COMPARISON OF THE POLYETHYLENE GLYCOL ESTERS OF THE PHENOXYACETIC ACID DERIVATIVES

By P. S. FERENS, Ivon Watkins Ltd., New Plymouth

To anyone interested in the field of hormone weedkillers the group under the heading polyethylene glycol esters can be a very fascinating study. At the present time under this heading there is PEG 2,4-D, which is available commercially, PEG MCPA, PEG 2,4,5-T, and PEG 4 chlorophenoxyacetic acid. The last three are still classed as experimental materials. It is concerning the comparative effectiveness on common weeds of these materials and the better known commercially available forms of 2,4-D, 2,4,5-T, etc., that I would like to tell you.

Very early in the development of 2,4-D as a plant growth regulator polyethylene glycol of a high molecular weight was used as a solubiliser for the 2,4-D acid. It was simply a case of the 2,4-D acid being dissolved in the polyethylene glycol. At a later stage of development of 2,4-D at the commercial product stage other methods of formulating were used. At a later stage again when it was known that the form of the 2,4-D ester and the method of formulation greatly influenced herbicidal activity the use of 2,4-D with polyethylene glycol was again investigated. This time, however, the 2,4-D acid was chemically re-acted with the polyethylene glycol to what is well known now as the polyethylene glycol ester. Various polyethylene glycol esters of 2,4-D can be made, each having a different ratio of oil to water solubility. The fact that the polyethylene glycol esters of 2,4-D are partially both oil and water soluble appears to be responsible for the apparently greater herbicidal activity with regard to perennials when compared on a pro rata basis with the conventional esters of 2,4-D.

We are familiar with the different effects of ester and amine formulations as regards absorption, penetration, and subsequent translocation, etc., and this is what Dr. A. S. Crafts of the University of California has to say on this point with regard to polyethylene glycols: "To penetrate the cuticle the herbicide molecules must be appreciably soluble in fatty substances; on the other hand, in order to part from the cuticle and enter mesophyll cells and eventually the phloem they must also be water soluble. Undissociated molecules of 2,4-D and 2,4,5-T acids and the glycol esters of these acids apparently have both of these properties; experiments prove that these compounds of balanced fat and water solubility (polyethylene glycol) are the ones that translocate best in plants. The highly polar salts have less tendency to penetrate the cuticle, the non-polar aliphatic esters dissolve in and penetrate the cuticle, but they do not part so freely into the aqueous mesophyll and phloem. From the above considerations it is evident that absorption of herbicides through cuticle depends largely upon the chemical nature of the molecules and hence on formulation.

"Movement across the mesophyll must take place in water solution and diffusion accelerated by protoplasmic streaming is probably the principal process concerned. A remarkable quality of the phenoxyacetic acid herbicides is that their molecules can apparently be absorbed by the

living protoplasts and transported from cell to cell without causing immediate and serious damage to those cells. If this were not true, 2,4-D would never reach the phloem, but would tie up in the mesophyll as do the dinitro herbicides."

The two most urgent research problems are the effect of the phenoxy compounds or their breakdown products on the dormant buds in the root-stem transition zone, and their movements into the natural rhizomes. This is exemplified when one considers such plants as Californian thistle, etc.

It must be emphasised that the following are results of preliminary investigations only and concern reports in many cases of only one or two field replications. Further variations in time, rate, and stage of application may considerably increase or decrease the percentage of control so far obtained.

POLYETHYLENE GLYCOL ESTER OF 2,4-D

Many of you will have made observations of your own following the use of polyethylene glycol ester of 2,4-D, more specially in the control of docks (*Rumex* sp.). The herbicidal activity of this form of 2,4-D is beyond doubt, but application details are still at a stage where improvement can be sought.

It has been typical in the control of docks species and Californian thistle (*Cirsium arvense*) that you may get away with lighter applications of other hormone applications, but PEG 2,4-D must be applied at the full recommended rate of application or control will diminish according to the reduced rates of application. Rates of application of PEG 2,4-D are relatively high and it is naturally of importance that damage to associated clovers be reduced to a minimum. Results in the field have shown that polyethylene glycol 2,4-D has been more damaging to clovers along the lines of accepted tolerance and susceptibility than was the case with initial experimentation. Extensive formulation investigation makes it appear very hopeful that this damage can be greatly reduced without lowering the herbicidal activity of the formulation to any degree.

With PEG 2,4-D on the commercial market for a complete season it was to be expected that both users and research workers would apply this formulation to many other common weeds and, of these most interesting results have been obtained on periwinkle (*Vinca major*). Top growth kills have been obtained with a concentration of 1 in 80 and a follow up spray at a lower concentration gives every indication of a satisfactory control.

Californian thistle in a number of areas has been most successfully controlled.

From our own experiments it appears that the lateral movement of 2,4-D or its breakdown products has an added power of movement in the lateral root system when applied as a polyethylene glycol ester formulation.

First year control of Californian thistles has in most cases been in excess of 60 per cent. to 70 per cent. and it is also interesting to note that in many cases, spraying a mixed association of both Californian thistle and docks, the spray has been applied at a stage to suit the docks rather than the Californian thistle. Even so good control of the Californian thistle has been obtained. All field trials so far conducted on Californian thistle have been with applications at bud or early flower, or with the more recent cumulative 3-separate treatment early in the growing season. The three applications of 2,4-D in three successive sprayings is, we know, rather more effective than the one application of the total amount. This

approach seems to be most effective when plants are being treated which can be killed to the ground line. The repeat sprays kill the sprouts which arise from natural rhizomes. This same approach is, however, quite ineffective on other types of plants, where all that is obtained is a foliage kill.

At present trials are under way at various stages to evaluate the effects of PEG 2,4-D, PEG MCP, and other forms of 2,4-D and MCP on Californian thistle. Results of these trials should produce much interesting data.

POLYETHYLENE GLYCOL ESTER OF 2-METHYL 4-CHLOROPHENOXYACETIC ACID (PEG MCPA)

Commercial availability of polyethylene glycol ester of 2-methyl 4-chlorophenoxyacetic acid (PEG MCPA) will depend on the results of further field tests, both by the Department of Agriculture and ourselves. The most astounding results so far obtained have been on a group of plants which are not altogether satisfactorily controlled with the available forms of 2,4-D and MCP. I refer here to ox-eye daisy (*Chrysanthemum leucanthemum*), Cape daisy (*Cryptostemma calandulacea*) and Chamomile daisy (*Matricaria chamomilla*). Control has been obtained at stages from very young up until just before flowering, and rates of application range from 1lb. to 3lb., the most economical and most satisfactory rate of application being 2lb. of MCPA per acre.

Because MCPA in the sodium salt or butyl ester form has given quite astounding results in the spraying of Californian thistle, extensive field work is now under way with PEG MCP at various rates and stages, and we hope that this will bring to light some interesting information.

MCPA is a most useful material primarily because of its tolerance to clovers. Polyethylene glycol is in itself non-phyto toxic to clovers and in the formulation of PEG MCPA no serious clover damage has been noted. In fact, a Tasmanian authority recently advised of its use in the spraying of strawberry clover, a most susceptible clover, without any apparent damage.

Giant buttercup (*Ranunculus acer*) is another serious pasture weed which has come under field experimentation with PEG MCP. In these particular trials all available forms of MCP were applied at varying rates and it is interesting that the herbicidal activity of MCP decreases markedly at the higher rates of application.

This trial also indicates that giant buttercup can be controlled just as satisfactorily at the lower rates of PEG MCP as with the other available forms of MCP. It must be pointed out here, however, that this is a fairly recent trial and the spring regrowth has yet to be evaluated. Rates of application have varied from $\frac{1}{2}$ to 3lb. of MCPA per acre and 2lb. per acre of PEG MCP was definitely more effective than 3lb. of PEG MCP per acre.

Inclusion of PEG ester of MCP in our barberry (*Barberis vulgaris* and *darwini*) trials had quite an astounding result. At the concentration of 1 in 100, applied in December, as a total over-all spray to barberry which had not been cut and was 8ft. high, total control was obtained. Other materials included in this trial were butyl MCP, sodium salt MCP, butyl ester 2,4,5-T, and butoxy-ethanol ester 2,4,5-T. None of these materials applied at equivalent concentrations and at the same time gave the same control as did PEG MCPA.

POLYETHYLENE GLYCOL ESTER OF 2,4,5-TRI- CHLOROPHENOXYACETIC ACID (PEG 2,4,5-T)

Formulation plays a very important part in weed control and this factor is certainly not lacking when it comes to the PEG type formulations.

Applications of PEG 2,4,5-T to both gorse (*Ulex europaeus*) and blackberry (*Rubus* spp.) are most disappointing. Results obtained after fairly extensive trials indicate that this formulation is definitely inferior to the ordinary esters of 2,4,5-T in the control of these brush species. Other species, however, do re-act more favourably to applications of PEG 2,4,5-T. With most woody plants the ordinary phenoxy compounds will kill the above-ground portion, but how far the effect of these chemicals extends past the root-stem transition zone with some species is still unknown. Ability to kill these woody plants seems to depend on such factors as the amount of stored food, the area in which dormant buds are located, the amount of chemical the leaves will absorb and transport, and the sensitivity of the plant to the particular phenoxy compound applied.

This is very true of brier (*Rosa eglanteria*). Applications of normal ester formulations of 2,4,5-T are not satisfactory in the majority of cases. Extensive basal regrowth takes place the following season with all plants, other than first or second year plants, and the end result is a very small percentage of control of the original plant. However, applications of PEG 2,4,5-T at concentrations of 1 part in 140 have given quite promising results when applied at petal fall or early hip formation. It has been rather puzzling, however, the variations we have had in these particular brier trials. Quite a number of them have been outstanding, but with an equally large number the results have been very poor. However, with further more elaborately designed sets of trials we hope to eliminate any variable factors.

Of interest to the majority of home gardeners will be the results of trials on oxalis (species *Rosea*, *Corniculata*, and *Cernua*). Applications of PEG 2,4,5-T at the rate of 1lb. active 2,4,5-T per acre in 3 separate applications have brought about a very satisfactory control of this plant. Applications commenced in September. This was followed by a fairly rapid foliage kill and fairly extensive regrowth within a few weeks. Further application again brought about a foliage kill, though not quite so rapid as the initial application, and regrowth from this second treatment was very slight. The third application, again some weeks later, has brought about a control somewhere in the vicinity of 80 per cent. Better timing of these treatments may possibly increase the percentage of kill.

PEG 4-CHLOROPHENOXYACETIC ACID (PEG 4-C)

Field experimentation with the PEG formulation of this relatively new phenoxyacetic acid derivative has been confined to weed control in peas. Overseas research work indicates that this material is much lighter on legumes even than MCPA. Experimentation has covered rates from 2 to 16oz. of active ingredient per acre applied in large quantities of water, usually 40 or 50 gallons per acre.

Fat-hen (*Chenopodium album*), nettle (*Urtica urens*), and Scotch thistle (*Cirsium lanceolatum*) are readily controlled at anything above a 3 or 4oz. rate per acre. The more difficult weeds present in this area, Prince of Wales feather (*Amaranthus retroflexus*) and black nightshade (*Solanum nigrum*), necessitate a higher rate of application which borders on the line of crop damage. Seasonal peculiarities were the main troubles

encountered in these particular field trials. When sufficient moisture was present to enable weed growth good weed control was obtained at 8oz. per acre, but during the drought period 10 and 12oz. are required to bring about a reasonable weed control, but at this rate crop damage was also noted. No varietal differences were noticeable in the peas sprayed, which were Green Feast, Onwards, Massey, Victory Freezer, and Freezer 109.

I have endeavoured to give an up-to-date picture of the position of polyethylene glycol weedkiller formulations as we have found them under New Zealand conditions. Much more work needs to be done, not only with this form of weedkiller but with most other formulations, or more particularly new hormone preparations, as it appears that both 2,4-D and 2,4,5-T must in time be superseded. I would suggest as a final thought that the downward movement of the phenoxy acids as mentioned previously in both woody plants and pasture species warrants further investigation and is the most important single problem confronting research workers in this field today. Polyethylene glycol esters have in part improved this limitation of insufficient translocation, but there is still much more room for improvement.

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DISCUSSION

Q.—In trial work with the comparison of 4-C and the PEG ester of MCP which was the most damaging to peas?

A.—The esters of 4-C appeared to be the more damaging.

Q.—Will PEG compounds always be more expensive to purchase?

A.—They are generally more costly to manufacture.