Willett M. Hays, Great Benefactor to Plant Breeding and the Founder of Our Association

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Abstract

Willett M. Hays was a great benefactor to plant breeding and the founder of the American Genetic Association (AGA). We commemorate the AGA’s centennial. We mined university archives, U.S. Department of Agriculture (USDA) yearbooks, plant breeding textbooks, scientific periodicals, and descendants for information. Willett Hays first recognized the individual plant as the unit of selection and started systematic pure-line selection and progeny tests in 1888. He developed useful plant breeding methods. He selected superior flax (*Linum usitatissimum* L.), wheat (*Triticum vulgare* L.), corn (*Zea mays* L.), barley (*Hordeum vulgare* L.), and oat (*Avena sativa* L.) varieties, and discovered Grimm alfalfa (*Medicago sativa* L.); all became commercially important. He initiated branch stations for better performance testing. Willett Hays befriended colleagues in other universities, in federal stations, in a London conference, and in Europe. He gathered and spread the scientific plant breeding gospel. He also improved rural roads and initiated animal breeding records and agricultural economics records. He started the AGA in 1903, serving as secretary for 10 years. He became assistant secretary of agriculture in 1904. He introduced the project system for agricultural research. He authored or coauthored the Nelson Amendment, the Smith-Lever Act, the Smith-Hughes Act, and the protocol leading to the United Nations Food and Agriculture Organization—all involved teaching agricultural practices that improved the world.

“Many friends of Willett M. Hays will be saddened to hear of his death, which occurred last week,” noted the editorial page of *The Farmer* (January 28, 1928) (Figure 1). “Prof Hays first came into national prominence as a result of his cereal investigations at Minnesota University Farm. A pioneer in systematic plant breeding and selection, Prof Hays accomplished the most noteworthy results in plant improvement up to that time. Plant breeding and selection methods in Minnesota as well as in many other states were founded on the work of Prof Hays. His ‘fooling with the breeding of plants’ was barely tolerated until the great value of his work was proved. Anticipating the future by years is rarely popular to those who think chiefly of the present. Prof Hays thought of things that should happen for the benefit of agriculture in future years and then burned out his energy to bring them about” (Anonymous 1928a).

Willett Martin Hays was born in 1859 in central Iowa on a farm near Eldora. His father died when Willett was six. From when he was about 12, under his mother’s direction, he and his brother took turns working the farm and attending school. While Willett was attending Oskaloosa College, founded by the Disciples Christian Church, the faculty and students divided into two factions. The liberal faction, including Willett Hays, which supported Darwin’s theory of evolution, merged with Drake University. Hays graduated from Drake in 1885. Keenly interested in scientific agriculture, he enrolled at Iowa State College at Ames, where he earned a Master’s degree in 1886. He then became associate editor of *Prairie Farmer* magazine in Chicago. In 1888 Hays was the first faculty member selected for the University of Minnesota’s new Minnesota Agricultural Experiment Station at St. Paul (Boss 1929).

He was appointed instructor of agriculture in the School of Agriculture and assistant agriculturist in the experiment station under Director E. D. Porter. By 1890 Hays had postulated that “There are Shakespeares among plants,” recognizing the individual plant as the unit of improvement. (Previous plant breeders bulked seed of selected plants.) He began systematically breeding and testing large numbers of plants to find the outstanding individuals and by 1900 had a crop nursery of several acres with millions of plants (Boss 1929).
To North Dakota and Back

Probably because of a combination of the restrictive policies of a new administrator and the lure of new opportunities, Hays left Minnesota late in 1891 and spent 1892 and much of 1893 as professor of agriculture at the North Dakota Agricultural College at Fargo. At North Dakota, as at Minnesota, he was the first professor of agriculture and agriculturist for the agricultural experiment station. There he also established the experiment station’s field crop test plots and lasting, productive, plant breeding programs. A wheat plot and a flax plot there have grown continuously since Hays first planted them in 1892. Both are registered in the National Register of Historic Places (Carter J, personal communication).

Hays returned to Minnesota in the fall of 1893, and served as professor and vice director of the agricultural experiment station through 1904. He was appointed assistant U.S. secretary of agriculture in December 1904 and served from 1905 until the Taft administration ended in 1913.

At Minnesota, Hays established his reputation as a scientist and educator. In 1894 he wrote, “Not content with the best kind of corn, wheat, oats, barley, field peas, timothy, etc., which the world affords, we have well under way numerous new varieties produced by selection and by a combination of crossing and selection” (Anonymous 1928a). Against opposition, he established branch experiment stations to test plants under a wider range of environmental conditions. He started the first systematic pure-line selection—landrace breeding—and progeny tests of oats in the United States at the Minnesota experiment station in 1888 (Stanton 1936). From testing plants grown 30.5 cm (1 ft) apart each way he went to a centgener (his word signifying 100 offspring of a selected individual) system of 100 plants 10 cm (4 in.) apart planted by a machine he designed. He was listed among the first four pioneers in barley breeding and tested barleys of hybrid origin as early as 1904, but none attained release (Harlan and Martini 1936). His 1889 selections of timothy plants at the Minnesota station are the earliest records of timothy improvement (Evans 1937). He started flax selection improvement in 1894 and used the centgener method to develop Minn 25 (Primost), the first pure-line flax variety developed and distributed in the United States (Dillman 1936). Along with Primost flax, he developed Minn 169 Blue Stem wheat, Minn 13 and 23 corn, Minn 105 barley, and Minn 281 and 295 oat varieties. All became important commercially (Boss 1929).

Early in his attempts to develop plant breeding methods, Hays gained the cooperation of agronomists in neighboring states and in the U.S. Department of Agriculture (USDA). Seed stocks were exchanged and conferences were held. Hays often visited other state and federal experiment stations to benefit from exchanges with colleagues. He traveled extensively in the United States, went to London for the 1899 Hybridizer and Genetics Conference, and on to Europe, becoming acquainted with plant breeders and the experimental methods in use there (Boss 1929).

As early as 1891, Hays issued a certificate certifying that wheat seed was purchased from the experiment station. Farmers could use the certificate as proof of origin when offering seed for sale. He also used the system for several years for seed of corn, oat, grass, and barley, but discontinued it when he found that varietal purity was not being maintained. To address that problem, he and Coates P. Bull, a former student who became his coworker, called a meeting in 1903 to organize the Minnesota Field Crop Breeders Association (Bull 1905). It evolved into the Minnesota Crop Improvement Association, which for many years was the highest-volume field crop certification agency in the United States.

Interested in livestock improvement, Hays was a leader in organizing breeding circuits, where the progeny of sires were studied and desirable sires were maintained for rotation or exchange among members. A Milking Shorthorn breeding circuit was organized in Minnesota, and it became the foundation for many of the state’s good Milking Shorthorn herds (Anonymous 1928a).

Convinced that farmers needed accurate cost of production information and unable to obtain it through experimental plot records, Hays, with Andrew Boss, a former student now a faculty member, began collecting information from farmers in the Northfield, and later the Marshall and Halstad, Minnesota, areas. The Northfield route was the first “Cost of Production Route” in the United States. Hays...
established cooperative relations with the USDA Bureau of Statistics, gaining both technical and financial assistance for this work, laying the foundation for the USDA’s Office of Farm Management and leading to development of agricultural economics as a subject matter field (Anonymous 1928b).

Government Service

As assistant secretary of agriculture, Hays introduced the project system for agricultural research, which later was extended by the USDA to state experiment stations (Boss 1929). He played a prominent role in formulating and advocating the Nelson Amendment, passed by Congress in 1907, which provided funds to each of the state land grant colleges for the more adequate “preparation of instruction for teaching the elements of agriculture and the mechanic arts.” Long interested in the development of improved public roads for farmers, Hays wrote the Good Roads Amendment of the Minnesota statutes. Later he helped organize the U.S. Bureau of Public Roads and Rural Engineering. He worked with Seaman Knapp in drawing up the Smith-Lever Act, foundation for the Agricultural Extension Service (AES), which finally passed early in the Woodrow Wilson administration. He also wrote the original draft of the vocational education bill, which came up in Congress under the names of various sponsors, finally passing as the Smith-Hughes Act later in the Woodrow Wilson administration (Anonymous 1928b).

The Later Years

Following his service as assistant secretary of agriculture, Hays wrote the protocol for the New International Institute of Agriculture, which was organized in Rome in 1913. It was the forerunner of the United Nations Food and Agriculture Organization. Late in 1913 he went to Argentina, where he helped organize the Argentine Department of Agriculture along the lines of the USDA. He also helped plan the grounds, buildings, and courses of study for the new University of Tucuman, and he organized the work of its agricultural experiment station into project statements. As he and his wife were returning to the United States on a British ship, the ship was captured by a German cruiser. The passengers were transferred to a coaling vessel for a week until food and water gave out and then landed at Para, Brazil, where they later were able to board another ship bound for the United States (Bascom RF, personal communication).

Back in Washington, DC, late in 1914, Hays suffered from ill health, both physical and mental, and decided he must return to the land, where he would regain his health. In 1915 he bought a farm in West Chester, Pennsylvania; from there he offered his services as an agricultural consultant. The passengers were transferred to a coaling vessel for a week until food and water gave out and then landed at Para, Brazil, where they later were able to board another ship bound for the United States (Bascom RF, personal communication).

In 1920 he sold the farm in Pennsylvania and returned to Iowa with his wife. When she became the housemother for a sorority at Ames, he went to Eldora to live with his widowed, attorney, brother Charles. His health deteriorated still further, Willet Hays was hospitalized in July 1927 and remained there until his death on January 15, 1928 (Bascom RF, personal communication).

Origin of the American Genetic Association

The year 2003 marks the centennial of the American Genetic Association (AGA). The inspiration for our organization came to Willet Hays at the Hybridizer and Genetics Congress in London in 1899. He suggested its need to the Honorable James Wilson, U.S. Secretary of Agriculture from 1897 to 1913 (a term longer than any other cabinet officer in U.S. history), who recommended an organizing committee be formed. The committee, formed in 1901, included Director L. H. Bailey and Professor T. F. Hunt of Cornell, Dean C. F. Curtiss of Iowa Agricultural College, and Dr. H. J. Webber of the USDA, with Hays as chairman (Hays 1905b; Wilson 1913).

Hays then chaired a meeting of academicians and business people interested in improving plants and animals at Central High School in St. Louis, Missouri, on December 29 and 30, 1903 (Figure 2). At this meeting, sponsored by the American Association for the Advancement of Science, the American Breeders Association (ABA) was formed. Membership was open to both plant and animal breeders. In his opening address, Hays made the following points: (1) Biological scientists should turn for a time from the interesting problems of historical evolution to the needs of artificial evolution. (2) Practical breeders should occasionally pause and study the laws of breeding. (3) Breeders and the students of heredity should associate themselves together for...
their mutual benefit and for the common good of the country and of the world (Hays 1905a).

The purpose of the organization was to study the laws of breeding and to promote the improvement of plants and animals by the development of expert methods of breeding. Hays was secretary of the organization from 1903 through 1912. Annual membership fees were $1 domestic and $2 foreign; life membership was $20 (Hays 1905b).

Plant breeders approach their work in a more scientific manner than animal breeders, he explained, suggesting that some successful breeders may have happened fortuitously upon a valuable strain or method and exploited it with good results. Some breeders use only artistic sense, or intuition and judgment; other breeders use statistical methods almost entirely. Whatever the method, the successful breeder can rarely advise his neighbor on how to proceed or assure him of success. The ABA was created to bring order out of this chaos. The first step was to create a large central organization with low membership fees, placing it within the reach of thousands of modest breeders whose collective experience would furnish the data to build a practical science of breeding. The ABA was designed to become a great school and clearinghouse for the latest and best thoughts in breeding. These thoughts from many sources would form the base upon which intelligent and practical work would proceed (Hays 1905a).

Successful breeding methods are expensive because they require large numbers of individuals and large amounts of time. Animal breeding is many times more expensive than plant breeding. Hays believed cooperative effort was needed to be most effective. He expected state and national governments would aid in this work. He estimated a potential $500 million (10%) annual increase in the value of U.S. crops and animals by breeding, at an estimated annual cost of $50 million (10% of the increase or 1% of total value). The ABA’s work was done through committees of three to seven members chosen for their experience in specific areas. Breeding problems were organized by specific plants or animals. The business side of breeding and the scientific investigation of breeding were considered by all committees. Committees reported to the association at annual and other meetings (Hays 1906).

Some years later, Hays (1909) listed three ABA objectives: (1) Determine the laws of inheritance in animals and plants. (2) Learn the application of these laws to increase the intrinsic commercial and artistic values of living things. (3) Aid in bringing about this desired improvement through associated effort.

The ABA built a membership of about 1000, with 100 life members. They published eight volumes of annual reports totaling 400 pages over a 10-year period (Hays 1909). The American Breeders’ Magazine, printed quarterly, was started in 1910, and overprinted with the reports until 1912.

The publication and organization names were changed between 1913 (volume 4) and 1914 (volume 5): The American Breeders’ Magazine published by the ABA became The Journal of Heredity published by the AGA. A complete reorganization was announced in the second quarter of 1913 because of the retirement from public life of James Wilson and the resignations of Professor Hays, secretary, and G. W. Knorr, editorial secretary. The new American Genetic Association was incorporated under the laws of the District of Columbia. The last quarterly volume of The American Breeders’ Magazine stated that the character and scope of the publication would remain the same (Anonymous 1913b). The first monthly volume of The Journal of Heredity described itself as devoted to plant breeding, animal breeding, and eugenics (Anonymous 1914). The new officers were David G. Fairchild, president; Professor W. E. Castle, vice president; G. M. Rommel, secretary; C. Thomas, treasurer; and P. B. Popenoe, editor (Anonymous 1913a,b, 1914).

### Professor Hays’ Contributions to Plant Breeding

Willet Hays was the strongest advocate for scientific plant and animal breeding in the 19th century. He set the annual value of the leading field crops in the United States at $2 billion as plant products, noting that this value nearly doubles for livestock feeding and processing, and could be increased again by 5% for plant breeding alone using the same crop cultivation practices. As science, through development of machinery and manufacturing processes, has increased the value of raw products, so, through application of the laws of heredity, would improved plants and animals produce larger returns (Hays 1901).

The origin of the pedigree breeding method is prehistoric (Darwin 1898). Pedigrees help select better parents for breeding and also help monitor inbreeding. Pedigrees provide the framework for family relationships. Louis de Vilmorin (1856), member of a pioneer wheat-breeding family, first published the use of family structure for sugar beet breeding in France. He selected by weighing a small silver ingot in the syrup of a core from each sugar beet to determine its sugar content. He then grew superior mother beets for seed production and priced the seed for sale based on the mother plant’s core sugar content. Seed (naturally cross-pollinated) from the most superior mother beets was used for further selection and for yield testing. This ingenious method combined seed production and plant breeding research. A production-oriented seeds person might describe the de Vilmorin procedure as quality assurance for customers. It is a top-down, parent-affects-progeny procedure where the parent’s performance determines the progeny’s value.

Hayes and Garber (1921) and Boss (1929) state the progeny test was first used in America by W. M. Hays at the University of Minnesota in 1890. Progeny tests show the breeding behavior of the parent, which may or may not breed true. Selection based on progeny rather than parent performance is more effective because differences are more likely to be heritable. De Vilmorin and Hays used family structure differently. Hays’ progeny test is a bottom-up, progeny-affects-parent procedure that judges the parent based on its progeny. It is commonly applied to head-to-row
or ear-to-row plantings. Selection is on a row basis. A self-fertilized ear row or head row may be discarded in spite of a few good progeny. Average progeny performance will more likely reflect the parent’s genetic potential and thus the future potential of the row. Progeny tests remain the most important concept in plant and animal breeding. If progeny tests were applied to humans, each of us would be judged by the achievements of our children.

Hays initiated pure-line (landrace) breeding, where new varieties are selected from older heterogeneous varieties, in 1891. Johannsen (1903) further developed the pure-line concept and its relation to improving self-fertilized crops. De Vries (1907) credits Hays’ method of isolating constant, pure strains as requiring only multiplication to give a new race.

Hays originated the centgener method and used it on several field crops. He devised planting equipment to uniformly space plants planted at a uniform planting depth, thus allowing yield comparisons of individual plants within as well as among rows. The centgener method grows 100 plants per generation (a head row or an ear row) from a single selected plant and then selects the best single plant from the best row and repeats. It emphasizes individual plant selection from many plants (single-plant descent). Hays later saved plants from five heads or ears per centgener, resulting in the first grid or replicated-parent system of selection. Up to 40 centgeneres were grown per selected variety. Corn centgeneres were thinned to 31,000 plants/ha (12,400/ac), which was a relatively high plant density for the 1890s. Corn selection was for more mature ears, higher yield of dry shelled corn, and more nitrogen in the grain (University of Minnesota Archives).

Development of Minn 13 Corn Variety

On April 1, 1893, Andrew Boss, farm foreman, at the request of Hays, purchased a yellow dent corn variety from DeCou & Company (North Star Seed Co.) in St Paul. Boss labeled the variety as the common corn grown in the St. Paul area (1894 nursery book; Troyer 1999). A few kilograms of this seed were sent out as North Star—DeCou & Company’s name for what became Minn 13. Hays selected the variety rigidly for mature ears and drier shelled grain for 3 years and then distributed 7,600 kg (300 bu) as University 13 in 1896. It was originally recommended for southern Minnesota (south of St. Paul). The name was changed to Minn 13 in 1899. Hays left in 1900 and Coates Ball continued selection and distribution through 1910, using isolated plots for increase. Poor plants were detasseled or entirely removed before pollination and the most mature ears from the best plants were selected in the fall. More than 25,500 kg (1,000 bu) were distributed as Minn 13 at $1 per 25.5 kg (1 bu) to cover costs (University of Minnesota Archives).

Minn 13 corn, a mid-early (95 RM) yellow dent, is described as early maturing but heavy yielding, adapted from southern Minnesota northward. Minn 13 became the most popular variety in the northern U.S. corn belt and at higher elevations; in 1936 it was recommended by the Arizona, Colorado, Idaho, Minnesota, Montana, Nebraska, Nevada, New Hampshire, North Dakota, Oregon, South Dakota, Utah, Vermont, Wisconsin, and Wyoming experiment stations (Jenkins 1936). Minn 13 moved corn growing northward 50 miles in the United States in a decade (Hays 1904a). Less than 400 thousand ha (1 million ac) of corn were grown in Minnesota in 1893 when Hays began work on Minn 13; acreage grew steadily to 2 million ha (5 million ac) in 1932. See Shoesmith (1910) for a morphological description of Minn 13 (Troyer 1999).

Minn 13 inbreds were developed at the Minnesota, Colorado, Montana, North Dakota, and Wisconsin experiment stations. The first popular, early-maturity hybrid in northern Iowa and southern Minnesota (Minhybrid 301/Pioneer 355) involved two Minn 13 inbreds. Minn 13 currently accounts for about 13% of U.S. hybrid corn background, tracing back to Minnesota inbreds A109, A237, C13, and C49, and South Dakota inbred SD105 (Troyer 1999). With the current annual U.S. corn crop’s farm value of $20 billion, Minn 13’s annual contribution is $2.6 billion.

Development of Winter Hardy Grimm Alfalfa

Wendelin Grimm and his family moved from near the town of Bohn in the Grand Duchy of Baden in southwestern Germany to Section 4, Laketown Township, near the small town of Victoria, in Carver County, Minnesota, in 1857. Carver County is the next county west of Minneapolis. In the spring of 1858, Grimm sowed alfalfa seed he brought from Germany. The original home of Grimm alfalfa in Germany has warmer minimum temperatures than Albuquerque, New Mexico, while the coldest winters in Berlin have similar average minimum temperatures to the warmest winters in St. Paul (Brand 1911). Clearly the original seed was not winter hardy for Minnesota conditions. Wendelin Grimm saved seed from plants that survived each winter and reseeded. The very severe winter of 1874–1875 nearly wiped out Grimm’s alfalfa, which was grown in obscurity for almost 50 years. The final results show what natural selection over time can do (Edwards and Russell 1938, Tysdal and Westover 1937).

Arthur B. Lyman, a schoolteacher in Carver County, became interested in alfalfa and encouraged his father to grow it in 1880. Attempts with commercial seed were winter-killed, but finally seed purchased from the Grimm neighborhood overwintered in 1890. Lyman met Willet Hays at a Hennepin County Grange picnic on Lake Minnetonka in 1900 and told him that winter hardy alfalfa was growing in Carver County. Hays and Andrew Boss packed their bags, hitched a team to a platform wagon, and drove 30 miles to Excelsior, where they spent 3 days with Lyman examining several fields and talking with farmers in the area. Hays and Boss dug up plants and obtained seed for the St. Paul nursery and encouraged Lyman to produce and to obtain all the Grimm alfalfa seed possible. However, poor seed production
kept seed in short supply for several years (Barnes DK, personal communication).

Willet Hays demonstrated that Grimm alfalfa was the most winter hardy alfalfa and issued a press release to that effect (Hays 1904b; Lyman 1904). The USDA began experiments with Grimm alfalfa in 1905 (Brand 1911). After extensive testing in experimental plots, Grimm alfalfa was distributed in 1910. Lyman produced seed in Minnesota and the Dakotas, but seed production gradually moved to the Pacific Northwest for higher seed yields. Although susceptible to soilborne bacterial wilt (C. michangense) in the United States, Grimm became the most popular alfalfa variety in the northern United States and a landmark in the development of forage plants for North America. Resistant varieties that were also winter hardy were released in the 1940s. Grimm is still produced in Canada, where bacterial wilt is not a problem. At 25 million acres, alfalfa is the fourth largest U.S. crop, with an annual value exceeding $10 billion (Barnes DK, personal communication).

Development of Wheat Breeding in Minnesota and the United States

This section summarizes Minnesota AES Bulletin 62, Wheat Varieties, Breeding, and Cultivation (Hays and Boss 1899). This 175-page bulletin, with 52 figures, 43 tables, and text exceeding 55,000 words is a primer, a guidebook, a history, an authority, and also a bible of wheat and wheat breeding. It was written after the Wheat Bonanza period in the Red River Valley and the use of rollers for milling hard red spring wheat.

The bulletin describes the necessary techniques for making field tests, including preparation of the land, soil descriptions, method of planting, care of grain from seed time to harvest, methods of threshing varieties of wheat, trial of the threshing machine in doing clean work, grading wheat, weights per bushel, diseased or rusted condition, liability to lodge, testing the quality of flour, method of milling samples, gluten test, baker's sponge test, and the reliability of milling tests. The botanical characteristics of wheat are described, including relatives of wheat; utility of wheat in studying plant and animal breeding; roots and stems of wheat; plan of the root system, root hairs, and root cap, branching of the culm, the spike, and the flower; how the flowers and anthers open; the kernel of wheat; the amount and quality of gluten; and the modern process of milling wheat. Perhaps their descriptions of plant and flower morphology inspired later works by Kieselbach (1949) on corn morphology and Bonnet (1936) on the flower structure of the cereals.

The authors provide a detailed history of wheat breeding in Minnesota starting in 1888, with more than 200 varieties from Minnesota, other states, Europe, and Canada. From 1892 to 1898 more varieties were collected from these sources and also from Australia, plus a large number from the Minnesota station made by crossing and selection. By 1889, 552 wheat entries had been tested; many were discarded after a single trial. The Russian wheat samples collected in 1893 and 1894 were eventually all discarded based on yield. Saunder’s crossbred wheat varieties received in 1896 were tested for 3 years and were discarded based on yield.

The general results indicated native varieties were superior to the foreign ones. An important new variety from materials collected before 1894 was Minn 146 (Bolton’s Blue Stem), which had the best value per acre, and was used extensively for a foundation stock in the production of new varieties. Minn 169 (Haynes’ Blue Stem) was the yield leader in the 1897 and 1898 tests.

The last 72-page section, on methods of breeding wheat, is an exemplary classic that should be read by every student of plant breeding. It is divided into sections on variation among wheat plants, a percentage scorecard for comparing varieties of wheat, how new wheat varieties are originated, and wheat breeding begun in 1889. The section on improving a good variety of wheat contains a step-by-step procedure: secure those varieties yielding large crops of wheat of superior quality in the first year; plant a large number of the seeds from the bulk grain in the nursery and by some suitable method find the choicest plants that are most promising for mother plants in the second year; plant 100 or more plants from each mother plant and choose from the strongest stocks the choicest plants as mother plants to continue breeding in future generations; after discarding the poorer plants and saving the seeds in bulk from the remaining plants the third year, use this bulk seed to plant a small field plot in the fourth year; sufficient seed is available for a 1/20-acre field plot in the fifth year; when this plot is harvested, enough seed is available, if the variety is promising, to send seed to other stations, after testing several times; the average yield shows the relative value of the varieties. This step-by-step, year-by-year, detailed procedure was used by many pioneer American plant breeders whose students took it to the rest of the world.

Another section is subdivided into how wheat is cross-pollinated, how crossing produces greater variation among individual plants, and the time required to reduce crossbred wheat to a uniform variety. They describe the period from 1893, when the cross was made, until 1897 and 1898, when several traits approached 100% uniformity.

Field management for wheat is subdivided into plans for crop rotation, reasons for poor profits in wheat farming, preparing corn land for wheat, preparing the soil for the seed, the kind of seed to sow, the amount, depth, and method of planting, and harvesting and storing wheat.

Hays and Boss (1899) summarize their conclusions as follows: Satisfactory methods of field, milling, and baking tests have been devised; Blue Stem and Red Fife are the best types for Minnesota; wheat breeding is outlined, hybridizing is illustrated, and a plan for disseminating new varieties is detailed; wheat flowers open early in the morning and are generally self-pollinated; great variability exists, especially from hybrids; wheat breeding is economically worthwhile; three new varieties are being disseminated; relations between breeding plants and breeding animals are discussed; wheat
should be grown on a small part of the farmer’s land where the yields will be large; and field and farm management can be systematized so profits can be made and the farm can become more fertile.

Epilogue

The U.S. Liberty Ship Willet M. Hays was launched at Permente Metals Corporation, Shipbuilding Division, Yard No. 2, Richmond, California, in February 1944, and delivered to the Hammond Shipping Co. on March 11. The Willet M. Hays was later purchased by the French government and sailed under the French flag in the early 1960s.

Of Willet Hays’ own progeny, son Silas graduated from the University of Iowa Medical School and later the U.S. Army Medical School. He eventually became, in 1955, Surgeon General of the U.S. Army. A great-grandson of Willet Hays, who is a grandson of Silas, is also a surgeon. Willet Hays’ daughter Doris, a graduate of Swarthmore, taught at Iowa State College and Kansas State University. The six children of Doris’s daughter, Ruth, a former mayor of Eugene, Oregon, all are members of the medical profession; three serve on medical school faculties. Willet Hays’ human progeny test is exemplary (Bascom RF, personal communication).

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