action, apparently not seriously affecting most grasses. Seeds of many plants, including grasses, can be destroyed by treatment with 2,4-dichlorophenoxyacetic acid. Concentrations as low as 1 ppm have a marked effect on germination and growth (*1*), and concentrations at 10 ppm will inhibit the germination of seeds of many plants. Although grass seeds are killed readily by 2,4-dichlorophenoxyacetic acid, high concentrations are required.

Muck soils and composted manure are frequently heavily infested with weed seeds. This suggests treatment of muck and manure to reduce the weed population. The importance of weed control is accentuated by the garden and truck crops commonly grown in muck and which require much hand weeding.

Muck soil in the vicinity of East Lansing, Michigan, was collected for treatment. The muck was placed in metal flats, and treatments were prepared at 1, 10, and 100 parts of 2,4-dichlorophenoxyacetic acid to 1,000 parts of muck. The 2,4-dichlorophenoxyacetic acid was applied to the muck in solution, a water-soluble preparation being used which contained 70 per cent of 2,4-dichlorophenoxyacetic acid obtained from the Dow Chemical Company. The concentrations were such as to give .01, .1, and 1 gram of 2,4-dichlorophenoxyacetic acid per square foot. After treatment, the muck flats were kept in a warm greenhouse at 60° to 80° F.

Two weeks after treatment, such weeds as lamb's-quarters (*Chenopodium album* L.), sow thistle (*Sonchus arvensis* L.), purslane (*Portulaca oleracea* L.), foxtail (*Setaria lutescens* Hub.), and redroot (*Amaranthus retroflexus* L.) began to appear in the untreated flats and to a much lesser degree in the flats containing 1 ppm of 2,4-dichlorophenoxyacetic acid. No weeds appeared in any of the flats treated at either 10 or 100 ppm of the chemical.

In order to test the residual effect in the soil, four weeks after treatment, bean and pea seeds were planted in the flats that had been treated at 10 and 100 ppm of 2,4-dichlorophenoxyacetic acid. The seeds germinated, and the plants grew normally.

In trials with 2,4-dichlorophenoxyacetic acid on manure, seeds of rape, rye grass, field pea, brome grass, meadow fescue, creeping bent grass, orchard grass, hairy vetch, and alsike clover were added to the manure in large numbers to insure their presence. The manure was then divided into three lots. One lot was treated at 10 ppm with 2,4-dichlorophenoxyacetic acid, a second was treated at 100 ppm and a third was left untreated as a check. The manure was then mixed with sand, the final mixture being about one part of manure to two parts of sand. The mixture was placed in metal flats and kept moist in a warm greenhouse. After three days, seeds in the control lot began to germinate, and after two weeks the surface of the mixture was covered with plant growth. The germination of seeds in the treated flats at 10 and 100 ppm was greatly inhibited, only a few of the grasses appearing in the 10 ppm flat.

Treatment with 2,4-dichlorophenoxyacetic acid is suggested as a method of controlling weed seed in manure and muck soils and where these materials are used in top dressings of lawns and golf courses. This treatment may also be of special value in conditioning nursery, tobacco, and other seed beds before planting.

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Herbicidal Action of 2,4-Dichlorophenoxyacetic Acid on the Water Hyacinth, *Eichornia crassipes*

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The water hyacinth, *Eichornia crassipes*, is a native of Japan and was carried about 70 years ago to South America, where it became widespread in fresh-water streams and lakes. At the International Cotton Exposition, held in New Orleans in 1884 (*1*), the Japanese government representatives gave away as souvenirs water hyacinths they had imported from Venezuela, where this pest had practically "taken over" the lower Orinoco. Very shortly thereafter the plant was introduced into Florida. Because it propagates prodigiously by both seeds and offshoots and matures two and sometimes three crops in a single season it presents a real problem in Florida and other subtropical regions, clogging the waterways, drainage ditches, and lakes.

Hildebrand and Palmiter (*3*) successfully employed the ammonium sulfamate herbicide for combating the *Prunus virginiana* wild host of the yellow-red virus disease of peach. Gowandloch (*1*) reviewed the various methods (chemical control, control by flame thrower, mechanical control, biological control) that have thus far been tried for water hyacinth control. He tested ammonium sulfamate and sulfamic acid for eradicating the water hyacinth and found that these killed only the plant parts above water.

Zimmerman and Hitchcock (*6*) developed some of the growth substances that may be toxic to plants in concentrations greater than that used to secure desirable responses such as rooting. Some of the more potent of these compounds are the substituted phenoxy

compounds, one of which, 2,4-dichlorophenoxyacetic acid (2,4-D), has received considerable attention as a herbicide.

Hamner and Tukey (*2*) reported on the herbicidal action of 2,4-D on bindweed, *Convolvulus arvensis*, and on a number of other plant weeds. They also found the related compound, 2,4,5-trichlorophenoxyacetic acid, showing promise as a herbicide. In this and in subsequent study by others (e.g. *4, 5*), 2,4-D worked best on broad-leaved plants.

In April 1945 the writer first tested 2,4-D (1:1430) for eradicating the water hyacinth in a flowing stream of water. In preliminary trials promising results were obtained by spraying with a knapsack sprayer from the shore. Three areas, each involving several hundred plants, were treated. The amount of material employed was about one gallon per 100 square feet for plants about 15 inches tall. One week after application the upper parts were epinastic and discolored. By the end of two weeks both the above- and below-water parts were nearly all dead, the stems separating from the roots, and the dead parts disappearing in the stream either by sinking or floating away within three weeks.

In the second experiment several irregular patches of water hyacinth plants, which were partially clogging the creek, were sprayed from a boat with 2,4-D (1:1140). As in the previous experiment, the above-water parts were well moistened with a coarse spray until dripping started. Again the sprayed plants died and disappeared in the stream in about three weeks.

A third experiment, a repetition of the second in most details, gave similar results. The 2,4-D chemical plus Carbowax 1500, according to the formula of Hamner and Tukey (*2*), was employed. This preparation seemed to give an improved surface coating on the hyacinth foliage. However, practically 100 per cent kill was obtained, and the sprayed specimens disappeared in the stream in the treated areas, whereas the untreated check plants remained normal and in place. These studies seemed to have demonstrated the feasibility of removing the water hyacinth from streams.

Small fingerling fish and other water fauna were abundantly present among the water hyacinth growths before, during, and after spraying with 2,4-D. No adverse effects to the water fauna were observed up through the time of disappearance of the plants at the end of the experiments. Since 2,4-D is a growth substance for plants which operates on the "hormone" principle, injurious effects to water fauna were not anticipated or encountered from its use.

Starting early in October a second series of experiments was conducted for eradicating water hyacinths growing in relatively quiet water, in a rectangular, excavated pond with water ranging from 4 to 8 feet deep. The water hyacinths invaded this pond through a small drainage ditch and covered the surface in a few months time. The growth was vigorous, dense, 16 to 24 inches tall, and in bloom at the start of the experiment. One-gallon quantities of 2,4-D spray ranging in concentration from 1:800 to 1:1700, when applied in 100-square-feet plots and replicated three times, all gave practically complete control. The use of Carbowax as a wetting agent did not seem to improve the herbicidal action of 2,4-D. When the spray concentration (1:1000) was held constant, one gallon gave complete control for areas ranging from 100 to 150 square feet. In another experiment where both the concentrations and areas treated were varied, one gallon of 2,4-D (1:1700), when applied to plots 150 square feet in area, failed to give complete control, although over 90 per cent kill was obtained. In one experiment when rain fell before the 2,4-D spray had time to dry or be absorbed, the herbicidal action was largely lost.

The first conspicuous symptom of herbicidal action, consisting of an abrupt epinasty or downward bending of the upper part of the leaf petiole, appeared about two days after spray application. Subsequently discoloration and death occurred in about three weeks. Although chlorotic and decomposing, the last part to remain floating was the buoyant, enlarged, lower portion of the petiole. By the time the plants were dead in the treated plots the surrounding growth was moving in to occupy the vacated space. Therefore, to control the water hyacinth all the plants in a given area, rather than small portions of an area, must be sprayed.

In order to study the more intimate details of the effects of 2,4-D, another series of experiments was conducted during the winter, employing open, 50-gallon drums to which 12 to 20 plants were transferred. The first experiment consisted in spraying the plants in three drums with 2,4-D (1:1000) at three successive weekly intervals starting the last week in November. The plants in four drums were held as checks. The sequence in symptom development of previous experiments was repeated and confirmed, but the rate or speed of herbicidal action was slowed by over two weeks. Here, however, all plants died, decomposed, or settled to the bottom. Various forms of water fauna, including mosquitoes, were present in abundance, as was duckweed.

The second and final drum experiment was started in February and concluded in March. Around 25 small hyacinth plants about 4 inches tall were placed in each drum. Five different sources of 2,4-D, diluted 1:1000 and including one of the acid form, two salts of the acid, and two esters of the acid, were each ap-

plied to the plants in two drums, leaving three checks. Because of the smaller size of the plants, the rate of herbicidal action was increased over that of previous experiments with larger plants. The roots did not die and decompose as rapidly as the stem portion, yet they appeared to have lost the power to produce offshoots. As the result of this study, the form of the 2,4-D preparation used seemed to make no difference in herbicidal action provided the leaves were well moistened and the 2,4-D spray allowed to dry and penetrate into the leaves.

The possibility that important waterways might be cleared of the water hyacinth by means of 2,4-D invites trial on a larger scale. The "Water Buffalo" amphibian tractor might be useful in this connection.

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Science Legislation

Selective Service and Student Personnel

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The recruitment of scientific and engineering students has just been dealt another blow by Selective Service and the Army—and perhaps by Congress, which may approve the extension of Selective Service for another nine months before this issue of *Science* reaches its readers. The bill extending Selective Service, by providing for the deferment of farm hands, will lay an especially heavy hand upon the students in our colleges and universities. If it passes in its present form, any hope that engineers and scientists may have had to recoup some of the losses incurred through the draft during the war will be gone for another year.

As every engineer and scientist knows, considerably more than 100,000 potential scientists were sacrificed during the war years, thanks to a military policy which made no provision whatever for the replacement of expendable scientific personnel. Neither our allies nor our enemies in the late war were as shortsighted as this, for most of them provided deferment for students who were specializing in scientific and engineering studies, and some of them encouraged new students of draft age to enter these professions. In dismal contrast to other nations, we not only drafted our prospective scientists and engineers, but also assigned them to military duties quite unrelated to the training which most of them had acquired. The Navy seems to have taken into account the special ability of students in so far as their training might prove useful, but the Army quite commonly showed a complete disregard of any background which even advanced students in specialized fields had acquired. This statement can be supported by the citation of any number of examples, but a quotation from one of several letters from young scientists will demonstrate the flagrant waste of scientific personnel, for which the Army must assume responsibility:

> So, with ten years of scientific training in biology, I was turned back to menial work (in an army hospital laboratory), most of which could be performed by a janitor. What with floor-mopping, latrine-cleaning (barracks and laboratory), window-cleaning, and scouring of glassware, three-fourths of one's time was spent on the sort of tasks for which any rookie chosen at random could be trained in one week.

There is in Army and Selective Service circles the bland assumption that returning veterans are filling in the gaps created by war, and letters from General Hershey addressed to the office of the Permanent Secretary reveal the lack of a factual basis for such an assumption. On 20 February he wrote:

> I am fully aware of the importance of the student group in which your Association has a vital interest. The technical, scientific and professional fields should be given due credit for their important contributions in the winning of the war and for the part they will play in the future.
>
> Veterans and other students are now entering college and university in very large numbers. They are studying at all levels ranging from the freshman class through graduate work. There is reason to believe that the rapid upward trend in enrollment will continue for some time. Engineering, scientific and professional study occupy a