APPARATUS FOR AERATING PLANTS.

BY

F. M. Andrews.

I have made use of the well known Bunsen pump with some additions or modifications for the purpose of aerating water cultures. Sometimes I have used it for aerating cultures not grown in water also with good results. In a previous paper[1] I have shown the advantageous effect that the passing of air through a water culture has on the plant. A like beneficial effect was also found when air was passed through soil in which the corn plant was growing. In the paper just referred to the Kekulé apparatus as described by Ostwald was also used for some experiments with equally favorable results. Of the Kukulé and Bunsen apparatus for the purpose of aerating the latter, as I arranged it, will furnish by far the greater amount of air to be passed through a culture. So far as convenience is concerned, however, in other respects there is the further advantage of the Bunsen apparatus in that much less space is required to operate it. The perpendicular tube which conveys the chain of bubbles of air and water downward must be of such a length that the sum of the lengths of the short columns of water in this perpendicular tube between the columns of air will more than equal the depth of the solution through which the air is to be passed. This necessitates a perpendicular tube of considerable length. In the Kukulé apparatus I used the perpendicular tube has a length of 120 cm. while the culture solution had a depth of only 20 cm. Of course the length of the perpendicular tube and the speed with which the chain of air and water will pass through it can be made to depend somewhat on the length of the single columns of water for sometimes these columns of water are short and sometimes long depending on the quantity of water which enters the tube in the form of individual drops. Another drawback to the Kekulé's apparatus is that the perpendicular tube is often rapidly clogged completely with algae of various kinds, mostly those belonging to the Cyanophyceae, and with iron deposits as well as some sediment. In the Proceedings of the Indiana Academy of Science for 1916 Mr. C. C. Beals[1], who carried out a piece of work on aeration under my direction, has shown a brief sketch of the Kekulé apparatus. At b in his diagram he shows the perpendicular tube in question. In order to form bubbles readily this tube as arranged should not be over 4 mm. in diameter. This smallness of size of the tube, however, contributes to the accumulation and stoppage of the tube. The algae as well as the iron can be quickly cleaned out of the tube by using 50% or 60% HCl. Weaker strengths as 10% and 15% HCl were tried at first to clean the tube but they were not effective. Experiments are in progress to try to prevent this troublesome phase of the accumulation of material in the tube. Its stoppage often occurred in a few days; at other times in two weeks. This necessitated the disconnecting

[1]The Effect of Soaking in Water and of Aeration on the Growth of Zea Mays. Bulletin of the Torrey Botanical Club, 1919, Vol. 46, PP. 94-100.

[1]Beals, C. C.—The effect of Aeration on the Roots of Zea Mays. Proc. nd. Acad. of Science. 1916, P. 177.

of the apparatus to effect the cleaning. The bubbles produced by the Kekulé apparatus as well as that by Bunsen should be as small as possible. However, it is not possible to constrict the submerged end of the tube much, otherwise the resistance to the passage of the bubbles and the water necessary to convey them will be so great as to prevent a sufficiently rapid flow. The Kekulé appartus while useful for airing a few cultures, is too small to furnish sufficient air for a series having a large number of cultures. I have therefore used for airing a series of seven or more cultures the Bunsen apparatus above referred to. The pump portion of the Bunsen apparatus was constructed by using the ordinary form of a large sized Chapman's brass air pump. For the tube below the Chapman pump I used an old condenser which had been broken and which had a diameter of about 5 cm. This I cut off so that it had a length of 45 cm. leaving near the end one of the lateral tubulares for the escape of air from the apparatus. This length of tube gave a column of water of sufficient height to easily force the air through the water culture solution in the 1.5 L capacity culture jars in which the depth was 20 cm. From the Bunsen appartus arranged as just described I conducted the air through a lead tube having a bore of .5 cm. and an external diameter of 1 cm. a distance of about 11 meters to the water cultures. These cultures, in many cases 14 in number, were placed about the center of the greenhouse in order to obtain the best light; otherwise they would have been placed nearer the pump. In order to prevent any possibility of water being blown over from the pump into the cultures a bottle was arranged so that the air passed into it and then out at the top before entering the cultures. This acted as a catch basin or pocket for the water in case any should pass through the lead pipe. In the use of the apparatus thus far, however, I have not observed that any water has been carried over to the bottle. This is probably because the lead pipe rises to a height of 2 meters or more before the air enters the cultures. If water should enter the culture solution after passing through the lead pipe it would, of course, be poisonous to the plants. If water should pass from the Bunsen pump so used to the water culture, it would be less poisonous to the plants than if it were distilled water, because as distilled water it is in the form of hydroxide of lead and would contain more lead, whereas in the case of natural water it is then in the form of carbonate of lead, which is less soluble and would contain less lead.

In the form of the apparatus as first used to distribute the air to the individual jars containing the culture solution I used a piece of cypress 5 cm. broad by 55 cm. long which carried two rows of T-tubes having seven T-tubes in each row. The cypress board was perforated with holes which allowed the central arm of each set of seven T-tubes to project through the board on each side. These T-tubes were connected with one another and to the glass tubes that conveyed the air down through the culture solutions by rubber tubing. There were in all about 45 rubber tube connections. These were troublesome to keep free from leaks owing to the cracking of the rubber tubing. The life of the rubber tubing in such situations as here used varied from one to several weeks. To obviate at least part of this difficulty I selected a heavy brass tube having an inside diameter of 1.5 cm. and a length of 120 cm. Into this tube directly opposite one another were threaded air tight small brass tubes having an internal diameter of 4 mm. an outside diameter 7 mm. and a length of 55 mm. This tube was supported at the center, between two rows of water cultures, by a ring-stand. This arrangement eliminated the breakage that often occurred with the glass T-tubes and by being fastened together in one piece it also eliminated 27 of the 45 rubber tubing connections, besides being more convenient in other ways as to neatness, compactness, etc. The Bunsen pump as I have it arranged and when working at full capacity will send through the above mentioned tubes 4 liters of air per minute overcoming at the same time the resistance offered by a column of water 20 cm. in depth. This would amount, if the pressure of the water mains remains constant, to 240 liters per hour or 5,760 liters per day when the pump continues to work at full capacity. As, however, only about one liter per hour was generally used, at this rate, about 240 separate cultures could be aerated simultaneously with this apparatus if properly arranged and adjusted. This will depend, as before mentioned, somewhat on the size of the glass tubes which conduct the air through solutions in the culture jars. If these tubes are very small or much constricted at the end so as to make small bubbles, which is desirable, so much back pressure will be generated in moving a large quantity of air that most of it will escape at the pump. In my experiments so far, however, only about seven to fifteen cultures have been aired at once and such a size of tubes used that the difficulty just mentioned did not occur.

A STUDY OF POLLEN II.

BY

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Since the appearance of the first of these two accounts on investigations made on pollen of various kinds, further studies have been in progress in order to study some of the points there indicated on a greater number of plants. In the first paper which appeared in 1917 I had investigated 435 plants. Since that time I have extended my study of the pollen so that now I have investigated 508 plants. This list of phanerogams include plants of many and distantly related families all of which have been subjected to the same conditions in order to ascertain how their pollen would behave. All of the pollen of these plants, as in the first paper, have been put under favorable cultural conditions in cane sugar. This medium was supplied to them in solutions of different strengths from weak to strong. Of the 73 plants so investigated since my first account appeared in 1917, about the same proportion of plants showed a response as there indicated.