Contrary to some statements, plants grown by the water culture method are not protected against diseases or insects attacking the aerial parts of plants. While the risk of strictly soil-borne disease can be ruled out, recent observations suggest that diseases peculiar to water culture may sometimes attack plants grown in nutrient solutions.

The results of our experiments confirm earlier views that the possibility exists of producing crops on a large scale by the water-culture method. The fact that yields and general quality of plant products are at least equal to those produced under extremely favorable soil conditions (admittedly not generally found) is considered of great interest, but no support was found for the assumption that the potentialities for crop production of a favorable nutrient solution medium far exceed those of a very fertile soil.

A sober appraisal of the commercial possibilities of the water-culture method should be based not on the expectation of fabulous yields, far in excess of any obtainable in soil, or unusual dietary qualities of plant products, but rather on the knowledge that under competent supervision very good crops could be produced in localities favored in climate and water supply, but where good soil is not available or when it is found too expensive to maintain highly favorable soil conditions. Also a water-culture medium when expertly supervised should be subject to more exact control than a soil medium. Other investigators have developed large-scale techniques for growing crops in inert solid media, such as sand and gravel.[7,8]

It must be clearly recognized that the application of the water-culture method for crop production will be limited primarily by economic considerations. What crops could be grown profitably by this method would depend on the value of the crop in the market served in relation to cost of production, which would include a large outlay for tanks and other equipment and materials, as well as special costs of supervision and operation. An important distinction must be made between field and greenhouse operations. It seems highly improbable, in view of the present cost of a commercial water-culture installation and its operation, that crops grown by this method could compete with cheap field-grown crops.[9] In greenhouses specializing in high-priced, out-of-season crops the method appears to have commercial possibilities. The expense of growing greenhouse crops in soil, including cost of equipment for sterilizing soils, may frequently stand comparison with the cost of growing crops by the water-culture method.

However, before any one undertakes to grow plants by the water-culture method, even in greenhouses, he should give the most careful consideration to the economic factors involved and to the need for expert guidance, in the absence of which commercial success is unlikely. The practical experience which many growers have acquired in growing plants in soil may prove of little avail in solving some unfamiliar problems of water-culture technique. It is suggested that those who contemplate installation of the water-culture method for commercial purposes make a preliminary test with a few tanks, to learn some of the requirements of the process.

The suggestion that important amounts of food could be produced economically in small-scale installations for home use has no sound basis, because of high costs of the installations and technical requirements for the successful use of the method.

The continued importance of the use of water-culture technique, as one important method of scientific experimentation in investigations of problems of plant nutrition, needs to be stressed. The development of large-scale water-culture techniques enhances the usefulness of the water-culture method as an experimental tool, by widening its scope of application to problems which involve growing plants to maturity on a large scale and under controlled conditions of nutrition.

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[7] H. M. Biekart and C. H. Connors, *New Jersey Agr. Exp. Sta. Bul.* 588, 1935.

[8] R. B. Withrow and J. P. Biebel, *Purdue Agr. Exp. Sta. Cir.* 232, 1937.

[9] Recently, popular journals have discussed a project for growing vegetables in tanks of nutrient solution, on Wake Island, in Mid-Pacific, to supply fresh vegetables (which constitute only a small proportion of the total food requirements) for the inhabitants of the island and for passengers of the Clipper airships. This, however, is a special case, and there is no reason to assume that it has any general agricultural significance.

THE CHORIO-ALLANTOIC MEMBRANE OF THE DEVELOPING CHICK AS A MEDIUM FOR THE CULTIVATION AND HISTOPATHOLOGIC STUDY OF PATHOGENIC FUNGI

ALTHOUGH the chorio-allantoic membrane of the developing chick has been used by numerous investigators as a medium for the cultivation and study of many bacteria, viruses, Rickettsiae and recently of a spirochete,[1] it has not been used extensively (as far as could be determined) for the study of fungi. Goodpasture[2] mentioned these micro-organisms in his Leo Loeb Lecture at the Washington University School of Medicine, on March 24, 1938, and in personal correspondence stated, "we have never made any consistent investigation of fungus infection in this host" (embryo chick). The purpose of this paper is to report briefly

[1] G. Morrow, J. T. Syverton, W. W. Stiles and G. P. Berry, SCIENCE, 88: 384, 1938.

[2] E. W. Goodpasture, *Am. Jour. Hyg.*, 28: 111, 1938.

the results of the successful inoculation of the chorio-allantois with fungi.

During the year of March, 1938, to 1939, work was started at Barnard Hospital to determine the possible virus etiology of a number of skin diseases, the causes of which are obscure. We have been equipped with the apparatus to carry on the technique of chick egg inoculation as practised in Goodpasture's laboratory and as elaborated by Goodpasture and Buddingh.[3] Dr. Floyd S. Markham, who has been carrying on the virus work, assisted in the inoculation of the chick membranes with fungi.

A wide variety of pathogenic fungi have been used, representing the causative agents of diseases which affect: (1) the superficial layer of the skin; (2) mucous membranes; (3) dermis and subcutaneous layers; (4) internal viscera. These organisms are known to produce pityriasis, superficial desquamations, localized granulomata, deep-seated ulcerative lesions, mucous membrane plaques; lymph stream invasion with dermic and subsequent epidermic involvement and visceral or generalized diseases. These microbes produce the following diseases: seborrheic dermatitis, tinea versicolor, endomycosis, geotrichosis, moniliasis, blastomycosis, coccidioidal granuloma, sporotrichosis, maduromycosis, trichophytosis, epidermophytosis, microsporosis, favus, cryptococcosis, paracoccidioidal granuloma, chromomycosis and actinomycosis.

The fertilized eggs used were 12 to 14 days old. Inoculations from cultures of the fungi were made directly on the chorio-allantoic membrane. The embryo lived from 4 to 11 days after inoculation, depending on the type of organism used. Macroscopically the diseases manifested themselves as thickened or thin, white, grayish or grayish-brown, confluent or discrete plaques on the membrane, depending again on the variety of fungus.

The infected membranes were fixed in Zenker's, embedded in paraffin, sectioned and studied. Histopathologically, the reaction of the tissue manifested itself in the form of nodules, ulcers, superficial growths and hyperplastic lesions, which were comparable in most instances to those seen in human infections. Further microscopic examination showed an increased activity in the membranes, as was evidenced by the intense infiltration, particularly with the invasive type of organism, of ectodermal cells, blood cells, fibroblasts, monocytes, accompanied in most cases by inflammatory changes in the mesoderm and marked edema at the sites of fungus growth. The thickening of the membrane in some cases was due to the cellular infiltrate, in others where the organism is known to produce granulomatous lesions, to the mat of mycelial elements of the fungus, but in most cases to the combination of both. Those membranes parasitized by *Monilia albicans,* in addition to the marked proliferation and hypertrophy of the ectoderm, showed, in the mesoderm, pearls of growth which correspond in human tissue to an increased hyperkeratinization. A degree of tissue specificity was also demonstrated in that fungi affecting mucous membranes and the superficial layer of the skin particularly involved the ectoderm, whereas those found affecting the dermis, subcutaneous layers and internal viscera seemed to affect in addition the entoderm and mesoderm. Intra-amniotic, intra-cerebral and body injections will be carried on to determine absolute specificity of tissues in the chick embryo to the various fungi.

The fungi stain very easily in section with methylene blue and eosine. In most cases the organisms revert to the forms seen in human lesions—their parasitic role. This reversion in morphology is complete with the yeast-like organisms in approximately 6 days, whereas with some filamentous forms it begins on the fifth day and is complete on the tenth or eleventh day.

In summary, it can be said, therefore, that the chorio-allantoic membrane of the developing chick can be successfully inoculated with pathogenic fungi. The organisms produce fatal mycoses with most microbes which in tissue response simulate closely human lesions, showing a degree of specificity as found in infection in man. This method, as contrasted with the use of standard laboratory animals, is much less expensive and, more significant than that, reduces the time elements from weeks or months to days. The inability to find suitable experimental animals or human volunteers enhances the value of the use of the chorio-allantois for fungous inoculations.

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[3] E. W. Goodpasture and G. J. Buddingh, *Am. Jour. Hyg.*, 21: 319, 1935.

THE TRANSMISSION OF LYMPHOCYTIC CHORIOMENINGITIS BY MOSQUITOES

ONE year ago a highly virulent spontaneous infection occurred among rhesus monkeys that were being used in this laboratory for the study of experimental malaria. The severity of the infection was such that eleven monkeys died in a week. The infection was characterized by dependent edema, serosanguineous nasal discharge, marked prostration and extremely rapid course. At death the outstanding gross abnormalities were partial consolidation of the lungs and an abundant collection of straw-colored fluid in the serous cavities. The causative agent of the epizootic was identified by Dr. Thomas Francis, Jr., as being the virus of lymphocytic choriomeningitis. Under normal conditions the mode of transmission of this disease, either in man or animals, is unknown, but since the