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CHEMICAL WEED CONTROL

PART 1

This Bulletin is to be issued in two parts. Part 1 deals with the principles of chemical weed control and the nature of the chemicals used. Part 2 deals with the application of weed-killers to weeds in crops and pastures. Part 1 is admittedly technical, but it is not difficult to follow. An understanding of the nature of weed-killers is desirable if they are to be utilised with maximum efficiency.

by

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Ever since man first attempted to grow crops he has been faced with the problem of controlling weeds. Using the improved cultivation machinery available to him the arable farmer can, by means of suitable crop rotations, achieve a certain measure of control of weeds. Such control, however, is purely temporary and can be lost with a change of ownership to a less skilled operator, by a reduction in farm prices causing the adoption of unsuitable rotations or even by a loss of efficiency of the farmer due to age. In other words, such control never approaches the standard of weed eradication. The problem is continuous. The position on grassland farms is very similar. Where the farm income justifies adequate topdressing and adequate fencing to permit controlled grazing the skilled operator can maintain a balance with weeds. But again, any loss of efficiency or reduction in farm income can tip the scales in favour of weeds. There is no question of weed eradication.

As an adjunct to weed control chemical weed-killers have been in use for fifty years. Bluestone, iron sulphate, sulphuric acid, sodium arsenite and sodium chlorate have all been used and still are used with more or less success. But the high cost per acre for materials, the explosion, poison, and fire hazards in some cases and equipment corrosion in others, together with only moderate success in weed control, left the science of chemical weed control in disrepute.

In the post-war period a revolution has occurred in chemical weed control. The chemist has placed and is placing in the hands of the farmer new materials which could lead to weed eradication. These materials include the hormone weed-killers 2-4-D, M.C.P. and 2-4-5.T., the (contact) herbicides D.N.O.C. and D.N.B.P., and the grass weed-killers T.C.A. and I.P.C. Of these the most spectacular have been the hormone weed-killers.

Nature of Hormone Weed-Killers, or growth regulating compounds.

It has been known for about twenty years that plant growth is regulated by minute amounts of chemicals called hormones. When extracted from plant tissue and applied to the growing plant these substances can induce various responses such as bending of stems and roots, stimulation of root growth on cuttings, prevention of premature fruit drop and the development of fruit without pollination. More recently, synthetic chemicals have been made with properties similar to those of the natural plant hormones. Some of these synthetic hormones have been found to be effective as weed-killers. The substances that have proved most effective so far are made from phenoxyacetic acid. These are:—

2-4 D: 2-4 dichloro phenoxyacetic acid

M.C.P.: Methyl chloro phenoxyacetic acid
2-4-5 T: 2-4-5 trichloro phenoxyacetic acid.
These substances are—
1. Selective in action, killing certain plants without injuring others.
2. Extremely toxic to susceptible plants.
3. Slow in action.
4. Harmless to man and animals.
5. Reasonably inexpensive.
6. Non-corrosive and non-inflammable.
7. Rendered innocuous in the soil in a period of 1-3 months.

The selective action of hormone weed-killers is not fully understood but is party explained by.
1. Differential wetting, e.g.. a waxy leaf is not easily wetted: the angle of leaves on some plants makes for ease of wetting.
2. Differential absorption; thick waxy skinned plants tend to absorb less.
3. Location of growing point, e.g., in grass it is below ground; in clover it is in the axils of the leaves.
4. Physiological differences within the plant.

In general the most susceptible plants are seedlings, young, actively growing succulent plants, wide flat-leaved plants and plants with their growing points exposed.

Selectivity is the main feature of hormone weed-killers—for example they can be used to kill wild turnips in oats, wild oats in turnips, gorse in a pasture and pasture plants among shrubs. However, it should be realised that this selectivity is relative. Only when dosages, methods of application and weed and crop species are properly co-ordinated, do these chemicals kill weeds selectively. Even tolerant plants will succumb if concentrations are too high or conditions during application are not suitable.

Translocation

Hormone weed-killers are sometimes referred to as translocated herbicides. For example, if an application is made to some of the leaves, the chemical penetrates into the leaf and travels in the sap flow to growing points and to deep-seated roots. Because of translocation, complete coverage in the case of M.C.P. and 2-4D is unnecessary. Consequently only small quantities of spray are required, even as little as two gallons of mix per acre being effective. It is this feature of translocation which gives hormone weed killers their superiority for weeds with deep-seated roots. Contact herbicides, killing only those tissues they come in contact with, are useful for seedlings, but fail to control deep-rooted perennials. As translocation is thus a vital feature for the success of hormone weed-killers, stage of growth, sap flow, weather conditions, methods of application and form of hormone used should all be such as to ensure penetration and translocation. Except for seedlings where a contact kill is secured, the concentration of the spray should be low enough to permit slow absorption and translocation. If it is high, a quick death of surface parts can permit regrowth from unaffected portions.

Effect on Plants

The actual mode of killing by hormones is not fully understood. However, hormones tend to increase the rate of respiration in plants; insoluble foods are converted to a soluble form and utilised, e.g., starch is converted to sugar, a change noted and appreciated by stock; proteins in the plant are affected and also the enzymes responsible for bringing about chemical changes; the transpiration rate is reduced causing swelling in plant cells; the growing tissue of the plant is stimulated to excessive but irregular activity causing the development of grotesque malformed leaves, stems and roots. At low concentrations the hormone may act as a plant stimulator, but at higher concentrations death will occur.

COMMERCIAL PREPARATIONS

Hormone weed-killers

The acids 2-4D, M.C.P. and 2-4-5T are insoluble powders. Before they can be used in sprays they have to be made into salts or esters. A "salt" is the compound of a base and an acid. Thus, if the base caustic soda is combined with 2-4D acid it forms the sodium salt of 2-4D. Similarly, amine salts of these acids can be formed. These salts are soluble in water to form a spray solution.

An "ester" is a compound of an acid and an alcohol. Thus, if ethyl alcohol is combined with 2-4D acid, the ethyl ester of 2-4D is formed. The properties of the ester will depend on the alcohol used. The esters in common use are oily liquids insoluble in water. However, they can be made into an emulsion with water by the use of an emulsifier just as winter oil is used for spraying fruit trees. Most esters are oil-based. This oil has an effect on their killing properties which may or may not be desirable. A few esters now available are water-based and offer a useful line of attack under certain conditions. Esters made from ethyl and methyl alcohol are said to the volatile, i.e., they give off vapours which may damage susceptible plants; on the other hand, volatile vapours may kill parts missed in the spraying. Esters made with heavier alcohols, e.g., the butoxy esters, are non-volatile.

Acid-equivalent

Because the acid is the active ingredient responsible for killing the weeds and because the amount of acid used in different sprays varies, it is usual to describe the quantity used as so many pounds of acid-equivalent (a.e.). In liquids it is usual to express acid-equivalent in pounds per gallon, e.g., many commercial preparations contain 3 lb a.e. per gallon. If a weed such as wild turnip requires ½ lb per acre for control then the amount of concentrate required per acre is one-sixth gallon, or 1⅓ pints.

Effect of different compounds

The sodium salts of the acids are the most selective weed-killers, and have least effect on crops. However, they have poor penetrating ability and on waxy or hard skinned weeds they are relatively ineffective. Once entry is made to the plant translocation is good. Amine salts are more toxic than sodium salts and therefore less selective but are effective against a wider range of weeds or weeds in a slightly more advanced stage of growth. Oil based esters are unaffected by rain; they are much more adhesive and consequently less selective. Generally they are not used on crops. Their penetration on waxy plants is much superior to that of salts but translocation is seriously affected by the oil base which causes a break-down in plant tissue. Water-based esters recently developed may prove valuable for the destruction of deep-rooted perennials.

As an indication of the difference in the composition Matthews suggests as a rough guide

½ lb a.e. ester = ¾ lb a.e. amine salt
= 1 lb a.e. sodium salt

In the product sold by the manufacturer we find a salt or ester of the acid, a solvent to dissolve this compound, an emulsifier in the case of oil based esters, and possibly a wetting agent, an adhesive and an activator. Such additions to the compound are costly and can cause variations in price. It is for the operator to choose the material most suitable for his purposes, not necessarily the cheapest product. Information on composition is given from time to time in the Journal of Agriculture and in the volume for April and May, 1952, Matthews gives a detailed account of the commercial preparations available.

2-4-5T. (2-4-5 Trichloro-phenoxy-acetic acid)

This material has proved exceedingly successful on gorse, blackberry and other woody perennial weeds resistant to M.C.P. and 2-4D. 2-4-5T is sold as a volatile and as a non-volatile ester and also mixed with the ester of 2-4D. Mixtures of 2-4D and 2-4-5T are not recommended by New Zealand research workers for control of woody perennials but could be useful for spraying a mixed flora.

The question of whether to use a volatile or non-volatile ester of 2-4-5T is the subject of some controversy as yet.

The Di-nitro Phenols—D.N.O.C. and D.N.B.P.

The di-nitro phenols have long been used as dyes in the textile industry but their use as selective weed-killers is recent. These dyes are somewhat irritating to the skin and in large amounts are poisonous. During prolonged exposure respirator, goggles, rubber gloves, overalls and hat should be worn, particularly during hot weather.

Being contact herbicides with little power of translocation sufficient spray must be used to wet the vegetation; the minimum quantity of spray should not be less than 20 gallons per acre and even at that figure demands a high pressure to give good atomisation.

D.N.O.C. (Di-nitro-ortho-cresol) was the first material used. It kills a wide range of weed seedlings but has the disadvantage of requiring activation by the addition of an ammonium salt.

D.N.B.P. (Di-nitro-butyl-phenol) is more selective and kills only the seedling growth of broad leaved weeds. It does not require an activator. D.N.B.P. is the first of what may prove to be a numerous series, a specific weed-killer for a specific crop—peas. Its value for the control of fathen, nightshade and other seedling weeds in peas is outstanding. It can also be used successfully on clovers, lucerne, linen flax and other crops susceptible to hormones.

The Grass Weed-killers; T.C.A. and I.P.C.

Unlike the hormones which kill broad-leaved weeds and are non-toxic to grasses, T.C.A. and I.P.C. control grasses and are relatively non-toxic to broad-leaved plants at normal rates of application. T.C.A. (Tri-chlor-acetic acid) is usually sold as the sodium salt and must be kept in air-tight containers as it absorbs moisture from the air. It possesses no fire hazard but is somewhat caustic and corrosive, so that skin and equipment should be washed after its use. T.C.A. may be used as a dust or spray. It gains entry to the plant mainly through the roots and is less effective when applied to tall top growth.

I.P.C. (Iso-propyl-phenyl-carbamate) is available as a powder for spreading as a dust and in emulsified soluble form for spraying. I.P.C. has no disagreeable properties. It is less toxic than T.C.A. and is mainly of value for seedling grasses whereas T.C.A. is effective on plants such as couch and creeping fog. As yet these materials are in the experimental stage and are unduly expensive.

A listing of plant tolerances to T.C.A. shows an almost complete reversal of tolerances to hormones, thus increasing the potentialities of chemical weed control.

One interesting trial in New Zealand on rape and turnips gave complete control of spurrey with no toxic effect on the crop. Results with these materials to date justify widespread trials.

Sulphuric Acid

This acid has been used for a variety of crop spraying, but in New Zealand is mainly confined to selective weed control in onions. The crop is sprayed before emergence and again when 4-6 inches high. Excellent control is achieved of annual weeds. However, it is a difficult acid to handle, being highly corrosive on equipment and dangerous to skin and flesh.

Kerosene

Power kerosene is used as a selective weed-killer in carrot crops, spraying being carried out at the two-fern leaf stage. Power kerosene is variable and some lines will kill carrots. Lynch (Journal of Agriculture, November, 1948) advocates a trial on a small scale before commencing spraying.

Other chemicals

We can anticipate numerous new chemicals, many of them developed for specific crops. Three in overseas use are: C.M.U. for soil sterilisation; maleic hydrazide for controlling weeds in cotton; and E.H.1 for controlling weeds in beans and spinach.

Development of strains and species of resistant weeds

Continued application of one weed-killer to an area can result in:

1. A change from one weed species to another, e.g., spraying for wild turnip can result in an increase in the infestation of wild oats and/or wire-weed. In England there has been an increase in the infestation of the resistant plant chickweed in cereals sprayed for control of susceptible weeds.
2. The development of resistant strains of a weed, e.g., in the United States using 2-4 D persistently has given rise to resistant strains of Californian thistle. These two factors suggest that chemical weed control has severe limitations. However, the remedy lies in the use of two or three weed-killers, each with a different mode of action, e.g., a waxy-skinned strain of Californian thistle resistant to M.C.P. may be susceptible to a strong form of 2-4 D. We have available a large number of chemicals and it is important that the grower should be prepared to make use of them to ensure against the development of resistant strains or species.

Advantages of chemical weed control

The suggestion has been made above that chemical weed control could lead to weed eradication. What advantages has this method to justify such a claim? Husbandry methods can achieve a certain measure of control up to the time of sowing the crop, but, except in the case of row crops, these methods can achieve only limited control in growing crops. Thus, even under the best of conditions there is always some re-seeding to perpetuate the problem. It is at this point in particular that chemicals can enter the field to produce crops completely free of those weeds susceptible to the particular compound or compounds used. If we have a sufficiently wide range of chemicals, then weed eradication is possible.

Copies of this Bulletin may be obtained from the Secretary, Canterbury Chamber of Commerce, P.O. Box 187, Christchurch.