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EXPERIMENTS IN THE SOCIAL SCIENCES[1]

By PROFESSOR HAROLD F. CLARK

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CAN you experiment in the social sciences? With the help of the Sloan Foundation and several universities, I have had the chance to try to get a partial answer to the question. What have we learned from these efforts regarding the limits of experimentation in the social sciences? Does experimentation offer any promise of throwing light on complicated social problems? Before we turn to our efforts at experimenting let us briefly review something of the history of science and see if we can obtain any light on the problem.

Animals hibernate in the mud at the bottom of streams in the winter. That is obvious; the animal is here in the fall, he is here in the spring. He must have gone in the mud. At least some of the greatest minds in the world said so only a little over two thousand years ago.

Every one knows that the way to cure a person of witches curse is to rub his head with ground-up bodies of dried wasps. So, at least, said some of the great medical authorities of the middle ages.

Rosen, in his recent book on "Hollywood," says many of the famous actors and actresses believe in the magic of numbers. One particular actor would never go on the stage unless the number of steps was exactly nine. He knew he would hurt himself if it was any other number. One day the studio built a set with ten steps on it. The actor insisted the steps be changed to nine. They were. That day he fell down

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[1] Address of the vice-president and chairman of Section Q—Education, American Association for the Advancement of Science, Cleveland, Ohio, September 12, 1944.

bisulfate was used as an activator, a white precipitate of the parent dinitro-*o*-cresol was formed which, applied in suspension, proved as toxic as the solution containing the ammonium salt.

From a number of exploratory experiments involving testing of some fifty nitro and chloro compounds of benzene, phenol and various substituted phenols[3] the following generalizations seem warranted. Toxicity to plants increases through the series benzenes, phenols, substituted phenols. Dinitro compounds are more toxic than nitro, chloro or nitro-chloro compounds. Ortho substituted salts are more toxic than meta or para. Of the dinitrophenols tested, aliphatic chain substitutions were more toxic than cyclic or aromatic. The 2,4 dinitro compounds of phenol, *o*-methyl, *o*-ethyl, *o*-isopropyl, and *o*-secondary butyl phenol respectively increase in toxicity in the order named. The *o*-amyl substituted compound drops off in toxicity. The ammonium salts of these phenols are soluble enough in water to serve as effective herbicides. The parent dinitro phenols are very slightly soluble in water, but their solubility in oil increases with increasing length of the substituted aliphatic chain. Dinitro phenol is too low in solubility in oil to be of use as a herbicide. Dinitro-*o*-cresol is soluble to about 5 per cent. and has been used as a fortifying agent in diesel oil for weed killing. Because of its high toxicity the secondary butyl compound is more effective, and its relatively greater solubility in oil enhances its value. Table 1 presents toxicity, solubility and composition data on these compounds. Toxicity of the ammonium salts in aqueous solution roughly parallels that of the parent compounds in oil.

In seeking an explanation for the increasing toxicity of the dinitro compounds of substituted phenols it seems that the increasing solubility in oil may offer a clue. As the substituted aliphatic chain becomes longer it influences to an increasing degree the chemical properties of the molecule (*Cf.* Table 1, column 4), the latter becoming more oil-like. In general, substances soluble in lipoids pass readily through cytoplasmic membranes, and penetration of the aliphatic chain into the cytoplasm may well bring about intimate contact with the toxic nitro groups. Toxicity reaches a maximum with the butyl substitution; as longer chains are added, the toxic effect of the nitro groups is apparently "diluted."

The first four compounds listed in Table 1 are solids at ordinary temperatures. The secondary butyl phenol melts at about room temperature, and the amyl compound is liquid at temperatures above −5° C.

Over three million gallons of fuel oil have been used annually in California alone for control of weeds. By mixing dinitro-*o*-secondary butyl phenol in such an oil at a concentration around 5 to 10 per cent. and adding emulsifiers so that the mixture will form a fairly stable ready-mix type of emulsion, a general contact herbicide can be made that would require only 3 to 6 per cent. oil. Such a mixture would effect a saving of over 90 per cent. of the oil that has been used for weed control; it will kill certain oil-tolerant weeds that are not ordinarily controlled; and, if made up in sufficient quantities, it should not exceed oils in cost. Mixed, as suggested above, it makes a concentrated stock solution that may be emulsified with water in the field. This saves hauling costs that are high with oils. The materials are not dangerously inflammable; the poison hazard is much less than with arsenic, livestock not being attracted by the taste as they are by sodium arsenite.

TABLE 1

SOLUBILITY IN OIL AND RELATIVE TOXICITY* OF DINITRO COMPOUNDS

Chemical	Solubility† in kerosene, at 20° C	Toxicity	$\frac{\text{Chain Wt.}}{\text{Total MW}} \times 100$
	per cent. (approx.)		
Dinitro phenol	0.14	38	0.0
Dinitro-*o*-cresol	0.58	64	7.5
Dinitrol-*o*-ethyl phenol	2.39	75	13.6
Dinitro-*o*-isopropyl phenol	3.43	90	18.9
Dinitrol-*o*-secondary butyl phenol	miscible	100	23.6
Dinitro-*o*-secondary amylphenol	miscible	90	27.8

* Toxicity in arbitrary units has been calculated to a basis of 100 per cent. for dinitro-*o*-secondary butyl phenol, the most toxic of the six compounds. This would require concentrations of approximately 0.5 per cent. on grasses and 0.125 per cent. on broad-leaved weeds if applied in non-toxic oil or oil emulsion under the conditions of these experiments.

† Solubility is higher in more polar solvents. The aromatic and olefin contents of petroleum fractions largely determine their solvent power for the nitrophenols.

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[3] These chemicals were kindly furnished by the Dow Chemical Company and Standard Agricultural Chemicals, Inc.

BOOKS RECEIVED

BONHAM, H. J. *Aids to Botany.* Second edition. Illustrated. Pp. viii + 215. Baillière, Tindall and Cox, London. $1.75. 1944.

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Reports of the Biochemical Research Foundation of the Franklin Institute: Vol. VII, 1942–43. Illustrated. The Institute.

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