(1) Seed Production in the United States of America

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(2) Introduction

(3) The U.S. seed industry has changed dramatically in the last 25 years. **(4)**Today, more farmers purchase seed providing testimony of its value because the seed possesses improved genetics resulting in enhanced yields**.** **(5)** As a result, seed companies have grown from small entities to large corporations concerned with breeding, production, conditioning and marketing. **(6)** More recently, seed companies have expanded their proprietary research and development programs and increased their output of genetically enhanced seeds**.** **(7)** Because seeds are the carriers of these improved genetics, their price has increased making seed companies attractive targets for consolidations. **(8)** Many seed companies in the U.S. and worldwide have experienced widespread mergers and acquisitions resulting in fewer seed companies producing more seeds – many with genetically enhanced traits. **(9)** Let's examine the dynamics that have led to the development of a competitive seed industry in the United States.

(10) Improved Seed Leads to Gains In Crop Yield. Farmers must be convinced that the price paid for seed leads to better yield and thus increased personal profit**.** **(11)** Over the past 70 years, there has been a remarkable increase in the yields of all major field crops in the United States and more than half this increase has been attributed to genetic improvements by plant breeders. Among the four major field crops, yield increases on a relative basis were more significant for corn followed by cotton, soybeans, and wheat, respectively (Figure 1).

These increases in yield have been a significant factor in convincing farmers that purchase of improved seed is a prudent investment. As farmers increasingly moved from using on-farm saved seed to commercial seed, seed company profits increased.

(12) Purchased Seed Use in the United States. The U.S. seed market is rapidly growing in both size and value. **(13)** In 1997, U.S. farmers used over 6.5 million tons of seed for major field crops (Table 1). The major field seed crops in the United States included **(14)** wheat, **(15)** soybean and **(16)** corn, respectively.

This is a 10% increase in seed use compared to 10 years earlier. (17) On a commercial scale, this seed was valued at $5.7 billion in 1997 which represents 20% of the world seed market (Table 2).

China and Japan followed in commercial markets for seed use. (18) When compared to the overall cost of field production, seed costs have only marginally increased from 2% in 1970 to 4% in 1997 (Figure 2) emphasizing the importance of this minor investment in seeds possessing improved genetics that lead to increases in overall yields. In the future,

as genetically modified seeds provide increasing numbers of stacked genetic traits, seed costs will surely increase above this figure.

(19) International Seed Markets in the United States. **(20)** The value of U.S. seed exports more than doubled from (21) $305 million in 1982 to (22) $698 million in 1996 (highlight the values in the table as they are read in the text). (23)

While both exports and imports of seeds grew substantially over the past two decades, the growth rate of seed imports that compete with domestically produced seed exceeded that of seed exports in the U.S. The value of total seed imports more than tripled from (24) $87 million in 1985 to (25) $314 million in 1996. (26) While many countries supplied these seed imports, the largest contributors were Canada (28%), Chile (18%), and the Netherlands (9%). (27) Using corn as an example, Canada, Chile, Mexico and Argentina were the largest provider of seeds for this important hybrid crop. (28) The countries receiving the largest amount of corn exports were Japan, Mexico, China and Egypt.

(29) Among crops being exported from the U.S. for seeds, vegetables, corn, and forages, respectively, were the largest values exports. Vegetables, corn, and flower seeds were the largest value imports into the U.S. Many of these crops are hybrid seeds emphasizing the importance of manual labor in accomplishing this process in other countries.

(30) Seed Industry Development in the United States. Until the late 1920s, seed industry development in the United States was limited. However, at that time, hybrid corn breeding programs began releasing superior seed that farmers found desirable. (31) Hybrid corn seed had many important advantages to the farmer. These included higher yield potential, greater uniformity in maturity, and resistance to lodging. These traits permitted large-scale mechanization of planting and harvesting. More importantly, from the perspective of the seed company, hybrid corn seed could not be saved by the farmer and used in producing next year's crop because the progeny of that seed was not uniform. (32) This is depicted in the following example where two inbred parents produced by a seed company produce 100% hybrid seed.

(33) When the hybrid seed is used as parental material, it produces the following progeny (34) demonstrating the lack of genetic uniformity and performance. As a result, only 50% of the seed possesses the advantages of heterosis making these crops typically less vibrant and significantly lower in yield. As a result, farmers had to return to the seed company to purchase hybrid seed on an annual basis.

(35) In the early 1900s, corn was the predominant crop in U.S. agriculture. Yet, despite this importance, crop yields were stagnant at the time. The development of hybrid seed reversed this trend in the 1930s. By the 1960s, hybrid corn seed was planted on 95% of the U.S. corn acreage and the establishment of a stable corn seed industry was in place.

More recently, another important advance in the American seed industry has been the development of genetically enhanced seeds. (36) Adoption of genetically engineered

(GE) soybeans, cotton, and corn with herbicide tolerance (HT) and/or insect resistance (Bt) traits by U.S. farmers has been rapid over the 11-year period following commercial introduction. (37) HT crops survive certain potent herbicides, enabling growers who adopt these varieties to control pervasive weeds more effectively. (38) In the U.S., HT soybean adoption has expanded more rapidly and widely than other GE crops, reaching 89 percent of soybean acreage in 2006. (39) The second most adopted variety, HT cotton, accounted for 65 percent of cotton acreage.

(40) Bt crops contain a gene from the soil bacterium *Bacillus thuringiensis* that produces a protein toxic to specific insects. (41) Bt seed use is concentrated in areas with high levels of infestations of targeted pests, so acreage shares for Bt corn and cotton are lower than for HT soybeans and cotton and vary widely across States. (42) Bt cotton, which controls tobacco budworm, bollworm, and pink bollworm, was planted on 57 percent of U.S. cotton acreage in 2006—ranging from 17 percent in California to 83 percent in Louisiana. (43) The U.S. acreage share of Bt corn leveled off during 1999-2002 because farmers with the greatest need to protect against the European corn borer had already adopted Bt corn. Adoption of Bt corn has since expanded, reaching 40 percent of corn acreage in 2006, following the introduction of a Bt variety to control corn rootworm.

(44) In spite of the rapid acceptance of genetically enhanced crops, their availability has created many important seed technology issues still being resolved. One of these is that the price of the seed is higher creating increased performance expectations by the farmer.

(45) Surveys have been conducted to better understand why American farmers have adopted genetically enhanced seed and are willing to pay increased premiums for them. The most important reason is that these crops provide increased yield. The second most important reason is that they save management time and make other production practices easier. A third reason is that these crops reduce pesticide costs and improve the environment.

(46) Probably the single most important factor affecting the establishment of a vibrant U.S. seed industry was the passage of the Plant Variety Protection Act in 1970. This single piece of legislation provided developers of new varieties such as seed companies' exclusive rights to market a new variety for 18 years. This provided seed companies the necessary incentive to establish aggressive breeding programs since they could protect their new varieties from competitor infringement by legal injunction as well as recover the cost of variety development for up to 18 years. **(47)** Using soybeans as an example, one can see an enormous shift from the use of public sector varieties to private sector varieties in less than 20 years. These changes also culminated in the increased importance of genetic purity testing programs that were rapidly established within seed companies.

(48) This is also displayed by observing the number of PVP certificates issued since passage of the Plant Variety Protection Act in 1970. It takes essentially 10 years for a

seed company to gear up with the establishment of a breeding program before new varieties are released. This figure shows a steady increase in protected varieties after 1980. In 2000, new biotech initiatives were underway and were responsible for the spike witnessed in the curve.

(49) There continue to be about 1,000 new permits approved annually in the United States for genetically enhanced varieties since 1998 demonstrating the popularity of these products with the American farmer.

(50) In addition to corn and soybeans, U.S. seed companies have developed genetically enhanced seed for potato, cotton, tomato, wheat and other crops.

(51) Today, the three leading genetically enhanced traits found in seeds include herbicide tolerance, insect resistance and agronomic traits. Other genetically enhanced traits are in various stages of development. For example, USDA's Animal and Plant Health Inspection Service has approved 1,256 field testing applications for crops with resistance to virus, 712 for resistance to fungus, 1,292 for improved agronomic properties (such as resistance to cold, drought, and salinity), and 2,687 for improved product quality (such as crops that increase protein and oil content, and crops with added vitamins and iron).

Worldwide, an estimated 220 million acres of biotech crops with HT and/or Bt traits were planted in 21 countries in 2005. The U.S. accounts for about 55 percent of this amount, and six countries combined (Argentina, Canada, Brazil, China, Paraguay, and India) account for nearly 43 percent.

(52) U.S. Organizations Facilitating Seed Production. Many organizations exist to promote and facilitate the production of high quality seed in the United States. **(53)** They have two principal purposes. They are:

- Interested in the orderly movement of seed from where it is produced to where it is used.
- Focused on the marketing and development of uniform laws to establish how to purchase and sell seeds.

(54) These organizations include:

(55) American Seed Trade Association (ASTA). ASTA was formed in 1883 and is based in Washington, D.C. It is an organization supported by American seed companies and its principal function is to lobby for favorable seed legislation and control issues at federal and state levels. For example, ASTA was a leading proponent supporting the passage of the Plant Variety Protection Act in 1970 in the United States. More recently, it has been engaged in promoting the value of genetically enhanced seed to consumers.

(56) Association of Official Seed Analysts (AOSA). AOSA was formed in 1908 and is composed of seed analysts from governmental state and federal laboratories. It is the organization responsible for developing standardized Rules for Seed Testing in the United States that must be followed when testing seeds for quality. Because each state has its own seed testing laws, most states have one AOSA laboratory. Membership in AOSA has been declining in the last 25 years.

(57) Society of Commercial Seed Technologists (SCST). SCST was formed in 1922 and is composed of seed technologists employed in commercial seed companies that monitor the quality of commercial seed supplied to the farmer. SCST administers a certification examination for seed technologists that, when passed, confers the title Registered Seed Technologist. As the seed industry has flourished in the last 25 years, membership in this Society has similarly increased. Both AOSA and SCST members convene a joint meeting once a year to discuss seed testing concern/issues as well as the impact of specific changes in the Rules for Seed Testing.

(58) Association of American Seed Control Officials (AASCO). This is an organization composed of state and federal seed control authorities that supervise AOSA laboratories. Their primary role is to apply and enforce state seed laws. They meet annually to discuss issues of common concern among the states regarding the orderly movement of seed within the country.

(59) Association of Official Seed Certifying Agencies (AOSCA). This organization was formed in 1919 and is responsible for certifying the quality of seed regarding germination, mechanical and genetic purity. Each state has a certifying agency and the implementation of certification for seed lots is voluntary among seed companies. Certification agencies have also worked closely with public land-grant universities in providing funds for the development of new and improved varieties. They are an independent and unbiased source of seed quality information.

(60) Impact of American Seed Industry Development on Public Research and Development. Historically, the American public sector including the U.S. Department of Agriculture and land-grant agricultural universities has been the central provider of agricultural research and development. **(61)** Beginning just before 1970 and before the passage of the Plant Variety Protection Act, expenditures by the private sector in plant breeding increased consistently to the present time while public efforts in plant breeding slowly declined.

(62) These changes in expenditures have been accompanied by structural change in the industry. For example, intense merger and acquisition activity led to the formation of larger seed conglomerates that took advantage of strategic research and development alliances among companies and larger economies of scale to conduct intensive research programs. As a result, there was a 1,300 percent real increase in private research and development plant breeding expenditures between 1960 and 1996.

(63) Private and public variety development research do not always emphasize the same areas (Figure below). The emphasis of the private sector on pure line field crops such as corn, soybeans, cotton, wheat, etc. suggests that one role for the public sector is to carry out research in otherwise neglected crops. Private sector research has expanded to include cultivar development on hybrid crops and prebreeding activities; meanwhile,

public plant breeding research has focused on basic germplasm and applied plant genetics. So, while private companies are engaged in research activities that were once the domain of the public sector, there remain important roles for both.

(64) Where is Seed Produced in the United States? **(65)** The United States is a large country with diverse geography, climate and agriculture. Commercial seed is produced throughout with the exception being the northeastern part of the country where the cool, moist climate and rough terrain make it unsuitable for major seed production. **(66)** Cotton seed is produced in Mississippi and Texas with production also moving to Arizona and southern California to take advantage of irrigated desert conditions that minimize disease development. **(67)** Arkansas and Louisiana take advantage of the rich, wet soils of the Mississippi in the south and California in the west produce the country's rice seed**.** **(68)** The corn belt is located in the middle of the country around Iowa and Illinois where soils are alkaline and grasses grow well. **(69)** Soybean seeds are also produced in the same area of the United States as the corn belt. (70) Sorghum seed is produced in the western part of the corn belt particularly around Kansas where conditions are drier than optimum for corn production. (71) Much of the wheat seed production occurs in the northern plains states from Washington and Montana through the Dakotas to Minnesota. (72) Field beans are produced in North Dakota, Idaho, Michigan, Colorado and Nebraska taking advantage of the dry climates to minimize disease pressures. (73) Sugar beet seeds are produced primarily in North Dakota and Idaho. (74) Sunflower seeds are produced in North and South Dakota. **(75)** The Pacific Northwest is characterized by a cool Mediterranean climate that is wet in the Winter and dry in the Summer that favors the production of turf grass seed and some vegetables such as sweet corn, beans, peas, etc. **(76)** The mountains of California create multiple micro-climatic sites favorable for a large variety of differing seed crops. Many vegetable and flower seeds are produced here as well as forage seeds such as alfalfa. Because of the unique geographical areas provided by California, its ability to store water in the mountains following rainfalls and dry climate, most of the major seed companies in the United States are located in this state.