treatise and compendium for readers having a fairly comprehensive physical and mathematical background rather than as an introductory text. On the other hand, a knowledge of the technique of the new quantum mechanics (matrices, "Eigenwert" theory, etc.) is unnecessary.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A METHOD FOR COMPARING THE VALUE OF AMMONIA NITROGEN AND NITRATE NITROGEN[1]

IN a series of experiments, cotton plants[2] were grown in two nutrient solutions of practically identical chemical composition but only different in the sulphate ion concentration and form of nitrogen. One solution contained only ammonia nitrogen as diammonium hydrogen phosphate and ammonium sulphate; the other solution contained only nitrate nitrogen as potassium nitrate, as source of readily available nitrogen. The hydrogen ion concentration was adjusted in each solution to give a maximum yield of dry matter, and the hydrogen ion concentration of the nutrient solutions was then kept constant by mechanical stirring, by aeration and by constant solution renewal. A rate of flow of 1.4 cc per minute per plant was found sufficient for maintaining the hydrogen ion concentration of the solution practically constant around the roots of the cotton plants up to an age of six weeks.[3]

Experiments are now in progress to determine the maximum growth with minimum salt concentration (or osmotic pressure) using the salts given in the solution mentioned in this article.

Johnston and Hoagland maintained a rate of flow of 8 cc per minute per plant when growing tomato plants.[4]

Besides being practically identical in chemical composition, easily buffered by phosphates and nitrogen compounds, and a constant supply of nutrient solution to the roots, these solutions are easily prepared. By simply adding ammonium hydroxide or potassium hydroxide to the monocalcium phosphate in the solution, diammonium hydrogen phosphate and dipotassium hydrogen phosphate[5] are formed.

A mixture of monocalcium phosphate, dicalcium phosphate and dihydrogen potassium phosphate is formed in one case, and monocalcium phosphate, diammonium hydrogen phosphate and dicalcium phosphate in the other. The composition of the solutions in volume-molecular proportions is as follows:

Ammonia Nitrogen Solution		Nitrate Nitrogen Solution	
$Ca(H_2PO_4)_2$	0.0010	$Ca(H_2PO_4)_2$	0.0010
$(NH_4)_2SO_4$	0.00575*	KNO_3	0.0120
NH_4OH	0.0005*	KOH	0.0005**
$MgSO_4$	0.0020	$MgSo_4$	0.0020
K_2SO_4	0.0070	K_2SO_4	0.00075**

* These can be varied according to optimum hydrogen ion concentration.

** Varied to obtain maximum yield of dry matter.

The hydrogen ion concentration of the above solutions was pH 5.8. The osmotic pressure of the above solutions is approximately one atmosphere. Iron as ferrous sulphate was added as needed to keep plants green. By varying the amount of ammonium or potassium hydroxide the hydrogen ion concentration can be varied from pH 3.8 to above a pH of 6.5.

The salts formed by the addition of NH_4OH and KOH given above make these solutions contain:

Ammonia Nitrogen Solution		Nitrate Nitrogen Solution	
$Ca(H_2PO_4)_2$	0.00075 m	$Ca(H_2PO_4)_2$	0.00075 m
$(NH_4)_2HPO_4$	0.00025	K_2HPO_4	0.00025
$CaHPO_4$	0.00025	$CaHPO_4$	0.00025
$(NH_4)_2SO_4$	0.00575	KNO_3	0.01200
$MgSO_4$	0.00200	$MgSO_4$	0.00200
K_2SO_4	0.00700	K_2SO_4	0.00075

The maximum yield obtained from the ammonia-nitrogen solution at various hydrogen ion concentrations was compared with the maximum yield of dry matter of the plants harvested from the solution containing only nitrate nitrogen at various hydrogen ion concentrations. Thus a comparative value was obtained for ammonia nitrogen and nitrate nitrogen.

The following are identical with the above nutrient solutions with respect to the nutrient chemical elements with the exception of the sulphur content and containing mixtures of ammonia nitrogen and nitrate

[1] Published with the approval of the director of the Georgia Experiment Station as paper No. 29, Journal Series.

[2] The results will be reported in another article.

[3] J. W. Shive and A. L. Stahl, "Constant Rates of Continuous Solution Renewal for Plants in Water Cultures," *Bot. Gaz.*, 84: 317–323. 1927.

[4] E. S. Johnston and D. R. Hoagland, "Potassium Required by Tomato Plants," *Soil Sc.*, 27: 89–109. 1929.

[5] D. E. Prianishnikov and M. K. Domontovitch, "The Problem of a Proper Nutrient Medium," *Soil Sc.*, 21: 327–348. 1926.

nitrogen. These solutions contain the following chemical compounds in volume-molecular proportions: mono-calcium phosphate, ammonium hydroxide, ammonium sulphate, potassium nitrate, magnesium sulphate and potassium sulphate. For 25 per cent. nitrate nitrogen, .0010, 0.0005, 0.00425, 0.0030, 0.0020 and 0.00575 respectively; for 50 per cent. nitrate nitrogen, 0.0010, 0.0005, 0.00275, 0.0060, 0.0020 and 0.00425 respectively; for 75 per cent. nitrate nitrogen, 0.0010, 0.0005, 0.00125, 0.0090, 0.0020 and 0.00275 respectively. The hydrogen ion concentration of these solutions can also be varied by varying the amounts of ammonium hydroxide and ammonium sulphate.

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A NEW TYPE OF RESPIRATION CHAMBER

In connection with the cold storage investigations which have been carried on by the pomology section of Iowa State College considerable study has been devoted to the respiratory activity of fruit held under various conditions of maturity, humidity and temperature. In the past, the respiration chambers which were used consisted of desiccators, bell-jars, Bruehl receivers and galvanized iron containers. None of these was entirely satisfactory. A review of the literature on respiration also showed that respiration chambers used by other investigators were often a source of error due to lack of capacity or efficiency.

The respiration studies which were to be carried on during the apple storage season of 1928–1929 demanded the use of a glass chamber of large capacity. Glass was essential for observation of the progressive development of various storage troubles. Correspondence with a number of manufacturers brought forth the information that suitable chambers of about five-gallon capacity with necessary tubulatures, lid openings and ground glass seals could be made for about $100 a dozen provided a mold was constructed at an additional cost of $100 to $150. It can be readily seen that the above figures made the cost almost prohibitive for extensive work with a limited current expense budget.

Finally the writers discovered in a grocery store a wide-mouthed five-gallon pickle bottle which looked promising. Bottles of this type were finally purchased at a price of $2 each. The pickle bottle was transformed into an efficient respiration chamber by making certain alterations as shown in Fig. 1. A hole large enough to insert a No. 10 rubber stopper was cut through the lacquered metal lid. In order to prevent the sharp edges from cutting into the stopper a metal collar was soldered around the opening as shown in No. 4, Fig. 1. The lid was made air-tight with a rubber gasket cut from 1/16-inch sheet rubber packing. This gasket was glued to the inner surface of the lid with tire patching cement. Then when a rubber stopper was inserted into the openings and the lid screwed down tightly repeated tests showed that the bottle was air-tight. As an extra precaution a heavy coating of vaseline was always applied to the edges of all openings when the bottles were in use. The suction connections were made from $\frac{1}{4}$-inch copper tubing and were installed as indicated in Fig. 1. The tube which took the carbon dioxide-laden air from the bottom of the chamber was bent to the shape of the side of the bottle in order to facilitate the insertion and placing of the material to be studied.

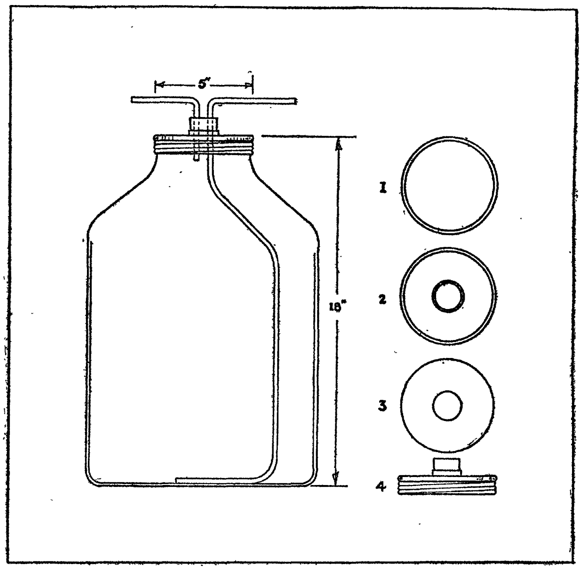

Fig. 1. Details of respiration chamber as developed from five-gallon pickle jar.

The most important feature of the pickle bottle was the five-inch mouth opening which permitted easy insertion of the hand and arm for the proper placing of the fruit or other materials. When used as a container for apples, the chamber held about seventy $2\frac{3}{4}$-inch to 3-inch specimens, or approximately 8,500 grams. In addition to the details shown in Fig. 1, the bottle was equipped with a heavy wire handle. From the standpoints of economy, efficiency and convenience, the respiration chamber gave satisfaction in every respect and was an improvement over the types of apparatus previously used in the work. At the present time several departments of the institution have adopted the pickle jar for use in various respiration experiments.

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