.

In this section, concentration in the agrochemical industry will be assessed. Then, patterns of consolidation in the seed business will be further explored so will be the case of agricultural biotechnology.

I. AGROCHEMICALS

A. The Global Agrochemical Market: Estimated Value

The end-user market value for agrochemicals (herbicides, insecticides, fungicides and other agrochemicals) was estimated at US$32,665 million in 2004.[1] Until 2003, the global agrichemical market had been stagnating for almost 20 years, with steady erosion since the late 1990s (down to an estimated $27,780 million in 2001, a 7 per cent fall on the previous year's outcome, according to the same analyst).[2] Factors behind this sluggish performance included a variety of reasons, from increasing regulatory constraints (notably, user restrictions in the European Union) to the expiry of patent-protected periods (e.g. the patent protecting the active ingredient in Monsanto's *Roundup* herbicide expired in the United States in 2000). Relatively adverse movements in commodity prices had been variously affecting farmers' expenditures on pesticides for specific crops throughout the last two decades. Some variations in sales were also attributable to weather conditions.[3] The 2004 rebound partially reversed this downward trend, with demand for agrochemicals fuelled, to some extend, by a relatively upsurge in certain commodity prices and strong planting seasons.[4]

B. Concentration Ratio, 2004

Based on assumptions previously described to estimate the size of the agrichemical market, the industry displays significant concentration. In 2004, the six major companies by reported sales, namely, Bayer (Bayer Crop Science), Syngenta, BASF, Dow (Dow AgroSciences), Monsanto, and DuPont, accounted all together for roughly 77 per cent of the market, or $25,146 million in sales value. The three leading corporate groups alone (Bayer, Syngenta and BASF) are estimated to represent approximately half of the market (2004 agrochemical sales, consolidated financial statements). Company ranking by sales is shown in Table 1.

Table 1: Top six agrochemical companies, ranking by sales, 2004

Company	2004 Agrch Sales (million US $)	Market Share (per cent)
Bayer	*6,155	19
Syngenta	6,030	18
BASF	*4,165	13
Dow	3,368	10
Monsanto	3,180	10
DuPont	2,249	7
Others	7,519	23
World	**32,665**	**100**

Source: UNCTAD secretariat, based on Company Records (either the Annual Report to Shareholders or SEC Form 10-K and Form 20-F. The reader is referred to Annex 2 for additional information on the sources used).
*Note**: Prices reported in EUR, converted into US $ by applying the corresponding exchange rate as reported by the IMF.

[1] The 18 major agrochemicals country markets are used as a proxy for the global market: Allan Woodburn Associates Ltd., *Agrochemicals - Executive Review*, 16th ed. (Midlothian, UK: Allan Woodburn Associates, 2005), quoted in Binham Dinham, "Agrochemical Markets Soar - Pest Pressure or Corporate Design?" *Pesticides News*, June 2005, at 9. According to analyst Phillips McDougall (Edinburgh), the value of the conventional chemical crop protection market grew an estimated 25 per cent in 2004, to reach $30.7 billion.

[2] Allan Woodburn Associates Ltd, *Agrochemicals - Executive Review* 13th ed. (Midlothian, UK: Allan Woodburn Associates, 2003).

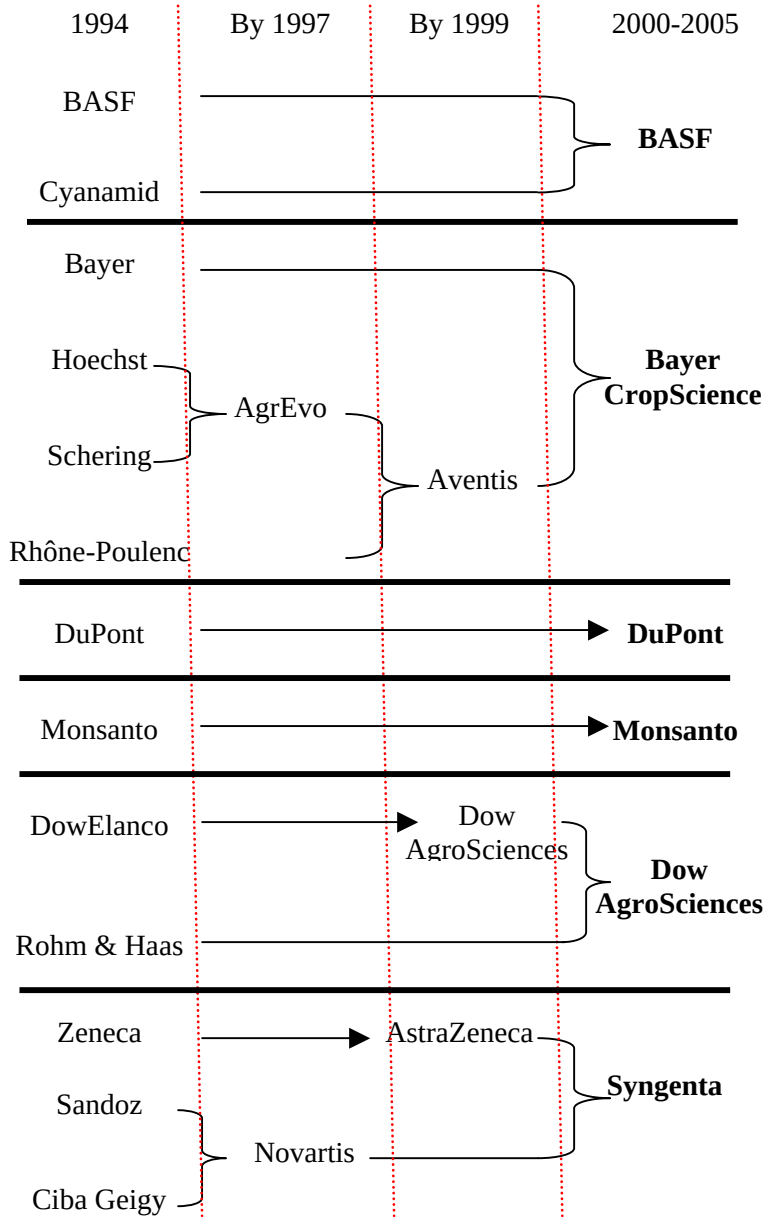
[3] In 2003 large agrochemicals markets in Europe such as France and Germany were hit by a drought. Whereas fungicides are usually given two applications, in the spring and summer, many farmers had only one application and because of the drought did not do another.

[4] Sean Milmo, "Signs for Like for Agrochemicals, Fertilizers," *Chemical Market Reporter*, 26 January 2004; Veronica MacDonald, "Agriculture: Agchem and Fertilizers Grow," *Chemical Week*, 5-12 January 2005; Robert Westervelt and Alex Scott, "Agchem and Seeds: Reaping Strong returns," *Chemical Week*, 17 August 2005.

C. Mergers, Acquisitions and Divestitures

Concentration in the agrochemical industry has been increasing substantially since the late 1990s (Figure 1).

Figure 1: Major mergers and acquisitions in the agrochemical industry, 1994-2005



Source: UNCTAD secretariat, based on company records and press releases. For a more comprehensive list of corporate deals, the reader is referred to Annex 1).

Before the formation of Aventis (1999), there were ten major global companies in the agrichemical sector, including BASF, American Cyanamid, Zeneca, Novartis, Rhone Poulenc, AgrEvo, DuPont, Monsanto, Dow AgroSciences and Bayer.

By 2000, the group had shrunk to seven: AgrEvo and Rhone Poulenc merged to form Aventis (which spun off its crop sciences division); BASF took over American Cyanamid; Zeneca and Novartis combined their agrochemical businesses to form Syngenta (2000).

In 2001, the number of global companies further shrank to six: Bayer acquired Aventis' agrochemical business, a controversial deal which raised antitrust concerns and liabilities over genetically modified corn.[5]

Table 2: Major M&A in the agrochemical sector, 1999–2004

Date	Deal
29 November 1999	Merger of Rhone-Poulenc SA with Hoechst AG to form Aventis SA (owned as to 53 per cent by Hoechst and 47 per cent by Rhone-Poulenc). AgrEvo and Rhône-Poulenc Agro were combined into Aventis Cropscience.
30 June 2000	BASF AG (Ludwigshafen, Germany) took over the Cyanamid agricultural products business of American Home Products Corporation (Madison, New Jersey). By this purchase, BASF doubled its crop protection products business and moved up into the ranks of the world's top three leading manufacturers of crop protection products.
13 November 2000	Novartis merged with AstraZeneca's agribusiness to form Syngenta, the first global group focusing exclusively on agribusiness.
3 June 2002	Bayer AG acquired Aventis Cropscience from Aventis SA (76 per cent stake) and Schering AG (remaining 24 per cent stake). Aventis Cropscience was integrated into Bayer and renamed Bayer Cropscience.
27 January 2004	Cargill Inc. agreed to combine its crop nutrition business (phosphate, potash and nitrogen assets) with IMC Global Inc to create a publicly traded fertilizer company with $4.1 billion in sales. In addition to operating phosphate and potash facilities in the US and Canada, the new company will hold key equity interests in phosphate production sites in Brazil and China.

Source: UNCTAD secretariat, based on company records and press releases as well as UNCTAD&Cyclope World Commodity Survey 1999-2000 (pages 36-37) and 2000-2001 (pages 66-67) . For a more comprehensive list of corporate deals, the reader is referred to Annex 1.

Consolidation has been continuing since then, throughout 2001-2005. Notably, each of the leading agrochemical companies has reached out to integrate seed ventures and biotech firms. This strategic action allowed them to establish synergies among the key segments of the agriculture market - crop protection, biotechnology and seeds. These segments will increasingly converge and support each other.

[5] Dale McDouglas, "Industry Giants," *Farm Industry News*, mid-February 2001, at 6.

II. SEED INDUSTRY

A. Evolving Structure of the Seed Industry

The seed industry has experienced extensive structural changes over the last three decades, as mergers and acquisitions created a new industry structure dominated by large companies with primary investment in related sectors. In the United States, this trend traces back to as far as the mid-1970s, when large multinational companies operating in pharmaceuticals and chemicals (such as -then- Ciba-Geigy, Sandoz, Royal Dutch/Shell) entered the faster growing seed business. Many of them branched out into seeds because of declining margins in the agrichemical market, and the increasing profit potentials of the seed market.

With the development of genetic engineering in the early 1980s, the seed industry reorganized again through extensive mergers and acquisitions. Some firms (for example, the former Monsanto and Novartis) developed into diversified "life sciences" groups, with interest in the fields of biotechnology, pharmaceuticals, biomedical technologies, food processing, and other. Most of these life sciences complexes then spun off and merged their agricultural products business.

During the late 1990s and early 2000s, the industry underwent additional transformation as the major agrichemical and agricultural biotechnology groups expanded their seed portfolio. Various factors underlined this new wave of acquisitions.

First, there is a strong potential for demand complementarity between agrichemical and seed businesses (Box 1).

Box 1: Complementarity between crop protection and seeds/genomics: The Case of Monsanto's *Roundup*

A number of companies have worked towards developing input traits that make crops herbicide-resistant. These genetically modified crops are designed to be tolerant to a company's brand herbicide, often a generic herbicide, which can then be sprayed over the crop without damaging it. For example, Monsanto's *Roundup Ready* corn was designed to be tolerant to the active ingredient in *Roundup*, Monsanto's best selling herbicide (a generic herbicide, normally lethal to corn). By this integration of agricultural chemicals and enhanced seeds, a company can offer a bundled package of brand products, each tied to another.

Moreover, agricultural biotechnology firms enjoy opportunities for "economies of scope": when a specific biotech trait has been developed (for example, herbicide resistance, as in the case of *Roundup Ready* traits, or insect resistance, as for *Bt* traits), it can be used in a number of crops. For example, *Roundup Ready* traits have been incorporated in soybeans, corn, canola, and cotton and *Bt* traits in corn and cotton). This may provide incentives to expand a company's seed portfolio.

Moreover, acquisitions of seed companies provided a means to better control and market proprietary lines of chemicals, genetic technologies and seeds, often sold in a single bundled package. Indeed, the largest acquisition targets (e.g. Seminis) integrated plant breeding, seed production and conditioning, as well as marketing functions. Accordingly, they provided vast distribution networks and other valuable assets (stock of cultivars, proprietary and non proprietary know-how, as well as breeding facilities) to the purchasing company (in the case of Seminis, Monsanto). In this respect, the race to buy seed companies has involved some forms of vertical integration downstream along the seed chain (Box 2).

Box 2: The seed industry: Segmental breakdown

A packet of seeds consist of two sets of features: i) varietal characteristics or genetic information, often referred to in the seed literature as "software", and (ii) physical properties, or

"hardware" features. This internal duality reflects a division of labor between firms that are primarily plant breeders and firms that are primarily engaged in seed production. Breeders and seed firms are engaged at various stages of the seed industry, which can be broken down into four separate functions:

Plant breeding. Breeders assemble genetic material, cross it to generate variation, select recombination and stabilize the variety. The varietal characteristics that result from breeding programmes may fall within the reach of plant variety protection systems. "Conventional breeding" (as opposed to genetic engineering) utilizes selection, crossing and other traditional methods to obtain the expression of the desired traits in a group of plants. Genetic engineering is the general term referring to all techniques used to isolate particular genetic material (i.e. DNA) from one organism and introduce it into another organism, thus resulting in the latter being "transgenic".

Seed production. Seed producers are primarily engaged in the sequential multiplication of breeder seed, seed processing and storage, and its marketing and distribution. Whereas the varietal characteristics are a result of breeding programmes and may fall within the reach of plant variety protection systems, the physical characteristics are determined by seed production and processing, and fit into a different regulatory system, that is, seed certification. Certified seed is seed of a known variety produced under strict seed certification standards to maintain varietal purity. There are four classes (generations) of certified seed (in order of genetic purity, breeder, foundation, registered and certified seed). Breeder seed (i.e. the original seed embodying the improved traits) and foundation seed (parent seed stock produced from the original seed) are produced under the breeder's control. Foundation seed is delivered to qualified growers, who produce registered seed, then contracted out in a similar manner to produce certified seed.

Seed conditioning. Once harvested, certified seed is dried, cleaned and sorted, treated with insecticides and fungicides, packaged and inspected. These operations are typically performed by firms engaged in seed production.

Seed marketing and distribution. Seed distribution may be undertaken by public sector agencies, cooperatives or the private sector or by more than one of these channels at the same time. Focusing on the private sector, the distribution of seeds may take place through retail outlets receiving their supplies directly from the seed producer, through intermediate distributors, or through wholly integrated companies which control all the major functions of breeding, production and distribution.

Source: UNCTAD secretariat. The "software" vs "hardware" distinction, common in the seed literature was drawn from Dwijen Rangnekar, *Access to Genetic Resources, Gene-based Inventions and Agriculture*, Study Paper 3a (background paper to the Commission's Report on Integrating Intellectual Property Rights and Development Policy, London, September 2002), at 2. On seed marketing: G. Mumby, *Seed Marketing* (Rome: FAO, 2004).

B. Measuring Concentration in the Seed Industry (sales-based concentration ratio)

According to the International Seed Federation (ISF), the estimated global value of the commercial seed market is approximately $25.2 billion.[6] In 2004 the four largest seed companies (ranking by reported seed sales in 2004) consisted of DuPont, Monsanto, Syngenta and the Limagrain Groupe, with $7,379 million in combined seed sales. If the level of concentration is assessed by the share of total industry sales of the four largest companies, the concentration ratio would be close to 30 per cent. Table 3 illustrates company ranking by sales (2004 reported sales, seed segment). It should be emphasized that with the acquisition of Seminis in 2005 (reported sales of $25.8 million in 2004) Monsanto surpassed DuPont in the global seed market.

[6] The total represents the sum of the commercial seed markets of the countries listed by ISF. Refer to International Seed Federation (ISF), *Statistics* (available at http://www.worldseed.org/statistics.htm. Accessed on 30 August 2005).

Table 3: Top four seed companies, ranking by sales, 2004

Company	2004 Seed Sales (million US $)	Market Share (in per cent)
DuPont/Pioneer	2,624	10
Monsanto	2,277	9
Syngenta	1,239	5
Limagrain	*1,239	5
Others	17,821	71
World**	**25,200**	**100**

Source: UNCTAD secretariat, based on Company Records (either the Annual Report to Shareholders or SEC Form 10-K and Form 20-F. The reader is referred to Annex 2 for additional information on the sources used.
Notes: *Prices reported in EUR have been converted into US Dollars by applying the corresponding exchange rate as reported by the IMF.
** The total represents the sum of the commercial seed markets of the 40 countries listed by ISF.

This aggregate figure may mask much stronger market concentration for major crops in specific regional markets. Also, it obscures the outstanding degree of consolidation in some of the major seed country markets. This is notably the case of the United States, whose seed industry has undergone major structural changes since the early 1970s (a 2004 USDA publication acknowledges the following four-firm concentration ratios for US commercial seed industry, 1998: 67 per cent for corn; 49 per cent for soybean; and 87 per cent for cotton).[7] Similarly, the overall ratio does not give account of the share enjoyed by individual companies across crops. Monsanto's branded seed business – including the Dekalb and Asgrow brands – would hold approximately 16 per cent of the US corn market (following the Channel Bio crop acquisitions); through its Holden's/Corn States licensing business, Monsanto is estimated to provide germplasm and traits to independent seed companies and distributors who reach 35 per cent of the market. With the acquisition of Seminis, Monsanto is estimated to account for roughly 40 per cent of the US vegetable seed market.

C. Mergers, Acquisitions, and Divestitures: The Race to Buy Seed Companies by the Biotech and Agrichem Giants

The years 2004-2005 saw an upsurge in seed industry takeovers and a shake-up in rankings. Monsanto, DuPont, Syngenta, all among the world's top-ranking pesticide firms, lead the pack. This acceleration in the acquisition process consolidated a trend that traces back to the late 1990s. Table 4 lists just some of the major seed deals that have occurred throughout 1999-2005.

Table 4: Major acquisitions in the seed industry, 1996-2005

Date	Deal
01.04.1996	Monsanto acquired 49 per cent of Calgene Inc. for a price of $30 million.
21.05.1996	Agracetus Transgenic Plant Division acquired by Monsanto.
03.02.1997	Monsanto acquired Asgrow Agronomics from Empresas La Moderna SA de CV ($240 million).
30.09.1997	Monsanto acquired Holdens Foundation Seeds for $945 million.
11.05.1998	Monsanto cancelled its agreement to acquire Delta & Pine Land (about $1.7 billion in stock).
29.06.1998	Monsanto agreed to buy Cargill's International Seed Operations
16.07.1998	Monsanto acquired Unilevers Plant Breeding International Cambridge (PBIC) ($524.8 million), in a deal that included PBIC operations in Scotland and France together with PBI Saatzucht, its German affiliate company.

[7] Jorge Fernandez-Cornejo, *The Seed Industry in U.S. Agriculture: An Exploration of Data and Information on Crop Seed Markets (by), Regulation, Industry Structure, and Research and Development* (Washington, DC: U.S. Department of Agriculture, Economic Research Service, February 2004).

Date	Deal
07.12.1998	Monsanto acquired the remaining 60 per cent of Dekalb Genetics it did not already own (about $2.1 billion cash).
04.07.2001	Monsanto acquired Limagrain Canada Seeds from Groupe Limagrain for an undisclosed amount. The acquisition gave Monsanto a leadership position in North American canola business.
09.09.2004	Monsanto Co acquired the Canola seed operations and assets of Interstate Seed Co, a North American unit of Advanta Seeds BV of the Netherlands.
17.11.2004	American Seeds Inc (ASI), a subsidiary of Monsanto Co, used as a vehicle to acquire seed producing companies, acquired Channel Bio Corp ($120 million in cash), a US seed company that included the brands of Crow's Hybrid Corn Company, Midwest Seed Genetics, Inc. and Wilson Seeds, increasing Monsanto's US corn seed market share by 2 per cent to 16 per cent.
02.03.2005	Through ASI, Monsanto also acquired NC+ Hybrids, Inc. (approximately $40 million), one of the top ten companies in US seed corn sales, and one of the top three in grain sorghum.
23.03.2005	Monsanto acquired Seminis Inc from SAVIA SA de CV and Fox Paine & Co LLC for US $ 1 billion in cash and $400 million in assumed debt, plus up to an additional $125 million contingent on the performance of the company through fiscal year end 2007.
05.04.2005	Monsanto acquired Emergent Genetics Inc from Hicks Muse Tate & Furst for $300 million in cash and commercial paper. Monsanto Co took over Emergent Genetics Inc to strengthen its cotton germplasm and traits platform. Emergent genetics was estimated to hold about 12 per cent of the US cotton seed market through the Stoneville and NexGen brands.
01.10.1999	DuPont acquired the remaining 79.4 per cent interest in Pioneer Hi-Bred International that it did not already own, paying $40 per share, 45 per cent in cash and 55 per cent in stock, for a total value of $7.7 billion.
25.06.2004	Syngenta AG acquired a 90 per cent voting interest in the Golden Harvest group of companies (Garwood Seed Co.; Golden Seed Co. LLC; Golden Seed Co. Inc.; J C Robinson Seeds Inc.; Sommer Bros Seed Co.; Thorp Seed Co.; and Golden Harvest Seeds Inc). The acquisitions ($180 million) collectively expanded Syngenta's US corn market share to 15 per cent and soybean share to 13 per cent.
09.09.2004	Syngenta AG acquired a 90 per cent stake in North-American Corn and Soybean Business (Garst Seed) of Advanta Seeds BV, a subsidiary of Advanta Seeds BV (EUR239 million) from AstraZeneca PLC and Royal Cosun.
03.06.2002	Bayer AG acquired Aventis Cropscience from Aventis SA (76 per cent stake) and Schering AG (the remaining 24 per cent stake). EUR 7.25 billion including the assumption of debt. Aventis Cropscience was integrated into Bayer and renamed Bayer Cropscience.
23.12.2004	The French Groupe Limagrain announced its intention to purchase Advanta's European field crop business (excluding the sugar beet seed business).

Source: UNCTAD secretariat, based on company records, press releases, and data retrieved form the Mergerstat M&A database. For a more comprehensive list of corporate deals, the reader is referred to Annex 1.

It is interesting to note the converging trajectories of the two leading companies in the global seed industry, i.e. Monsanto Co. and Pioneer Hi-Bred International.

In the mid-1990s, Pioneer and Monsanto held leadership positions in their respective market segments. Pioneer was the top ranking seed company. Monsanto figured prominently in agricultural transformation technologies and genetic contents (following acquisitions of Calgene, Agracetus and Asgrow), with scarcely no presence in the seed business (it appropriated value for its technology through non-exclusive licensing agreements with seed companies).

Since this time, the trajectories of these companies have converged, mainly as a result of the increasing integration between biotech and seed firms (Box 3). In 1999 Pioneer was acquired by the pharmaceutical and chemical giant DuPont. The latter company also began to make substantial investment in agricultural biotechnology (acquisition of Verdia Inc). Late in the 1990s Monsanto branched out in the seed business with an ambitious programme of extensive takeovers. It expanded its North American seed portfolio with the acquisition of First Line Seeds (Canada's major soybean seed supplier) in January 2004 and Advanta BV's North American canola seed assets in September 2004 and through American Seeds Inc. (ASI - holding company, wholly owned subsidiary of Monsanto Company, which then acquired Channel Bio Corp. and NC+ Hybrids, Inc.). Eventually, early in 2005 Monsanto acquired Emergent Genetics, Inc. (a leading cotton seed company) and Seminis (the global leader in the vegetable and fruit seed industry). There are numerous ramifications associated with the purchase by a biotech giant of a company that serves the organic community (Seminis relied heavily on conventional technique of cross-pollination). Also, there are speculations that Monsanto's expertise in genetic manipulation would likely branch out into horticulture.

Box 3: Convergence between seed and biotech firms

Biotech companies have reached out to the seed industry for a number of reasons. First, there was a strong complementarity between seeds and agricultural biotechnology, as seeds embody the invented technologies and contents and provide access to the genetic raw material (germplasm). Seed companies provided the required raw materials (stock of cultivars) and other valuable assets (proprietary and non proprietary know-how, and breeding facilities) to the purchasing biotech company. Second, the largest seed companies (integrated plant breeding, seed production and conditioning, as well as marketing functions) provided access to downstream facilities, particularly vast distribution networks, to the purchasing company. On the other side of the ledger, the threat that biotechnology posed to the conventional seed business has forced many seed companies to seek alliances with the biotech companies. The combination of biotech and seed companies has been crucial to the market penetration of GM varieties.

It is interesting to note some of the largest agricultural biotechnology companies in Europe and the United States have emerged as significant players in the rapidly growing Brazilian seed market. By these acquisitions the largest biotech companies have established global corn and oil-seed business through which to commercialize crop enhancement products in Brazil, a country that had for long resisted GM crops. Moreover, the gene giants have secured access to stocks of raw material (elite seed germplasm).

Box 4: Target country: Brazil

Buyer (Parent)	Deal Description
Monsanto	– On 24 November 1997 (closing date of the transaction) Monsanto acquired *Sementes Agroceres* (Brazil) for an undisclosed amount. The acquisition brought a company with 30 per cent of the corn seed market in Brazil, one of the top corn seed markets in the world. – On 29 June 1998 (date of announcement) Monsanto declared its intention to buy *Cargill's International Seed Operations* in Central and Latin America (Brazil).
Dow	– On 7 August 2000 (closing date) Dow Chemical, through its subsidiary Dow AgroSciences, acquired *Empresa Brasileira de Sementes* from AstraZeneca and Advanta to strengthen its efforts to build a global network market and commercialize seed and biotechnology traits in Brazil. – On 20 April 1998 (date of announcement) Mycogen (controlled by Dow Chemicals Dow AgroSciences) agreed to acquire *Dinamilho Carol Productos Agricolas Ltda* (Brazil) to establish global corn and oil-seed business through which to commercialize crop enhancement products.

Buyer (Parent)	Deal Description
	– On 14 September 1998 (date of announcement), Dow Chemical, through Mycogen, agreed to buy *Hibridos Colorado and FT Bio-genetica* (Brazil). The deal, combined with the previous acquisition of Dinamilho Carol Productos, allowed Mycogen to become a significant player in the rapidly growing Brazilian seed market.
Bayer/Aventis	– 19 November 1998 (closing date), Hoechst Schering AgrEvo GmbH, a unit of Hoechst AG (then incorporated into Bayer AG/Aventis Cropscience), acquired *Granja 4 Irmaos SA*, the largest producer in Brazil of rice seeds. – On 1 May 1999, Hoechst Schering Agrevo GmbH acquired the Brazilian seed companies *Sementes Ribeiral Ltda* and *Sementes Far-tura Ltda*, as well as the corn research company *Mitla Pesquisa Agricola Ltda*, Brazil.
DuPont/Pioneer	– On 22 March 1999 (closing date), DuPont, through its subsidiary Pioneer Hi-Bred International, acquired *Dois Macros* in Brazil to enhance its soybean lines worldwide.

Source: UNCTAD secretariat (refer to Annex 1 for a more comprehensive list of corporate deals).

D. The Transgenic Seed Industry

Companies do not generally distinguish between conventional seeds and genetically engineered (GE) varieties in their financial reporting. Absent publicly available data set accounting for the proportion of GE seeds in corporate seed sales, it is difficult to assess concentration in the transgenic seed industry by means of sales-based concentration measures.

Thus, it was decided to assess concentration by replacing market share with the proportion of approvals for unregulated release of GM crops secured by the different firms. In the United States, once a new variety has been successfully tested and the research is fully documented, the innovator may apply for a "determination of non-regulated status" from the USDA's Animal and Plant Health Inspection Service (APHIS). If APHIS grants deregulated status, the transgenic variety may be commercialized in the same way as any traditional variety, with no further regulation specific to its transgenic status. All of the deregulated varieties and of the varieties tested in field trials are protected under various types of intellectual property rights.

We are focusing here on the transgenic seed industry (here defined, after Oehmke and Wolf, as "the business of selling seed for commercialized transgenic plant varieties"), as distinct from the R&D industry (i.e. the business of developing gene constructs), which we will consider at a later stage.[8] Suffice here to anticipate that in that separate context we will rely on concentration measures at the field-trial level, rather than on concentration measures at the deregulation and output-market levels, which are used in the present context.

1. Individual Companies

Table 5 shows that only a few companies have secured approval in the United States (the largest GM crop market for which comprehensive sets of data are available) for unregulated release and commercialization of genetically modified crops between 1992 (since when data are available) and 2005. Four companies alone (AgrEvo, Calgene Inc., the Dow Chemical Co., and Monsanto Co.) accounts for a combined 67 per cent of all deregulated crops over the period. The Monsanto Company has an individual share of 33 per cent. This measure of concentration treats each company as an independent entity, irrespective of links of corporate affiliations between companies.

[8] See James F. Oehmke and Christopher A. Wolf, "Measuring Concentration in the Biotechnology R&D Industry: Adjusting for Interfirm Transfer of Genetic Materials," *AgBioForum* 6, no. 3 (2003), 134-140.

Table 5: Petitions for "deregulation" (approved), by institution, 1992-2005

Company/University	Petitions approved	Company/University	Petitions approved
AgrEvo	10	DuPont	2
Agritope	1	Monsanto	22
Asgrow	1	Northrup King	1
Aventis	3	Novartis Seeds	1
Bejo	1	Pioneer	1
Calgene	9	Plant Genetic Systems	1
Ciba-Geigy	1	Syngenta	1
Cornell U	1	U of Saskatchewan	1
DeKalb	2	Upjohn	1
DNA Plant Tech	1	Vector Tobacco	1
Dow	4	Zeneca & Petoseed	1
Grand Total			**67**

Source: UNCTAD secretariat (Data retrieved from Environmental Releases Database, Biotechnology Regulatory Services, APHIS, USDA).

2. Corporate Groups

By accounting for the extensive divestitures and acquisitions that have taken place throughout the reference period, an attempt was made to obtain a potentially more accurate measure of concentration. Of the four companies mentioned above, Calgene was subsumed under the Monsanto group (in 1996, Monsanto Co. acquired 49 per cent of Calgene Inc.), whereas AgrEvo was eventually absorbed by Bayer (in 2002, Bayer AG acquired Aventis Cropscience — combining Rhone-Poulenc Ag Company and AgrEvo — from Aventis SA and Schering AG).

Table 6 shows the pattern of concentration after accounting for these and other acquisitions. Up to 85 per cent of the approvals were issued to companies that by 2005 were part of one of four leading corporate groups (i.e. Monsanto, Bayer, Syngenta and Dow).

Table 6: Approvals for unregulated release by corporate groups (after accounting for acquisitions), 1992-2005

Group	No. of approvals	Share (in per cent)
Monsanto	**35**	52
Monsanto	22	
Calgene	9	
Asgrow	1	
DeKalb	2	
Upjohn	1	

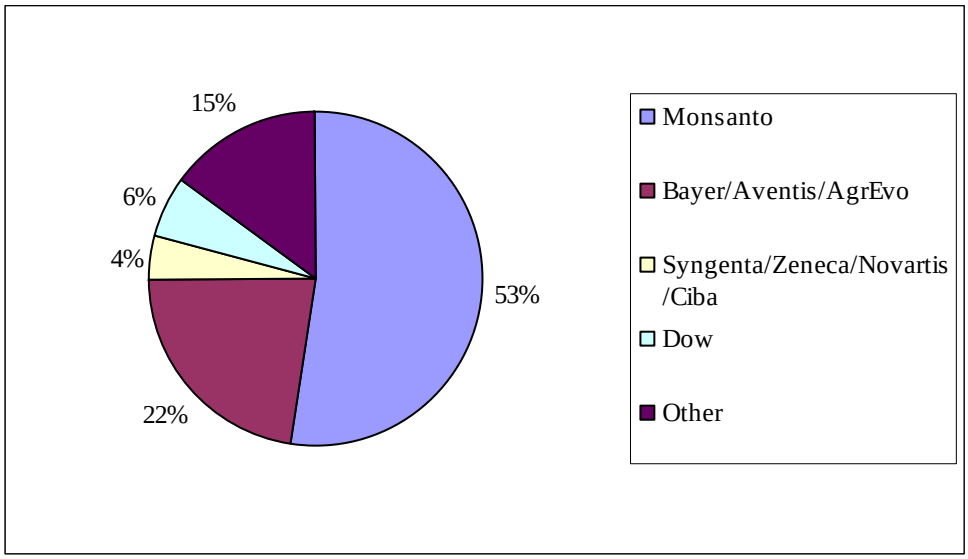
Bayer/Aventis/AgrEvo	**15**	22
Aventis	3	
AgrEvo	10	
Agritope	1	
Plant Genetic Systems	1	

Syngenta/Zeneca/Novertis/Ciba		**3**	4
Syngenta	1		
Novartis Seeds	1		
Northrup King	1		
Dow		**4**	6
Dow	4		
Other		**10**	15
Total		**67**	100

Source: UNCTAD secretariat (Data retrieved from Environmental Releases Database, Biotechnology Regulatory Services, APHIS, USDA; corporate groups construed by accounting for mergers, divestitures and acquisitions - see Appendix).

The Monsanto group alone (Monsanto Co. and its subsidiaries) accounted for more than half of the unregulated release of GM crops in the United States (Figure 2).

Figure 2: Approvals for unregulated release of GM crops, by corporate group, 1992-2005



Source: UNCTAD secretariat (Data retrieved from Environmental Releases Database, Biotechnology Regulatory Services, APHIS, USDA; corporate groups construed by accounting for mergers, divestitures and acquisitions - see Appendix).

E. Evolutionary Path

Although multinational corporations have been active in the seed industry for a long time (and in the US since the mid-1970s), developments since 2000 point to an evolutionary path with the following distinct features:

1. Unprecedented integration among the three key segments of the agriculture industry (crop protection, seeds, and biotechnology), with a handful of major companies (including Monsanto, DuPont, Syngenta, and Bayer) each controlling under branded names proprietary lines of chemicals, seeds, and genetic traits;
2. Various cooperative strategies and collusive practices between the few major competitors, notably through the establishment of elaborate cross-licensing structures (see *infra*, section III.C.3);
3. Vertical coordination upward along the food chain, with the establishment of food chain clusters that combine agricultural inputs (agrochemicals, seeds and traits) and the grain handlers' extensive handling, processing and marketing facilities (see *infra*, section III.C.4).

III. AGRICULTURAL BIOTECHNOLOGY

In order to fully appreciate the reasons for, and implications of, industry concentration in agricultural biotechnology and seeds, it is important to address how the patent's system policies and practices have been applied to the patenting of plant biotechnology. In this section, we first discuss developments in the area of proprietary rights in plants, then briefly analyze the breadth of agricultural biotechnology patents in the United States and Canada, and next investigate patterns of industry concentration in the field of proprietary biotechnology.[9]

A. Towards the Privatization and Patenting of Agricultural Innovation

Innovation in seed technology has historically been considered a public good in most of countries, including the United States. Farmers freely saved and shared the higher-yielding varieties they developed with neighbors, and public research laboratories produced innovations in seed technologies that were commonly distributed through public channels. Much of varietal development was done, absent specific proprietary rights, at publicly funded institutions (such as Land Grant Colleges (LGCs) in the United States), which also created seed certification programmes to ensure seed quality. Not until the late 1920s did a large-scale private sector seed industry, based on hybridization technologies, arose in some industrialized countries and particularly in the United States, heralding a move towards asserting legally protected rights in new plant varieties, and a shift away from public plant breeds to hybrids developed from closed proprietary lines. In the United States, the primary inroad of the private seed industry had been in vegetables and forage grasses, which were harvested for leafy growth and not for seed (which represented a natural barrier to seed saving and re-use). Private capital became interested in grain as high-yield hybrid seeds (developed by public breeders) became available. Lower yield tends to be observed with transplanted hybrid "progeny", providing incentives for the farmer to return to the seed company in an attempt to maintain high yields. This period (1930s and 1940s) witnessed a displacement of public breeding from a central to a marginal position. On the basis that public funds should not be used to pursue activities that attract private investment, professional associations articulated the idea that the proper place for public investment was in fundamental agricultural research (development of inbred lines), whereas the decisions as to particular combinations of inbreds to be marketed as commercial hybrids had to be reserved to private breeders. Nonetheless, public plant breeding is still dominant in most developing countries, where innovations remain largely in the public domain, despite the emergence of private sector seed companies that are marketing privately developed hybrids and serve as distribution channels for publicly developed seed innovations.[10]

Against this background (redefinition of the role of public plant breeds and increasing private investment in seed technology), there was a parallel move in statutory and case law towards conferring

[9] This section draws extensively on existing literature to establish a base understanding of how the patent system is being implemented with respect to agricultural commodities. In particular, the analysis blends critical insights from: Keith Aoki, "Weeds, Seeds & Deeds: Recent Skirmishes in the Seed Wars," *Cardozo Journal of International and Comparative Law* 11 (2003), 247; Michael R. Taylor and Jerry Cayford, "American Patent Policy, Biotechnology, and African Agriculture: The Case for Policy Change," *Harvard Journal of Law and Technology* 17 (2004), 321; Keith Aoki, "Malthus, Mendel and Monsanto: Intellectual Property and the Law and Politics of Global Food Supply: An Introduction," *Journal of Environmental Law and Litigation* 19 (2004), 397; Mark D. Janis, "Supplemental Forms of Intellectual Property Protection for Plants," *Minnesota Journal of Law, Science & Technology* 6 (2004), 305. We supplemented this literature with analytical work based on data retrieved from the US and European patent databases.

[10] This section draws from Keith Aoki, *Weeds, Seeds & Deeds*, *supra* note 9, and Taylor and Cayford, *American Patent Policy*, op. cit. note 9. As a matter of fact, public "fundamental research" created various breeding techniques that were then utilized by the private sector to create proprietary products. In this respect, publicly-funded seed development infrastructures became transformed into "a "source" of raw materials, information, and germplasm from which private entrepreneurial capital could draw upon to "create" proprietary and lucrative seed products" (Aoki, at 273).

and protecting intellectual proprietary rights of seed germplasm (a trend that has accelerated significantly since the advent of modern biotechnology in the 1980s). As a result of subsequent legal developments, a complex hierarchy of intellectual property (IP) rights has emerged for agricultural innovation. Different technological components of a transgenic crop variety may be covered under different forms of IP law. [11]

1. In a few countries, patent protection is poised to become the dominant intellectual property mechanism for agricultural innovation. Technologies used to transfer gene traits are patentable subject matter in most countries. In many jurisdictions, the patenting of invented genes has also become common practice. However, only in a few cases (including the United States and Japan), the germplasm of a plant variety (the plant itself) may be patented as such.[12] The practice of patent grant offices in many countries suggests that the key issue for protection is whether or not the invention meets the patent granting criteria, rather than its subject matter.
2. Plant varieties can be claimed as a form of IP under a Plant Variety Protection (PVP) system. In most jurisdiction, these plant breeders' rights systems continue to occupy (alongside with patents, in countries such as the United States and Japan) the first tier of intellectual property protection for both clonally propagated and sexually reproduced plants.
3. Other forms of intellectual property protection (including trade secrets, trademarks, and unfair competition) remain important in the seed industry, although in a supplemental role. [13]

An attempt to clarify the distinction among plant variety protection systems, patent protection, and supplemental forms of IP protection in the seed industry is made below.

Plant Variety Protection (PVP) systems:

PVP often referred to as "breeders' rights" systems, arose as a distinct form of intellectual property protection because of difficulties in the recognition of plants as patentable subject matter.[14] In the 1920s and 1930s, several countries introduced legislation aimed at providing a proxy of patent protection to "plant breeders". Major legal developments in the United States include the 1930 Plant Patent Act (PPA)[15], administered by the US Patent and Trademark Office (PTO), extending patent-like protection to asexually propagated species and the 1970 Plant Variety Protection Act (PVPA)[16], within the scope of the United States Department of Agriculture (USDA), for sexually reproduced varieties. PVPA was enacted in response to Western European nations forming in 1961 the International Union for the Protection of New Varieties of Plants (UPOV), the first intergovernmental organization dedicated to plant variety protection.[17] As a result of the UPOV agreement, PVP systems are widely

[11] For in-depth illustrations, D. Graff Gregory *et al*, "Access to Intellectual Property Is a Major Obstacle to Developing Transgenic Horticultural Crops," *California Agriculture* 58, no. 2 (2004), 120-126.
[12] In the United States, for example, if a variety is clonally propagated, the germplasm can be claimed as IP at the US. Patent and Trademark Office under a Plant Patent, established in 1930 by the Plant Patent Act. And since 1980, following a landmark decision by the Supreme Court, all kinds of "invented organisms", including novel plant germplasm, have come to be claimed as IP under standard US utility patents.
[13] On this new hierarchy of intellectual property rights, and particularly on supplemental forms of intellectual property protection, see Janis, *Supplemental Forms of Intellectual Property*, *supra* note 9.
[14] In the United States, for example, until 1980 the prevailing view was that plants did not fall under the purview of the protections afforded under the patent statute (*35 USC 101*), since they were natural products and not innovations. Patents issued under 101 were referred to as "utility patents" on account of the requirement that a patentable invention under this section be useful.
[15] 35 USC §§ 161-164 (2003).
[16] 7 USC §§ 2321-2583 (2003).
[17] The International Union for the Protection of New Varieties of Plants (UPOV) was established by the International Convention for the Protection of New Varieties of Plants (UPOV Convention). The UPOV

available worldwide for the protection of plant varieties (in particular, clonally propagated varieties), and such varieties do tend to be widely registered in multiple countries.

Several features differentiate breeders' rights from patents. In particular, an important feature of a PVP system vis-à-vis the patent system lies in the exemptions it (generally) contains. These exemptions include: (i) farmers' rights to save seeds (broadly intended, this exemption allows farmer to dispose, as they wish, of their farm produce, including protected seeds); (ii) research exemption (whereby the underlying genetic resource embodied in a protected plant variety is freely available to third parties for the purpose of breeding other varieties). These exemptions are not generally possible under patent law, although this would be ultimately a matter for domestic law and, eventually, license terms.

Under the seed saving exception, farmers are authorized to save protected seed, and to re-use them as they wish, without the permission of the rights holder. This right is subject to the non-use of the brand name of the protected variety, and in general does not extend to sale on a commercial scale. A broad seed saving exception was enshrined in India's Protection of Plant Varieties and Farmers' Rights Act (1999), which allows the farmer to "save, use, sow, re-sow, exchange, share or sell his farm produce including seed of a variety protected" (also, for a broad endorsement of the notion, the "African Model Legislation for the Protection of the Rights of Local Communities, Farmers and Breeders and for the Regulation of Access to Biological resources", Organization for African Unity, 2000, Article 26). In contrast, the exception has been restricted, but not entirely eliminated under UPOV 1991 (the farmer is not allowed to sell protected seeds, but is limited to its re-use for propagating purposes on its own holding) and in the US PVPA, as amended (a farmer may sell seeds of a protected variety, but only that amount that could have been saved for the farmers' own replanting purposes).

Pursuant to the research exemption, the breeder's rights traditionally extended to the protected variety itself, not to the underlying genetic resources embodied in the protected variety. Accordingly, other breeders may use protected plant varieties freely to develop new varieties. In a number of cases, this exception was also narrowed by declaring that a variety which is "essentially derived" from a protected variety would be considered an infringement.[18]

Patents:

Following a landmark decision by the Supreme Court in Diamond v. Chakrabarty in 1980,[19] all kinds of "invented organisms" (living creatures in a non-naturally occurring form), including novel plant germplasm, are now claimed as IP under standard US utility patents. Subsequent legal developments (Ex Parte Hibberd, JEM AG Supply, Inc. v. Pioneer Hi-Bred International, and other cases)[20] now allow utility patents to protect specific gene traits, as well as biotechnology tools (such as transformation of genetic contents or selection using genetic markers), and even the germplasm of the plant variety (i.e. the seed or plant cultivar itself). Patenting of plants and plant varieties is allowed in only a few countries (including the United States, Japan and Canada). However, laboratory tools required to genetically engineer plants, as well as invented genes, are patentable subject matters under

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Convention was revised in 1972, 1978 and on 19 March 1991. It was adopted on 2 December 1961 and entered into force on 10 August 1968.

[18] For example, under the International Convention for the Protection of New Varieties of Plants (UPOV Convention), as revised in 1991, and under the Plant Variety Protection Act (PVPA), as amended..

[19] The case concerned the issuance of a patent on a genetically engineered bacterium that could break down crude oil [447 US 303 (1980)].

[20] In 1985, in *Ex Parte Hibberd* [227 USPQ 443 (Bd. of Patent App. and Interferences, 1985)], the United States Board of Patent Appeals expanded the scope of what it considered patentable technologies for microorganisms to genetically modified plants. In 2001 a US Supreme Court decision held that sexually propagated plants are patentable subject matter if they otherwise meet the novelty, non-obviousness, and utility requirements of the US Patent Act [*JEM AG Supply, Inc. v. Pioneer Hi-Bred International, Inc* 534 US 124 (2001)].

most jurisdictions (hence, the exclusion from patentability only refers to the germplasm of the plant variety).

Patents confer considerably more extensive rights than PVP certificates. In particular, patents include the right to control what people do with the derivatives of the plant in question, which means, among other things, that researchers are not free to use patented plants when developing and commercializing new plants. Similarly, farmers would not be free to save the seed from their genetically modified crops and use them the next year and thereafter. These issues are discussed further in the following section. Suffice here to mention that, as a result of extending utility patents to sexually reproduced plants, the PVP farmer and research exceptions have been significantly constrained.

Supplemental forms of intellectual property protection:[21]

Supplemental plant protection tolls include, among others, trademarks and trade secrets. A significant part of the value of an agricultural variety often lies in its recognition and reputation among consumers in the marketplace. That "brand" name can be protected as IP by registering it as a trademark. Seed firms have largely employed trademark protection (for example, Monsanto has registered the brand *Roundup Ready* for seeds and herbicide-tolerant genes; Pioneer has also registered its logo).

Trade secrets, possibly the least formalized of all types in IP protection, cover all manner of confidential information that has value as a consequence of its secrecy. An assertion of trade secret protection that is considered to be typical in the seed industry concerns the identity and genetics of inbred parents of a commercially-distributed hybrid on the basis of a very close similarity between the Pioneer and Holden seeds, the court inferred prima facie misappropriation and shift to Holden the burden of proving independent development).[22]

The challenges posed by multiple layers of IP law are considerable, when tracking "who owns what" in crop biotechnology.

B. The Breadth of Biotechnology Patents in the United States and Canada and their spillover effects in the international arena

The US experience was taken to illustrate how the patenting of biotechnology has been supplanting traditional agricultural understanding of seeds, the rights of farmers and breeders, both within the United States and elsewhere.

It is important to stress that, although the analysis that follows mainly refers to the US patent policies and practices, it may hold significance for other countries as well.

1. License Restrictions in the Seed Industry: A Reversal of Traditional Farmers' Rights?

Until formal breeding programmes were introduced, varietal and cultural improvement depended on a process of seed selection and experimentation by farmers. The concept of farmers' rights advocates legal recognition for the innovative work that farmers engaged in, and calls for reserving to farmers the traditional ability to select, save, use and exchange seed stock grown in their own field. The crop seed market traditionally functioned on the assumption that farmers would purchase seeds and be able to save and select seeds from their crops.[23]

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[21] Drawing from Janis, *Supplemental Forms of Intellectual Property*, supra note 9.
[22] See for example, Pioneer Hi-Bred Int'l Inc. vs. Holden Found Seeds Inc. [35 F3d 1226 (8th Cir 2001).
[23] Seed saving is particularly important for farmers in relation to open pollinated food crops such as cereals and tubers, whereas for inbred species and horticultural crops, it is not generally an attractive option.

The privatization and patenting of agricultural innovation has resulted in a drastic erosion of these traditional farmers' rights, as the assertion of proprietary lines on seed technologies and genetic contents has changed farmers from "seed owners" to mere "licencees" of a patented product. In the United States and elsewhere, this change has been brought about by means of contractual terms and judicial decisions, rather than through a statutory process.

In fact, to gain physical access to patented seeds, growers (and researchers when it comes to patented gene traits, enabling technologies and knowledge to exploit them) must enter into intellectual property license agreements that may place strict post-sale contract restrictions on a grower's (or researcher's) use of purchased material.

(a) Examples of license restrictions in the seed industry[24]

There are two broad classes of post-sale contract restrictions in the seed industry.

First, license restrictions might limit a grower's use of purchased seeds. This restriction typically entails prohibiting seed saving, seed replanting on one's own holding or elsewhere, and seed resale outside authorized distribution channels. Examples include the Monsanto's technology agreement (MTA) for growers that purchased Monsanto's *Roundup Ready* seed. The MTA litigated in Monsanto Co. vs. McFarling[25], for example, required that the grower not "save any crop produced from [Monsanto's patented] seed for replanting, or supply saved seeds to anyone for replanting", and that purchased seed be used "for replanting a commercial crop only in a single season". Similarly, Pioneer Hi-Bred's "bag tag" standard licenses for hybrid seed corn[26] included the following language: "…Pioneer intends to supply only hybrid seed. Customer agrees that it is not acquiring the rights to use any parental line [used in producing seeds] for any purpose other than the production of forage or grain for feeding or processing"[27].

Second, license provisions might prohibit purchasers of protected seeds from using the seed for breeding or research purposes. This restriction may also extend to reverse engineering.[28]

Strictly speaking, the use of license restrictions is a matter of contract law and conflict of law rules, rather than patent policy. As a practical matter, restrictive licensing terms have considerably extended the reach of agricultural biotechnology patents even beyond disposal of the farm produce.

Seed firms have succeeded in litigation so far in the United States over the enforceability of such post-sale contract restrictions. Overall, cases decided to date suggests that seed firms in the United States have considerable latitude in expanding the scope of agricultural biotechnology patents vis-à-vis farmers' rights.

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[24] Based on Mark D. Janis, *Supplemental Forms of Intellectual Property Protection, op. cit*. note 9, at 324-333; Michael R. Taylor and Jerry Cayford, *American Patent Policy, op. cit*. note 9, at 376; and relevant cases.

[25] Monsanto Co. v. McFarling, 302 F.3d 1291, 1293 (Fed. Cir. 2002).

[26] Litigated in *Pioneer Hi-Bred Int'l, Inc. v. Ottawa Plant Food, Inc., 283 F. Supp. 2d 101, 1025 (N.D. Iowa 2003)*.

[27] Additionally, contracts between the seed company and farmers may incorporate terms such as restrictive growing requirements (e.g. the use of the company's brand herbicides only; the implementation of insect or pest management programmes in compliance with guidelines issued by the company; allowing the company to regularly inspect fields); disguised royalty payments (typically in the form of "additional technology fee" on each bag of seed); marketing restrictions (a prohibition to market the branded seeds outside the United States); and far-reaching choice of law and forum clauses (growers must be prepared to suit or defend themselves in the corporate headquarters' state, under the law of the forum). See Nicole C. Nachtigal, "A Modern David and Goliath. Farmer v. Monsanto: Advising A Grower on the Monsanto Technology Agreement 2001," *Great Plains Natural Resources Journal* 6 (Fall 2001), 50.

[28] See, for example, Pioneer Hi-Bred Int'l Inc. v. DeKalb Genetics Corp., 51 USPQ 1987 (SD Iowa 1999).

(b) Review of relevant cases as regards farmers versus seed and biotech companies over disposal of seeds harvested from protected crops

Seed firms have succeeded in a number of cases over the enforceability of license restrictions. These were some areas of contention:

Patent exhaustion as a default rule:

Most intellectual property regimes (including that of the United States) includes a principle that is variously called "exhaustion by sale" or the "first sale" doctrine. Under this principle, an IPR is typically exhausted by the "first sale" or "placing on the market" of the good embodying it.

Farmers sought to invoke patent exhaustion against claims of patent infringement filed by seed companies. For example, in Monsanto v. McFarling (similarly in Pioneer v. Ottawa), the grower argued that when he purchased Monsanto's seeds, Monsanto's control over the purchased seeds (and over seeds harvested from crops that were grown from the purchased seeds) ceased.

Courts held that when licensing agreements expressly forbid seed saving and replanting, these express contract terms override the principle of exhaustion.[29]

Extending the scope of patent protection: From genetic traits (software) to seeds (hardware)

In a number of cases, farmers alleged that, through such license restrictions as the prohibition of seed saving, the patentee had broadened the scope of the patent beyond its ordinary scope.

This argument (patent misuse) was rejected in all relevant cases. In *Pioneer v. Ottawa*, the Court held that a license restriction against resale of patented seed is an assertion of the exclusive rights under patent law (a utility patent confers absolute rights to exclude others from using and selling,) not an attempt to broaden the scope of those rights.[30]

Again, in *Monsanto Co. v. McFarling* the US Court of Appeals for the Federal Circuit found that the farmer infringed a patent by saving and planting glyphosate-tolerant soybean seed. The Court rejected McFarling's patent misuse argument, which claimed that by prohibiting seed-saving Monsanto had extended its patent on gene technology to include germplasm (i.e. the seed itself).[31]

Patents and plant variety protection (PVP) system: The quest for coherence

Where the law allows for multiple forms of protection for the same variety, the patent license restrictions may infringe on the provisions in the PVP statute. For example, contract restrictions precluding saving and replanting of patented seeds may contradict the statutory seed saving provision (recognizing farmers' rights to save seeds) in a PVP Act.

In *Mc Farling I* and *II*, the Federal Circuit held that patent holders can enforce seed saving prohibitions in patent license agreements even when they infringe on the statutory limitations of PVP rights allowing seed saving. A limitation of intellectual property rights in one regime does not limit rights acquired under intellectual property regimes.[32]

License restrictions specified in labels on seed bags (bag tag license): Inferred knowledge

[29] Pioneer Hi-Bred Int'l, Inc. v. Ottawa Plant Food, Inc., 283 F. Supp. 2d 1018, 1031-33 (ND Iowa 2003), Monsanto Co. v. McFarling, 302 F.3d 1291 (Fed. Cir. 2002), at 1293-94 and 1298-99; Monsanto Co. v. Swann, 308 F. Supp. 2d 937 (ED Mo 2003), at 941-942.
[30] Pioneer Hi-Bred Int'l, Inc. v. Ottawa Plant Food, Inc., 283 F. Supp. 2d 1018, 1045 (ND Iowa 2003).
[31] Monsanto Co. v. McFarling, 363 F.3d 1336 (2004), at 1341-43.
[32] Generally McFarling I, 302 F2d 1291 (Fed Cir 2002); McFarling II, 363 F3d 1336 (Fed Cir 2004).

Courts held that where the grower who receives the bag has knowledge of the bag tag license and fails to object within a reasonable time, the license is enforceable.[33] The requisite knowledge on the part of the licencee can be inferred. According to some commentators, the courts could have argued differently, on the basis that the standard label license "materially altered" the bargain between the parties (growers and seed companies).

The breadth of patent protection has been extended in case law to the point that, with a patent on the crop, any farmers may be possibly subject to liability for patent infringement, not only if they saved patented seed, but also if they saved seed contaminated by patented pollen from neighboring fields, as recent jurisprudence seems to suggest (Box 5).

Box 5: Monsanto v. Schmeiser: illustration of "indirect" patent infringement?

In Monsanto Canada v. Schmeiser, the Supreme Court of Canada upheld a decision that a farmer infringed Monsanto's patents by growing seeds that he knew or ought to have known were from plants that were *Roundup* resistant.

Mr. Schmeiser had been growing canola for almost a half-century. According to conventional practices he retained seeds from each crop for planting the next year, rather than purchasing canola annually. In 1998 he grew seeds that were from his 1997 crop, which happened to include plants that were Roundup resistant. There was no finding that Mr Schmeiser had illicitly obtained modified canola seeds to plant the 1997 crop. Mr Schmeiser explained the degree of *Roundup* resistance by means of genetic pollution (seed spills from trucks or farm equipment, cross-pollination or seeds carried by the wind from near-by fields, where *Roundup Ready* canola was grown). Mr Schmeiser also declared not to have selected the seeds from the field containing the modified crop himself for planting in 1998.

Three sets of issues merit close scrutiny in this case.

The first point relates to the breadth of patent protection. In essence, Monsanto's patent was on a genetic insert which, when introduced into the DNA of canola cells by a transformation vector, produced a variety of canola resistant to glyphosate-based herbicides (such as Monsanto's *Roundup Ready* herbicide). The patent claims did not explicitly extended to canola plants as a whole. The court determined that patent rights to a gene and a cell comprising the gene provide the patentee with the right to prevent any person from growing entire plants containing the gene or cell, even absent patent claims on the plant itself. This conclusion, as in similar cases, demonstrates no trend towards heightened distinction between rights in the invention and rights in the crop as a whole (the point was made that, by applying the same reasoning in other intellectual property contexts, then Coca Cola could argue that it owns bottles in a consumer's fridge because of the presence of its registered trademark).

Second, as highlighted above, there was no finding that Mr Schmeiser had illicitly obtained modified canola seeds to plant the 1997 crop. Monsanto withdrew its allegation that Mr Schmeiser had illicitly obtained its modified canola from a licensed user. The defendant claimed that the degree of *Roundup* resistance (of which he became only accidentally aware) was due to genetic pollution. In practice, it may be very difficult to control the diffusion of a Transgene in cases of uncontained release (as for commercial GM crops). It is very likely that many conventional, unlicensed farmers are planting crops that include at least some genetically modified material without knowledge of the contamination. Seed saving from these contaminated crops may possibly amount to patent infringement.

The third point relates to the use of the patented invention. The advantage of *Roundup Ready* Canola is that it is tolerant of the glyphosate-based herbicide Roundup. The functional utility that follows is that farmers can spry *Roundup* herbicide on the modified crop (Roundup, a generic herbicide, is less expensive than conventional post-emergence canola herbicides, which are lethal to weeds but benign to canola). Mr Schmeiser allegedly ignored the presence of the characteristic in his crop, and he did not spry *Roundup* herbicide on canola "in-crop" (he only used it around power pools and in road ditches). Accordingly, the defendant claimed that he did not use the invention itself, in that he never operated or took commercial advantage of the patented

[33] Cf. Pioneer Hi-Bred Int'l, Inc. v. Ottawa Plant Food, Inc., 283 F. Supp. 2d 1018, 1047-48 (ND Iowa 2003) and Monsanto v. Scruggs, 249 F. Supp 2d 746 (ND Miss 2001).

invention, as he never sprayed a growing crop with Roundup. The Federal Court Trade Division (FCTD) stated that "the utility of a patent does not define or confine its purpose or its possible uses", and that it is the "taking of the essence of the invention without leave or license of the owner that constitutes infringement". The court held that by growing seeds from plants that were Roundup resistant the Defendant had infringed upon Monsanto's patent interests. It later assessed over $150,000 of costs against the Schmeiser Corporation. Although the Supreme Court of Canada (SCC) then reversed the decision on damage (no damage was own because the farmer's profits were no different than they would have been if he had planted and harvested ordinary canola), still it concluded that Schmeiser infringed Monsanto's patent by growing canola from seeds saved from the contaminated crop. Saving seeds containing protected genetic contents and replanting them would amount to infringement, even if this does not involve taking commercial advantage from the genetic modification in the crop.

Source: *Monsanto Canada Inc v. Schmeiser*, decision of the Federal Court Trial Division [2001 FCT 256]; decision of the Federal court of Appeal [2002 FCA 309]; decision of the Supreme Court of Canada [2004 SCC 34]. The review relies on the study by Robert Stack, "How Do I Use This Thing? What Is It Good for Anyway? A Study of the Meaning of *Use* and the Test for Patent Infringement in the *Monsanto Canada Inc v Schmeiser* Decision," *Intellectual Property Journal* 18 (2004/2005), 277.

2. The "Patent Ticket": Jeopardising Research in Agricultural Biotechnology?

Academic scientists engaged in agricultural research report problems of access to important technologies due to an overlapping set of intellectual property (IP) rights on research tools and genetic contents.[34] The reasons would lie in the increasing number of patents being issued, increasing patent breadth and uncertain ownership of rights, all resulting in IP congestion and uncertainty. The accumulated transaction costs involved (tracking down owners, conducting negotiations, and multiple royalty payments to administer) have created a major access obstruction that is hampering agricultural research, according to some commentators.[35]

(a) Increasing Number of Patents

Considering only biotechnology specifically applicable to agriculture, it has been calculated that about 2,247 inventions were patented in the United States between 1975 and 1998.[36] Biotechnology patents are increasingly being issued at a rapid pace: in scientific areas closely related to plant biotechnology, data reported by the US Patent and Trademark Office (PTO) show that the number of patents issued per year increased almost nine-fold between 1981 and 2001 (overall utility patents per year slightly more than doubled). Most agricultural biotechnology patents are in private hands; out of 2,247 inventions covered by agricultural biotechnology patents, 525 patents were issued to universities or public institutions, 812 were held by small firms or individuals, and 970 were issued to corporations (bearing in mind that a single patent can be granted to multiple assignees).[37] The dominance of the private sector may be even greater than these numbers suggest, particularly if we consider that some important agricultural patents developed in the public domain are exclusively licensed to private corporations. In particular, public-private cooperative agreements often include an option for the private partner to receive an exclusive license to any resulting patents filed by the public institution.

(b) Increasing Patent Breadth

[34] Their concerns are expressed, for example, in the proceedings of a 1996 forum at the National Academy of Sciences (Natural Research Council, *Intellectual property Rights and Plant Biotechnology*, Proceedings of a Forum Held at the National Academy of Sciences, 5 November 1996 (Washington, D.C.: Natural Research Council, 1997).

[35] Taylor and Cayford (2004), *supra* note 9, at 347-349.

[36] D. Gregory Graff, "The Sources of Biological Technologies for Agriculture: Public and Private Innovation and Patenting," (10 April 2001) (presented at the AAEA NC208 Conference on R&D Policies and Impacts, University of California-Berkeley, 30-31 March, 20 (quoted in Taylor and Cayford, *American Patent Policy*, *op. cit.* note 9, at 348.

[37] *Ibid*.

Not only the number but also the scope of patents being issued is having a considerable impact on access to agricultural biotechnology. It has been noted, in this regard, that some biotechnology patents are significantly broad in scope or cover widely applicable tools. Some commentators stress that such patents would allow their holders not only to exclude others from using the tools for purposes that compete directly with the patented invention, but also from other far removed uses.[38] For example, Monsanto filed patent applications on laboratory tools and techniques that have very wide utility to researchers in many situations, including patents relating to the *Agrobacterium tumefaciens* vector system, marker-assisted selection (MAS) techniques and the CaMV 35S promoter.

(c) Multiple Claims on Different Technological Components of a Transgenic Crop

The IP situation is further complicated by the fact that various patented features may be stacked in a single cultivar. A genetically engineered seed or plant cultivar may contain three different kinds of components that can be protected as intellectual property, namely:

1. gene sequences and genetically coded traits and enhancements that code for specific physical or behavioral traits of an organism (often referred to as "software");
2. the research tools needed to transfer the new genetic trait into plant cells and to regenerate from these engineered cells genetically modified plants with the new genetic trait stably integrated and properly expressed ("enabling" technologies, such as transformation vectors and systems, gene transfer promoters, and transformation marker systems); and
3. the germplasm of the plant variety, that is, the seed or plant cultivar itself, genetically transformed to create enhanced varieties ("hardware").[39]

That means, given the cumulative and complex nature of varietal development:

1. either the transgenic variety is developed by a large company backed by a broad portfolio of patents; or
2. a number of owners have valid patent entitlements on the technologies and genetic contests included in the cultivar, or on particular aspects of each technology.

In the first case, the barrier to accede innovative contents and technologies is the single owner who may refuse to license; in the latter case, the accumulated transaction costs that would accrue from tracking down "who owns what" and negotiating with all the single patent assignees. The potential for high transaction costs associated with the multiplicity of patent owners in core technology areas was exemplified in the development of β-carotene-enriched rice by public-sector researchers who used at least 40 patented or proprietary methods and materials belonging to a dozen or more different IP owners in the gene transfer process.[40]

To make things more complex, proprietary rights for a biotechnology tool or gene may be sold or licensed to another person at any time and under various terms (for use in just one crop or in various crop, in the issuing country or in multiple territory, and exclusively or non-exclusively). In practice, the confidential nature of some licensing agreements may make it particularly difficult to obtain information on "who owns what" (patent assignee) and "who owes what to whom" (patent licencee).

[38] Taylor and Cayford, *American Patent Policy*, *op. cit*. note 9, at 347-349.
[39] Gregory D. Graff *et al*, "Agricultural Biotechnology's Complementary Intellectual Assets", *Review of Economics and Statistics*, Vol. 85, Issue 2, May 2003, pp. 349-363,; "The Public−Private Structure of Intellectual Property Ownership in Agricultural Biotechnology," *Nature Biotechnology* 21 (2003), 989.
[40] R.D. Kryder *et al*, "The Intellectual and Technical Property Components of Pro-vitamin A Rice (GoldenRice): A Preliminary Freedom-to-operate Review," *ISAA Brief*, no. 20 (2000).

3. Territorial nature of patent law and the impact of patent-related policies in the international arena[41]

As a matter of law, patents are only legally enforceable in the issuing country. Indeed, to obtain patent protection in foreign countries, an application must be filled in each country where protection is sought. For this reason, patent law is often described as "territorial" in effect.

On this basis, one might reasonably contend that countries, especially developing countries, are free to tailor their intellectual property systems to meet their particular needs in relation to biotechnology, irrespective of the stringent standards adopted in the major markets — such as the United States, Europe and Japan.

This argument overlooks the fact that countries with stringent patent policies and practices in the field of agricultural innovation may use their current leverage in trade negotiations, as well as trade sanctions and tariff benefits, to press observance abroad of their intellectual property regimes. Also, it does not take into account that the legal impact of patents issued in country A could well reach producers in country B, if crops are intended to be exported in country A (for example, importing a crop in the United States produced with US-patented technology constitutes an infringement of the patent, unless the use is licensed). Finally, to gain physical access to the patented products, farmers must typically sign restrictive licensing agreements with a local subsidiary of the biotechnology company, or with the the company itself. As a practical matter, this use of technology agreements can extend the impact of US patents beyond the United States.

As regards the first point (the use of trade leverage to overcome the territorial limitation on intellectual property protection), it is worth considering in some detail how this has occurred in negotiating practice.

At the *bilateral level*, countries have variously used both their leverage in ongoing trade negotiations and the threat to withdraw tariff benefits to press observance abroad of their intellectual property rights. The UK Commission on Intellectual Property Rights documents several situations in which countries that favored international adherence to stringent standards have obtained "TRIPS plus" intellectual property provisions in bilateral trade agreements.[42] Beyond a country's leverage in trade negotiations, trade sanctions and tariff benefits have also been used to press observance of domestic property rights abroad, and to seek adoption of patent regime that goes beyond what is required by TRIPS.

As regards the *multilateral level*, a concerted effort (led by the United States and other Western industrialized countries) is being pursued through WIPO to harmonize the basic legal principles that govern the issuance of patents, and to ensure mutual recognition of patents among the parties (one international patent filing would have the same effect in all signatory countries). This standardization would likely constrain flexibility to tailor the patent system to local circumstances. Similarly, some countries are pressing to repeal the right to exclude plants from patentability under Article 27.3(b) of the TRIPS Agreement (which is undergoing a mandated review).[43] If this exemption

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[41] Based on Michael R. Taylor and Jerry Cayford, "American Patent Policy, Biotechnology, and African Agriculture: The Case for Policy Change," *Harvard Journal of Law and Technology* 17 (2004), 321, at 364-371.

[42] Commission on Intellectual Property Rights, *Report of the Commission - Integrating Intellectual property Rights and Development Policy* (London, 2002), 163.

[43] Article 27.3(b) of the WTO TRIPS Agreement deals with whether plant and animal inventions should be covered by patents, and how to protect new plant varieties. The review of Article 27.3(b) began in 1999 as required by the TRIPS Agreement. It is important to point out that with the Doha Declaration, the discussions in the TRIPS Council have had an additional focus. Paragraph 19 of the 2001 Doha Declaration says the TRIPS Council should also look at the relationship between the TRIPS Agreement and the UN Convention on Biological Diversity and at the protection of traditional knowledge and folklore. Most recently discussed are proposals on disclosing the source of biological material and associated traditional knowledge.

is repealed, developing countries would lose an important source of flexibility to tailor patent IP systems to their particular needs in respect of biotechnology.

C. Concentration and Technology

Because of the aforementioned reasons (increasing number of patents, patents being increasingly issued on fundamental technologies, multiple claims over various aspects of a technology), companies often find it difficult to avoid infringing patents when conducting product development research. In practice, each company's patent portfolios have become so substantial that every firm is likely to infringe patents held by each of its competitor. Monsanto and DuPont, DuPont and Syngenta, Monsanto and Syngenta, Syngenta and Dow have all filed suits against one another involving claims of patent infringement. Still unsettled is the dispute between Syngenta and Monsanto. Syngenta is being targeted with a lawsuit filed by Monsanto alleging infringement of one of Monsanto's patents involving glyphosate-tolerant crops. Syngenta had acquired certain rights to a glyphosate-tolerant trait in corn known as GA21 from Bayer CropScience, with the reported intent to commercialize GA21 corn. Monsanto alleged that Syngenta would infringe its patent covering the fundamental technique used in producing glyphosate-tolerant plants that include the GA21 corn trait.[44] Besides litigation, "defensive patenting" (companies tend to patent as much as they can to deter litigation though the threat of reciprocal suits) has become common practice within the industry.

The need to consolidate patent portfolios and thus ensure freedom to operate appears to have created incentives for the extensive mergers and acquisitions that have occurred in the agricultural biotechnology and seed businesses and for other cooperative responses short of full integration (such as cross-licensing). We will consider both in turn.

1. The Emerging Industry Structure for Agricultural Biotechnology

The emergent industry structure is characterized by a relatively small number of tightly woven alliances, each organized around a major firm.

Since the late 1980s and continuing into the 1990s, a variety of firms had secured agricultural biotechnology patents. It is expedient to distinguish between two categories of firms that have been, or still are, involved in plant agricultural biotechnology (ag-biotech): (i) small research-oriented ag-biotech firms; (ii) and multinational enterprises.[45] The first group consisted primarily of relatively small privately held firms with very high ratios of R&D spending per employee and specific research capabilities. Among the best known of this group were the US-based Agracetus, Calgene, Ecogen, Plant Genetic Systems. Individually these firms had small and often uncoordinated IP portfolios; however, collectively they held a fairly comprehensive set of technologies. The second group included established "incumbents" that turned to biotechnology to further their core businesses. Despite considerable overlaps, this class of firms consisted of companies that had been historically somewhat distinct: large, vertically integrated seed companies (for example, Pioneer Hi-Bred Int'l and Seminis); agricultural product companies primarily involved in grain handling and processing (e.g. Cargill); food corporations (such giants as Procter & Gamble and Unilever); chemical corporations with secondary agrochemical interests (significant involvement in agricultural biotechnology was found, for example, with Dow, Bayer and DuPont); and pharmaceuticals with large divisions and subsidiaries in agricultural products (which was the case of Novartis, Zeneca, Rhone-Poulenc).

Beginning in the late 1990s, intellectual property ownership has increasingly consolidated in a dwindling number of large multinational corporations. Small start-up companies still figure

[44] *Chemical Market Reporter*, "Syngenta Acquires Advanta; Sued by Monsanto," 17 May 2004, 2; and Monsanto Company, *Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934* (2004 Form 10-k), Item 3 (Legal Proceedings).

[45] Gregory D. Graff, *The Agricultural Biotechnology Industry in Overview*, Department of Agricultural and Resource Economics, U.C. Berkeley, July 1997.

prominently, but as acquisition targets or as licensor to the large corporations.[46] A recent study has analyzed changes in patent ownership of more than 3,000 ag-biotech patents issued between 1976 and 2000 to US and European companies. The study reveals that by 2002, 95 per cent of patents originally held by seed or small ag-biotech firms had been acquired by large chemical or multinational corporations.[47]

This increasingly concentrated industry structure has emerged as a result of two concurrent developments.

First, as seen above, divestitures and mergers among several large chemical and pharmaceutical firms led to the emergence of new agronomic system giants. For example, in November 2000, the two pharmaceutical conglomerate Novartis and AstraZeneca, both with substantial interests in agriculture, divested and merged their agrochemical businesses, leading to the emergence of Syngenta. Monsanto, originally a traditional chemical and industrial materials company that then diversified into pharmaceutical and had emerged as a life sciences company, in the late 1990s unbundled its pharmaceuticals, nutritional and agricultural business.

Second, the new agrochemical giants went on a buying spree in the plant biotechnology and seed. It has been calculated that between 1995 and 1998 approximately 68 seed companies were acquired by or entered into joint ventures with a handful of large multinational companies.[48] This trend became more apparent in the late 1990s and early 2000s, when the largest agrochemical and biotechnology companies reached out to envelop virtually all the largest seed firms in North America. Similarly, small ag-biotech firms became acquisition targets by the new agronomic system giants.

As a result of these extensive mergers and acquisitions, ownership of agricultural patents and of other forms of relevant IP rights has consolidated in the hands of a few conglomerates, including the following corporate groups:

1. Monsanto(Monsanto/Agracetus/Asgrow/Calgene/DeKalb/ Holden'sFoundationSeed/Seminis/ EmergentGenetics/ASI)
2. DuPont/Pioneer/OptimumQualityGrains
3. Syngenta(Novartis/Zeneca)/Garst/Holden
4. Dow/Mycogen/Agrigenetics/Phytogen
5. Bayer/Aventis(Hoechst/Rhone-Poulenc)

2. Measuring Concentration in Agricultural Biotechnology: Field Releases and Patent Ownership

To construct a measure of concentration in innovation activity for the case of agricultural biotechnology, we borrow from traditional concentration measures developed for output markets and adapt them to biotechnology. Typically, a sales-based four-firm concentration ratio (CR4, the aggregate market share of the four largest firms, expressed as a percentage) is adapted by replacing data on product sales with data on R&D activity. We rely on two sets of data on R&D activity in agricultural biotechnology: (i) the proportion of transgenic field trials conducted by the different firms; and (ii) ownership of agricultural biotechnology patents.

[46] David Schimmelpfennig *et al*, "Ag Biotech Patents on the Move," *Amber Waves*, June 2005.

[47] See David Schimmelpfennig and John King, "Mergers, Acquisitions and Flows of Agbiotech Intellectual Property," in *International Trade and Policies for Genetically Modified Products*, Eds. R.E. Evenson and V. Santeniello (CABI Publishing, 2005).

[48] Margaret F. Brennan *et al*, *Impact of Industry Concentration on Innovation in the US Plant Biotechnology Industry*, paper presented at the Transitions in Agbiotech: Economics of Strategy and Policy conference, Washington, DC, June 1999.

Field release permits, as patents, are issued to individual companies within the group, not to corporate groups — deprived of legal personality. Under a concentration measure that treats each biotechnology firm as an independent entity, a parent company's patent portfolio is kept distinct from the propriety entitlements of its subsidiaries. Similarly, each firm performing field trials is treated as an independent observation. Measures that account for mergers and acquisitions provide a different and potentially more accurate assessment of R&D concentration. We will consider both measures in turn.

(a) Field Releases Approved by APHIS

We first assess concentration with reference to transgenic field trials conducted under USDA regulations.

USDA regulations state that a "release into the environment" (field test) of a "regulated article" (organism that may pose a plant pest risk) requires a permit from the USDA's Animal and Plant Health Inspection Service (APHIS). A large majority of genetically modified organisms developed for agricultural purposes in the US fall under these regulations. If a permit is granted, institutions may perform the field tests on several sites in several states within a specified amount of time. When an institution has gathered enough supporting field test data, it may apply to APHIS for deregulation of the tested organism in the form of a petition. If APHIS determines that there is enough evidence, it will deregulate the organism and clear the way for the crop to be commercialized.

We constructed a measure of concentration based on field test permits granted under both the traditional "permitting process" (Release Permits) and the streamlined "notification process" (Notifications).[49] For most purposes, there is no difference in these two categories, and together, they equal the number of field releases approved by APHIS. We only took into account requests for controlled open air field release. We counted permits classified as issued (pending and withdrawn permits were not taken into account) plus notifications reported as acknowledged (pending, denied, void or withdrawn notifications were not counted). The date is the actual date the request was received into APHIS Biotechnology Regulatory Services (BRS).

It has been calculated that, between June 1987 and September 2005, 11,083 field releases were approved by APHIS under both the traditional permitting process and the streamlined notification process. With respect to the phenotype category, 33 per cent of total field release approvals were for varieties with herbicide resistance and 28 per cent for insect resistance (agronomic properties, bacterial resistance, fungal resistance, marker gene, nematode resistance, other product quality, and virus resistance accounting for the balance). The majority of field test approvals were for testing improved variety of corn (46 per cent of field releases approved by APHIS over the period).

We first assess concentration under a measure that treats each company as an independent entity, irrespective of corporate affiliation. We then appraise concentration after accounting for mergers and acquisitions within the industry.

(i) Concentration without Accounting for Group Structures

Table 7 shows the percentage of field releases obtained by the leading four firms (CR4) and the leading ten firms (CR10) throughout 1987-2005. Over the period, the top four firms controlled over 50 per cent of these approvals (the proportion of the top ten firms exceeded 60 per cent), suggesting concentration in R&D, as well as at the level of deregulation and output markets.

[49] Notifications are a type of release permit. As of 30 April 1993, certain field tests may qualify for the notification process which expedites the permitting procedure. Field tests may be conducted under this process upon submission of a letter of notification and approval by APHIS.

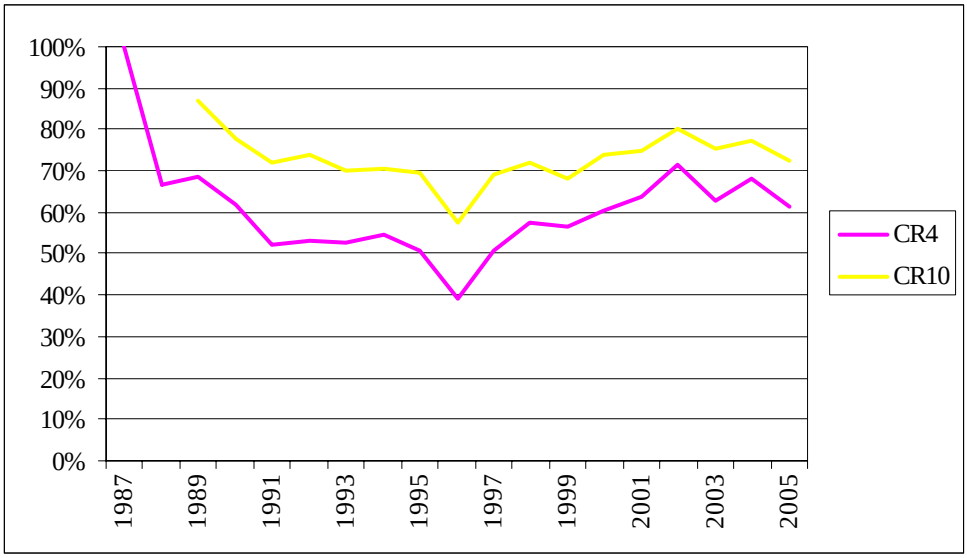
Table 7: Percentage of field releases obtained by the four top (CR4) and the ten top (CR10) companies, 1987-2005 (not accounting for corporate links)

Year	4CR		10CR		Total
	No.	Share (per cent)	No.	Share (per cent)	No.
1987	9	100	-	-	**9**
1988	12	67	-	-	**18**
1989	26	68	33	87	**38**
1990	36	62	45	78	**58**
1987-1990	74	60	95	77	**123**
1991	56	52	77	72	**107**
1992	80	53	111	74	**150**
1993	161	53	214	70	**306**
1994	324	55	419	71	**594**
1995	348	51	477	70	**684**
1991-1995	909	49	1231	67	**1841**
1996	245	39	360	58	**626**
1997	376	51	513	69	**744**
1998	626	58	783	72	**1086**
1999	555	56	673	68	**986**
2000	564	60	691	74	**937**
1996-2000	2225	51	2737	63	**4379**
2001	717	64	847	75	**1128**
2002	814	71	914	80	**1141**
2003	512	63	615	75	**815**
2004	654	68	740	77	**959**
2005	429	62	505	72	**697**
2001-2005	3039	64	3493	74	**4740**
Grand Total	5758	52	6896	62	**11083**

Source: UNCTAD secretariat (Data: Field Tests Database, Biotechnology Regulatory Services, APHIS, USDA).

As illustrated in Figure 3, the concentration measures show a period of rapidly decreasing concentration (the CR4 ranges from 100 per cent in 1987 to 39 per cent in 1996), followed by a period of increasing concentration (in 2005, the four top firms accounted for a combined 64 per cent of field release approvals, up from as low as 39 per cent in 1996).

Figure 3: Concentration measures, 1987-2005 (not accounting for corporate links)



Source: UNCTAD secretariat calculations (Data retrieved from Field Tests Database, Biotechnology Regulatory Services, APHIS, USDA)

(ii) Concentration after Accounting for Corporate Affiliation

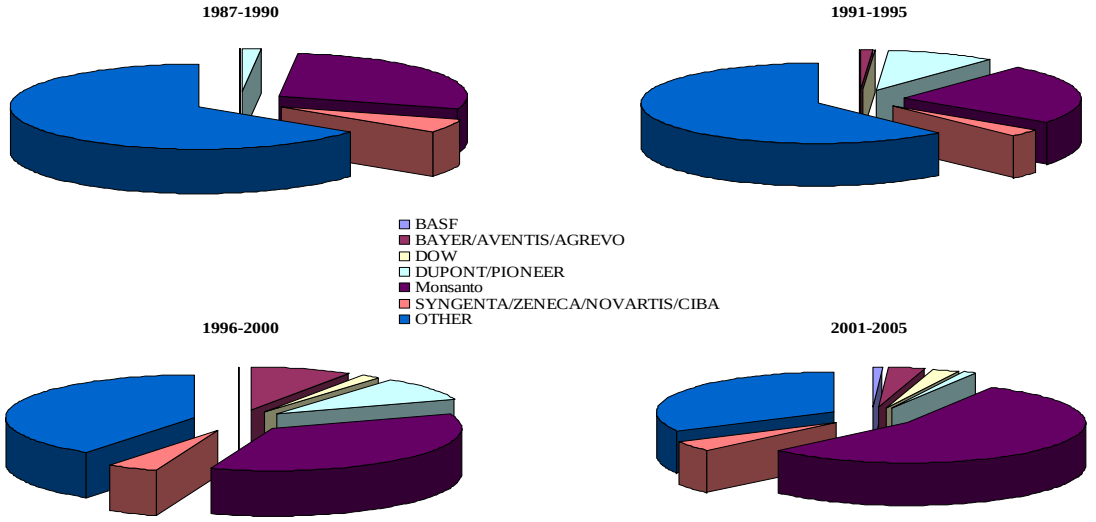
For a thorough search of a company group's record, we first had to track all the relevant acquisitions that had occurred throughout the reference period. We then aggregated all documents assigned to smaller entities known to be subsidiaries of the larger entities under the name of their respective parent entities. For our purposes, subsidiaries are conventionally defined as those entities in which the parent company has an interest of more than one half of the voting rights or otherwise has the power to exercise control (i.e. the direct or indirect power to govern the financial and operating policies of an enterprise).

Companies acquired during the period were included in the group's record from the concluding date of the transaction. In other words, approvals obtained by a company were recorded in the parent's record only if that company was owned or controlled by the parent the year the permit was requested. [50]

Throughout 2001-2005, companies within the Monsanto group received over 2,616 field release approvals, or 55 per cent of all field releases approved, up from 35 approvals during 1987-1990 (28 per cent of the total). The performance of the other conglomerates was less consistent throughout the years.

[50] An example of our aggregration for Monsanto illustrates this process. For the purpose of the present analysis approvals issued to the Monsanto group during 1987-2005 include those issued to Calgene Inc. from 1996 (i.e. the year Monsanto acquired a 49 per cent equity stake in Calgene Inc.), to Agragetus since 1996 (100 per cent acquisition of Agracetus Transgenic Plant Division by Monsanto Co.), to Holdens since 1997 (100 per cent of Holdens Foundation Seeds), to Asgrow since 1997 (100 per cent of Asgrow Agronomics), to DeKalb since 1998 (Monsanto acquired the remaining 60 per cent of Dekalb Genetics it did not already own), to Upjohn in 2000 (Monsanto and Pharmacia & Upjohn completed their merger-of-equals transaction), to Limagrain since 2001 (Monsanto acquired 100 per cent of Limagrain Canada Seeds), to Interstate since 2004 (Monsanto acquired the Canola seed operations and assets of Interstate Seed Co.), to NC+Hybrids, Seminis and Emergent Genetics since 2005 (100 per cent acquisition of NC+ Hybrids Inc., Seminis, Inc., and Emergent Genetics, Inc.).

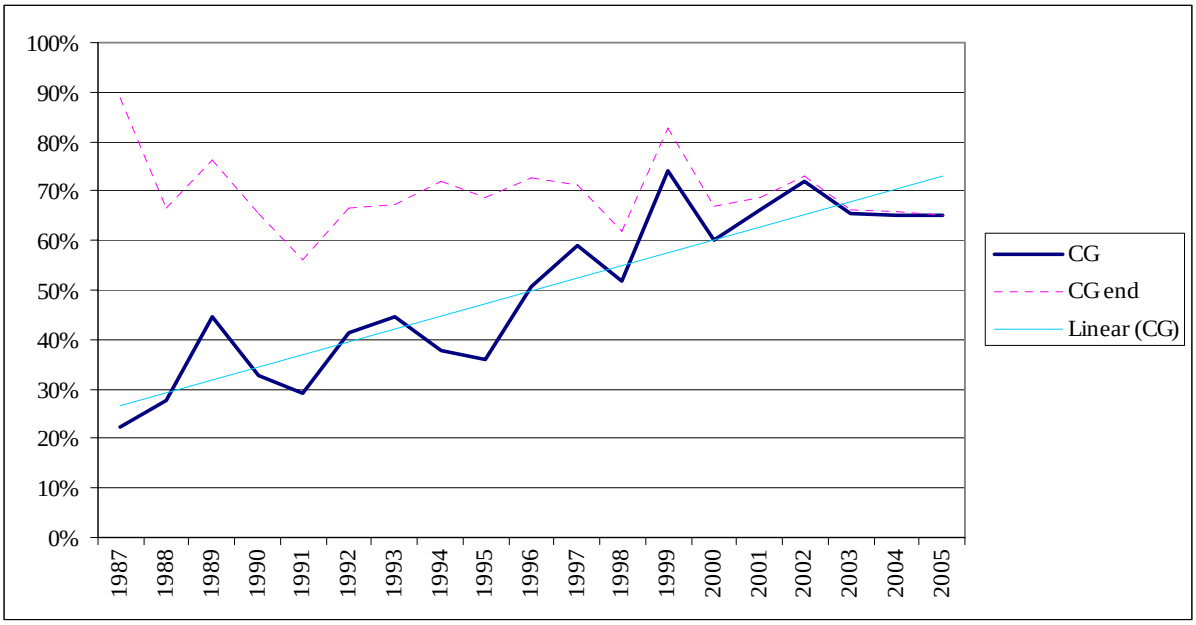
Figure 4: Field release approvals, breakdown by corporate groups, 1987-2005



Source: UNCTAD secretariat calculations (Data retrieved from Field Tests Database, Biotechnology Regulatory Services, APHIS, USDA; adjustments for acquisitions on the basis of tracked mergers and acquisitions - see Annex 1 and Footnote 50).

The aggregate share of the six corporate groups (CG), i.e. Monsanto, Syngenta, BASF, Bayer/Aventis/AgrEvo, Pioneer/DuPont, and Dow/Advanta, has expanded significantly throughout 1987-2005. The continuous CG line in Figure 5 shows the percentage of field release approvals obtained during 1987-2005 by the six conglomerates. The measure shows a pattern of increasing concentration throughout the reference period. The share of approvals obtained by the six groups combined has increased from as low as 22 per cent in 1987 to over 65 per cent in 2005, with a peak of 74 per cent in 1999. By this measure of concentration (CG), we took acquisitions into account as they occurred. For example, approvals obtained by Agragetus were not allocated to Monsanto as a parent entity until when Agragetus was acquired by Monsanto (1996). The dashed line (CG end) considers group affiliation retroactively. This measure of concentration aggregates under the name of the parent company approvals issued to an entity that only at a later stage (by 2005) became a wholly owned subsidiary, even if the issuing company was not yet part of the group when the permit was issued.

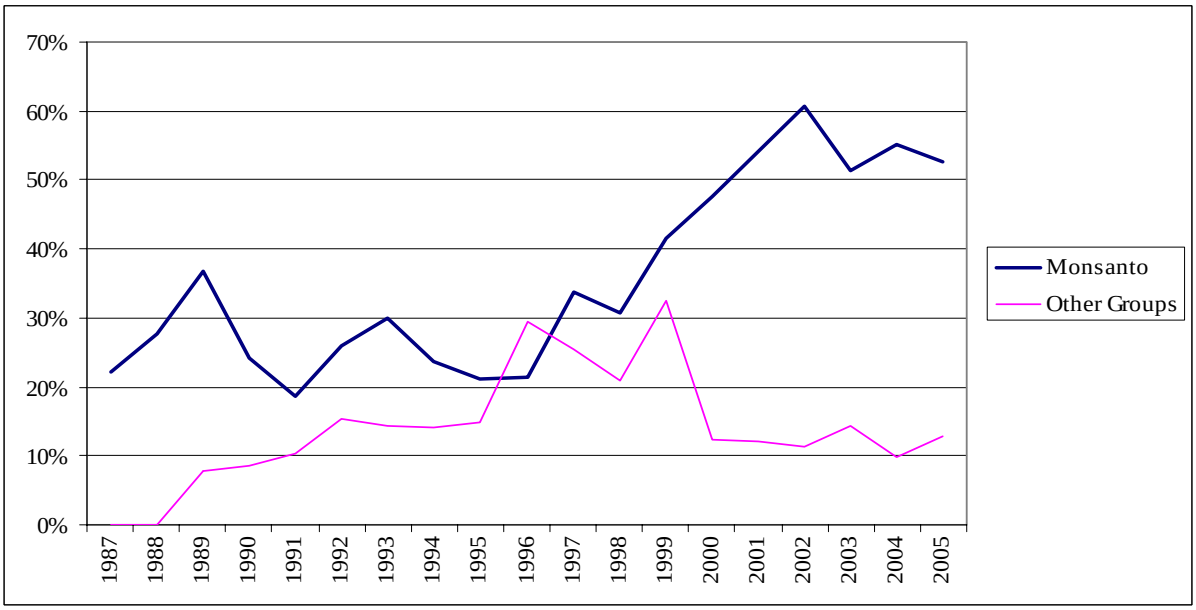
Figure 5: Approved field releases, share by Monsanto, Syngenta, BASF, Bayer/Aventis/AgrEvo, Pioneer/DuPont, and Dow/Advanta (accounting for acquisitions), 1987-2005



Source: UNCTAD secretariat calculations (Data for individual companies retrieved from Biotechnology Regulatory Services, APHIS, USDA; Adjustments for acquisitions on the basis of tracked mergers and acquisitions - see Annex 1 and Footnote 50)

It should be stressed that much of the rise since 1999 can be attributed to the remarkable increase in Monsanto's market share. The trend seen in Figure 5 would be much less consistent if Monsanto was not included.

Figure 6: Approved field releases, Monsanto v. Syngenta, BASF, Bayer/Aventis/AgrEvo, Pioneer/DuPont, and Dow/Advanta (per cent), 1987-2005 (accounting for acquisitions)



Source: UNCTAD secretariat calculations (Data for individual companies retrieved from Biotechnology Regulatory Services, APHIS, USDA; Adjustments for acquisitions on the basis of tracked mergers and acquisitions - refer to Annex 1)

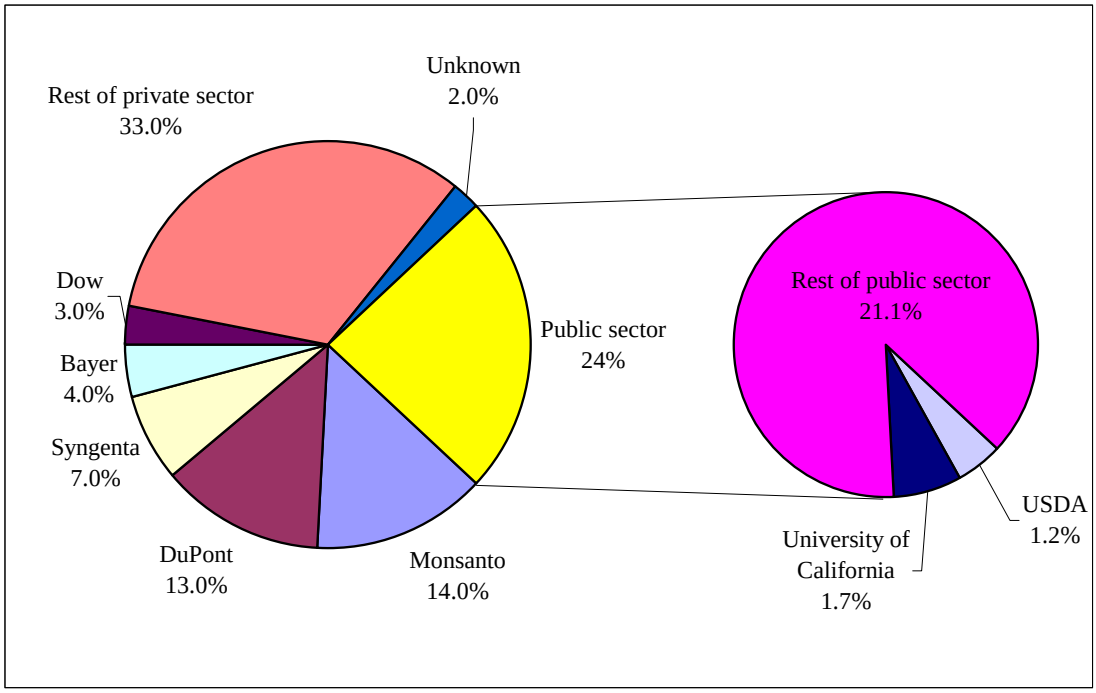
(b) Agricultural Biotechnology Patents

The territorial nature of patent law, coupled with differences across jurisdiction as to the subject matter of patentability and the forms of intellectual property protection for plants, does not

make it possible to appreciate concentration in patent ownership at the global level. In this section we focus on a single patent jurisdiction (i.e. the US PTO's remit) and on a single form of IP protection for crops (US utility patents, not accounting for US plant patents and plant variety protection certificates). In examining patent ownership and concentration pattern, we rely extensively on two heterogeneous information sources: (i) findings from relevant research performed at University of California-Berkeley (based on a collection of 4,319 patents in plant biotechnology granted from 1982 to 2001);[51] (ii) the comprehensive database on agricultural biotechnology patents developed for research purposes by USDA Economic Research Service (ERS) (11,761 agricultural biotechnology patents with issue dates between 1976 and 2000).

There is evidence suggesting that a large amount of intellectual property in agricultural biotechnology aggregated into a few very large IP portfolios held by the agrochemical giants. Findings from Gregory D. Graff and colleagues from the University of California-Berkeley indicate that the top five corporations held 41 per cent, of agricultural biotechnology patents granted from 1982 to 2001 in the United States. Monsanto and DuPont controlled the largest corporate portfolios (14 and 13 per cent, respectively), followed by the Syngenta group (7 per cent), Bayer (4 per cent) and Dow (3 per cent). The balance (24 per cent public-sector holdings and 33 per cent "rest of the private sector") was scattered among many small biotechnology start ups, physical persons, and public institutions, none of which individually owned a package of technology sufficient to develop a novel transgenic plant variety.

Figure 7: US agricultural biotechnology patents, 1982-2001 (breakdown by patent assignees)



Source: UNCTAD secretariat (information content from Gregory D Graff *et al*, "The Public-Private Structure of Intellectual Property Ownership in Agricultural Biotechnology," *Nature Biotechnology* 21, no. 9 (Sept. 2003), 989).
Note: The collection of IP documents in the field of plant biology was developed from patent data maintained by MicroPatent, through queries based on a combination of international patent classification (IPC) codes and technology-related search terms.

If we consider licensing transactions, which are not typically recorded in patent office data and are often confidential, the dominance of the top four corporate conglomerates may be even greater than these numbers reveal. In this respect, a portion of the public sector portfolio was exclusively licensed to the largest private corporations (cross-sector public-private collaborations often include an option for the private partner to receive an exclusive license to any resulting patents filed by the public

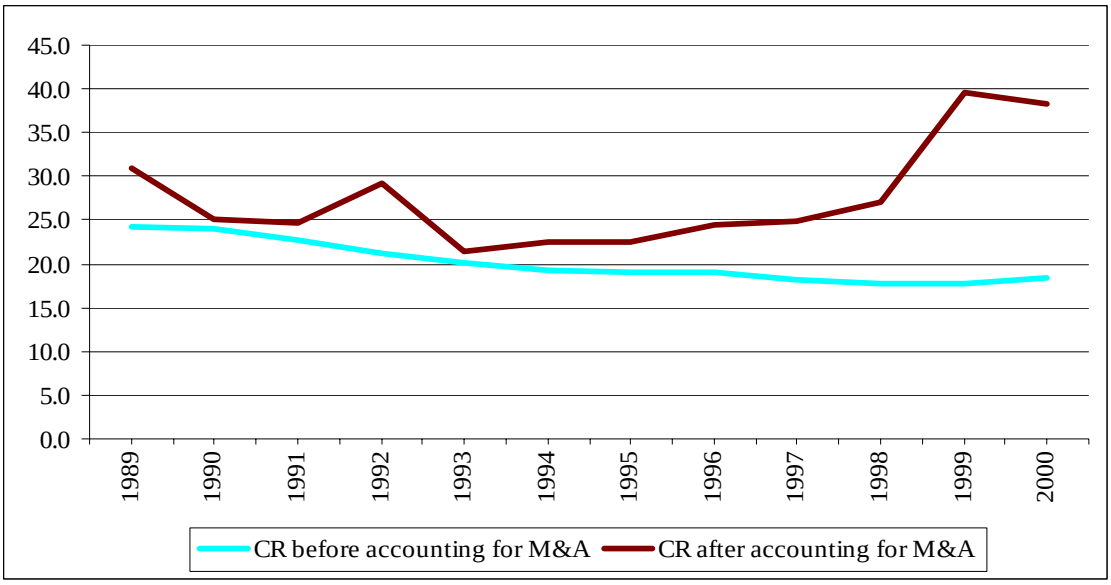
[51] Findings documented in Gregory D. Graff *et al.* "The Public−Private Structure of Intellectual Property Ownership in Agricultural Biotechnology", *Nature Biotechnology*, 21 (2003), 989-995.

institution). Within the rest of the private sector, small independent start-up companies and individuals pursue innovative avenues of research mainly in order to benefit from licensing revenues.

The figures we are considering aggregate all patents assigned to subsidiaries or former entities under the name of the parent company or the company resulting from merger deals. For example the IP portfolio of Syngenta (7 per cent) includes earlier patents assigned to the holdings of Novartis and AstraZeneca (who then merged their agricultural divisions to form Syngenta), plus filings under the Syngenta name. It should be stressed that much of the increase in concentration in agricultural biotechnology over the past decade reflects mergers and acquisitions among firms consolidating their patent portfolios.

Figure 8 (ERS's agricultural biotechnology patent database) shows an initial decline in concentration of ownership for agricultural biotech patents counteracted partially in the mid- to late-1990s by mergers and acquisitions. The ERS database uses the broadest possible definition of agricultural biotechnology, including such technology classes as pharmaceuticals and metabolic pathways and biological processes in animals. A more focused approach to specific technology classes and subclasses would show higher concentration ratios (as in Figure 7).

Figure 8: Concentration ratio (CR) of US agricultural biotechnology patent awards, top 10 patent holders, 1989-2000 (including adjustment for acquisitions)



Source: USDA, ERS, agricultural biotechnology patent database (based on data compiled from records of the US PTO)

3. New Patterns of Convergence: Informal Alliances

In measuring R&D concentration, an attempt to take into consideration the extensive divestitures, mergers and acquisitions that had occurred throughout the reference period was made. However, cooperative strategies short of (vertical or horizontal) integration were not counted towards the share of R&D of the inventing company.

Cooperative strategies include licensing, cross-licensing agreements, subcontracting, and other contractual structures that frame patterns of inter-company alliances. These are current practices in agricultural biotechnology. Indeed, because of the cumulative nature of the genetics and biotechnologies embodied in transgenic varieties, the next innovation is likely to "stack" traits upon those developed in the previous innovation. To avoid encroaching upon each other's patent entitlements, companies are obliged to enter into licensing and cross-licensing deals. All the leading firms in agricultural biotechnology (including Monsanto) are themselves licensed under various patents, which expire from time to time, covering many products, processes, and product uses. Under a cross-licensing agreement, two parties grant a license to each other for the exploitation of the subject-

matter claimed in patents. In some cases, cross-licensing is the mutual sharing of patents between companies without even payment of royalties if both patent portfolios are deemed equal in value.

Evidence suggests a trend towards heightened strategic cooperation among the largest competitors, with the industry's leading corporations swapping and pooling their patents on key technologies. In 2002, for example, DuPont and Monsanto agreed to dismiss all of the lawsuits that were pending against each other over their biotechnology programmes (Box 6). The agreement gave both companies access to each other's enabling technologies. Other similar deals included the following: in November 2004, DuPont and Syngenta settled their dispute over seed technology patent (under the disclosed terms of the agreement, DuPont Pioneer would receive commercial licenses to Syngenta patents on *Herculex* and *YeldGard* insect-resistant corn traits); in 2002 Dow reached an agreement with Monsanto which gave the company access to *Roundup Ready* technology, allowing Dow to offer *Roundup Ready* technology in their Phytogen variety in the future; on 24 August 2004 Syngenta and Delta and Pine Land (D&PL) announced a long-term agreement to develop and commercialize novel biotechnology products for cotton (Syngenta will grant licenses to D&PL for its insect resistance biotechnology traits in cotton).

Box 6: DuPont and Monsanto cross-licensing deal

In 2002, DuPont and Monsanto agreed to dismiss all of the lawsuits that were pending against each other over their biotechnology programmes. There were at least 13 suits pending between the companies, including Monsanto's attempt to invalidate a license that gave DuPont's Pioneer Hi-Bred subsidiary the right to produce and market Monsanto's *Roundup Ready* glyphosate-tolerant GM soybean seeds. The license, signed before the commercial viability of the seeds became clear, included a royalty structure that was far below what Monsanto charged other companies. Monsanto claimed that DuPont's 1999 purchase of Pioneer terminated the agreement. In March 2000 DuPont filed an antitrust suit against Monsanto, alleging that the company forced farmers into agreements that made it virtually impossible to buy competing brands of glyphosate-based herbicides in exchange for gaining access to *Roundup Ready* seeds. The companies also fought over patents and intellectual property involving seed traits and germplasm, the genetic raw material in seeds.

The agreement gives both companies access to each other's enabling technologies that enhance the performance of corn, canola, and soybean crops. Under the terms of the agreement, Pioneer received: a royalty-bearing license to Monsanto's newest *Roundup Ready* com technology; a new license to Monsanto's *Roundup Ready* soybean technology under an amended royalty structure; renewal of Pioneer's existing royalty-bearing license to *Roundup Ready* canola technology; freedom to operate from Monsanto for its second-generation insect-resistant corn products and future rootworm-resistant corn products, through a royalty-bearing license. Pioneer's existing license for use of Monsanto's *MON810 YieldGard* Corn Borer product was modified to expand geographic coverage and include more favorable terms.

Monsanto received permission to operate for certain corn transformation technology and certain terms of DuPont's existing glyphosate supply agreement were revised. In addition, Monsanto and DuPont have resolved all issues related to certain previously contested germplasm and have entered a plant breeding accord in respect of proprietary germplasm. Both Monsanto and DuPont agree to dismiss all pending lawsuits. Other terms were not disclosed.

Source: Monsanto's corporate website (*Monsanto Statements & News Releases*, "DuPont and Monsanto Reach Agreement that Brings New Technologies to Farmers Worldwide," April 2, 2002); *Chemical Week*, April 10, 2002, 9.

The sharing of proprietary biotechnology is an interesting way for companies to establish synergies without falling within the purview of antitrust law. Concerns about these cooperative responses are echoed by the Canada-based public interest organization ETC Group. The Group claims

that leading companies are establishing "global technology cartels" that have been overlooked by competition authorities or who do not come within the regulators' remit.[52]

4. Food Clusters

Over time a host of new vertical cooperative deals, short of full ownership or control, began to develop along the commodity chain. These new relationships, often referred to as "alliances" or "seamless systems", range from joint ventures to partnerships, long-term contractual agreements, and other cooperative strategies where companies collude, instead of compete. Eventually, these alliances frame the dynamic boundaries of clusters of companies, located at different stages of the chain, which control segments of the food system from gene to shelves. A reason for concern is that, within these emerging clusters, there will be no open markets and thus no price discovery along the line of production from the gene to the shelf. In a food chain cluster, the product is passed along from stage to stage, without changes in location of decision-making.[53]

It is interesting to note a trend towards heightened cooperation along the food chain between, on the one hand, the largest agricultural input companies (the agrochemical, seed and biotech giants) and, on the other, the global grain handlers (engaged in trading, processing, as well as marketing). The agricultural input companies needed the grain handlers' extensive handling and processing facilities to guarantee a downstream market to producers using their (genetically modified) seed stock. By strengthening cooperation with upstream partners, grain traders enhanced their access to farmers and raw materials. The Food Circles Networking Project has profiled three emerging "food system clusters", namely: (i) Cargill/Monsanto Joint Ventures and Strategic Alliances; (ii) Novartis/Archer Daniels Midland (ADM); (iii) DuPont/ConAgra. Each of these alliances would define a dense network of contractual relationships and equity interests that envelop a leading agribusiness firm providing inputs for the production stage and a global grain trader (grain collection, processing and trade). It is worth considering in some detail the Cargill/Monsanto scheme.

For instance, in September 1998, Monsanto and Cargill entered into an agreement (the Renessen Agreement, as amended from time to time) to form the Renessen LLC joint venture (equity affiliate). This joint venture combines Monsanto's seed assets and biotechnology capabilities with Cargill's global grain processing, marketing and risk management infrastructure. Figure 9 illustrates some aspects of the deal (the continuous lines refer to equity investment, whereas the dashed lines show technology transfers).

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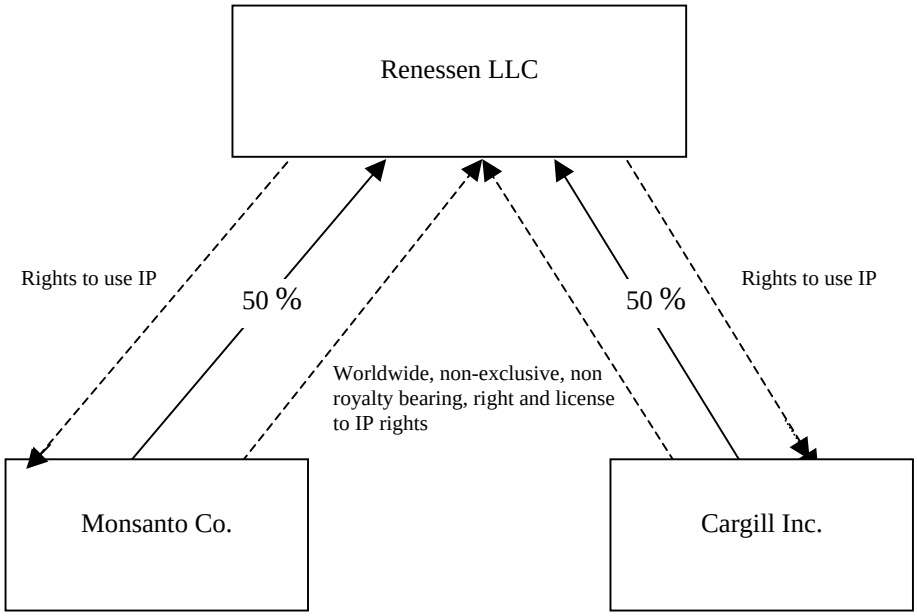
[52] ETC Group, "Oligopoly, Inc. Concentration in Corporate Power: 2003," *ETC Communiqué*, Issue 82, November/December 2003; ETC Group press release "The five gene giants are becoming four: DuPont and Monsanto – 'living in sinergy'?,", 9 April 2002: http://www.etcgroup.org/documents/nr2002apr9.pdf.

[53] Food Circles Networking Project, Consolidation in the Food System. Papers available online at http://www.foodcircles.missouri.edu/consol.htm (accessed on 26 September 2005). William D. Heffernan, *Consolidation in the Food and Agriculture System: Report to the National Farmers Union* (Columbia, Missouri: Department of Rural Sociology University of Missouri, 1999).

Figure 9: Monsanto/Cargill alliance



Cargill and Monsanto each have a 50 per cent interest in Renessen, make equal contributions to fund its business plan, and have equal representation on the governance board. It is interesting to note that Renessesn condenses Monsanto's and Cargill's IP portfolios: Cargill and Monsanto each has granted a worldwide, non-exclusive, non-royalty bearing right and license to their respective patents and other IP entitlements needed for Renessen to pursue the approved business plan.

Renessen LLC will initially develop and market GM products for the grain processing and animal feed markets, including GM maize, soybeans and wheat products with altered nutritional properties for use in animal feed. Other GM products in the pipeline include oil seeds and wheat varieties with altered processing properties.

It should be stressed that the organization of corporate clusters is very complex and dynamic, with equity and contractual relationships crossing cluster boundaries and firms realigning to different alliances.

IV. CONCLUSION

The structural changes that are being unfolding in the agricultural input industries are subtle. First, they are difficult to detect because of the complexity of corporate deals that often escape public scrutiny (e.g. licensing arrangements). Besides, it is difficult to fully apprehend their implications, in that they work and spread in a concealed manner (e.g. by reversing traditional understandings of seeds, farmers' rights and breeders' rights).

In order to fully appreciate the reasons for and implications of tightened industry concentration in the agricultural input sector, it is important to consider structural changes within the industry (changes in the number and size of input companies; emerging vertically coordinated agrifood clusters, with associative rather than arms-length supply relationships; and the changing business arrangements between farmers and input companies) alongside relevant institutional developments (the privatization and patenting of agricultural innovation). The combined result of these two interrelated processes has been a marked increase in corporate control in agriculture, which refers in different respects to business realities and legal structures.

The crop seed market traditionally functioned on the assumption that farmers would purchase seeds and be able to save and select seeds from their crops. Nowadays, the leading agricultural biotechnology firms have proprietary entitlements that eventually encroach on the farmers' disposal of his/her farm produce. In many contexts, concentrated market structures being associated with the privatization and patenting of agricultural innovation has resulted in a drastic erosion of traditional farmers' rights and status, with a translation from "seed owners" to mere "licencees" of a patented product. In the United States and elsewhere, this change has been brought about by contractual means rather than through a statutory process (cases decided to date suggests that seed firms in the United States have considerable latitude in expanding the scope of agricultural biotechnology patents vis-à-vis farmers' rights). Post-sale contract restrictions on a grower's use of purchased seeds typically entail prohibiting seed saving, seed replanting on one's own holding or elsewhere, and seed resale outside authorized distribution channels.

To gain physical access to patented seeds, commodity producers (and researchers, with regard to patented gene traits, enabling technologies and knowledge to exploit them) will typically enter into some licensing arrangements with a local subsidiary of the biotechnology company, or the company itself. These dealings may include far-reaching choice of law and forum clauses. As a practical matter, this use of technology agreements can extend the impact of, for example, US patent policy beyond the United States, and effectively harmonize the international patent system with the standards of those countries that adhere to stringent IP regimes.

These patterns of private conduct may possibly impact on the effectiveness of a strategy based on the special and differential treatment of developing countries (for example, amending the TRIPS Agreement so that developing countries, or at least a subset of them, do not have to introduce product patents in particular sectors of their choice). This strategy overlooks the fact that, in practice, it may be difficult to press observance of domestic standards on private dealings between farmers and a foreign company.[54] On the other side, this course of action in agriculture appears to forecast a parallel move in law towards conferring and protecting intellectual property rights of seed germplasm. In several instances, "TRIPS-plus" intellectual property provisions have been inserted into bilateral and regional trade agreements, threatening the use of TRIPs flexibilities in relation to IP protection of plant varieties and the rights of farmers. Furthermore, efforts are being pursued in WIPO to ensure mutual recognition of patents among the parties (one international patent filing would have the same effect in all signatory countries). Similarly, some countries are pressing to repeal the right to exclude plants

[54] In legal terms, this is a matter of domestic law - choice of law rules and rules on contract enforceability.

from patentability under Article 27.3(b) of the TRIPS Agreement (which is undergoing a mandated review).

Turning to research and development, the original purpose of patents was to encourage innovation. Some argue that the increase in concentration, coupled with IP "congestion", is having the opposite effect. The major multinational agrochemical companies, with their growing control over essential proprietary technologies, may represent a barrier to the entry of innovative start-ups. In addition, they may have an inhibiting effect on public research, including public research in developing countries.[55] It is worth recalling that in developing countries technical progress in agricultural biotechnology traditionally occurred through a process of on-farm experimentation. Subsequently this was supplemented by purposive breeding largely conducted in the public sector by national research institutes. In most developing countries, innovations are often embryonic and/or remain largely in the public domain, despite the emergence of private sector seed companies that are marketing privately developed hybrids and serve as distribution channels for publicly developed seed innovations.

The key issue here is the large number of patents on "research tools" and technologies that are possible inputs into one or several downstream processes. It is interesting to note that, in agricultural biotechnology, much research consists of the development of existing technologies. When a multinational company is backed by a broad portfolio of patents, including proprietary entitlements on key enabling technologies, it may impede access to innovative contents and technologies, by refusing to license.[56] Another issue is the appropriation by the large biotech companies of knowledge that was developed in the public domain. The privatization and patenting of biological resources by agricultural biotechnology companies is sometimes claimed to be predatory in that it involves the unauthorized use of biological resources outside of a country which has pre-existing knowledge (often in the form of traditional knowledge, which, because its communal ownership and unwritten form, does not fit the requirements of western IPR systems).

To conclude, the speed of concentration in the agricultural input sector, associated with the privatization and patenting of biological resources, raises serious competition issues. Further, it raises concerns over social justice and food security. This appears to be an instance where globalization has made it necessary to improve world governance on questions of corporate conduct and competition.

[55] "While patent protection provides an incentive for R and D, the patenting of intermediate technologies (particularly gene-based ones) required in the research process may actually create disincentives for researchers in terms of accessing, or unwittingly infringing patents on technologies they need. This is an area where patent practices in the developed world can impinge directly on what research is done for people in the developing world, and there are implications for the type of patent regimes that developing countries adopt" (Commission on Intellectual Property Rights (2002), at p. 34).

[56] On the other hand, when a number of owners have valid patent entitlements on the technologies and genetic contests included in the cultivar, or on particular aspects of each technology, the barrier to accede innovative contents and technologies accrue from the accumulated transaction costs in tracking down "who owns what" and "who owes what to whom", and in negotiating with all the single patent assignees.

Annex 1: Selected mergers and acquisitions

Monsanto							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
17/05/93	Divestiture	Horizontal	Ortho Lawn & Garden Products	United States	Industry and farm equipment and machinery	Produces lawn and garden products	Monsanto Co. (former)
22/02/95	Divestiture	Horizontal	Kelco	United States	Chemicals, paints and coatings	Specialty chemicals	Monsanto Co. (former)
01/04/96	Divestiture Minority interest	Horizontal	Calgene, Inc.	United States	Miscellaneous services	Develops genetically engineered plants	Monsanto Co. (former)
15/04/96*	Acquisition of private company	Horizontal	White Swan Ltd	United States	Agricultural production	Makes lawn and garden seed products	Monsanto Co. (former)
21/05/96	Divestiture	Horizontal	Agracetus Transgenic Plant Division	United States	Food processing	Develops transgenic plants for the agricultural industry	Monsanto Co. (former)
03/02/97	Divestiture	Horizontal	Asgrow Agronomics	United States	Agricultural production	Produces soybean seeds	Monsanto Co. (former)
01/09/97	Acquisition of non-US (foreign) company	Horizontal	Schwarz Pharma AG	Germany	Drugs, medical supplies and equipment	Develops and manufactures medicinal chemicals and botanical products	Monsanto Co. (former)
30/09/97	Acquisition of private company	Horizontal	Holdens Foundation Seeds Inc	United States	Agricultural production	Produces foundation corn seeds	Monsanto Co. (former)
30/09/97	Acquisition of private company	Horizontal	Corn States Hybrid Service Inc	United States	Wholesale and distribution	Markets and sells corn germplasm and parent seeds to create hybrid seeds	Monsanto Co. (former)
24/11/97	Acquisition of non-US (foreign) company	Horizontal	Sementes Agroceres SA	Brazil	Agricultural production	Makes seed corn	Monsanto Co. (former)
16/07/98	Divestiture	Horizontal	Plant Breeding International Cambridge Ltd	United States	Agricultural production	Produces and markets new and improved crop varieties	Monsanto Co. (former)
29/06/98	Divestiture	Horizontal	Cargill's International Seeds Operations	Brazil	Agricultural production	Conducts seed research, production and testing in 24 countries	Monsanto Co. (former)

Monsanto							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
07/12/98	Acquisition of public company - Tender offer	Horizontal	DEKALB Genetics Corp	United States	Agricultural production	Researches and develops hybrid agricultural products	Monsanto Co. (former)
31/03/00	Acquisition of public company - Merger	Horizontal	Pharmacia and Upjohn, Inc.	United States	Healthcare; Drugs, medical supplies and equipment	Pharmaceutical preparations	Monsanto Co. (former)
04/07/01	Divestiture	Horizontal	Limagrain Canada Seeds Inc	Canada	Agricultural production	Grows and produces cash grains	Monsanto Co.
21/09/01*	Divestiture	Horizontal	Unipork Genetics	Canada	Agricultural production	Breeds animals	Monsanto Co.
09/09/04	Divestiture - Assets acquired	Horizontal	Interstate Seed Co. /Canola Operation/	United States	Agricultural production	Farms and produces canola	Monsanto Co.
17/11/04	Acquisition of private company	Horizontal	Channel Bio Corp	United States	Agricultural production	Produces corn, soybean and alfalfa seeds	Monsanto Co. / American Seeds, Inc.
02/03/05	Acquisition of private company	Horizontal	NC+ Hybrids, Inc.	United States	Agricultural production	Markets seeds	Monsanto Co.
23/03/05	Divestiture	Horizontal	Seminis, Inc.	United States	Agricultural production	Produces specialty fruit and vegetable seeds	Monsanto Co.
05/04/05	Divestiture	Horizontal	Emergent Genetics, Inc.	United States	Agricultural production	Produces and sells agricultural products to farmers including seeds and herbicides	Monsanto Co.
18/04/05	Divestiture - Assets acquired	Vertical	Icoria, Inc. /Agricultural Assets/	United States	Miscellaneous services	Conducts agricultural research	Monsanto Co.
05/09/05	Acquisition of private company	Horizontal	Trelay Seed Co. / Stone Seed Farms, Inc. / Stewart Seeds, Inc.	United States	Wholesale and distribution	Provides corn and soybean seeds	Monsanto Co.

Source: Developed from data maintained by Mergerstat M&A; Supplemental information sources: Company records and press releases (*date of announcement)

DuPont / Pioneer							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
03/12/1997	Divestiture	Horizontal	Protein Technologies International	United States	Food processing	Supplies soy proteins to the food and paper processing industries	DuPont - E.I. du Pont de Nemours & Co.
26/01/1998	Divestiture	Horizontal	Dalgety's Cereal Derived Functional Ingredients Business	United Kingdom	Agricultural production	Makes wheat ingredients for use in soups, sauces, dairy products and vegetarian foods	DuPont - E.I. du Pont de Nemours & Co.
28/04/1998	Acquisition of non-US (foreign) company	Horizontal	Lafarge's Hybrinova SA	France	Agricultural production	Hybrid wheat	DuPont - E.I. du Pont de Nemours & Co.
22/03/1999	Acquisition of non-US (foreign) company	Horizontal	Dois Macros	Brazil	Agricultural production	Develops soybean seeds	Pioneer Hi Bred International, Inc.
06/11/2003	Divestiture	Financial	Griffin LLC	United States	Chemicals, paints and coatings	Produces crop protection chemicals	DuPont - E.I. du Pont de Nemours & Co.
01/10/1999	Acquisition of public company	Horizontal	Pioneer Hi Bred International, Inc.	United States	Agricultural production	Develops, produces, and markets hybrids of corn, sorghum, and sunflower	DuPont - E.I. du Pont de Nemours & Co.
01/05/2000	Acquisition of private company	Horizontal	Agrevo Isoproturon Business	France	Chemicals, paints and coatings	Produces agro-chemicals	Griffin Corp. / DuPont - E.I. du Pont de Nemours & Co.
18/09/2000 *	Acquisition of public company	Horizontal	IPK Oranica doo	Croatia	Agricultural production	Produces and retails maize and maize seeds	Pioneer Sjeme (Pioneer Hi-Bred International, Inc.)
02/07/2004	Acquisition of non-US (foreign) company	Horizontal	Verdia, Inc.	United States	Agricultural production	Provides molecular breeding to corn, cotton and soybean	DuPont - E.I. du Pont de Nemours & Co.

Source: Developed from data maintained by Mergerstat M&A; Supplemental information sources: Company records and press releases (*date of announcement)

Dow / Mycogen / Agrigenetics							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
28/08/1992*	Divestiture	Horizontal	Agrigenetics Co	United States	Agricultural production	Agricultural seed and plant sciences	Mycogen Corp.
06/01/1994	Divestiture	Horizontal	Mycogen Plant Sciences	United States	Miscellaneous services	Agricultural research	Mycogen Corp. / Mycogen Plant SCiences
27/02/1995	Divestiture	Horizontal	Delta & Pine Land Co.'s Seed Corn & Sorghum Unit	United States	Agricultural production	Seed corn and sorghum	Mycogen Corp.
21/08/1996	Divestiture	Horizontal	United AgriSeed	United States	Miscellaneous services	Corn breeding research	Mycogen Corp.
01/10/1996	Acquisition of non-US (foreign) company	Horizontal	Morgan Seeds	Argentina	Agricultural production	Seed company	Mycogen Corp.
20/04/1998*	Acquisition of non-US (foreign) company	Horizontal	Dinamilho Carol Productos Agricolas Ltda	Brazil	Agricultural production	Develops and sells high-yielding hybrid seed corn products	The Dow Chemical Co. / Mycogen Corp.
14/09/1998*	Acquisition of non-US (foreign) company	Horizontal	Hibridos Colorado Ltda/FT Biogenetica De Milho Ltd	Brazil	Agricultural production	Develops and markets seed products for corn and sorghum	The Dow Chemical Co. / Mycogen Corp.
02/11/1998	Acquisition of public company - Tender offer	Horizontal	Mycogen Corp	United States	Chemicals, paints and coatings	Manufactures and sells chemicals, plastics, and industrial and agricultural products	The Dow Chemical Co. / Dow AgroSciences LLC
07/08/2000	Divestiture	Horizontal	Empresa Brasileira de Sementes	Brazil	Agricultural production	Operates infrastructure for breeding, development, production, and sale of corn and grain seeds	The Dow Chemical Co. / Dow AgroSciences LLC
01/10/2000	Divestiture	Horizontal	Astrazeneca PLC /Acetochlor Corn Herbicides Business/		Chemicals, paints and coatings	Produces herbicides	D The Dow Chemical Co. / Dow AgroSciences LLC
01/11/2000	Acquisition of private company	Conglomerate	Cargill Hybrid Seeds North America	United States	Agricultural production	Produces high performance hybrid seeds	The Dow Chemical Co. / Mycogen Corp

Dow / Mycogen / Agrigenetics							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
01/06/2001	Divestiture	Horizontal	Rohm & Haas Co. /Agricultural Chemicals Business/	United States	Chemicals, paints and coatings	Provides agricultural chemicals, ion exchange, and consumer and industrial specialties	The Dow Chemical Co. / Dow AgroSciences LLC
04/10/2001	Divestiture	Horizontal	RohMid LLC	United States	Chemicals, paints and coatings	Manufactures turf insecticide	The Dow Chemical Co. / Dow AgroSciences LLC

Source: Developed from data maintained by Mergerstat M&A; Supplemental information sources: Company records and press releases (*date of announcement)

Syngenta							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
17/11/2000	Divestiture	Horizontal	Agrochemicals and Seeds Business of Novartis and Zenmex	Mexico	Chemicals, paints and coatings	Produces agricultural chemicals	Syngenta AG / Syngenta Mexico
02/05/2001	Acquisition of private company - Assets acquired	Horizontal	Hoffman Seeds Inc	United States	Agricultural production	Produces seeds	Syngenta AG / Syngenta Seeds Inc.
24/07/2001	Acquisition of non-US (foreign) company	Horizontal	Tomona Agrica	Japan	Chemicals, paints and coatings	Distributes chemical products used in agriculture	Syngenta AG
15/10/2001	Acquisition of non-US (foreign) company	Vertical	CC Benoist SA	France	Agricultural production	Farms cereal and grain	Syngenta AG
26/06/2002	Divestiture	Horizontal	Wilson Genetics LLC	United States	Agricultural production	Produces corn	Syngenta AG / Syngenta Seeds Inc.
07/11/2002*	Divestiture	Horizontal	Syngenta India Ltd	India	Chemicals, paints and coatings	Provides agricultural services	Syngenta AG
16/02/2004	Acquisition of non-US (foreign) company	Horizontal	Dia Engei, Inc.	Japan	Agricultural production	Produces seedlings for flowering plants and vegetables	Syngenta AG
25/06/2004	Acquisition of private company	Horizontal	Golden Harvest Seeds	United States	Agricultural production	Produces and distributes seeds for hybrid corn, soybeans, grain, and alfalfa	Syngenta AG
09/09/2004	Divestiture	Vertical	Advanta Seeds BV /North American Corn and Soybean Busi-ness/	United States	Wholesale and distribution	Distributes seeds	Syngenta AG

Source: Developed from data maintained by Mergerstat M&A; Supplemental information sources: Company records and press releases (*date of announcement)

Bayer / Aventis / Agrevo							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
08/04/1994	Acquisition of public company - Tender offer	Horizontal	ChemDesign Corp.	United States	Chemicals, paints and coatings	Manufactures organic chemicals for the agricultural, repro-graphic, photographic and advanced materials	Bayer AG / Miles Inc
01/12/1995	Divestiture	Horizontal	Clause Sa	France	Stone, clay and glass		Aventis SA
01/08/1996	Acquisition of non-US (foreign) company	Horizontal	Plant Genetic Systems International	Netherlands (Holland)	Miscellaneous services		Schering AG / Hoechst Schering Agrevo
26/09/1998*	Divestiture - Assets Acquired	Horizontal	Cargill Hybrid Seeds North America	United States	Agricultural production	Produces high performance hybrid seeds	Hoechst AG / Hoechst Schering Agrevo
19/11/1998	Acquisition of non-US (foreign) company	Horizontal	Granja 4 Irmaos SA	Brazil	Food processing	Produces rice seeds	Hoechst AG / Hoechst Schering Agrevo
24/02/1999	Acquisition of non-US (foreign) company	Horizontal	BioGenetic Technologies	United States	Chemicals, paints and coatings	Operates as a holding company for the fertilizer manufacturer, Proagro	Hoechst AG / Agrevo
08/03/1999	Divestiture	Conglomerate	Pbi Home & Garden		Miscellaneous services	Makes garden products	Bayer AG
09/03/1999	Acquisition of private company	Horizontal	Pursell Industries Inc	United States	Chemicals, paints and coatings	Makes fertilizers for lawn, garden, and food plants	Bayer AG
01/05/1999	Acquisition of non-US (foreign) company	Horizontal	Rio Colorado Seeds Inc	United States	Miscellaneous services		Agrevo / Nunza Bv
01/05/1999	Divestiture	Horizontal	Sementes Ribeiral Ltda	Brazil	Agricultural production		Hoechst Schering Agrevo
01/09/1999	Acquisition of non-US	Horizontal	Planttec Biotechnologie Gmbh	Germany	Chemicals, paints and coatings	Provides for the improvement of	Hoechst AG / Hoechst

Bayer / Aventis / Agrevo							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
	(foreign) company					carbohydrate metabolism in plants	Schering Agrevo
29/11/1999	Acquisition of non-US (foreign) company - Merger	Horizontal	Hoechst AG	Germany	Healthcare; chemicals, paints and coatings	Produces specialty chemicals and pharmaceutical products	Aventis SA
01/02/2000	Divestiture Minority interest	Horizontal	Novance Sa	France	Food processing	Producer of vegetable-based oil for industrial purposes	Aventis SA / Aventis Cropscience
01/02/2000	Divestiture	Horizontal	Nannau Ltd		Chemicals, paints and coatings	Manufactures and sells plant foods and associated garden and houseplant products to wholesalers, ret	Bayer AG / PBI Home & Garden Ltd
01/03/2000	Acquisition of non-US (foreign) company	Horizontal	Misung Ltd	South Korea	Chemicals, paints and coatings	Manufactures crop protection chemicals	Bayer AG
01/10/2000	Divestiture	Horizontal	Novartis Agribusiness /Flint Fungicide Business/	Switzerland	Chemicals, paints and coatings	Produces fungicide	Bayer AG / Bayer Crop Protection
05/02/2002	Divestiture	Horizontal	Maxforce Business of Clorox Co	United States	Miscellaneous services	Provides pest control services	Aventis SA / Aventis Cropscience
03/06/2002	Divestiture	Horizontal	Aventis Cropscience	France	Agricultural production	Manufactures crop protection products	Bayer AG
10/12/2002	Acquisition of private company	Horizontal	Pau Seeds Inc	United States	Chemicals, paints and coatings	Produces innovative crop science used for crop protection, biotechnology and seed markets	Bayer AG / Bayer CropScience
31/03/2004	Acquisition of private company	Horizontal	Gustafson LLC	United States	Chemicals, paints and coatings	Manufactures crop protection products	Bayer AG / Bayer Cropscience India Ltd

Bayer / Aventis / Agrevo							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
12/08/2004	Acquisition of non-US (foreign) company - Tender offer	Horizontal	Aventis SA	France	Healthcare; Drugs, medical supplies and equipment	Develops pharmaceuticals and vaccines for preventative medicine	Sanofi Synthelabo SA
01/10/2004*	Acquisition of non-US (foreign) company - Tender offer	Vertical	Hoechst AG	Germany	Chemicals, paints and coatings	Produces specialty chemicals and pharmaceutical products	Sanofi-Aventis SA
03/12/2004	Divestiture Minority interest	Horizontal	Novexel SA	France	Healthcare; Drugs, medical supplies and equipment	Research, produces and distributes pharmaceuticals	Sanofi-Aventis SA

Source: Developed from data maintained by Mergerstat M&A; Supplemental information sources: Company records and press releases (*date of announcement)

BASF							
Closing Date	**Transaction Type**	**Purpose**	**Target Name**	**Target Country**	**Target Industry**	**Target Description**	**Buyer Name**
30/06/2000	Divestiture - Assets acquired	Horizontal	American Home Products' Cyanamid Ag product business	United States	Agricultural products	Crop protection	BASF AG
14/12/2000*	Assets acquired	Horizontal	ExSeed Genetics LLC	United States	Agricultural products	Enhanced grain	BASF Plant Science LLC
31/03/2003	Divestiture	Horizontal	Bayer AG /Insecticide and Fungicide Products Business/	Germany	Mining and minerals	Develops insecticides and fungicides	BASF AG
16/02/2004	Divestiture - Assets acquired	Horizontal	St Aubin Les Elbeuf Crop Protection Operations of Aventis SA	France	Chemicals, paints and coatings	Manufactures crop protection agents and fungicidal active ingredients	BASF AG

Source: Developed from data maintained by Mergerstat M&A; Supplemental information sources: Company records and press releases (*date of announcement)

Annex 2: Notes, references and bibliography

A. Notes

a. Information Sources:

This report combines information from a broad variety of sources, including, but not limited to press releases, business records, statutory filings, official statistics, and legal proceedings.

The Securities and Exchange Commission (SEC) requires all publicly-held US companies to file reports disclosing their financial condition, results of operations and any other information that is of significance to investors. SEC Online tracks all companies whose securities trade on the New York or American stock exchanges and, in addition, approximately 260 selected NASDAQ (NMS) companies. SEC filings (in particular, SEC Form 10-K -the report filed annually by most publicly held companies incorporated in the United States, and SEC Form 20-F -annual document equivalent to 10-K filed by public companies headquartered outside the US whose securities trade on the New York or American stock exchanges) were retried through SEC's Electronic Data Gathering, Analysis, and Retrieval system (EDGAR) (URL at **http://www.sec.gov/edgar.shtml**).

b. Terminology:

The term "public company" refers to types of companies that are roughly equivalent to a "public company" in the United Kingdom (for example, the German "*Aktiengesellschaft*" or the "*société anonyme*" constituted under French law"). Similarly, the denomination "private company" is to be understood as encompassing a broad range of broadly equivalent mechanisms across jurisdictions (such as the English "private company" and the French "*société à responsabilité limitée*").

A company's name is used to refer to the parent company or to the group of companies controlled by the parent. For example, the term "DuPont" as used hereafter will refer to E.I. du Pont de Nemours and Company (exact name of registrant as specified in its Charter), or to E.I. du Pont de Nemours and Company *and* its consolidated subsidiaries, as the context may indicate.

c. Abbreviations and acronyms

APHIS: Animal and Plant Health Inspection Service (USDA)
BRS: Biotechnology Regulatory Services (USDA/APHIS)
CR: Concentration Ratio
ERS: Economic Research Service (USDA)
FCTD: Federal Court Trial Division (Canada)
GM: Genetically Modified
IP: Intellectual Property
IPC: International Patent Classification
M&A: Merger and Acquisition
PTO: Patent and Trademark Office
PVP: Plant Variety Protection
PVPA: Plant Variety Protection Act
R&D: Research and Development
SCC: Supreme Court of Canada
UPOV: International Union for the Protection of New Varieties of Plants
USDA: United States Department of Agriculture
TRIPS: Trade-Related Aspects of Intellectual Property Rights
WIPO: World Intellectual Property Organization

B. References and bibliography

1. Statistical sources/databases

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Animal and Plant Health Inspection Service (APHIS). (2004). Crops No Longer Regulated By USDA [database]: http://www.isb.vt.edu/cfdocs/biopetitions1.cfm
USDA Economic Research Service (ERS). Agricultural biotechnology patent database: http://www.ers.usda.gov/data/AgBiotechIP/
United States Patent and Trademark Office (USPTO): http://www.uspto.gov/
International Seed Federation (ISF), Seed statistics: http://www.worldseed.org/statistics.htm

2. Cases, Statutes and Treaties

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J.E.M. Ag. Supply, Inc. v. Pioneer Hi-Bred Int'l, Inc., 534 U.S. 124 (2001).
Monsanto Canada Inc. v. Schmeiser, [2004] S.C.R. 902 (Can.) [Monsanto v. Schmeiser]
Monsanto Co. v. McFarling, 302 F.3d 1291 (Fed.Cir. 2002) [McFarling I].
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Monsanto v. Scruggs, 249 F. Supp. 2d 746 (N.D. Miss. 2001)
Pioneer Hi-Bred Int'l, Inc. v. DeKalb genetics Corp., 51 U.S.P.Q. 1987 (S.D. Iowa 1999)
Pioneer Hi-Bred Int'l, Inc. v. Holden Found. Seeds, Inc., 35 F.3d 1226 (8th Cir. 1994).
Pioneer Hi-Bred Int'l, Inc. v. Ottawa Plant Food, Inc., 283 F. Supp. 2d 1018 (N.D. Iowa 2003) [Pioneer v. Ottawa]
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Diamond v. Chakrabarty [447 US 303 (1980)].
Ex Parte Hibberd [227 USPQ 443 (Bd. of Patent App. And Interferences, 1985)]
Plant Patent Act (PPA) of 1930 [35 U.S.C. 161-164 (2003)].
Plant Variety Protection Act (PVPA) of 1970 [7 U.S.C. 2321-2583 (2003)].

3. Company filings

a. Publicly-held companies incorporated in the United States (US) and Canada: either
    i. the Annual Report to Shareholders (ARS) or
    ii. SEC Form 10-K (the report filed annually by most U.S. companies 90 days after the end of their fiscal year).
b. Public companies registered in Europe:
    i. SEC Form 20-F (Annual document equivalent to 10-K filed by companies headquartered outside the US whose securities trade on the New York or American stock exchanges);
    ii. Company financial filings, acceded through the corporate websites and/or searched via online databases.

4. Business database services

a. Company information: focused searching and retrieval was made via the following on-line databases:
    i. *US Companies*: Hoover's Company Profile Database; America's Corporate Finance Directory; Company Briefs-Gale Group (US); Company Intelligence – US; Directory of Corporate Affiliations(TM); Disclosure(R) Online Database-US Public Company Profiles; Nelson's Public Company Profiles; Standard & Poor's Corporate Descriptions Plus News; US Business Directory.
    ii. *European Companies*: Hoppenstedt Company Database; Hoover's Company Profile Database – Europe; The Major Companies Database; Company Intelligence International - Int'l Company Profiles; ICC Directories; COFISEM, Sociétés Cotées Françaises et Européenes.

b. Mergers, acquisitions and divestitures:
    i. Mergerstat M&A Database;
c. Group structure and shareholders (inside ownership, five per cent ownership and institutional ownership):
    i. US public companies: SEC Exhibits 3 (Articles of Incorporation and By-Laws), 4 (Instruments Defining the Rights of Security holders, including Indentures), and 9 (Voting Trust Agreement);
    ii. Companies listed on the Swiss Stock Exchange: Disclosure notifications made by the company in the Swiss Commercial Gazette in accordance with the Swiss Stock Exchange Act (concerning a party that held five or more than five of the share capital).
    iii. All companies: Disclosure(R) Online Database; Directory of Corporate Affiliations(TM).

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