Bolley's Conquest of Flax Wilt[1]

by H. L. Walster[2]

As the North Dakota Agricultural Experiment Station enters upon the sixtieth year of its existence, it recalls with pride the splendid contributions of its founders. A handful of men made up its first staff; among them was Henry Luke Bolley who joined the staff in 1890.

Henry Luke Bolley, now retired from the institutional staff, was 85 years of age on February 1, 1950. In his long years of service to the state of North Dakota as botanist, plant pathologist, and state seed commissioner, he was a fearless trail blazer who cut deep and lasting "blazes" in the forest of ignorance about plant diseases. He waged a constant battle for crop improvement. That story is much too long to tell in one chapter. He is best known as "The Conqueror of Flax Wilt." That brilliant achievement occurred so many years ago and is published in such inaccessible sources that few have ever read the story. This article dates each step in the story, and, as far as possible, quotes significant parts of the story as told by Bolley himself, or others.

Discovery of Cause of Flax Wilt First Announced

The first official announcement by Bolley concerning the cause of flax wilt appeared in a paper entitled "A Preliminary Note on the Cause of 'Flax Sick Soil'—*Fusarium Lini Sp Nov.*" which was published in the Proceedings of the 22nd Annual Meeting of the Society for the Promotion of Agricultural Science held at Denver, Colorado August 26, 27 and 28, 1901. Bolley stated on that occasion:

"I am now able to affirm that this flax sickness of soil is due to the presence of a fungus which persists there from year to year living upon humus and less decayed vegetable matter, especially the remains of its host. It is found that spores of the fungus are introduced into new fields by way of flax seed and other farm methods, and infection areas are started which enlarge from year to year. From an infection started in a drill row from a single part of diseased flax straw or an infected seed, several plants may sicken and die the first season, the disease spreading by way of the soil from plant to plant.

"The plants attacked die at all ages from seed germination to maturity. Seedlings may die by rapid wilting or by a type of damping off, according to atmospheric and soil moisture. Plants attacked in the later woody stages turn yellowish to blighted in appearance, then wilt rather suddenly at the more succulent apices, quickly followed by a characteristic droop, drying and death.

[1]Second in a series of articles describing early history of the North Dakota Agricultural Experiment Station.
[2]Director.

"It is not proposed to give in detail the life history of the parasite or to describe the methods of experiment. This will be published later in a station bulletin.

"The fungus concerned is a species of Fusarium, which, though possessing many marked saprophytic habits, is also capable of genuine parasitic activity upon the flax plant. It produces during its life cycle at least three spore forms, two conidial stages, and a resting spore of the chlamydospore type.

"Six successive crops of flax upon lands of the college farm resulted in complete 'flax sickness' on the sixth year, most of the plants failing before three inches high. Soil from this plot readily transmits the disease to soils known to be free from the fungus, but when sterilized by boiling will produce a healthy growth of flax plants from spore free seed. Experiments in the application of chemicals, fertilizers, etc., to the 'flax sick' soil has not lessened the growth of the Fusarium."

Earlier in this paper Bolley stated, "This note will be limited to a general statement of some of the most salient features of an infectious disease of the flax plant, which is, no doubt, cosmopolitan in distribution with its host. As far as I have investigated it does not bring about diseased conditions in any other cultivated crop, and, so far as I am aware, **this is the first affirmation of the cause of a very serious flax trouble common to all flax growing countries.** There have been several descriptions of flax troubles which apparently have reference to the disease now under consideration but I have not seen an account which refers to a definite causal agent."

The reader will note that Bolley refers to the later publication of an Experiment Station bulletin. That bulletin appeared December 1901 under the title "Flax Wilt and Flax Sick Soil", Bulletin No. 50 of the North Dakota Agricultural Experiment Station. The author signed the bulletin under date of March 1, 1901, so apparently the text of this bulletin had been prepared before Professor Bolley delivered his Denver address, but the publication was delayed until December 1901. As a matter of fact, the publication date on a bulletin is frequently much earlier than the actual date of distribution which may very well have been later than December 1901.

Getting a Pure Culture of Flax Wilt

Writing in Bulletin 50, H. L. Bolley described the causal fungus and how pure cultures of it were obtained as follows:

"The fungus which produces the disease belongs to a genus of minute plants which botanists have called Fusarium. As it appears to be a species which is new to botanical descriptions, I shall call it *Fusarium lini* after the plant which it attacks.

Much difficulty was experienced in procuring a pure culture of an organism which could attack a live flax plant. The difficulties

arose chiefly from the presence of numerous miscellaneous fungi and bacteria which are always present in the soil, upon and within the decaying parts of the diseased plants. The fungus was first procured in pure form July 6, 1900, by the following method:

"Stems of moderately mature green flax plants, which were just beginning to wilt, were selected. Four inches of the apparently healthy main stem was cut out, stripped of its leaves, washed in distilled water and soaked two minutes in a solution of formaldehyde, made by adding two and one-half parts of standard formaldehyde to 1000 parts of water. Clippings made from the internal woody part of these stems were placed in a sterile moist chamber. In four days there grew out from the cut ends of these clippings a beautiful down-like white growth of filaments.

"By a series of baits made from sterile, decorticated, green, healthy flax stems, it was easy to get the fungus transferred to the usual solid culture medias. On these, it makes good growth and fruits abundantly, with quite characteristic effects upon slightly acid agar."

An illustration on page 35 of Bulletin 50 is a cut made from a "Photograph of a pure culture of the flax wilt fungus (*Fusarium lini nov. sp.*) growing upon sterilized flax roots."

T. F. Manns on "Flax Wilt"

In June 1932[1] the North Dakota Agricultural Experiment Station published Bulletin 259 entitled "Fungi of Flax Seed and of Flax Sick Soil" by H. L. Bolley and T. F. Manns. The main part of Bulletin 259 is by T. F. Manns. The publication is an abridged statement of his thesis for the master's degree at the North Dakota Agricultural College, June 1903. It contains additional investigations which he performed as assistant botanist and plant pathologist, 1903 to July 1904, and included some later observations on the dissemination of flax diseases in a lighter soil region of North Dakota.

Bolley contributed a foreword dated March 1932 in which he refers to a visit that he made to Dr. Otto Lugger at the Farm School and Experiment Station of the University of Minnesota at St. Anthony Park, Minnesota in the autumn of 1890. Bolley writes in this foreword:

"He (meaning Otto Lugger) explained that there was a destructive "blight" of flax which needed careful study and suggested that it was well that I was young because it might be a difficult problem. In the fields and gardens, I was shown what he had done and some of the outstanding field characteristics of the disease. Much impressed, I at once started structural and mycological and bacteriological studies based upon the flax plant, its seeds and soils upon which infection occurred.

[1]Upon discovery that the manuscript by T. F. Manns had long been in the files of the Botany Department I urged upon former Director P. F. Trowbridge its publication as Bulletin 259. (H.L.W.)

But slight progress was made during a number of years until the use of the physician's centrifuge was applied to the sedimentation of washings from flax seed in the spring of 1900. Certain conidial spores were quite uniformly observed in the sediment from samples examined. These were none other than the spores of a Fusarium often previously observed upon the dead roots and stems of wilted, dead, or dying flax plants and upon harvested flax lying unprotected in the fields.

"A few days sufficed to produce distinctive cultures upon agar and later but a few weeks were necessary to procure pure cultures from the interior of the fibrovascular bundles of wilting but living flax plants, and to prove the pathogenic nature of this Fusarium to flax seedlings by pure cultures applied to sterilized and virgin soil."

A footnote is added here, indicating that Bolley largely paraphrases material that he has already published in Bulletin 50. (The footnote reads "Bulletin 50, North Dakota Agr. Exp. Sta. Dec. 1900." This is an error, Bulletin 50 was dated December 1901. H.L.W.)

Japanese Scientist Makes First Discovery of Cause of Flax Wilt

Miyabe, a Japanese, discovered the cause of flax wilt in 1892. On pages 3-6 of Bulletin 259, Manns quotes Dr. Yoshihiko Tochinai's paper entitled "Comparative Studies on the Physiology of *Fusarium Lini* and *Collectotrichum Lini*" in the Journal of the College of Agriculture, Hokkaido Imperial University, Volume 14 Part 4 pages 173-176, Sapporo, Japan, 1926[1]. Manns lists all of the literature cited by Dr. Tochinai including Bolley's paper in 1901 before the 22nd Annual Meeting of the Society for Promotion of Agricultural Science, and Bolley's Bulletin 50 of December 1901. The following significant two paragraphs appear in the quotation from Tochinai:

"*Fusarium Lini* causes the wilt-disease of flax. This disease must have existed in Europe and elsewhere for centuries before the discovery of its causal organism at the end of the nineteenth century in Japan.

"In 1892, K. Miyabe first found that a species of Fusarium is concerned in the wilt-disease of flax, and under his direction N. Hiratsuka investigated this disease. He confirmed the assumption that the causal organism of the wilt-disease of flax is a species of Fusarium, and explained the principle of the rotation of crops with long intervals in the cultivation of flax adopted by the cultivators in Europe. In America, H. L. Bolley discovered, in 1901, quite independently of the researches by Miyabe and Hiratsuka, the causal fungus of the wilt-disease of flax and named it *Fusarium Lini*. Before them, O. Lugger carried out an investigation on the wilt-disease of flax. He did not succeed in finding its causal organism."

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[1]Manns and Bolley incorporated this reference into the original manuscript when it was prepared for publication in 1932. (H.L.W.)

It appears that K. Miyabe did not publish in 1892 but Hiratsuka did publish in Japanese in Volume 48 of a publication called "Resources of Northern Japan" under the title "Report of the Investigations of Flax Wilt Disease" in 1896. Bolley had not learned of Hiratsuka's work at the time of publishing his initial paper in the Proceedings of the Society for Promotion of Agricultural Science in August 1901, nor at the time of publishing Bulletin 50 in December 1901. Hiratsuka recognizes Bolley's contribution, however, in his papers which appeared in Japanese in the Bulletin of the Agricultural Society of Hokkaido Volume 2, No. 25, 1903 under the title "On the Cause of Flax Wilt Disease and its Prevention." Tochinai wrote several other papers on flax wilt. Dr. O. Lugger's paper which appeared as Bulletin 13 of the Minnesota Agricultural Experiment Station in December 1890 was entitled "A Treatise on Flax Culture" but as already noted, Lugger did not recognize the cause of the disease.

Manns, writing in his thesis which appeared in 1932, although written in 1903, states, "During the summer of 1902 Dr. Kingo Miyabe, under whom Hiratsuka was a student, pronounced the fungus upon which Hiratsuka worked to be the same as H. L. Bolley found to be the cause of the disease and which he had named Fusarium lini Bolley. Dr. Miyabe had also verified the description and manifestations of the disease in the wilt as detailed by Bolley and as earlier outlined."

The History of Plot 30 as it Relates to Investigations on Flax Wilt

The 6th Annual Report of the North Dakota Agricultural Experiment Station, published February 1, 1896, contains a table showing the plan of rotation experiments which were begun on the experimental farm of the North Dakota Agricultural Experiment Station in 1892. (See pages 48-51 and also page 40.) This series of experiments had originally been laid out by Willet M. Hays, the first agriculturist of the North Dakota Agricultural Experiment Station. They are known in the records of the North Dakota Agricultural Experiment Station as Rotation Series I, consisting of 35 plots numbered from 1 to 35 inclusive.

The history of Plot 30 as far as is known is as follows: 1882—broken from the virgin prairie as was the rest of that portion of Section 36. 1883-1891—continuously cropped to wheat, land being in private ownership. 1892—land acquired by the North Dakota Agricultural College by Special Act of Congress transferring the school Section 36 to the state of North Dakota for the use of the North Dakota Agricultural College.

1892	wheat	9.4 bu. per acre
1893	wheat	8.6 bu. per acre
1894	flax	9½ bu. per acre
1895	flax	12⅝ bu. per acre
1896	flax	12.6 bu. per acre
1897	wheat	22 bu. per acre
1898	flax	12.34 bu. per acre
1899	flax	7.37 bu. per acre
1900	No record	

Since 1900 it has been continuously cropped to flax and devoted to investigations on the diseases of flax.

Writing in Bulletin 50 Bolley stated:

"In the summer of 1893 Professor Shepperd agreed to crop one of his regular ⅛ acre rotation plots continuously to flax **until something should happen. This something came markedly to notice July 1, 1901 when all of the young plants on the flax plot were found to be dead or rapidly wilting.** The records for this plot show that in spite of improved drainage and cultural methods, which had sufficed to raise the standard of all other crops upon the adjacent plots, the yield of flax was less each year after 1895. In 1899 it dropped from 12.3 bushels, the yield of 1898, to 7.4 bushels. In 1900 all plants were dead by the Fourth of July.

At this time Professor Shepperd turned the plot over to the botanical department for investigation. I have since been unable to get any flax plants to reach maturity upon the soil of this plot. Indeed, most plants succumb before reaching a height of three inches. This plot is known in the college records as Rotation Plot No. 30."

A. C. Dillman, formerly associate agronomist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, U.S.D.A., in his paper "Improvement in Flax" which appeared in the Yearbook of Agriculture for 1936, paid tribute to Bolley's work in two significant paragraphs which appear in "boxes" in that article. On page 748 there appears the following statement: "The story of flax improvement is primarily about the successful battle against diseases that threatened to wipe out the industry completely. x x x In 1900 H. L. Bolley of North Dakota determined that flax wilt was caused by a parasitic fungus which he segregated, described and named.

Bolley's work is classical. He was probably the first man in the history of agriculture to submit plants to an epidemic of disease in order to obtain selections resistant to disease. This method makes deliberate use of the principle of the survival of the fittest. Today it is basic in all crop improvement. x x x Bolley's work completely altered the outlook for flax production in this country."

In another "box" there appears the following statement: "Plot 30 at the North Dakota Agricultural Experiment Station, where Bolley and his associates did their work on disease resistance, is perhaps as important in human affairs as any historic battlefield. Its function, however, has been the saving, not the destruction of man's resources."

One other person played a conspicuous role in this story of the tracing down of the cause of flax wilt. John H. Shepperd, former president of the North Dakota Agricultural College and second agriculturist of the North Dakota Agricultural Experiment Station, tells this story in his own words in the little Special Circular issued by the Extension Service in May 1938 entitled "Tales of the First Fifty Years—Rescuing the Flax Crop." Here is what he says:

"In the winter of 1890-91, when I was a student in the University of Minnesota, I chanced one day to be in the greenhouse used by Dr. Otto Lugger, of the Minnesota Experiment Station, in St. Paul, and I saw three beds of flax planted side by side. The two outside beds had good even stands of nice, healthy, vigorous flax plants of good color, three to four inches high; while those of the same height in the middle bed were yellow, wilting and turning brown.

"I asked Dr. Lugger what had happened to the sick and dead flax plants, and he replied, 'I wish I knew. Bed No. 1 has been watered with tap water; Bed No. 2 has been watered with an ooze made from soaking plants like this (pulling up a dry wilted plant); and Bed No. 3 has been watered with tea made by boiling the wilted flax plants in water. The water is applied with a sprinkling pot, after it has cooled. I have proved that it is something in the flax that boiling water takes out. The unboiled tea from the flax plants (Bed 2) kills flax.'

"That clear-cut trial struck deep into memory and three years later, upon coming to this College, I told E. F. Ladd, chemist, and H. L. Bolley, botanist, about it.

"We were all of one opinion, viz., that flax did not exhaust land by taking plant food from the soil any more than wheat did, if indeed as much; and that the poor flax crops secured on the land in later years resulted from some other cause than soil exhaustion.

"At the close of the conversation, I announced to my associates that I was going to establish a half dozen plots of known history and try cropping systems with flax as the key, or money crop, and that a check plot, No. 30, would be planted to flax continuously until I produced 'flax-sick' or a 'flaxed-out' condition; and that upon producing it I would call the committee together for another conference.

"It required six flax cropping years to produce a scourge of the disease on Plot 30—the same time that it took the Patriarch, Jacob, to produce the ring-streaked and grizzled cattle in Laban's herd during scriptural times.

"In 1900 the third-acre plot (No. 30) had only enough flax plants reach maturity to make two normal sheaves. x x x

"The third-acre of flax plants on Plot 30, in July, 1900, resembled the ones I saw in the middle (dying bed) in Dr. Lugger's greenhouse in St. Paul 10 years before, upon which he had sprinkled tea (not boiled) made from sick flax plants. x x x

"I called the committee, consisting of Professor E. F. Ladd, chemist, and Professor H. L. Bolley, botanist, together and we went out to see the 'flax-sick' land. x x x

"Dr. Ladd analyzed the soil and that of its neighbor plots which had been producing wheat during the time, and his results cleared the flax crop of the maligning charge which it had borne for two centuries. The soil was not exhausted of plant food.

"Professor Bolley said, when he saw the flax plants on that summer day in 1900, 'Men, I'll warrant that a parasitic fungus is causing those plants to wilt.'

Shepperd continues, "He (Bolley) started an immediate hunt for the parasitic culprit that he suspected was causing the trouble.

1. "On July 4, 1900, he scattered fine dirt particles from Plot 30 upon a bed of young flax. Result: many of the plants died of the disease before reaching maturity. A check bed remained free from the disease.

2. "Another bed was moistened with water in which soil from Plot 30 had been soaked. Result: the typical wilt disease had developed by July 19.

3. "Flax plants just coming through the soil were watered from a cold infusion, made by soaking wilted flax plants. Result: July 19, the disease took full charge of the bed and the plants were dying with all of the standard symptoms.

4. "Diseased flax-straw was buried in a bed and flax was seeded over the top of it. Result: the plants became thoroughly diseased.

"All of the above four beds were prepared, treated, and seeded on the fourth of July, 1900."

By February 1, 1903, Bolley had clearly defined his objectives in this battle against flax wilt. He stated them as follows in the 13th Annual Report of the Experiment Station: " (a) the perfection of methods of seed treatment for the purpose of preventing the introduction of flax parasites into the soil; (b) the study of methods of freeing the soil from the disease after it is once introduced; and (c) plant breeding and selection for the purpose of obtaining strains of flax which shall be immune or resistant to disease."

On March 31, 1903, Bolley announced in Bulletin 55 p. 193 that "We have found a small percentage of plants were resistant to the disease."

In the 13th Annual Report Bolley suggested "sending a special agent to the oldest flax-growing regions of the Old World to make a careful study of the crop, and especially with reference to the selection of varieties and strains of flaxseed upon which to carry on the attempts of producing immune varieties." He was very shortly appointed as the joint agent of the United States Department of Agriculture and of the North Dakota Agricultural Experiment Station on such a mission.

On January 17, 1905 in an address before a meeting of the North Dakota Farmers' Institute held in Fargo, North Dakota, Bolley outlined the use of the "Survival of the Fittest" principle in plant breeding in a paper entitled "Elimination of the Weak and Disease-Bearing Types on Farm Crops." In that discussion he re-

viewed 11 years of his work in plant diseases. He pointed out that his work really began in 1896 when he secured the use of Plot 30. On this plot he promoted "the greatest possible development of the particular disease." In this case the flax wilt disease was promoted by constant cropping to flax.

The First Wilt Resistant Varieties

By 1903 he had secured sufficient immunity or resistance to the disease so that by 1908 he was able to make the first distribution of two strains of selected wilt-resistant seed flax; namely, NDR No. 52 and NDR No. 73. Bolley tells the story of this accomplishment in a footnote to a re-issue of Press Bulletin No. 23. Press Bulletin No. 23 was originally issued in March 1907. It appears likely that the footnote relative to NDR No. 52 and NDR No. 73 was added in the re-issue dated April 1913.

Bolley's Wilt Resistant Flaxes

The early distribution by Bolley of numbered strains of wilt-resistant flaxseed is documented by Bolley in Press Bulletin No. 53 dated March 1912 as follows:

"North Dakota Resistant 22 is a type of flax developed from a single plant which is very resistant to wilt, but exposed to rust conditions, rusts quite badly."

"N.D.R. 52 is the oldest of our selections. This is a rather short, sturdy, branching type of flax which resists wilt attack and the wilt-sick ground very sturdily. x x x It rusts slightly at times, but seems to be largely resistant to rust." (A. C. Dillman in Yearbook of Agriculture, USDA, 1936 states that N.D.R. 52 was selected by Bolley in 1902 and distributed in 1908. H.L.W.)

"N.D.R. 73 is a rather typical type of oil producing flax. It is less wilt resistant than N D.R. 52 and N.D.R. 22 but is very strongly resistant to rust, seldom showing any rust under ordinary conditions. x x x"

N.D.R. 114 is a flax which has been selected from one of the previous strains and the selection made especially with a view of obtaining wilt resistance and rust resistance." (A. C. Dillman in the Yearbook of Agriculture, USDA, 1936, p. 776 says that N.D.R. 114 was first selected by H. L. Bolley in 1902 as a selection from "common" flax, North Dakota flax, and that it was first distributed by Bolley in 1912. The U. S. 1929 acreage of N.D.R. 114 was estimated to be 1,000,000 acres.

The Department of Agronomy of the station maintains permanent accession books in which are recorded all pertinent facts about new seeds subjected to field trials in that department. Accession Book No. 226 furnishes the following information about three other varieties introduced by Bolley; namely, Buda, Bison, and Golden:

Buda, Agronomy Dept. No. 40019; N.D.R. 119; CI 326, from H. L. Bolley, May 1922. Larger seeded and later than NDR No. 111 and 114. Entered in special trial (10 lbs.). The following is a quotation of a letter of May 8, 1923 from H. L. Bolley to T. E. Stoa: "No. 119 seems to date back to selections made from small samples secured near Budapest. S.P.I. 10,018. This, at time of introduction was a mixture of tall fibre flax and large seeded flax." Bolley. A. C. Dillman in Yearbook of Agriculture, USDA states that Buda was selected by Bolley in 1906 and distributed in 1921.

Bison, Agronomy Dept. No. 40032; C. I. 389. History of variety as given by H. L. Bolley in a telephone conversation with T. E. Stoa on December 5, 1928: Bison is the increase of selections from commercial sample supposed to represent fiber strains received by Bolley in 1911 from Ghent, Belgium. According to Bolley from 5 to 10 best plants were selected each year until increased for distribution. A. C. Dillman, in the Yearbook of Agriculture, USDA 1936 states that Bison was selected in 1912 and distributed in 1925, and that it was developed by H. L. Bolley and O. A. Heggeness.

Later introductions by Bolley follow:

B5128 (Golden x Rio) was released by H. L. Bolley in 1943. Highly resistant or immune to races of flax rust common to this area. Less resistant to wilt than Bison and more susceptible to pasmo than Bison. A tall blue flowered plant. With larger brown seed than Bison. Later than Bison. (See T. E. Stoa "Varieties of Flax and Disease resistance" N. Dak. Agr. Exp. Sta. Bimonthly Bulletin Vol. VII No. 3, pp. 18-23, Jan.-Feb. 1945.)

Victory (Bolley's No. 5585) is from a Czechoslovakian flax crossed with Argentine, and a selection from this crossed with Smoky Golden. Increase of this variety begun in 1941. Variable in type and rust resistance; mid-late, large white flower, large brown seed; highly resistant to rust; rather susceptible to pasmo, moderately resistant to wilt. (See T. E. Stoa, "Varieties of Flax and Disease Resistance", N. Dak. Agr. Exp. Sta. Bimonthly Bulletin Vol. VII, No. 3, pp. 18-23, Jan.-Feb. 1945.)

Smoky Golden (Bolley's No. 1821) has dull yellow or "smoky" colored seed. More resistant to wilt than other goldens; good resistance to rust. (See T. E. Stoa "Which Varieties of Flax to Grow in 1942," N. Dak. Agr. Exp. Sta. Bimonthly Bulletin Vol. IV, No. 4, pp. 2-6, March 1942.)

Other disease resistant strains developed by Bolley include N.D.R. No. 5: (See H. L. Bolley "Flax Cropping" in N. Dak. Agr. Exp. Sta. Bimonthly Bulletin Vol. III No. 6, pp. 9-12, July 1941); B. 5577 with very good rust resistance, a higher yielder in 1941 (See Table 1, p. 5 in T. E. Stoa "Which Flax Varieties to Grow in 1942" N. Dak. Agr. Exp. Sta. Bimonthly Bulletin Vol. IV No. 4, March 1942). N.D.R. No. 9 was also an early introduction.

Varieties Introduced by Bolley's Associates in the Department of Botany and Plant Pathology

Rio (L-79) C. I. No. 28 (Argentine) a selection by H. D. Long is of Argentine origin.

Walsh, a selection made in 1924 by H. D. Long was distributed in 1931 according to A. C. Dillman, U. S. Dept. of Agriculture Yearbook 1936.

Viking is a selection by O. A. Heggeness in 1926 from a cross B-Golden x Burbank's Golden ("Viking Flax" by O. A. Heggeness in North Dakota Agr. Exp. Sta. Bimonthly Bulletin Vol. III No. 4 pp. 7 and 8, March 1941).

Varieties Introduced by Bolley Used by Others in Creating New Varieties of Flax

Plant breeders throughout the world are constantly seeking sources of disease resistance, of improved agronomic quality, and of better technological quality. The many varieties introduced by H. L. Bolley have been extensively used by the flax breeders of the U. S. Department of Agriculture and of the several states in the creation of new varieties of flax.

Bison, although highly susceptible to rust and of somewhat low iodine number, has, because of its excellent resistance to wilt and vigorous habits of growth, been used as one of the parents of many new varieties. The following list names seven varieties of flax produced by plant breeders outside of North Dakota in which Bison is used as one of the parents, one variety in which B5128 is a parent, and one variety in which Buda is a parent. The end is not yet, for the list will be added to with the passing years.

Parent Introduced by Bolley	Parent Used by Other Plant Breeders	New Variety and Its Introducer
Bison	Renew	Dakota (A. C. Dillman, USDA)
Bison	Frontier x Argentine	Koto (USDA)
Bison	Ottawa 770 B	Crystal (Minnesota Station)
Bison	Redwing	Biwing (Minnesota Station)
Bison	Renew	Arrow (Montana Station)
Bison	C. I. 649[1]	Minerva (Minnesota Station)
Bison	Redwing	Redson (Minnesota Station)
B5128	Redson	Redwood (Minnesota Station)
Buda	Ottawa 770 B	Sheyenne (H. H. Flor, USDA)

In his essay on Self-Reliance, Ralph Waldo Emerson said, "An institution is the lengthened shadow of one man." Paraphrasing Emerson one may well say that the flax fields of the Northwest are today "the lengthened shadow" of Henry Luke Bolley.

[1]The C. I. 649 times Bison cross was backcrossed to Bison several times.