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Recent advances in Agriculture: Growth Regulators as Weed Killers *

by

S. KRISHNAMURTHI & K. M. SRINIVASAN
Department of Agriculture, Annamalai University

The aim of this paper is to give a comprehensive summary of the various aspects concerned with the use of growth regulators as weed killers.

Growth regulators used as weed killers: The derivatives of following three parent acids of growth regulators have been in vogue as herbicides:—

1. 2, 4 – dichlorophenoxy acetic acid.
2. 2 methyl – 4 – chlorophenoxy acetic acid.
3. 2, 4, 5 – trichlorophenoxy acetic acid.

In recent years, a few more hormone herbicides have been under trial, but are yet to come into as wide a use as the above.

Formulations used: These parent acids are used in the form of acids, salts, esters or amides, and they vary in volatility, solubility and availability. In the use of salts, sodium and ammonium salts are more widely in vogue as they are highly soluble in water. There is also some considerable difference of opinion with regard to the efficacy of these various formulations when used as herbicide. While Zimmerman and Hitchcock (1942) state that salts, esters, and amides are approximately equal in activity to the acid, Hamner *et al* (1947) make a general statement that esters are more effective than acids, and acids are more effective than salts. Taylor (1946) points out that 2, 4 - D acid caused greater inhibition than ammonium salt in certain plants. On the contrary, Ennis and Boyd (1946) after extensive spray treatments on a variety of broad leaved plants showed that the effectiveness of ammonium salt was in no way statistically different from 2, 4 - D acid.

Forms in which they are applied: These substances are applied for control of weeds in the form of sprays, dusts and aerosols. Very recently, the use of these chemicals in pellet forms has also come into practice. In order to make the sprays and dusts as active as possible and give a uniform coverage and distribution, the use of adjuants, wetting agents and carriers is resorted to. Usually

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polyethylene glycols, like Carbowax 1500 is used as a wetting agent in aqueous sprays; and talc and powdered China clay as carriers for dusts. The preparation of solutions and dusts, and addition of wetting agents and carriers have all been elaborately described by Marth and Mitchell (1944), Carl *et al* (1948), Slade *et al* (1945) and Templeman and Right (1950).

Mode and time of application : Direct foliar applications as well as treatments of soil are being done. The treatments to soils may be made as a preplanting treatment (i. e. before sowing or planting in the soil), or as a pre-emergent treatment (after seeds are sown but before seedlings emerge) or a post-emergent treatment (after seedlings have emerged). Particularly in vegetables and legumes which are susceptible to the direct foliar applications of growth regulators, treatment of soils is resorted to. In all cereals in which the growth regulators can be applied as a direct foliar spray for control of weeds, it is safe to apply after the crops have tillered and upto the *early boot stage :* i. e. when the upper sheath is begining to swell with enlarging head.

Sensitivity of weeds to growth regulators and factors influencing their kill : Many aquatic weeds, broad leaved plants, woody shrubs and vines, and perennials are effectively killed or controlled by growth regulator type of weed killers. Hildebrand (1947). Hitchcock *et al* (1949 and 50), and Jackson (1951) and a host of others have stated that water hyacinth *(Eichornia crassipes)* and other aquatic weeds could be successfully killed by 2, 4 - D and allied substances at concentrations raging from 1000 to 3000 parts per million. Destruction of dense woody shrubs, vines and trees by 2, 4 - D and other similar substances have been demonstrated by Hamner and Tukey (1945), Tam (1947) and Thimman (1948). Concentrations ranging from 2000 to 10,000 parts per million have been used by them. Hitchcock and Zimmerman (1948), Mitchell and Marth (1948) Zimmerman (1953), and Hemphill (1953) state that many broad leaved plants can successfully be killed at concentrations ranging from 250 to 1000 parts per million. In general, a wide range of weed species are killed by hormone herbicides.

Although many weeds are susceptible to these substances, factors such as weed species, stage of growth, concentration of chemical used, temperature, rainfall etc. govern and influence their herbicidal toxicity. In general, all annuals are susceptible to 2, 4-D, when they are young and actively growing; and resistance increases

with advancing maturity. Perennials are most susceptible when treated at the bud or very early bloom stage, but are altogether less susceptible than the annuals. Temperature and rainfall are the two important factors affecting herbicidal property of these compounds. Tam (1947) reports that temperature ranging from 70° to 85°F through a large percentage of days are highly favourable for the action of 2, 4-D and other hormone herbicides. Marth and Davis (1945), Kelly Sally (1949) have all shown that warm weather and higher temperature accelerate the herbicidal activity of 2, 4-D. Rainfall has an adverse effect on the herbicidal action value of 2, 4-D and allied substances, and Tam (1947), Thimman (1948), and Weaver et al (1946) have all shown that the rain following the application of 2, 4-D considerably decreases the herbicidal toxicity. As Avery (1947) points out, it is better for maximum effectiveness to apply these herbicides on sunny days in warm weather when weeds are young and actively growing, and rainfall is not expected within 24 hours of application.

General responses of crops to growth regulators: The successful use of growth regulators as herbicides in crops depends on the efficacy of these substances in killing weeds with least or no injury to crops. Crops however vary in their tolerance to growth regulators. In general, broad leaved plants are susceptible to them and members of the grass family are resistant to them. Although cereals in general are tolerant to these herbicides, variation in their responses is being reported. Templeman (1946), and Olson (1952) point out that barley is more liable to damage than either wheat or oat. Variation in the different varieties of the cereals like oat, corn, and sorghum had been observed by Dearbon *et al* (1948), Ellis and Bullard (1948), Derscheid *et al* (1953), and Gassaway *et al* (1952). Dunham (1951) in summarising the responses of plants to 2, 4-D brings out that the differential responses of plants to growth regulators may be attributed to the crop species, variety, dosage, time of application, stage of growth and environment. Mathews (1952) observing the tolerance of plants to growth regulators has classified them into three groups, viz. susceptible, moderately tolerant, and resistant. Legumes without waxy covering, brassicas, tomatoes, sugarbeets, onions, grapes, parsnips, and ornamental plants are generally classed as susceptible; potato, linseed and clover as moderately tolerant, and members of the grass family as resistant. Although vegetables and legumes are susceptible to direct foliar application of herbicides, good weed control without damage to them is possible with soil applications of hormone herbicides. In

fact, Alban and Keirns (1948), Warren (1948), Warren and Hernandez (1948), Havis and Sweet (1948). Danielson (1948), Lachman (1947) and many investigators have demonstrated the possibility of growing vegetables successfully in soils treated with growth regulators and at the same time controlling the weeds in those vegetable plots.

Residual effects on soils: The wide-spread application of hormone herbicides has created an important problem of the persistence of toxicity in soils. The toxicity of growth regulators persists in soils from a few days to several weeks or months depending on the soil condition and environmental factors. Brown and Mitchell (1948), Hernandez and Warren (1950), Jorgenson *et al* (1948), Akamine (1951) and many others have pointed out that factors like soil type, pH, soil moisture, addition of manure, autoclaving, temperature, rainfall and other environmental factors play a vital role in the dissipation of toxicity of these substances. Krishnamurthi and Srinivasan (1954) working on the nature of persistence of toxicity of 2, 4-D under topical conditions report that sandy soils with a low pH, retain toxicity for a longer time than clayey soils with a high pH value, and have stressed the importance of pH, and soil type on the inactivation of 2, 4-D toxicity when applied at herbicidal rates to soils. Although it is well known that the growth regulators are inactivated in soil after some time, the exact manner by which it takes place is not yet well understood. Micro-organisms are suggested as a primary factor for the dissipation of toxicity. The effect of growth regulators on micro-organisms, and *vice versa* have been studied to some extent. The action of growth regulators on micro-organisms is negligible but the effect of micro-organisms on growth regulators seems to be of paramount significance. Audus (1951, 52) has amply demonstrated that micro-organisms play a vital role in the dissipation of toxicity of growth regulators.

General progress in other countries with special reference to U. S. A.: Phenomenal progress has taken place in the western countries in the field of weed control by chemicals and the utilisation or hormone herbicides for elimination of weeds has become an established practice. Particularly in U. S. A., there is a heavy demand for these hormone killers, and the 1951 figures reveal that 112 million pounds of phenoxy acetic acid derivatives alone have been consumed for weed killing purposes. There seems to be no crop or place in which they have not found use. They are used in field

crops, orchards, highways, aquatics and bushy forests. The following is somewhat the general dosage of 2, 4-D and allied substances in U. S. A. for weeding in certain important crops. It should be noted that the time and method of application vary with the crop.

Crop	Dosage employed (pounds per acre)
Corn	$\frac{1}{4}$ to $\frac{3}{4}$
Sugarcane	2
Wheat, oat & barley	$\frac{3}{4}$ to 2
Flax	1/8 to 1/3
Grasslands	$\frac{1}{4}$ to 3
Orchard Crops:	
(i) Apples, brambles etc.	$\frac{1}{2}$ to 2
(ii) Straw berries	2 to 3 (pre-planting treatment)
Vegetables, Legumes etc.:—	
(i) Asparagus, onion & bean	1 to 3 (pre-planting or pre-emergent)
(ii) Potatoes	$\frac{1}{4}$ to $\frac{3}{4}$
(iii) Peas	$\frac{1}{2}$
(iv) Clover	$\frac{3}{4}$
(v) Lucerne	$\frac{1}{2}$

Although U. S. A. has made great progress in this field and a vast amount of literature on this subject continues to be published in the States, it should be pointed out that some advances have been made elsewhere too. It can be claimed that Great Britain has all along been in the van of progress in the matter of weed control particularly in grass-land improvement, reclamation of marshland and in other directions with the help of these herbicides, but the utilisation of chemicals in cereals and orchards crop has been somewhat limited. In France, Australia, New Zealand, Italy, Peurto Rico, Hawaii and Japan, the use of these hormone weed killers and other chemical treatments for eradication of weeds has commenced. In Japan, Indonesia and Malaya, 2, 4-D and similar substances are used in rice fields for combating weeds.

In India the work in the field of herbicides is in its infant stage and apart from some preliminary and disconnected trials, very little has been attempted or achieved in an organised systematic

manner. Responses of some annual and aquatic weeds to hormone herbicides have been reported by Kar (1947), Padwick (1948), Thomas and Srinivasan (1949), Joshi *etal* (1950), Imperial Chemical Industries (1951) and Solomon and Rao (1950). Venkatarathnam (1950) has made some gross observations on the nature of responses of some South Indian crops to herbicides. Krishna Rao *etal* (1951) and Thakur (1952) have studied to some extent the effect of 2, 4-D and MCPA on nut grass. For the past two years, in the Department of Agriculture, Annamalai University, some systematic trials, particularly the effect of hormone herbicides on weeds, crops and soils under tropical conditions have been made and some of the results have been published as indicated elsewhere in the body of this paper, and others await publication.

Conclusion: Growth regulators are being widely used in some of the Western countries specially for control of weeds of several kinds viz. aquatic weeds, herbs, shrubs, trees and deep rooted perennials. The growth regulators used for herbicidal purposes, the formulations used, forms in which they are applied, mode and time of application, sensitivity of weeds to growth regulators and factors influencing their kill, general responses of crops to growth regulatiors, and residual effects on soil are all briefly described. The knowledge of behaviour of these substances on weeds, crops and soils is as yet incomplete, and the future work is bound to bridge the gap in our knowledge. However it can be said that one of the recent advances in agriculture is the use of growth regulating substances or plant hormones for herbicidal purposes.

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