A NEW SYSTEMIC HERBICIDE

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Summary

The discovery of a new systemic herbicide and growth regulator known as "Tordon"*, which has shown high activity in the control of woody species and deep-rooted perennial herbaceous weeds, is discussed. In general, the activity of "Tordon" has been found to be approximately four times that of 2,4,5-T for scrub control, and up to ten times that of the standard herbicides used for controlling several important perennial weeds. Most established grass species are tolerant to foliage applications at the rates usually needed to control broadleaved weeds and woody species, but pre-emergence application controls many seedling grasses. Some of the early trial results are described.

INTRODUCTION

THE USE of herbicides to control scrub and undesirable trees has expanded rapidly since 1950. The phenoxy compounds 2,4-D and 2,4,5-T, particularly the latter, have been the primary products used, and, while a high degree of success has been achieved, repeat treatments are often necessary with some woody plants. This is especially true for those species which have underground buds from which new shoots may develop, even when all top growth is repeatedly removed by chemical or physical means.

An intensive research programme directed towards the discovery of a compound which would overcome some of the limitations of present chemical scrub control methods, has resulted in the development of 4-amino-3,5,6-trichloropicolinic acid—identified by the trademark "Tordon". It has the following structural formula:

Full chemical and physical descriptions, toxicology and assay methods, are printed elsewhere (Dow Chemical International S.A., 1963). Briefly, it can be stated that toxicological studies indicate that "Tordon" herbicide is safe to handle and should present no hazard to wild life. The LD₅₀ for rats is 8,200 mg/kg.

"Tordon" has been formulated as the potassium and triisopropanolamine salts, which are highly soluble in water. It is readily absorbed by plant foliage and roots, and is translocated through the plant. The herbicidal activity of "Tordon" is manifested initially by characteristic growth responses, and finally in the death of susceptible broadleaved plants. These growth responses resemble some of those produced by the phenoxy herbicides, but generally

* Trademark of The Dow Chemical Company, U.S.A.

can be recognized as different by the trained observer. Initial reactions of the plants include cupping or curling of the leaves and twisting of new growth. Stem splitting may occur and some leaflets or leaves may develop as thickened petioles with only a small ball of proliferated tissue in place of the blade. It has been observed that "Tordon" symptoms develop rather slowly, especially at low dosages, although laboratory tests have shown that, with cucumber, the absorption and translocation out of the leaves is rapid.

While most broadleaved plants are susceptible to "Tordon", most grasses are tolerant of foliar sprays. However, many annual grasses are killed with pre-emergence applications. Rhizomatous grasses such as twitch (*Agropyron repens*) have been killed with soil applications of "Tordon" at relatively high rates applied when the grasses were dormant, prior to initiation of growth from the rhizomes.

Several preliminary tests have shown that "Tordon" persists in soil for extended periods. In greenhouse experiments, "Tordon" has been found to persist longer than simazine and fenac when each was applied as a pre-emergence application to 20 lb (all rates given in active ingredient per acre) and watered to maintain good growing conditions without leaching. Under such conditions, approximately 50% of the herbicidal activity of "Tordon" was lost in 18 months.

Exploratory studies indicate that "Tordon" is not as readily decomposed by micro-organisms as is 2,4-D and 2,2-dichloropropionic acid, but it is leached in soil at a rate similar to 2,4-D and 2,4,5-T. Lateral movement of "Tordon" herbicide on the soil surface has been limited in field experiments.

"Tordon" has been widely tested on a field scale throughout the U.S.A. during the past two years, with special attention directed towards the control of woody species, and deep-rooted perennial herbaceous weeds, especially those not well controlled with 2,4-D or 2,4,5-T. Limited work has been done on the selective control of weeds in crops.

Extensive trial work with "Tordon" is in progress throughout New Zealand and Australia. Some of the northern hemisphere results have already been confirmed, and a number of new species have been controlled.

EXPERIMENTAL RESULTS

WOODY PLANTS

Following exploratory work in which it was found that "Tordon" was highly active at 0.1% concentration on a wide range of woody plants, including representatives of the conifers, cherry, willow and apple groups, extensive field tests were initiated to evaluate the effect of "Tordon" on utility right-of-way scrub complexes in the Eastern United States (Watson and Wiltse, 1963). Power sprayers were employed to deliver approximately 200 gal as leaf-stem wetting sprays. In many instances the tests have extended over two growing seasons. Complete top-kill without resprouting was obtained with "Tordon" herbicide applied at ½ lb/100 gal on the following species:

Willow (*Salix longifolia*), wild cherry (*Prunus serotina*), paper birch (*Betula papyrifera*), Macartney rose (*Rosa bracteata*), mesquite (*Prosopis juliflora*), and poison oak (*Rhus diversiloba*).

Conifers and maples were also effectively controlled with low rates of "Tordon" as shown in Table 1. For comparison, a treatment of 2,4,5-T as the propylene glycol butyl ether ester was included.

In Table 1 it can be seen that "Tordon" is at least four times as active as 2,4,5-T but a few species, including white ash (*Fraxinus americana*), were not effectively controlled with "Tordon" at ½ lb/

TABLE 1: SUMMARY OF RESPONSE OF MAPLES, CONIFERS AND OTHER SPECIES SPRAYED WITH LEAF-STEM SPRAYS OF "TORDON" AND 2,4,5-T ESTER

	Average Control Ratings*		
	"Tordon" ½ lb/ 100 gal	"Tordon" 1 lb/ 100 gal	2,4,5-T 4 lb/ 100 gal
Red maple (<i>Acer rubrum</i>)	10	10	8.5
Silver maple (<i>Acer saccharinum</i>)	10	10	9
Hard maple (<i>Acer saccharum</i>)	9	9	8
Balsam fir (<i>Abies balsamea</i>)	10	9	4.5
Ground juniper (<i>Juniperus depressa</i>)	8	10	1
Spruce (<i>Picea glauca</i>)	10	10	5
Slash pine (<i>Pinus echinata</i>)	6.5	10	2
White pine (<i>Pinus strobus</i>)	2	8.5	2
Loblolly pine (<i>Pinus taeda</i>)	7.5	10	1.5
White poplar (<i>Populus alba</i>)	9.5	10	10
Black locust (<i>Robinia pseudo-acacia</i>)	10	10	6
Sassafras (<i>Sassafras albidum</i>)	10	10	8.5

* Control Ratings 0 = no effect, 10 = complete kill)

100 gal. Limited tests have shown that, with ash and other species that are more tolerant, sprays or pellets applied to the soil around the root collar, in addition to leaf-stem sprays, have given much better control.

It is too early to give conclusive reports on the effect of "Tordon" on most of the woody species treated in New Zealand in autumn, 1962, but the results to date are impressive. Species which can be reported as controlled with "Tordon" at 2 lb/100 gal are willow (*Salix* sp.), broom (*Cytisus scoparius*), gorse (*Ulex europaeus*), elderberry (*Sambucus nigra*) and tree lupin (*Lupinus arboreus*). Inspection of the roots of each species showed that they were completely dead. The high degree of die-back or "brown-out" at 1 lb/100 gal suggests that treatment at the time of active growth could effect complete control at this rate of application. There has been a significant amount of die-back of sweet brier (*Rosa rubiginosa*) following a late-autumn application of "Tordon" at 2 lb/100 gal but the bases of many stems are still alive. However, the buds on the live portion of the stems are dead.

PERENNIAL WEEDS

While the discovery of "Tordon" was the result of an intensive search for a herbicide of superior efficiency than the phenoxy materials for scrub control, it has shown great promise as a means to control many deep-rooted perennial herbaceous weeds (Laning, 1963). Californian thistle (*Cirsium arvense*) and convolvulus (*Convolvulus arvensis*), two notorious weeds of cultivated land in many countries, have been thoroughly evaluated in the United States. Both species have been completely controlled in several experiments at different locations following foliage sprays of "Tordon" at 2 lb applied in the early-bloom growth stage. At 1 lb, "Tordon" has given 90% and 98% control of convolvulus and Californian thistle, respectively.

Russian knapweed (*Centaurea repens*) has also been controlled with foliage sprays of "Tordon" at 2 lb when rated one year after treatment.

In the United Kingdom, excellent control of bracken fern (*Pteridium aquilinum*) was achieved in 1962 with "Tordon" at 2 and 4 lb applied when the fronds were still emerging and had not unfurled.

The following species have been reported as controlled with foliage sprays of "Tordon" herbicide at 1 lb/100 gal:

Common milkweed (*Asclepias syriaca*), wild carrot (*Daucus carota*), field horsetail (*Equisetum arvense*), horseweed (*Erigeron canadensis*), prickly lettuce (*Lactuca scariola*), curled dock (*Rumex crispus*) and yellow wood sorrel (*Oxalis corniculata*).

Plots treated with "Tordon" in New Zealand would appear, at this stage, to confirm the overseas results on Californian thistle, convolvulus and curled dock, but the final assessment cannot be made until early summer, 1963, when any regrowth should have occurred. At one trial site in Christchurch, plants were selected at random and dug up for root inspection. The roots of all three species were completely decayed at the 2 lb rate. There was no live root tissue in the Californian thistle plants treated at 1 lb but a vestige of live tissue was observed in the centre of the crowns of curled or broad-leaf docks treated at this rate. In one trial at Palmerston North, bracken fern (*Pteridium esculentum*) has been killed by an autumn application 0.2% "Tordon" to mature fronds. Giant buttercup (*Ranunculus acris*) and hemlock (*Conium maculatum*) have been controlled with 1 lb of "Tordon" in limited trials but regrowth of giant buttercup has occurred at the ¼ lb rate.

ANNUAL AND BIENNIAL WEEDS

Very low rates of "Tordon" control most young annual and biennial broadleaf weeds. Cape weed (*Cryptostemma calandulacea*) is readily controlled with 2 oz and stagger weed (*Stachys arvensis*) with 3 oz. Narrow-leaved plantain reacts to extremely low rates of "Tordon" but 4 oz appears necessary to kill young plants.

The control of broadleaf weeds with "Tordon" in turf and cereal crops, without damage to the turf or reduction in yield of cereals, have been achieved. Some brassica crops have tolerated up to 2 lb of "Tordon" applied as either pre- or post-emergence sprays.

GENERAL OBSERVATIONS

Foliar sprays of "Tordon" herbicide do not appear to give as rapid or as uniform leaf kill as sprays of 2,4-D or 2,4,5-T. Some oaks (*Quercus* spp.) retain green leaves for several months following spraying with "Tordon". It has been found that combination sprays of "Tordon" herbicide with phenoxy compounds have given more rapid and uniform leaf kill than "Tordon" used alone. In some instances, the addition of 0.5% wetting agent to the "Tordon" potassium salt formulation has improved the results. Extensive research now in progress with "Tordon" throughout the world will soon indicate which formulations are best suited for particular tasks.

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