THE KILLING OF PLANT TISSUE BY LOW TEMPERATURE

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BY

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BIOGRAPHY.

WILLIAM HENRY CHANDLER

I was born July 31, 1878, on a farm in Bates county, Missouri. My common school education was secured in the Public Schools of this county, and, later, I attended the Butler Academy at Butler, Missouri. For several years I served as a teacher in the public schools of Bates county.

In September, 1901, I entered the College of Agriculture of the University of Missouri. The degree of Bachelor of Science in Agriculture was given to me in 1905. For the school year of 1905-6 I served as Fellow in Horticulture at the University of Missouri and in June, 1906, took the degree of Master of Science in Agriculture. The subject of my thesis was: "Winter Killing of Peach Buds as Influenced by Previous Treatment of the Trees."

In 1906, I became Assistant in Horticulture, University of Missouri, and in 1909, Instructor in Horticulture. My rank was raised to Assistant Professor of Horticulture in 1911. I was elected Professor of Research in Pomology, Cornell University, in 1913, which position I still hold.

I have published, or have in press, the following papers of the Missouri Agricultural Experiment Station:

Bulletin 74 The Winter Killing of Peach Buds as Influenced by Previous Treatment of the Trees.
Bulletin 97 Co-operation Among Fruit Growers.
Bulletin 102 Combating Orchard and Garden Enemies.
Bulletin 113 Commercial Fertilizers for Strawberries.
Research Bulletin 8 The Killing of Plant Tissue by Low Temperature.
Research Bulletin 14 Sap Studies with Horticultural Plants.

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THE KILLING OF PLANT TISSUE BY LOW TEMPERATURE

W. H. CHANDLER

Summary

1. The term sap density, as often used in this publication, refers, not to specific gravity, but to molar concentration. These sap densities have been determined by the freezing point method, making use of the fact that the molecular weight in grams of any non-electrolyte lowers the freezing point 1.86° C. The sap density is generally given in terms of depression, meaning the number of degrees Centigrade that the freezing point is lower than the freezing point of water.

2. By the eutectic point is meant the temperature at which the substance in solution crystallizes out. At that temperature there would be at the same time ice, crystals of the solute, and unfrozen solutions.

3. There are several forms of injury from cold, some of them purely mechanical, such as tearing of tissue due to tension developed at low temperature, or evaporation from the surface when the conducting tissue is frozen so as to prevent the movement of water to that tissue, and killing as a result of long continued exposure to low temperature. The term *freezing to death,* however, is applied here only to a very specific set of phenomena. With all plant tissues, when a certain temperature is reached very shortly after thawing, it will be found that the tissue has taken on a brown, water-soaked appearance, and evaporation from that tissue is much more rapid than from living tissue. These are characteristics of plant tissue frozen to death.

4. Results of many investigations have shown that during freezing (which may or may not result in freezing to death), ice forms in the tissue, generally not in the cells but in the intercellular spaces, the water moving out of the cells to form crystals in these spaces. The most commonly accepted theory is that killing from cold results from the withdrawal of water from the protoplasm. The amount of water loss necessary to result in death varies with the different plants and different tissues. (Pages 9-17.)

5. In the experiments described in this bulletin, the killing temperature of plant tissue that kills at relatively high temperature has been reduced whenever the sap density of the tissue has been increased. (Pages 17-49.)

6. In addition to ripe apples and pears, and the leaves of *Agave Americana* observed by Müller-Thurgau and Molisch, leaves of lettuce kill at a slightly lower temperature if they are thawed slowly than if thawed rapidly. In case of all other tissues tested by this station or by others, including unripe apples and pears, there is no indication that the rate of thawing has anything to do with the amount of killing at a given temperature. (Pages 49-56.)

7. Rapid wilting of tissue has not generally increased the resistance of plants to low temperature over that of unwilted tissue with a dry surface. However, tissue with a wet surface killed worse at a given temperature than did tissue with no moisture on the surface. (Pages 56-60.)

8. Slow wilting or partial withholding of water through a long period increased the resistance of tissue to low temperature. (Pages 60-61.)

9. In case of hardy winter buds and wood, a rapid decline in temperature greatly increased the severity of injury from a given low temperature. (Pages 61-67.)

10. There seems to be no constant relation between the rate of growth of plant tissue and resistance to low temperature. Young leaves of fruit trees kill at a higher temperature than do old, mature leaves, while the young leaves of lettuce withstand a lower temperature than do the older leaves. (Pages 80-85.)

11. Previous exposure to low temperature above that at which the tissue kills seems to increase the resistance of tissue to low temperature. (Pages 85-86.)

12. The most important feature affecting the hardiness of plant tissue is maturity, that is, the condition of resistance that the plants reach during the winter dormant period. Maturity in the case of cambium may be intimately associated with the process of drying out. However, this can not be true at least of cortex of winter twigs. There is little difference between the moisture content of unfrozen cortex in seasons when it is very tender and seasons when it is hardy. The wood at the base of the trunk and at the crotches of all rapidly growing branches seems to reach a condition of maturity in early winter more slowly than does most other tissue. (Page 79.)

13. Of the tissue above ground during periods when the most complete maturity is reached, the most tender parts are the pith cells and the fruit buds. During periods of rapid growth there is little difference in hardiness of the different tissues. The tissue which is most tender at all seasons of the year is the root. There

is much less difference, however, in the killing temperature of roots in summer and winter than between the killing temperature of twigs or other wood in summer and winter. (Pages 86-103.)

14. Roots of the French crab used as stock seem to be more tender than roots which come from scions of an average variety of apple. (Pages 103-105.)

15. Marianna plum roots are certainly more hardy than Myrobolan roots, and Mahaleb cherry roots seem slightly more hardy than Mazzard roots. (Pages 105-115.)

16. That part of the root system nearest the surface and the largest, oldest roots are more resistant to cold than are small roots further from the surface. (Pages 89-115.)

17. Pollen of the apple will withstand much lower temperatures than will any other tissue of the flower when in full bloom. (Page 115.)

18. Scales of peach buds do not serve to protect them from low temperature. Buds frozen in the laboratory with the scales removed were slightly more resistant to low temperature than were buds with the scales not removed. (Pages 116-118.)

19. The killing of wood of peach trees from freezing is one of the most important determining factors in peach growing. Little can be done to influence the amount of killing except to have the trees start into winter in proper condition of maturity. The weakest growing trees, however, do not generally reach this condition of maturity in the most satisfactory manner. Trees one or two years in the orchard, or old weak trees, are most liable to succumb to effects of low temperature. Pruning the trees severely following a winter when the wood has been killed, altho apparently in the best condition of maturity, seems to reduce the amount of killing. However, such pruning following winters when the wood has been killed on account of its not having reached the proper condition of maturity in the fall, generally due to the presence of wet weather following a drought the season before, is liable to result in greater loss than if no pruning were done. (Pages 118-122.)

20. The hardiness of peach buds when in fully dormant condition seems to be greatly increased by continuous low temperature preceding the date at which the temperature goes low enough to kill. This capacity to withstand low temperatures seems likely to be due to the slow fall in temperature under such conditions rather than to hardiness developed as the result of exposure to low temperature. (Pages 122-131.)