of which was bent and led under the earth in a secondary pot to encourage rooting and thus form a readily detachable second plant. The rooting process was hastened by a partial cut between the original and secondary pots. There was thus produced a "colony" with all its units organically connected but capable of being separated at any time and in any fashion desired. The colonies were grown in a greenhouse under a close cheese-cloth cage. The greatest care was taken throughout to avoid accidental infection through insects, handling, touching of leaves, watering, etc. There is no evidence that any such accidental infection occurred anywhere in the series.

When all secondary plants were well rooted but still attached to the parent plant a single shoot of the parent was inoculated with freshly expressed juice from tomato leaves showing marked mosaic. A glass tube drawn to a capillary point was used for the purpose, pressure being supplied by means of a dropper bulb on the end. Inoculations were made near the growing point.

Table of Results indicating the Rate of Spread of Tomato Virus in Tomato Plants

Series of Colonies	Condition of all shoots twenty-four days after inoculation date; 0 – healthy; X – mosaic					
	Inoculated shoot	Daughter plants separated from colony at specified intervals after inoculation date				
		3 days	10 days	15 days	19 days	24 days
A	X	0	X	X	X	
B	0	0	0	0	0	
C	X	0	0	X	X	
D	X	0	0	0	X	X
E	X	0	X	X	X	X
F	X	0	X	X	X	XX
G	0	0	0	0	0	0
H	X	0	0	X	X	

After inoculation a single secondary plant was removed from each colony at intervals of three, ten, fifteen, nineteen and twenty-four days where the number of daughter plants was sufficient for such a series. These isolated plants were kept under observation to see if mosaic developed.

Twenty-four days after inoculation a record of the various series indicated that in two colonies (B and G) the inoculation had failed. There was no sign of mosaic in the shoot originally inoculated or any of the daughter plants in either colony. In the remaining six all plants removed after nineteen days had marked mosaic symptoms on the young growth; in five of the six the disease had appeared in plants removed after fifteen days; and in three plants taken away after ten days the disease was also evident. None of the plants removed after three days had developed mosaic twenty-four days after inoculation.

It is evident from the above results that the infective principle was unable to pass from the point of inoculation beyond the place of separation in any case in three days; that in half the cases not more than ten days was required to traverse this distance; that in five out of six cases the virus had passed into the daughter plants in less than fifteen days; and that in only one case was a period of fifteen days insufficient. In this case the two plants removed after nineteen days were both affected by mosaic on the twenty-fourth day, so that if one allows for a suitable incubation period it is evident that the point of separation must have been passed near the fifteen-day period.

The distances to be traversed by the virus in these colonies varied from eight to eighteen inches. We may see from the above records that these distances were traveled by the virus in periods which might be something less than ten days or slightly more than fifteen days. We have no right to assume that a uniform advance was made during this period, but for purposes of expressing the rate of progress of the virus in concrete fashion it may be permissible to adopt the average rate in common usage for such purposes. On this basis the transfer of mosaic virus appears to take place through the shoots of the tomato plant at a rate somewhere in the neighborhood of one to two inches per day or one to two millimeters per hour.

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FEEDING PLANTS MANGANESE THROUGH THE STOMATA[1]

Does manganese benefit plants mainly by increasing the oxidative power of the soil, as has been claimed by Skinner and Reid[2] or is its chief value as a promoter of enzyme activity within the plant, as stated by Bertrand?[3] McHargue[4] has demonstrated

[1] Contribution 354 of the R. I. Agricultural Experiment Station, Kingston, R. I.

[2] Skinner, J. J., and Reid, F. R., "The Action of Manganese under Acid and Neutral Soil Conditions." *U. S. D. A. Bull.* 441. 1916.

[3] Bertrand, Gabriel, "Sur l'intervention du Manganese dans les Oxidations provoqués par la laccase." *Compt. Rend. Acad. Sci.* (Paris) I: 124: 1032–1035.

[4] McHargue, J. S., "The Rôle of Manganese in Plants." *Jour. Am. Chem. Soc.* 44: 1592–1594. 1922.

that it is essential for the normal development of many kinds of plants. Gilbert, McLean and Hardin[5] have found it to be a cure for lime-induced chlorosis of spinach and oats. Similar beneficial results have been obtained with tomatoes on lime soils in Florida, according to Schreiner and Dawson.[6] Unpublished data also show similar benefits to beets, lettuce, onions, corn and millet on neutralized soils.

Since the need for manganese on neutralized soils appears to be so general with many kinds of plants it is worth while to know whether its action is mainly on the soil or within the plant itself. This question was answered in the experiment here described by supplying some chlorotic plants with manganese through the soil, and introducing it into the tissues of others directly through the stomata of the leaves. This last was accomplished by an adaptation of the porometer, used by Darwin and Pertz[7] for studying stomata openings, and modified by McLean and Lee[8] for inoculating citrus leaves with canker organisms. The apparatus consisted of a small glass medicine-dropper tube with a rubber lip on the large end so that it could be pressed against a delicate leaf without causing injury. The small end of the tube was connected with a rubber atomizer bulb so that air could be forced into it under pressure. Then the tube was filled with a dilute manganese solution, its open large end pressed downward on a leaf, and the solution pumped into the intercellular spaces through the stomata. By using potted plants and tilting the pots on their sides, it was possible to inject the intercellular spaces of the leaves nearly full of the solution, then wash off with distilled water any surplus that might adhere to the leaves, without getting any of the solution into the soil.

In this way the effects were noted of supplying manganese to chlorotic spinach plants into the leaves through the stomata and also of supplying it to the soil. Equally prompt benefits were observed by both methods of treatment.

For this test six Wagner pots, each filled with about 10 kilograms of neutralized soil, were planted to spinach on April 20. On May 17, the plants had two to three leaves each and were very chlorotic. The pots were then arranged in pairs, each pair containing comparable plants. Then the plants in one of each pair of pots were treated with manganese sulphate solution. The treatments were as follows:

Pot No.	79	150 cc. solution of 50 p.p.m. of manganese poured on the soil.
" "	166	Control, no manganese.
" "	15	Injected 50 p.p.m. manganese solution into leaves of alternating plants; eight being injected, nine left untreated.
" "	36	Control, no manganese.
" "	78	Ten plants injected with 50 p.p.m. manganese solution, eight plants injected with 5 p.p.m. manganese solution.
" "	62	Control, no manganese.

On May 24, one week after treatment, the plants injected with 50 p.p.m. manganese solution were greener than the control plants and showed the greatest improvement. The plants injected with 5 p.p.m. manganese solution and those receiving manganese through the soil were also greener than the control plants, but not equal to those receiving 50 p.p.m. On May 31, it was noted that the plants which received 50 p.p.m. of manganese were greener, but smaller, than those receiving only 5 p.p.m.

On June 7, the plants were harvested and weighed green, with the following results:

Pot No.	Treatment	Number of plants	Green weight total	Green weight per plant	Per cent. increase over control
			gm.	gm.	per cent.
79	50 p.p.m. manganese on soil	13	85	6.5	51
166	Control	13	56	4.3	
15	Injected 50 p.p.m. manganese solution	8	57	7.1	29
15	No treatment	9	49	5.4	
36	Control	11	60	5.5	
78	Injected 50 p.p.m. manganese solution	10	60	6.0	20
78	Injected 5 p.p.m. manganese solution	8	57	7.1	42
62	Control	19	95	5.0	

The average weight of the control plants was 5.1

[5] Gilbert, Basil E., McLean, Forman T., and Hardin, Leo J., "The Relation of Manganese and Iron to Lime-induced Chlorosis." *Soil Science* 22: 437–446. 1926.

[6] Schreiner, Oswald, and Dawson, Paul R., "Manganese Deficiency in Soils and Fertilizers." *Jour. Ind. and Eng. Chem.* 19: 400–404. 1927.

[7] Darwin, F., and Pertz, D. F. M., "A New Method of Estimating the Aperture of Stomata." *Proc. Royal Soc.* London, Ser. B, No. B569: 136–154. 1911. Cited by Samuel F. Trelease and B. E. Livingston, "The Daily March of Transpiring Power as indicated by the Porometer and by Standardized Hygroscopic Paper." *Jour. Ecol.*, No. 14: 1. 1916. Abstract in SCIENCE, New Ser., 43: 363. 1916.

[8] McLean, Forman T., and Lee, H. Atherton, "Pressures required to Cause Stomatal Infection with the Citrus Canker Organisms." *Philippine Jour. Sci.* 20: 309–320. 1922.

grams, and of the treated plants 6.6 grams, the average increase due to the manganese being 30 per cent.

Manganese was apparently about equally effective whether injected into the tissues of the leaves or applied to the soil. Also, the control plants in Pot 15, which alternated with the injected plants in the same pot, were benefited neither in weight nor appearance by the treatment of the adjoining plants. So it is quite safe to conclude that this lime-induced chlorosis was cured by the action of the manganese within the body of the plant. The changes brought about in the soils by additions of manganese may be beneficial, but such changes were clearly not necessary for the recovery of the spinach in these experiments, while the injection of manganese solutions into the plants was clearly beneficial.

This method of injection of solutions into the leaf tissues through the stomata may be advantageously employed in the study of other diseases of plants suspected to be due to deficiency of soluble substances.

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SOUTHWESTERN ARCHEOLOGICAL CONFERENCE

ON August 29–31, 1927, there was held at the excavation camp of Phillips Academy, Andover, at Pecos, New Mexico, an informal gathering of workers in Southwestern archeology and related fields. There were present: C. Amsden, Southwest Museum; Monroe Amsden, Southwest Museum; Lansing Bloom, Museum of New Mexico; K. M. Chapman, Museum of New Mexico; H. S. Colton, University of Pennsylvania; C. B. Cosgrove, Peabody Museum of Harvard; Harriet Cosgrove; Byron Cummings, University of Arizona; A. E. Douglass, University of Arizona; Clara Lee Fraps, University of Arizona; Charlotte Gower, University of Chicago; O. S. Halseth, Arizona Museum; M. R. Harrington, Museum of the American Indian; E. L. Haury, University of Arizona; E. L. Hewett, Museum of New Mexico; Walter Hough, U. S. National Museum; N. M. Judd, U. S. National Museum, National Geographical Society; A. V. Kidder, Carnegie Institution and Phillips Academy; Madeleine A. Kidder; A. L. Kroeber, University of California; T. F. McIlwraith, University of Toronto; H. L. Mera, Indian Arts Fund; Paul Martin, Colorado State Museum; S. G. Morley, Carnegie Institution of Washington; Frances R. Morley; E. H. Morris, Carnegie Institution of Washington; Ann A. Morris; J. L. Nusbaum, National Park Service; Frank Pinkley, National Park Service; E. B. Renaud, University of Denver; Oliver Ricketson, Carnegie Institution of Washington; Edith B. Ricketson; F. H. H. Roberts, Jr., Bureau of American Ethnology; Linda Roberts; J. A. B. Scherer, Southwest Museum; H. Shapiro, American Museum of Natural History; Leslie Spier, University of Oklahoma; Erna Gunther Spier; H. J. Spinden, Peabody Museum of Harvard; J. B. Thoburn, Oklahoma Historical Society; T. T. Waterman, University of Arizona; R. Wauchope, University of South Carolina.

The purposes of the meeting were: to bring about contacts between workers in the Southwestern field; to discuss fundamental problems of Southwestern history, and to formulate plans for coordinated attack upon them; to pool knowledge of facts and techniques, and to lay foundations for a unified system of nomenclature.

The morning of Monday, August 29, was spent in inspecting the academy's excavations in the pre-Pecos site at Bandelier Bend, and in visiting the main Pecos ruin. Monday afternoon and the mornings and afternoons of Tuesday and Wednesday were devoted to the business of the meeting, less formal campfire gatherings being held each evening. On Thursday, September 1, several members of the group visited the excavations of the School of American Research at Puyé by invitation of Director E. L. Hewett.

In the preliminary discussions, special attention was paid to the classification of Southwestern culture-periods. There was entire unanimity in regard to the general nature of Southwestern culture-growth, *i.e.*, that its basic element, maize agriculture, was derived from the South; that from time to time certain other highly important elements such as cotton-growing, loam-weaving, and probably pottery-making, were also introduced from the same source; but that little more than the germ-ideas of these elements penetrated to the Southwest; and that the development of its culture was essentially autochthonous.

There was practical unanimity as to the course of development, *i.e.*, that agriculture was taken up by a previously resident, long-headed, nomadic or semi-nomadic people, who did not practice skull-deformation, and who already made excellent coiled basketry, twined-woven bags, sandals, and used the atlatl; but whose dwellings were of perishable nature. The newly acquired art of agriculture led to a more settled life and to the development of more permanent houses. For some time, however, pottery-making was unknown. At a later date pottery was introduced, or possibly independently invented, houses of the pit type were perfected, and became grouped into villages, and the bow-and-arrow began to supplant the atlatl. The long-headed race, however, still persisted.