TIMELY TURF TOPICS

Issued By The

UNITED STATES GOLF ASSOCIATION GREEN SECTION

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PLANT INDUSTRY STATION
BELTSVILLE, MD.

2,4-D,--WHAT IS IT? 2,4-D is an organic acid (2,4-dichlorophenoxyacetic acid) which belongs to the group of chemicals which have been demonstrated as affecting the growth of plants in various ways and hence have been called plant growth regulators, or, by the layman, plant hormones. It is not directly soluble in water and must therefore be put into solution in one of several different ways. Either it must be dissolved in a carrier in which it can be dispersed in water; a soluble salt of it must be made; or it must be mixed with another salt or alkali which, when added to water, will react with the 2,4-D to make its soluble salt. During this spring and summer all 3 of these types of products have been tested by the Green Section in cooperation with the National Capital Parks and all of them have been found to be reasonably effective. In all tests 2,4-D in Carbowax has been used as the standard of comparison. So far as herbicidal effectiveness is concerned the 2,4-D in Carbowax has not been consistently surpassed by any of the products so far tried. In the greenhouse during the winter months various solvents were tested in cooperation with Dr. Paul C. Marth of the Hormone Project in the Plant Industry Station, with the result that Carbowax 1500 was found to be among the very best of those which are readily available commercially because (1) it readily dissolves the 2,4-D and then disperses it in water very satisfactorily; (2) it is not injurious to the grasses, even to creeping bent maintained at putting green height; and (3) it gave evidence of favorably influencing the effectiveness of the 2,4-D.

RECOMMENDED RATE OF APPLICATION OF 2,4-D: As discussed in the November issue of TIMELY TURF TOPICS the rate of application of 2,4-D which the Green Section recommends for use on turf is an application of 5 gallons of a 0.1% solution of 2,4-D. This necessitates the use of 2 ounces of the 2,4-D for every 3,000 square feet or 1 and 3/4 pounds to an acre. Since uniform coverage is an important factor, the use of 5 gallons of solution to 1,000 square feet or 200 gallons to the acre is recommended. When using commercial products which have 2,4-D as their active ingredient the method of preparation of spray solution recommended by the manufacturer should be followed. The concentration of the solution, however, and the amount applied per acre can readily be calculated on the basis of the aforegoing figures, by using the manufacturers' statement of the percentage of 2,4-D which the product contains.

It has been the Green Section's experience that some weeds may require 2 or even 3 times as much 2,4-D whereas others may require much less than the recommended 5 gallons of a 0.1% solution (2/3-ounce of 2,4-D) to 1,000 square feet. This seems to be a generally satisfactory application, however, and therefore the Green Section recommends it as a starting point in determining the effectiveness of 2,4-D on turf weeds under any particular set of conditions. Bluegrass and Bermuda grass have been treated during this season at rates up to 6 times the recommended rate without any injury whatsoever to the grass, so there should be no question of danger to these grasses if the concentration must be elevated to kill particularly difficult weeds.

Some weeds, such as chickweed, which form dense mats of vegetation have to be retreated after 2 or 3 weeks' time in order to cover vegetation which was not reached with the first application.

RESPONSE OF TURF WEEDS TO 2,4-D: Many plants are extremely sensitive to 2,4-D in very small quantities. Others are quite resistant to it. In order to determine which of the turf weeds are sensitive to it and can therefore be readily killed by it, it has been necessary to run a large number of tests on the common turf weeds as they occur throughout the various seasons. In the early exploratory experiments last fall, time and labor did not permit the testing of 2,4-D on a large number of weed species.

In March of this year, however, in cooperation with Mr. Horace V. Wester of the National Capital Parks the Green Section initiated a comprehensive test of 2,4-D and many proposed formulations of it on a wide variety of turf weeds as they occurred throughout the season on the turf of the National Capital Parks. The turf was composed of numerous grasses and maintained at various heights. These weeds together with those which were tested last fall in the vicinity of Washington, D. C., as well as those on which reports have been received from other sections of the country, (particularly Florida) are listed below, arranged alphabetically according to their common names. In order that there may be no question as to the identity of the weeds when referred to by their common names the scientific names are included in parenthesis for each of the weeds. In some cases the species have not been determined, in which case only the name of the genus is given.

0 Bugleweed (Ajuga reptans)
xx Buttercup (Ranunculus sp.)
Carrot, wild (Daucus Carota)
Catchfly (Silene sp.)
xx Chaerophyllum (Chaerophyllum procumbens)
xx Chickweed, common (Stellaria media)
xx Chickweed, mouse-ear (Cerastium sp.)
xx Cinquefoil (Potentilla sp.)
xx Clover, white (Trifolium repens)
0 Crabgrass (Digitaria sp.)
xx Cress (Barbarea vulgaris)
xx Cress, swine (Coronopus didymus)
Daisy, ox-eye (Chrysanthemum Leucanthemum)
xx Dandelion (Taraxacum officianale)
Dandelion, false (Krigia virginica)
xx Dichondra (Dichondra repens)
xx Dock (Rumex sp.)
Dog fennel (Anthemis Cotula)
xx Fleabane (Erigeron canadensis)
xx Gill-over-the-ground (Nepeta hederacea)
0 Goosegrass (Eleusine indica)
xx Heal-all (Prunella vulgaris)
xx Henbit (Lamium amplexicaule)
xx Knotweed (Polygonum aviculare)
x Lambs-quarters (Chenopodium album)
xx Lespedeza (Lespedeza striata)
xx Lippia (Lippia sp.)
xx Moneywort (Lysimachia Nummularia)
xx Mustard, wild (Brassica sp.)
0 Nimblewill (Muhlenbergia Schreberi)
xx Onion, wild (Allium sp.)
0 Paspalum (Paspalum sp.)
xx Pennywort (Hydrocotyle bonariensis)
xx Pennywort (Hydrocotyle rotundifolia)
xx Pennywort (Hydrocotyle umbellata)
xx Peppergrass (Lepidium virginicum)
xx Plantain, broad-leaf (Plantago major)
xx Plantain, narrow-leaf (Plantago Lanceolata)
xx Purslane, milk (Euphorbia maculata)
xx Pussy toes (Antennaria plantaginifolia)
Ragweed (Ambrosia artemisiifolia)
0 Sedges (Cyperus spp.)
xx Shepherds-purse (Capsella Bursa-pastoris)
x Smartweed (Polygonum Persicaria)
x Sorrel sheep (Rumex Acetosella)
0 Sorrel, wood (Oxalis sp.)
xx Speedwell (Veronica Tournefortii)
xx Speedwell, rock (Veronica arvensis)
Sticktight (Bidens sp.)
xx Strawberry, false (Duchesnea indica)
xx Veronica, ivy-leaved (Veronica hederaefolia)
0 Violet (Viola sp.)
xx Whitlow grass (Draba verna)
Wormwood (Artemisia sp.)
Yarrow (Achillea Millefolium)

In this list the weeds which have been satisfactorily eradicated at any time as a result of applications of 2,4-D at the recommended rate are preceded by the symbol "xx". Attention should be drawn to the fact that no attempt is made to indicate in this table the season of the year in which the weeds have been most satisfactorily eradicated. This question of the seasonal variation in the sensitivity of the weeds is discussed in another section of this issue. The weeds which have required much higher rates of application for eradication are marked with a single x. Those which have definitely been strikingly resistant to the 2,4-D to the place where it has not been possible to satisfactorily eradicate them at the rates used, are marked with a zero. The remaining weeds are ones on which the evidence to date is not sufficient to justify a conclusion. Wild onion has been marked with the "xx" because it was removed entirely from the turf in the spring, although it is

recognized that the final story concerning complete eradication cannot be told until the bulbs have had a chance to sprout again this fall or next spring.

It may be stated that various members of the mustard family which are not listed here because they were not present in sufficient numbers did occur on various plots and in all instances they were killed. All members of the mustard family so far treated in turf have been eradicated with the 2,4-D.

To those who have used other herbicides, the active ingredient of which is an arsenical, chlorate, one of the dinitro compounds, etc.; several important contrasts between the activity of these two materials and that of 2,4-D should be emphasized. 2,4-D acts more slowly but much more completely on the plants as a whole if they are sensitive to it. In other words, if the 2,4-D affects the growth of the plants at all, its effect on the root system is likely to be just as severe as its effect on the tops. Since the 2,4-D does not produce a burning of the tops accompanied by a resulting starvation of the roots but rather an effect on the growth of the entire plant, it is readily understood why it frequently takes from 2 to 3 weeks to produce ultimate death with the 2,4-D.

The first symptom which may occur in as short a time as 24 hours or which may in the case of some weeds under some conditions require 5 or 6 days to appear, is a curling of the leaves or the petioles. This is followed by a yellowing of the green tissue and eventual death and decomposition after 2 or 3 weeks' time. As is indicated elsewhere in this issue the speed with which the effect becomes evident depends on the growing conditions at the time and on the weed itself and its sensitivity to 2,4-D. For the most part most weeds may be expected to react most violently at the time of year in which they are growing rapidly. In the case of some weeds such as dandelion, physiologically mature plants have been more easily killed than seedlings.

Much can be learned from preliminary tests with the material under any particular set of conditions before undertaking large-scale applications. Therefore such "on the spot" tests are strongly urged before large scale operations are initiated.

LARGE SCALE APPLICATIONS OF 2,4-D NOTABLY EFFECTIVE AT THE U. S. NAVAL ACADEMY: Mr. A. E. Rabbitt, Agronomist in the Bureau of Aeronautics of the Navy Department, informed the Green Section that the Navy Department applied 2,4-D in Carbowax in May of this year to 35 acres of turf at the U. S. Naval Academy at Annapolis, Md., with outstandingly successful results. Six acres of this area were seriously infested with dandelion at the time of application. When Mr. Rabbitt inspected the treated area approximately a month later only 9 dandelion plants could be found in the entire 6 acres of the parade grounds. In the remaining acreage in the athletic area which was heavily infested with narrow-leaf plantain the treatment resulted in approximately a 95% control. One small area of approximately 1/2-acre will require a second application. The spray solution was prepared according to the directions published in the November, 1944, issue of TIMELY TURF TOPICS, 1-3/4 pounds of 2,4-D being dissolved in 8 pounds of Carbowax, which in turn was dispersed in 200 gallons of water and sprayed on an acre of turf.

WHEN TO USE 2,4-D: When the weed population in turf reaches a sizable proportion it is advisable always to remove those weeds at a time when the turf grasses can most easily be encouraged to fill in the bare areas left following the removal of the weeds. Therefore in most cases it will probably be advisable to remove the weeds with 2,4-D in spring or early fall in order that the turf may be reseeded if necessary and certainly fertilized without running the risk of fertilizing the weedy grasses. With spring and fall applications of 2,4-D it is possible to distribute the seed and fertilizer before applying the 2,4-D thus enabling the grass seedlings to develop as the weeds disappear. In some instances when one or more of the predominant weeds happen to be, like broad-leaf plantain, decidedly most sensitive in midsummer, it may be necessary to treat at that time. Midsummer treatments, particularly in crabgrass areas, however, are likely to result in the crabgrass merely replacing the weeds which 2,4-D removes. If on lawn areas it is desirable to remove weeds such as dandelion and plantain without too seriously injuring clover, however, midsummer applications may be advisable since it has been demonstrated that these weeds may be removed from turf in the midsummer at the recommended rate without completely killing the clover. It will be recalled that it has been stated elsewhere in TIMELY TURF TOPICS that clover has been most easily killed in the fall and spring.

EFFECT OF CLIMATIC FACTORS ON HERBICIDAL PROPERTIES OF 2,4-D: Tests have been made during this season to determine the influence of shade, rainfaill, and temperature on the effectiveness of 2,4-D. Where comparable series have been established in open sun and in partial shade it has been demonstrated that the response of broad-leaf plantain, dandelion, and clover has been more prompt in the open sun than in the shade. However, the eradication after a month's time was just as complete in the shade as in the open sun. In fact in the case of clover the eradication was much more perfect in the shade. It has not yet been demonstrated whether this effect was due to a light factor or to a lower average temperature on the shaded plots than in the sun.

It has definitely been demonstrated that temperature affects the effectiveness of 2,4-D, the optimum temperature for eradication varying with different weeds. Last winter, for instance, flats of pennywort, heal-all and chickweed were growing in a greenhouse maintained at 60 to 65°C. They were treated with 2,4-D and its sodium and ammonium salts and maintained in this greenhouse at the same temperature for 10 days. The chickweed in this time curled, began to yellow and showed signs of death, which eventually was complete at this temperature. The pennywort and heal-all gave practically no evidence of having been treated with 2,4-D over this 10-day period, whereupon they were moved into an 80° greenhouse. At the higher temperature the effect of the 2,4-D became evident within a few hours and after 4 or 5 days the flats of both weeds were dead. The chickweed on the other hand died while maintained in the cooler greenhouse.

Unlike other herbicides, the effectiveness of 2,4-D, particularly when it is applied in Carbowax, is not seriously reduced by heavy rains following as close as 1/2-hour after application. When applied to wide-leafed weeds such as dandelion, plantain, and the mustard family, the effectiveness of neither the 2,4-D-Carbowax solution nor the soluble formulations of 2,4-D has been reduced by rains immediately following the application. In fact, in one series of tests in which the potassium, sodium, ammonium, and calcium salts were being compared with each other and with 2,4-D-Carbowax it was drizzling throughout the time in which the applications were made and a heavy rain followed within a few hours after application. In spite of this the treatments resulted in almost complete control of dandelion, broad-leaf plantain and clover - the predominating weeds in the turf. In another series, however, when the soluble formulations as well as the Carbowax solution of 2,4-D were applied to the very small leaves of young seedling knotweed and a drenching rain followed within 30 minutes after the last application, the effectiveness of the soluble formulations was definitely reduced by the rain. The 2,4-D in Carbowax, however, resulted in a very satisfactory control of the knotweed in spite of the rain. No well controlled tests have yet been made of the influence of soil moisture on the effectiveness of 2,4-D but some observations indicate that higher rates of application may be necessary when soil moisture content is unusually low.

SEASONAL VARIATIONS IN WEED SENSITIVITY TO 2,4-D: Tests with 2,4-D have been under way by the Green Section for 11 months. Results from these tests have indicated in some cases a striking fluctuation in the response which certain weeds make to applications of 2,4-D, at various stages of growth, and in different seasons. Broad-leaf plantain, for instance, was only slightly curled by treatments made last fall at the standard rate of 5 gallons of a 0.1% solution to 1,000 square feet, whereas this summer there has been a complete eradication of this species on many series of plots established through May, June and July, not only with the 2,4-D in Carbowax but also with most of the formulations under test. Wild onion also was apparently untouched by most fall applications whereas applications made in March and April of this year resulted in very striking immediate effects. The onion tops turned purple, were curled severely in such a manner that they lay on the ground prostrate although very turgid. When the tops were removed by cutting, completely chlorotic shoots appeared, which in turn were removed by the mower. Observations this fall and again next spring on these treated plots will be necessary before any statement can be made concerning the permanent eradication of the onions from the turf.

Quite to the contrary, clover which was completely eradicated by treatments at the above mentioned rate last September and October as well as in March and April of this spring has required a much higher rate or repeated applications at the above rate for complete control in May, June and July applications. Shepherds-purse, cress, and various other members of the mustard family, as well as narrow-leaf plantain, have been completely eradicated with applications made throughout the growing season from late August to the present time. Even

applications made to dormant narrow-leaf plantain in December and January, although they gave no evidence of immediate effect caused the plants to die when growth was initiated in early spring. Generally speaking, however, it seems that the control is most efficient when applications are made at the time of year in which the weed concerned is growing most actively.

In dandelion there seems to be some evidence that physiologically mature plants,--that is, plants which are in flower or seed, are much more effectively eradicated than are plants when they first initiate growth in the spring. Applications in the National Capital Parks made on March 12 to dandelion plants which had developed considerable foliage and yet showed no signs of flowering were temporarily curled and yellowed but were not killed, whereas applications made the same day to plants which, because of being in a sheltered area, were in bud and flower, resulted in complete eradication. All subsequent treatments of dandelion this year as well as tests last fall have resulted in an outstandingly complete eradication of dandelions.

CAUTION! CLEAN SPRAYERS THOROUGHLY FOLLOWING APPLICATIONS OF 2,4-D: Many vegetable and ornamental crops are extremely sensitive to very minute quantities of 2,4-D. Therefore when using spray equipment for spot treating with 2,4-D or for small-scale tests of this material it is vitally essential that that equipment be thoroughly cleaned before it is used for spraying such plants as tomatoes, potatoes, roses, etc. It has been demonstrated that even after rinsing with hot water, hand spray equipment which has been used for 2,4-D, there is frequently enough left in the spray tank to seriously injure tomato plants sprayed subsequently. The best answer to this danger is to use spray equipment which is reserved exclusively for applying 2,4-D. If, however, the equipment is never used for the protection of vegetation other than turf this precaution is not necessary. For thorough cleaning of the spray equipment following the use of 2,4-D it is advisable to wash it with hot soap suds and rinse repeatedly with hot water. A solution of trisodium phosphate (1 pound in 25 gallons of water) is perhaps even better than soap suds for the removal of 2,4-D from spray equipment.

DUST VS. SPRAY APPLICATIONS OF 2,4-D: All golf courses do not have the necessary spray equipment for large-scale spraying of fairways and rough in order to remove weeds. Therefore it seemed desirable to determine whether or not dusts can be prepared which will be as efficient as the spray applications of 2,4-D which have been discussed in the November issue of TIMELY TURF TOPICS as well as in other portions of this issue.

In preliminary experiments last fall in which the 2,4-D was applied dry mixed with fertilizer or sand it was found that narrow-leaf plantain was not satisfactorily killed except where amounts of 2,4-D approximating 18 to 20 times that which is applied in 5 gallons of a 0.1% solution were used. Moreover, it is very uncertain how such relatively large amounts of 2,4-D applied to the soil might affect the fertility of the soil. Therefore the possibility of applying the 2,4-D in this way was at least temporarily given up. It should be mentioned, however, that within a few days after the dry mixture had been applied a series of heavy rains caused some washing on these plots.

Later in the greenhouse, dusts were applied to clover-grass mixtures growing in flats to determine both the tolerance of the grass and the sensitiveness of the clover. The dusts were prepared in various carriers including Pyrax, Fuller's earth and Cherokee clay. The requisite amount of 2,4-D was dissolved in alcohol and mixed with the dust carrier to form a thick paste. This in turn was dried, finely pulverized, thoroughly mixed, and applied at the rate of 4 pounds to 1,000 square feet. The dust was prepared with concentrations of 2,4-D varying from 0.5% to 10%. The 1% dust furnished the same amount of 2,4-D when applied at the rate of 4 pounds to 1,000 square feet as does 5 gallons of a 0.1% solution. The 1% dust, although it resulted in a slight immediate curling and yellowing of the clover, did not permanently injure it whereas the 2.5% dust killed approximately 85% of the clover and did not injure the bluegrass in the flat. The 5% dust gave a 95% kill of the clover but also resulted in considerable injury to the grass for the first 2 to 3 weeks following the treatment. Six weeks following treatment, however, there was no noticeable effect on the grass, which apparently had recovered completely. The 10% treatment resulted in a decidedly thin turf although it of course gave a complete kill of all clover present. Following these tests 1% and 2% dusts were prepared and are being tried in small

scale plots in the field this summer but results are not yet in. If dusts are to be used they should be applied when the grass is wet with dew in order to hold the active ingredient on the leaves a sufficiently long time to permit its being absorbed by the plant tissue.

The major concern in applying 2,4-D in dust form is that the dust flies and therefore may be more injurious to sensitive ornamental plants bordering the fairways than are sprays likely to be. Also before 2,4-D dusts are to be used in a large-scale manner, tests should be made on any possible effect of the inhalation of such dusts.

COMMERCIAL SOURCES OF 2,4-D: 2,4-dichlorophenoxyacetic acid (now commonly known as 2,4-D) is not sufficiently soluble in water to permit its use in aqueous solution without the use of a carrier. Several of these carriers are being used by various manufacturers as evidenced by the following products which are now available at widely different costs.

"Chipman 2,4-D Weed Killer"
Manufactured by the Chipman Chemical Company, Inc., 6200 N. W., St. Helens Road, Portland 10, Oregon

"Concentrate No. 6" (This is a preparation of 2,4-D for mixing with ammonia).
Manufactured by Chemical Concentrates Company, 342 Madison Avenue, New York 17, N. Y.

"En-Dow-Weed" (This is a mixture of 2,4-D and a sodium salt and is soluble in water)
Manufactured by the Dow Chemical Company, Seal Beach, Pittsburgh, Calif.

"Weedanol M1" (2,4-D in Carbowax 1500 which readily dissolves in warm water)
Manufactured by Associated Chemists, Inc., North Collins, New York; distributed by Eaton Brothers Corpn., Hamburg, New York

"Weedicide" (Tablets, which should be dissolved in hot water)
(Liquid, in which 2,4-D is made soluble with "phenoxysol"
Manufactured by the Wm. T. Thompson Company, 2727 Hyperion Avenue, Los Angeles 27, Calif.

"Weedone" (2,4-D in an oil-like base)
Manufactured by the American Chemical Paint Co., Ambler, Pa.

"Weed-Tox 2, 4-D" (This is a mixture of 2,4-D and Carbowax)
Manufactured by Veith Chemical Company, 1261 Blackstone Avenue, Fresno, Calif.

The sodium, ammonium, potassium, and calcium salts of 2,4-D may be dissolved directly in water. Various companies in addition to the above, including the E. I. DuPont deNemours & Company, Wilmington, Del.; Merck & Company, Inc., Rahway, N. J.; and the Standard Agricultural Chemicals, Inc., Hoboken, N. J.; are using this fact as a basis for experimenting this year with 2,4-D products which will be directly soluble in water. These latter firms, however, to date have material available only for experimental purposes. To those who are interested in preparing their own 2,4-D-Carbowax mixtures as recommended in the November issue of TIMELY TURF TOPICS it should be stated that the Carbowax 1500 can be purchased from the Carbide and Carbon Chemicals Corporation, 30 East 42nd St., New York 17, N. Y.

MORE ABOUT 2,4-D IN AUGUST ISSUE: Because of lack of space in this issue, additional facts concerning the behavior of 2,4-D will be published in the next issue of TIMELY TURF TOPICS, which is already in the hands of the printer.