EFFECT OF HIGH PRESSURE ON GERMINATION OF SEEDS (MEDICAGO SATIVA AND MELILOTUS ALBA).*

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The application of high pressure (2000 atmospheres) is found to have a definite effect on germination. The action of the high pressure is apparently complex, and seems to involve both physical and chemical changes.

Röntgen (1892) and Tammann (1894) found that the velocity of inversion of cane-sugar by hydrochloric acid increased slightly under 500 atmospheres pressure. Rothmund (1896), Stern (1896), and Cohen and de Boer (1913) observed a result contrary to this; Rothmund observed a decrease of 5 per cent, and Cohen and de Boer of 8 per cent, under 500 atmospheres pressure. Rothmund (1896) and Cohen and Kaiser (1914–15) found a large increase (20 to 37.4 per cent) in the rate of saponification of ethyl acetate by sodium hydroxide under 500 atmospheres pressure. Henderson and Brink (1908) applied 500 atmospheres pressure to frog muscle and found the compressibility was less than 2 per cent. Later, Henderson, Leland, and Means (1908) applied the same pressure to frog muscle for 30 minutes and noted little injurious effect (determined by electrical stimulation). Harvey (1922–23) applied 1000 pounds oxygen pressure and 1800 pounds nitrogen pressure (falling to 1300 pounds during the experiment) for 3 hours to leaves of *Baptisia tinctoria*, without injurious results. Bridgman (1914) applied pressure to egg albumen, and found that pressures below 5000 atmospheres had only slight effect, while higher pressures produced characteristic coagulation of the albumen.

The writer applied 2000 atmospheres pressure[1] at 20°C. to seeds of *Medicago sativa* (alfalfa) and *Melilotus alba* (sweet clover), and found an increase in percentage germination. After the pressures were applied, the seeds not needed for immediate tests were dried on glass plates in a warm room (25°C.) and tested for germination, at 20°C., after 30 days, 6 months, and 10 months.

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[1] For the technique of such high pressure experiments, see Bridgman (1914, *a*).

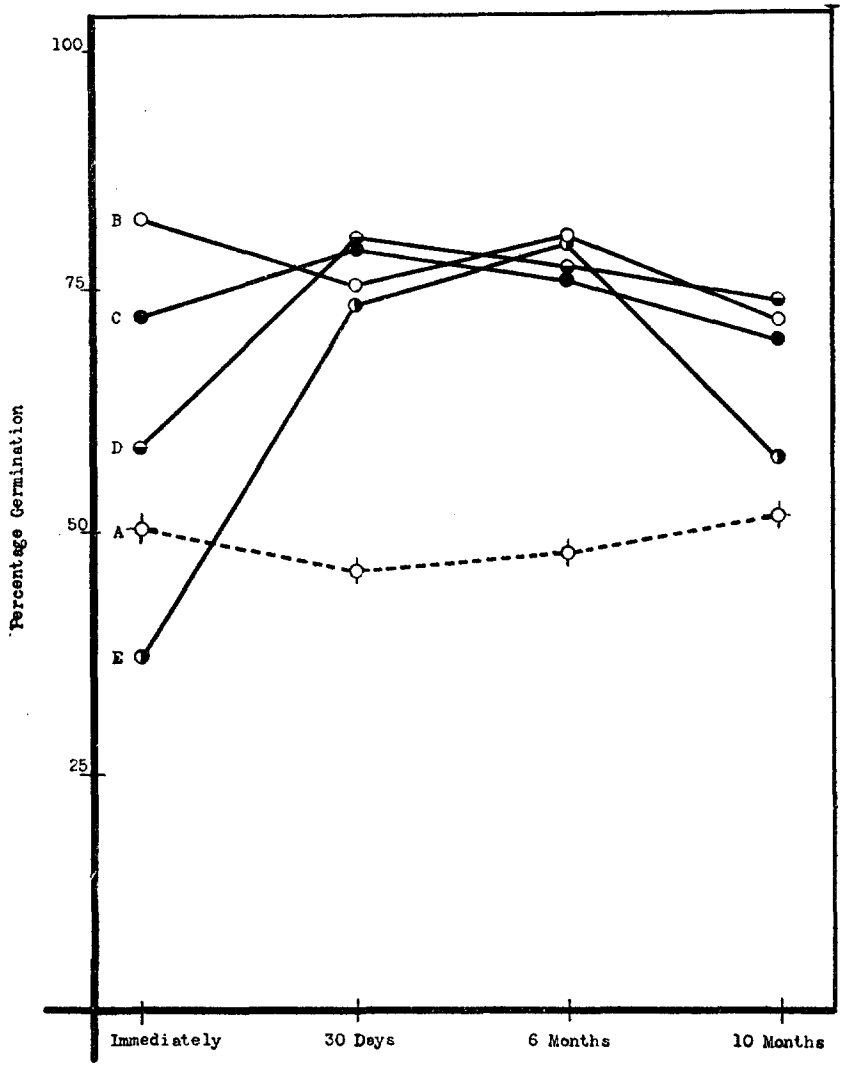

FIG. 1. Showing the effect of pressure on germination of seeds of *Medicago sativa*. Curve *A* (dotted line) represents the percentage germination of the control; *B*, *C*, *D*, and *E*, exposures for 1, 2, 5, and 10 minutes respectively.

Fig. 1 shows the effect of the pressure on germination of *Medicago sativa*. Tested immediately after the pressure was applied, an in-

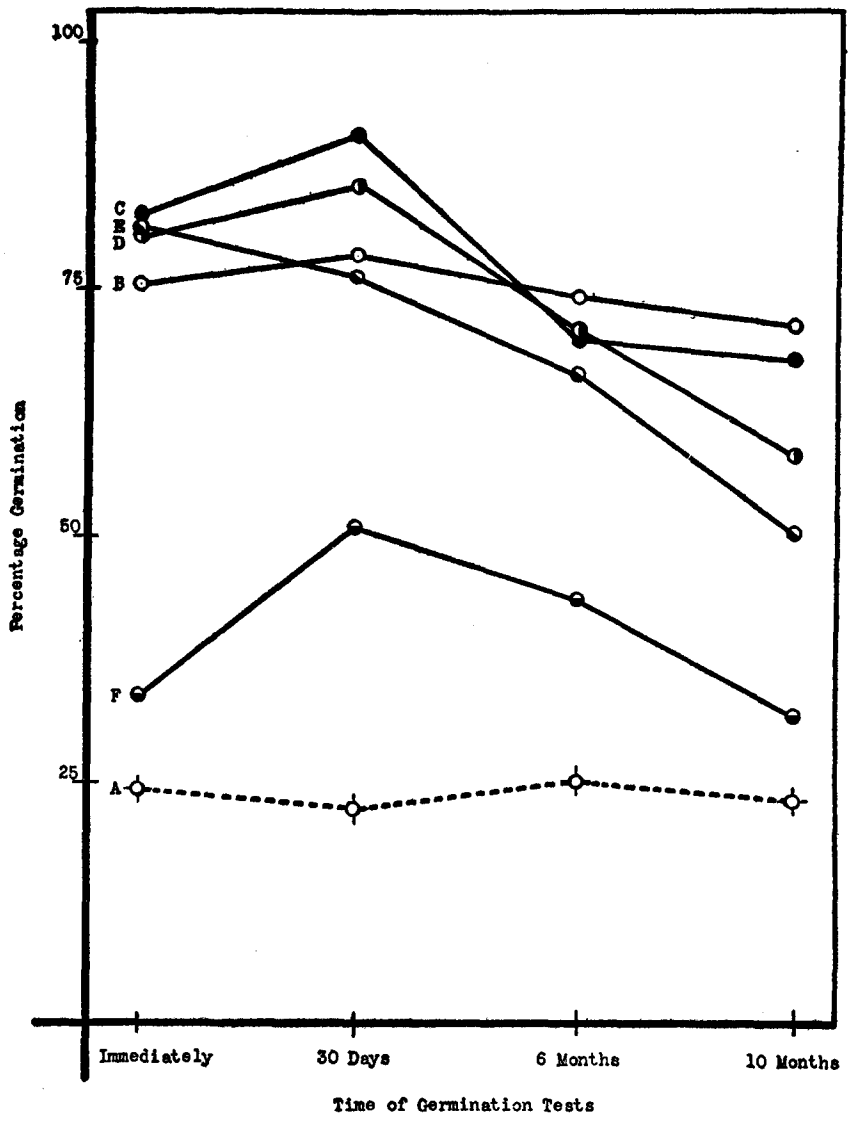

FIG. 2. Showing the effect of pressure on germination of seeds of *Melilotus alba*. Curve *A* (dotted line) represents the percentage germination of the control; *B*, *C*, *D*, *E*, and *F*, exposures of 5, 10, 15, 20, and 30 minutes respectively.

creased percentage germination was obtained from seeds exposed for different lengths of time. *A* represents the control,[2] *B* 1, *C* 2, and *D* 5 minutes exposure respectively. Following 10 minutes exposure (*E*) a decrease in percentage germination is noticed. In the 30 days tests an increased percentage germination is apparent in seeds exposed for 2, 5, and 10 minutes, the increase being greatest in the case of the 10 minutes exposure. The 6 months tests give practically the same results as found for the 30 days tests. In the 10 months tests the percentage germinations for exposures of 1, 2, and 5 minutes were nearly constant, but a rapid drop occurred in the case of the seeds exposed for 10 minutes.

Fig. 2 shows the effect of the pressure on seeds of *Melilotus alba*. In the tests immediately after the pressures were applied, the percentage germinations of the seeds exposed for 5 (*B*), 10 (*C*), 15 (*D*), and 20 (*E*) minutes were practically the same; but with 30 (*F*) minutes exposure, although the percentage germination is above that of the control (*A*), the increase is much less. In the 30 days tests slight increases in percentage germinations are noticed for seeds exposed for 10, 15, and 30 minutes; and in tests after 6 months and 10 months there is a general decrease in percentage germinations, being greater in the tests at 10 months after treatment.

Data later to be published in detail show that 500 atmospheres pressure for longer exposures is less advantageous for germination than shorter exposures at 2000 atmospheres; under low pressures the seeds normally germinating are more rapidly destroyed than the hard impermeable seeds rendered permeable by the pressure treatment. Exposures to 2000 atmospheres at 0°C. give no better results, with respect to germination, than exposures to the same pressure at 20°C.; the only difference being, that at 0°C. longer exposures (approximately $2\frac{1}{2}$ times for seeds of *Medicago sativa* and approximately 5 times for seeds of *Melilotus alba*) are necessary to produce the same increase in percentage germination.

[2] The control is a sample of the original lot from which seeds were taken for pressure experiments, saved, and germinated at the same time (30 days, 6 months, and 10 months) as the treated seeds.

SUMMARY.

An increase in percentage germination is obtained with seeds of *Medicago sativa* exposed for 1 to 10 minutes at 2000 atmospheres hydraulic pressure at 20°C., dried, and germinated after 30 days; and from seeds of *Melilotus alba* under the same conditions of pressure, when exposed for 5 to 30 minutes, dried, and germinated 30 days later. Exposures to 500 atmospheres pressure was less advantageous for germination; the vitality of seeds normally germinating was more rapidly destroyed than the hard impermeable seeds rendered permeable by the pressure treatment. At 0°C., it required approximately $2\frac{1}{2}$ times the exposure to 2000 atmospheres for seeds of *Medicago sativa*, and approximately 5 times the exposure for seeds of *Melilotus alba*, as it did at 20°C.

BIBLIOGRAPHY.

Bridgman, P. W., 1914, *J. Biol. Chem.*, xix, 511; 1914, *a*, *Proc. Am. Acad. Arts and Sc.*, xlix, 627.

Cohen, E., and de Boer, R. B., 1913, *Z. physik. Chem.*, lxxxiv, 41.

Cohen, E., and Kaiser, H. F. G., 1914–15, *Z. physik. Chem.*, lxxxix, 338.

Harvey, E. N., 1922–23, *J. Gen. Physiol.*, v, 215.

Henderson, L. J., and Brink, F. N., 1908, *Am. J. Physiol.*, xxi, 248.

Henderson, L. J., Leland, G. A., Jr., and Means, J. H., 1908, *Am. J. Physiol.*, xxii, 48.

Röntgen, W. C., 1892, *Ann. Physik u. Chem.*, xlv, 99.

Rothmund, V., 1896, *Z. physik. Chem.*, xx, 168.

Stern, O., 1896, *Ann. Physik u. Chem.*, lix, 660.

Tammann, G., 1894, *Z. physik. Chem.*, xiv, 444.