damage occurs and the character of the damage, as previously described, will provide an estimate of toxicity of equivalent weights of the standard and the new herbicides.

Attention is called to the convenience and economy in the use of *Lemna minor* for estimating the phytocidal action of chemicals where a large number of tests are needed and where cost and availability of chemicals are important considerations. This plant may be useful as physiological test material in assaying the potency of commercial preparations of weed killers, particularly those containing organic poisons not easily determined by conventional methods of chemical analysis. Results of toxicity tests on duckweed should be directly applicable to practical problems in the control of aquatic plants.

References

1. Beal, J. M. *Bot. Gaz.*, 1944, **105**, 471.
2. Fromm, F. *Science*, 1943, **98**, 391.
3. Hamner, C. L., and Tukey, H. B. *Science*, 1944, **100**, 154.
4. Hessenland, M., Fromm, F., and Saalmann, L. *Angew. Chem.*, 1933, **46**, 577.
5. Mitchell, J. W., and Hamner, C. L. *Bot. Gaz.*, 1944, **105**, 474.
6. Offord, H. R., and d'Urbal, R. P. *J. agric. Res.*, 1931, **43**, 791.

Tributyl Phosphate as a Solvent for Preparing Concentrated and Oil-miscible Solutions of 2,4-Dichlorophenoxyacetic Acid and Similar Substances[1]

W. B. Ennis, Jr., Lt., H. E. Thompson, Lt. (j.g.), and H. H. Smith, Lt., USNR

Camp Detrick, Frederick, Maryland

Concentrated solutions of many difficultly-soluble growth-regulating compounds for use in oil solutions may be prepared by the use of tributyl phosphate.

During the past few years much attention has been given to the use of 2,4-dichlorophenoxyacetic acid as a plant growth regulator and weed killer. For practical use in sprays, this compound, and others of a similar nature, must be used with a diluent or carrier. This acid is only slightly soluble in water, and attempts to dissolve it directly in inexpensive mineral oils, such as kerosene and fuel oil, have been unsuccessful. In an effort to find a suitable co-solvent of 2,4-dichlorophenoxyacetic acid for use in mineral oils, over 50 of the more common organic solvents were tested, and of these only tributyl phosphate proved satisfactory. The others were found to be unsuitable either by reason of insufficient solvent power, immiscibility with oil, or undesirable volatility. The co-solvent ability of tributyl phosphate in this combination is a critical property of this compound, since closely related substances such as triethyl phosphate and tricresyl phosphate are unsatisfactory.

At ordinary temperatures tributyl phosphate will dissolve up to about 36 per cent, by weight, of 2,4-dichlorophenoxyacetic acid. A range of from 5 to 36 per cent of the compound dissolved in tributyl phosphate was found convenient and useful for subsequent dilution with mineral oils. Best results have been obtained with solutions in which the ultimate concentration of 2,4-dichlorophenoxyacetic acid was from 0.5 to 5.0 per cent by weight after dilution of the tributyl phosphate solution with kerosene or low-grade fuel oil.

The solutions of 2,4-dichlorophenoxyacetic acid and tributyl phosphate are stable at ordinary temperatures, have no heat of solution when dissolved in mineral oils, and are miscible with them in all proportions. In addition, tributyl phosphate causes local burning of plant tissues at points of direct contact, which, for herbicidal purposes, may be desirable. There is evidence that greater inhibition, per unit weight of compound, is produced in some broad-leaved plants when 2,4-dichlorophenoxyacetic acid is applied in oil solutions containing tributyl phosphate than when the acid is applied in the form of aqueous solutions. It is not known whether the increased inhibitory effectiveness of such solutions is due to the contact injury produced by tributyl phosphate.

Tributyl phosphate also has been found to be capable of dissolving large amounts of 2,4,5-trichlorophenoxyacetic acid, para-chlorophenoxyacetic acid, 2-methyl-4-chlorophenoxyacetic acid and other substituted phenoxyacetic acids. In general, 2,4-dichlorophenoxyacetic acid can be replaced with equivalent amounts of one of the three compounds named above. This solvent likewise is useful in preparing concentrated solutions of mixtures of such compounds for use as such or in oil solutions.

[1] Studies conducted at Camp Detrick from January to September 1945, under the direction of Dr. A. G. Norman.

Treatment of Muck and Manure with 2,4-Dichlorophenoxyacetic Acid to Inhibit Germination of Weed Seeds[1]

C. L. Hamner, J. E. Moulton, and H. B. Tukey

Department of Horticulture, Michigan State College, East Lansing

Herbicidal sprays containing 2,4-dichlorophenoxyacetic acid have been used to destroy noxious plants (*2, 3*). Aqueous sprays at 1,000 ppm are selective in

[1] Journal Article 787 (N.S.) from the Michigan Agricultural Experiment Station, accepted for publication December 1945.