Journal of the American Pomological Society 71(2): 121-128 2017

W. G. Brierley: Pioneering Pomologist of the Prairie

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Despite newspaperman Horace Greeley's purported proclamation that he "would not live in Minnesota because you can't grow apples there," Minnesota produced almost 25 million pounds of apples in 2014 (Luby, 1991; NASS, 2015). The University of Minnesota's fruit breeding program has worked since the 1860s to prove Greeley wrong and produce new cultivars of apples, as well as many other fruits, that could survive the variable and often difficult Minnesota winter. Much of the University's success in understanding the winter behavior and hardiness of fruit crops can be traced to one man: Wilfred Gordon Brierley (Figure 1). Brierley's career at the University of Minnesota lasted over forty years, in which time he made significant contributions to the Department of Horticulture, the fruit breeding program, and the field of pomology as a whole.

This paper will review some of Brierley's most significant findings and will publish, for the first time, a consolidated bibliography of Brierley's works in Table I. The paper, as well as the bibliography are organized by crop, as Brierley's research focused on winter hardiness but covered many different species of fruit. Digitized versions of Brierley's publications that are currently in the public domain will also be made available through the University of Minnesota's Digital Conservancy (https://conservancy.umn.edu). In publishing Brierley's complete bibliography, it is our hope that researchers can recognize his significant contributions to the field of horticulture and honor him as the Pioneering Pomologist of the Prairie.

Fig. 1. Image of W. G. Brierley (from Brierley, 1916)

Wilfred Gordon Brierley was born in Dover, New Hampshire in 1885. He left New Hampshire for his studies, receiving a B.S. in 1906 from Cornell University and an M.S. from the State College of Washington (now Washington State University) in 1913. Following the completion of his master's thesis, 'Modern Marketing and Storage for Fruits and Vegetables,' Brierley began working in the Division of Horticulture at the University of Minnesota, where he remained until his retirement in 1954. Unlike the typical faculty member today, Brierley was able to work as a professor for seventeen years before com-

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pleting his Ph.D. in 1930. His dissertation, 'A Study of Senescence in the Red Raspberry Cane,' reflects his expertise in just one of the many fruit crops he studied during his time at the University of Minnesota—in addition to his work on raspberries, Brierley published significant findings about apples, strawberries, grapes, blueberries, plums, and even nut trees. In his long career at the University of Minnesota, Brierley published over 60 reports, bulletins, and journal articles.

Many of Brierley's findings found their way to the public through the Minnesota Horticulturist magazine, a precursor to Northern Gardener magazine, which is still published today by the Minnesota State Horticultural Society. A disclaimer at the head of Brierley's Minnesota Horticulturist publications reminded readers that the articles only "recite the experience and opinions of the writers, and this must be kept in mind in estimating their practical value" (Brierley and Child, 1926). Despite the caveat, Brierley was a trusted and respected pomologist whose work has been cited as recently as 2014 (Read and Gamet, 2014).

In addition to being a highly respected scholar, Brierley was known as a kind and gentle man who went out of his way to support of his students. In 1970, an announcement to the University of Minnesota's Senate of Brierley's passing described him as "never too busy to discuss personal or academic problems with his students," and as a mentor who "did his utmost to smooth the bumpy roads that students have to travel." He had a particular affinity for athletes, having been one in college, and attracted graduate students from all around the United States and Canada to work with him (University of Minnesota, 1969).

As mentioned, Brierley's primary area of interest was winter hardiness. In his paper "The Winter Hardiness Complex in Deciduous Woody Plants", published in the Proceedings of the American Society for Horticultural Science, Brierley explained the many factors influencing woody plant survival of winter, asserting that hardiness is the ability to survive not only cold temperatures, but also the other numerous difficult environmental conditions of the winter months (Figure 2; Brierley, 1947a). In addition to publishing in the Proceedings of the American Society for Horticultural Science, Brierley made the same information available to industry groups via their publications, showing his dedication to public outreach (Brierley 1947b, 1948).

A 1948 Brierley paper published in the Minnesota Horticulturist gives a thorough description of a 'test winter,' and is a particularly interesting look back at how horticulturists' ideas about test winters have developed over time (Brierley 1948). Using the framework of the 1947 paper, Brierley described the injuries that resulted from the winter of 1947-1948, and the ways in which the factors of the hardiness complex for apples, plums, grapes, raspberries, evergreens, strawberries, and apple nursery stock were lacking and thus resulted in severe damage to the crop. Brierley's thorough analysis of winter damage mirrors the work of horticulturists in Minnesota today who

TABLE I—FACTORS OF THE HARDINESS COMPLEX

I. *Basic Factors*
1. Condition of plant
2. Variety
3. Maturity
4. Exposure

II. *Water Relations*
5. Winter desiccation

III. *Temperature Relations*
6. Rest period
7. Dormancy
8. Time of development of cold resistance
9. Rate of development of cold resistance
10. Ultimate or absolute cold resistance
11. Retention or loss of cold resistance
12. Ability to regain cold resistance

Fig. 2. Table of Factors of the Hardiness Complex (from Brierley, 1947b)

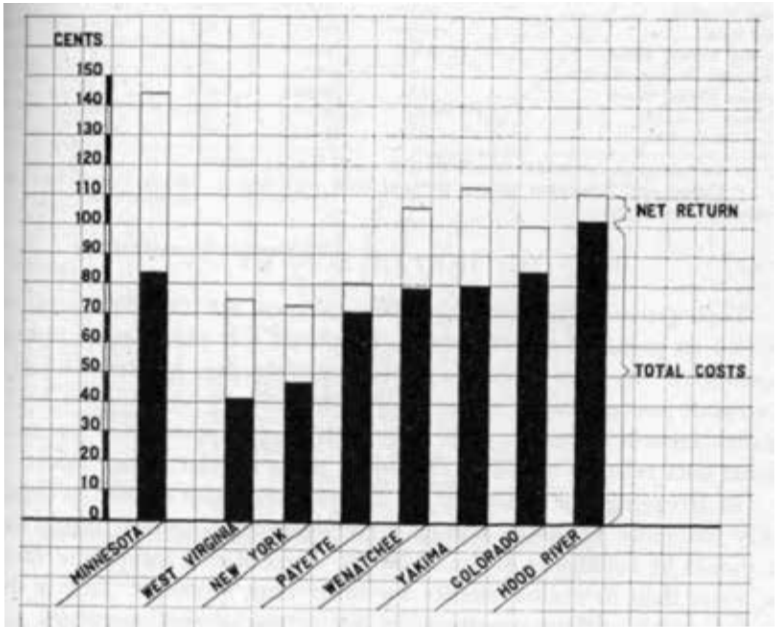

Fig. 3. Comparison of Total Costs and Net Returns per Bushel in Minnesota and Other Sections (from Brierley et al., 1924)

still discuss test winters and try to understand factors causing plant death, guided by the desire to have plants survive Minnesota's variable climate.

Brierley is perhaps best known at the University of Minnesota for his work on apples. His master's thesis from the State College of Washington focused on the marketing and storage of apples and, when he arrived at the University of Minnesota in 1913, he immediately began searching for the best Minnesota apple cultivars for cider and vinegar. His search eventually led to his first published paper, "Cider-and vinegar-making qualities of Minnesota apples" (Brierley, 1919). As his work began shifting towards winter hardiness and general survivability, Brierley published data on the longevity of apple trees growing in Minnesota (Brierley, 1921). In his 1921 paper, Brierley addressed the "wide variation in length of life" of apple trees, and the difficulty of separating climate from the other factors that affect how long a tree lives, a question still considered today. The 1921 survey of orchards throughout the state indicated that most orchards were planted between 1900 and 1906, and that older orchards were few in number; few if any orchards had trees older than 25 years. It is interesting to note that there were very few orchards planted prior to 1900, as there were many fewer people in Minnesota, and fewer still cold hardy apple cultivars.

Using data from a large survey of orchardists, Brierley published an apple longevity study that concluded that the high net return for apples in Minnesota made up for the large total cost of growing the fruit (Figure 3; Brierley et al., 1924). Brierley also happily concluded that Minnesota growers were averaging ¢196 per bushel between 1915 and 1920, which was at least 30 to 80 cents above the earnings of growers in Idaho, Illinois, Colorado, Michigan, West Virginia, Oregon, Washington, and New York. Today, a bushel of apples, assuming forty pounds (approximately 18 kilograms) per bushel, grown in Minnesota could make a grower on average

$33, which is still higher than growers in neighboring Michigan, Illinois, Missouri and Wisconsin (NASS, 2015). Brierley reported that while Minnesota growers had among the highest total costs compared to other regions, the net return was much higher (Brierley et al., 1924).

By 1925, Brierley had begun to make a name for himself in studying the various aspects of survivability of apple trees and his focus on winter hardiness solidified. He examined the healing of pruning wounds on apple trees, concluding that vigorous apple trees could have limbs thinned from November into the following spring with no impact on tree survival (Brierley 1925, 1932). Brierley's focus soon turned to winter hardiness issues in other crops, but he continued to publish research on apples until 1955.

Brierley took a hiatus in the 1920s to pursue his Ph.D. at Michigan Agricultural College (now Michigan State University). In 1930, he published his thesis work on raspberry cane senescence, in which he reported that cambial activity in second year canes developed xylem and phloem only when associated with lateral bud development (Brierley, 1930). Following his Ph.D. research, Brierley spent several years focusing on the physiology and production practices in raspberry. Though he received his Ph.D. in Michigan, it appears that Brierley conducted his research at the University of Minnesota and continued working in Minnesota while pursuing his final degree.

Brierley's work centered on the 'Latham' red raspberry, released from the Minnesota Experiment Station in 1920. Brierley used this cultivar in many of his studies, including the effect of pruning height on yield and berry size (Brierley, 1931a), growth habits of old, new, and lateral flower producing canes (Brierley, 1931b), transpiration rates of raspberry cane (Brierley, 1931c), the impact of cane tipping to increase lateral bud formation (Brierley, 1934), and numerous articles on winter survival, including studies of cold resistance in raspberry canes and roots (Brierley and Landon, 1946a; Brierley and Landon 1946b; Brierley et al., 1952).

Brierley also spent significant time in the 1930s and 1940s studying winter hardiness in strawberries. In 1937, Brierley and his colleagues examined plant metabolism and gas exchange in overwintering strawberry plants, concluding that while respiration slows significantly when the soil temperature falls below 0° C, it never completely ceases, showing that the plants respire even when the soil is frozen (Brierley and Landon, 1937). Brierley also examined strawberry plants' ability to survive 'smothering' under ice (Brierley and Landon, 1942), the impact of cooling and warming cycles (Brierley and Landon, 1944), the physiology of hardening (Brierley, 1943), and the minimum temperatures at which plants could survive (Brierley and Landon, 1943). In addition, Brierley published recommendations for local growers on mulching techniques and the best cultivars for the Upper Midwest. 'Burgundy,' 'Catskill,' 'Gem,' and 'Wayzata' topped the recommendations in 1943; none of these cultivars are recommended today (Brierley and Landon, 1944; Hoover et al., 2016). Brierley, working in conjunction with the Division of Home Economics, also released cultivar recommendations and technique tips for strawberry canning and jam making (Brierley and Child, 1926).

Brierley is perhaps best known for his work with apples, raspberries, and strawberries, but he did not stop there. During his long career at the University of Minnesota, Brierley, like many horticulturists, had broad expertise and many interests. He published research and reports on cherries, plums, grapes and blueberries that focused on cold hardiness and adaptability to Minnesota winters (Brierley and Alderman, 1938; Brierley and Angelo, 1934; Brierley and Hildreth, 1928; Brierley and Kenety, 1920; Brierley et al., 1952; Brierley and McCartney, 1950). As he approached his retirement, Brierley also began studying walnuts, hickory nuts, and hazelnuts, and published recom-

mendations for cold hardy nut cultivars. In addition to a review of noted apple breeder Peter Gideon's contributions to nut breeding, he seemed particularly interested in grafting techniques, and wrote several assessments of apple and nut graft trials as his final publications (Brierley, 1944).

Brierley dedicated half a century to exhaustively researching cold hardiness in numerous fruit crops and in doing so, significantly contributed to the body of knowledge on fruit crop dormancy and low temperature survival. His findings and publications "laid the groundwork for the University of Minnesota to develop into an internationally known center for cold hardiness research," as his University of Minnesota Senate obituary announced. The obituary also stated that with Brierley's help "the University of Minnesota gained a reputation as a center of excellence in the studies of the nature of the problems of winter survival of fruit plants" (University of Minnesota, 1969). The thousands of acres of apples, strawberries, raspberries, and other fruit crops that now grow in the Minnesota landscape serve as proof of Brierley's contributions, and to his ultimate success in proving Horace Greeley wrong.

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Instructions to Authors

Journal of the American Pomological Society

The prime purpose of the Journal of the American Pomological Society is to provide a repository for information on all aspects of fruit and nut crops. The long-term emphasis of the journal on cultivars and rootstocks continues, but manuscripts reporting original research on a wide range of fruit and nut crops are welcomed. Acceptable areas of research including pruning, nutrition, growth regulators, cultural practices, economics, and pest control. Studies involving the interaction of one or more of these aspects with either cultivars and/or rootstocks are particularly appropriate. If in doubt about the suitability of a particular manuscript, please contact the Editor.

Reports on field studies are expected to contain data from multiple years. Reports are to be the result of adequately replicated trials and the data should be subjected to appropriate statistical analysis. Manuscripts submitted for publication in the Journal must not have been previously published, and submission implies no concurrent submission elsewhere.

Scientific names and authorities for plants, disease organisms, and insects should be included parenthetically when the organism is first mentioned. American spelling conventions and SI units should be used. Manuscripts should be double spaced throughout. Typical organization is as follows: Title, Authors, Abstract, Introduction, Materials and Methods, Results, Discussion, Literature Cited, Tables, Figures. The Results and Discussion sections are often combined. Author addresses, email adresses and acknowledgements are in footnotes on the first page. More detailed instructions for manuscript preparation can be found at: http://www.americanpomological.org/journal/journal.instructions.html

Before submission, manuscripts should be reviewed by at least two colleagues and revised accordingly. At the time of submission, the corresponding author must attest in the covering letter to the Editor that all coauthors on the paper have had the opportunity to review it before to submission, that it has not been published previously, and that it is not presently under consideration for publication elsewhere. In addition, the names and full contact information (mailing address, e-mail and telephone numbers) for three potential reviewers should be provided. Submit manuscripts electronically to the Editor: Dr. Richard Marini, 203 Tyson Building, Department of Plant Science, University Park, PA 16802-4200 USA; E-mail: richmarini1@ gmail.com. Acceptable format is MSWord.

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