

INEXPENSIVE EQUIPMENT FOR MICRONUTRIENT ELEMENT STUDIES WITH PLANTS

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INTRODUCTION

In studies of deficiencies of micronutrient elements of plants, other than boron, the use of Pyrex containers has generally been advocated. The cost of such containers, however, is often prohibitive under conditions of limited budget, when extensive replication is desired, or where it is necessary to use very large vessels. Another serious consideration in the use of Pyrex is the replacement cost. In recent years reports have appeared which indicate that certain plastic containers can be used in micronutrient investigations (Dozer and Dole, 1952; Hewitt, 1952; Odhnoff, 1957). Containers of polyethylene appear to be quite suitable and have the advantages of being less fragile and less expensive than Pyrex ware. They have the disadvantage of Pyrex of permitting light transmission through the walls, necessitating the use of opaque material around them. Some polyethylene containers are manufactured which appear to be sufficiently opaque, but the vessels of this type tried by the authors have been found unsatisfactory because of leaching of the opaquing pigment into the nutrient solution.

A technique making use of polyethylene in the form of thin-walled bags (thickness of about 0.0015 inch) has been used by the authors over a period of several years and

been found satisfactory for studies with several of the micronutrient elements. This paper describes such a method.

Polyethylene bags were placed inside of rigid, opaque vessels. Containers which we found quite satisfactory and readily available were 46-fluid-ounce, fruit-juice cans (Fig. 1). Cans of this size have sufficient volume to permit plants to be grown for an extended period of time. Several small holes were placed in the bottom of each can so that any leaking bags could be detected.

Into such cans were placed bags measuring 5 or 6 inches wide, with a 3-inch gusset, and 15 inches long (commonly listed as a 5 (or 6) by 3 by 15-inch bag). Although the bags are sealed at the bottom, it was found that the weight of the nutrient solution was sometimes sufficient to break this union. To prevent leakage at this bottom seam several techniques were tried but the simplest and most satisfactory proved to be a tight overhand knot in the bottom of the bag (Fig. 1). After the bag was placed in the can and filled with nutrient solution, the polyethylene extending above the top of the container was folded down to prevent contamination of the solution from the edge of the can (Fig. 2). The bags were used as obtained from the distributor with no attempt being made to clean them before use.

Numerous materials have been

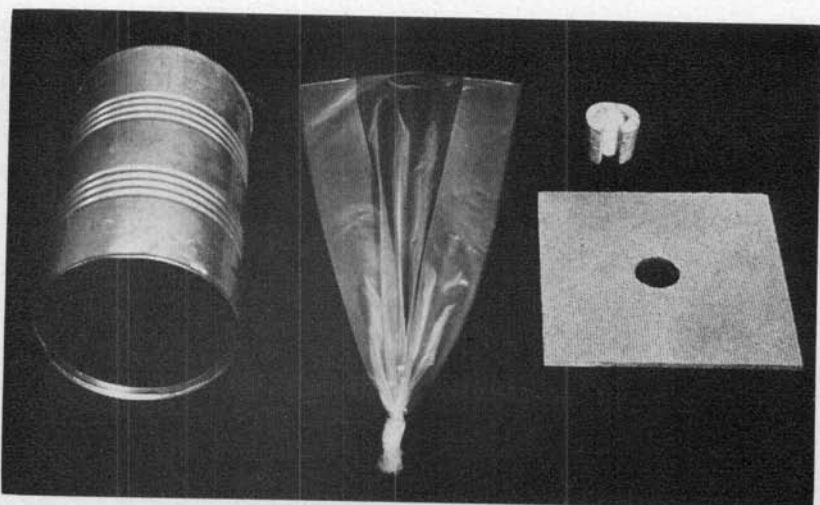


FIG. 1.—Component parts of equipment used in micronutrient element studies, (left to right) 46-fluid-ounce can, polyethylene bag knotted at bottom, cover, and cork.

used for the construction of container covers (Hewitt, 1952); we found $\frac{1}{8}$ -inch tempered hardboard (Masonite) satisfactory. Square covers were cut large enough to extend over the edge of the container about $\frac{3}{4}$ inch. A 1-inch hole was drilled in the center and the covers were then waterproofed with varnish (Waterlox). A No. 12 cork, in which was drilled a $\frac{1}{2}$ -inch hole, was halved with a sharp knife and the two pieces were hinged on one side with masking tape (Fig. 1). The plant was held in the cork with loose non-absorbent cotton (Fig. 2).

There were two reasons for the use of a top of the type described above. First the large hole in the cover permits the plant's root system to be passed through the cover without excessive root damage. Second, since the covers are relatively thin and offer little support for the plants once they attain much height,

the corks serve as guides to keep the plants in an upright position.

The macronutrient solution used was Hoagland and Arnon's No. 1 (1950). In studies of boron, reagent grade chemicals and demineralized water were used in the preparation of the nutrient solutions. For experiments with other micronutrient elements the solutions were prepared with stock salt solutions, purified according to the procedure of Stout and Arnon (1939), and demineralized water. Boron deficient solutions were stored in soft glass containers and all others in Pyrex carboys. These solutions could have been stored in large vessels lined with polyethylene. Micronutrient elements were added to the nutrient solutions in the amounts recommended (Hoagland and Arnon, 1950). Iron was normally added in a chelated form (salt of ethylenediamine-tetraacetic acid).

RESULTS AND DISCUSSION

Using the technique described, deficiency symptoms for iron, boron, manganese and/or zinc have been produced in: basswood, *Tilia americana* L.; cocklebur, *Xanthium pennsylvanicum* Wallr.; corn, *Zea mays* L.; cotton, *Gossypium hirsutum* L.; red kidney bean, *Phaseolus vulgaris* L.; spinach, *Spinacia oleracea* L.; and sunflower, *Helianthus annuus* L. Although attempts have not been made to produce deficiency symptoms of copper or molybdenum, it appears likely that with the proper precautions this technique also offers promise in studies with these elements.

The low cost of the equipment described makes studies of micronutrient elements feasible, even with a meager budget. In our experience the cost of the bag and materials for construction of the top was less than ten cents.

The polyethylene bags were very inexpensive, costing only about two percent of the price of a rigid polyethylene container. Such bags may be purchased from several laboratory supply houses and a number of local stores, where they are sold as refrigerator or frozen food bags. Because of their low cost, the authors routinely discard bags after using them once; employing new bags each time was found to be less expensive than cleaning used ones.

Since polyethylene bags can be purchased in a multitude of sizes, this technique can be adapted to use with vessels of any size desired. If very large tanks are used, polyethylene sheeting can be purchased and liners fabricated by the user.

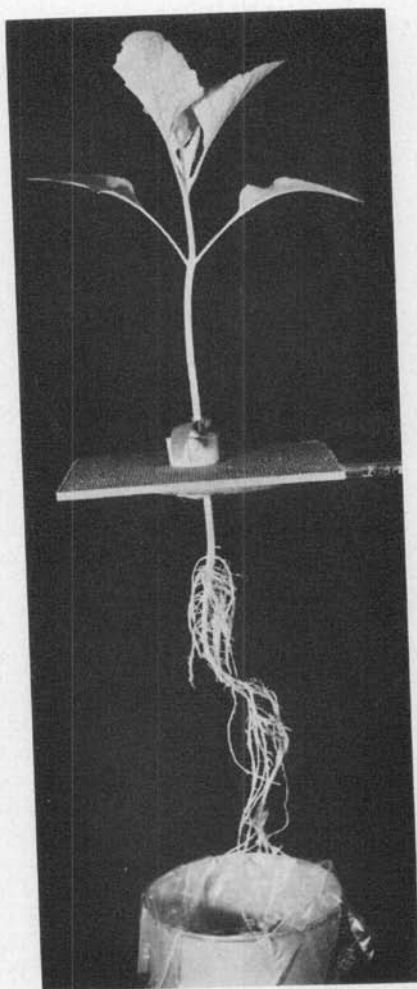


FIG. 2.—Experimental setup showing an iron-deficient, cocklebur plant. Cover and cork holding plant elevated to show polyethylene bag inside of can.

Not only does this method seem to offer distinct advantages in micronutrient element experiments, polyethylene bags (or sheeting) can also be used to line containers which might yield toxic products to the nutrient solution in macronutrient

studies. Therefore, any container which has sufficient rigidity and satisfactory opaque qualities can be lined with polyethylene and used in nutrient studies with plants.

It should be pointed out that since numerous companies manufacture polyethylene bags it is possible that various brands or lots of bags may differ in their utility for micronutrient work. An advisable precaution, therefore, before extensive experimentation is undertaken using the technique described, would be a preliminary study to insure that the bags have not been contaminated with micronutrients in the manufacturing process.

ACKNOWLEDGMENT

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SUMMARY

Inexpensive equipment for use in micronutrient element studies with plants is described. This technique makes use of rigid, opaque containers lined with thin polyethylene bags. With the method indicated, deficiency symptoms of iron, boron, manganese, and zinc have been produced in a number of plant species.

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