THE BIFLON* SYSTEM

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Summary

The phenomenon of drift associated particularly with aerial application of pesticide chemicals applied as aqueous solutions or dilute oil-in-water emulsions has long been recognized and numerous mechanical and physical innovations have been introduced in attempts to minimize this problem with conventional sprays. Alteration of the physical properties of the spray liquid to produce a highly viscous liquid has been shown to be a promising approach to the problem. The Biflon system provides a means of applying in a practical manner extremely viscous water-in-oil emulsions and evidence is available from field trials that this system can be used commercially for weed control with the advantage that spray drift is reduced to insignificant proportions. The use of insecticide formulations is being investigated to determine to what extent the rates of toxicant can be reduced with the Biflon system.

INTRODUCTION

THE INVENTION of a bi-fluid spraying system which offers a practical method of applying viscous pesticide formulations was described by Morrow and Phillips at the Second International Agricultural Aviation Congress in 1962 (Morrow and Phillips, 1962). The results of studies in the U.S.A. comparing the performance of high viscosity water-in-oil emulsions applied by this new technique with conventional oil-in-water sprays showed that very substantial reduction in the quantity and extent of spray drift could be obtained (Phillips, 1963). A preliminary report on overseas trials and possible lines of investigation in New Zealand with the bi-fluid system was given to this Conference by Thomson in 1963.

PHYSICAL PROPERTIES

The physical properties of water-in-oil emulsions have been described elsewhere (Beatty *et al.*, 1959; Colthurst *et al.*, 1965) and some preliminary data on the spraying characteristics of these products have already been published (Colthurst *et al.*, 1965; Lee *et al.*, 1963).

Essentially, invert emulsions are non-Newtonian fluids exhibiting special physical properties, the most important of which is concerned with viscosity. Viscosity increases as the phase ratio of water to oil is raised since, as further water is added, the continuous oil phase becomes more tightly packed with water droplets.

* "Biflon" is a Shell trade mark.

DROPLET SIZE AND SPRAY DRIFT

The first investigations of droplet size were carried out in late 1963. This work suggested that, given similar nozzles and operating conditions, invert emulsions produced a much coarser spray. It became obvious from this work that the problem of measuring droplet sizes of invert emulsions was complicated, but, very recently, a new technique has been found which should give more satisfactory information.

Since the beginning of 1964, the question of the droplet sizes given by invert emulsions has been approached from two points, a fundamental approach for which liquids of pre-determined viscosity have been employed, and, secondly, a look at the droplet spectra produced by invert emulsion sprayed from various nozzles both in the laboratory and in the field. In the laboratory, it can be demonstrated that, giving similar operating conditions, invert emulsions produce sprays having a higher mass medium diameter than conventional materials. When an aircraft is used, however, the wind velocity over the nozzle introduces another parameter which markedly influences the result.

In late 1963, a new type of nozzle was introduced which is particularly suitable for invert emulsion spraying. Sprays even of conventional liquids produced by such nozzles have a large mass medium diameter (620 to 830 microns according to one series of measurement). Passing invert emulsion through the same nozzles under similar operating pressures has given sprays with the mass medium diameter of 1,000 to 1,200 microns..

Experiments to measure the extent of spray drift have been carried out using methods based on chemical recovery or response of plants to hormone weedkillers. Real differences in drift between conventional and invert emulsions have been shown under similar meteorological conditions. These differences have clearly demonstrated the no-drift properties of invert emulsions.

Since the viscosity of invert emulsions also depends on the water/oil ratio, it is to be expected that changes in this ratio will influence droplet size. The practical implications of such phase ratio changes have not been demonstrated as yet, but for most purposes it has been accepted that water/oil phase ratios of less than 5:1 are unlikely to give sprays having sufficiently high viscosity to influence droplet size from the point of view of drift control. Water/oil phase ratios of up to 12:1 can be achieved using special invert oils which have been developed.

BIOLOGICAL ACTIVITY

HERBICIDES

Attention initially was given to phenoxyacetic acid herbicides since it was considered at the time that the Biflon system as a means of drift control was of more immediate commercial value in this field. This early work showed superior phytocidal effects with the oil-soluble phenoxyacetic acid derivatives applied as water-in-oil emulsions. These appeared to be more active on a weight basis as well as being better translocated. These formulations are of very low volatility which enhances their value in areas where susceptible crops are grown adjacent to sprayed areas.

(a) *Brush Control*

The first field trials were designed to assess the biological efficacy of 2,4-D and 2,4,5-T invert emulsions for brush control and the results were sufficiently encouraging to warrant continued investigation. The conclusions drawn from this early work were that invert emulsions of 2,4-D and 2,4,5-T, though causing less initial defoliation than conventional materials, gave more effective control of brush when regrowth was assessed. Later field trials have confirmed these conclusions and have shown also that, when applied as water-in-oil emulsions, the water-soluble amine salts of 2,4-D and 2,4,5-T are equally as active as the oil-soluble ester formulations applied as invert oils.

(b) *Aquatic Weed Control*

Trials carried out in the United Kingdom and in Italy during 1964 and 1965 against the common reed (*Phragmites communis*) showed that an invert emulsion containing the sodium salt of 2,2-dichloropropionic acid applied at a rate of 12–14 lb (all rates expressed as active ingredient per acre) in a total volume of 9 gal per acre, gave extremely effective control—greater than 95% kill being obtained from one application (Vavassori and Muller, 1965).

Attention has also been given to assessing the efficacy of this technique in applying 2,4-D for the control of water hyacinth (*Eichhornia crassipes*) in the United States (Robinson, 1965) and in the Sudan. Fixed-wing aircraft and helicopters have been used and the results have been entirely satisfactory at application rates of 1 to 2 lb in 5 to 15 gal total volume, compared with conventional treatments at 3 to 4 lb.

For aquatic weed control, invert emulsions possess a unique advantage in that spray droplets not impacting directly on foliage remain as discrete droplets floating on the water surface. As they are carried by water movement, these droplets adhere to foliage emerging from the water surface. The loss of active material through dilution and dispersion when applying herbicides in a conventional aqueous spray to the water is overcome.

(c) *Selective Weed Control in Cereal Crops*

The use of the Biflon system as a means of applying selective herbicides from aircraft to cereal crops has obvious attractions, since in many parts of the world the aerial application of growth-regulating herbicides is severely restricted and a potentially large market for the agricultural aircraft operator is virtually closed on account of the drift hazard. Clearly, there are different criteria from those adopted for brush and aquatic weed control to be considered. Whilst a smaller droplet size is required to obtain the crop penetration and coverage necessary for seedling weed control, the droplet size must be kept at a level compatible with effective drift control. The results of field work have shown that satisfactory weed control and effective regulation of spray drift can be obtained simultaneously under most conditions.

During 1964–5, a number of trials were carried out in the United Kingdom, and 500 acres of wheat and barley were sprayed on a semi-commercial basis. Dosage rates of 0.25 to 0.5 lb 2,4-D and

MCPA in a total volume of 2 to 3 gal gave satisfactory weed control compared with 0.6 to 1.5 lb for conventional materials, and a much greater degree of control over spray drift than hitherto obtainable. The aircraft utilization rate was highly satisfactory, the pilot being able to complete spraying in wind speeds of up to 20 m.p.h. During 1966, the system has been operated commercially for cereal weed control.

INSECTICIDES

Results from early field trials with insecticidal invert emulsions suggested that these formulations were more active than conventional formulations in the field.

The potential use of the Biflon system as a method of applying invert emulsion as insecticide carriers is now being evaluated to determine to what extent improved biological performance through increased adhesion, persistence, reduction in evaporation rate and improved deposition is obtainable. The work so far has been carried out using non-systemic insecticides, endrin and endrin/methyl parathion mixtures, since it is considered that, if advantages are found with these products, these advantages will apply to all types of insecticides.

EQUIPMENT

The essential feature of the Biflon system is the separate pumping during spraying of the mobile oil and water phases of the invert emulsion into one or more specially designed mixing chambers where invert emulsification occurs. This is a continuous process during application and the highly viscous emulsion formed can easily be sprayed.

Application equipment that will meet the requirements of a diversity of users is in various advanced stages of development. Equipment has already been designed for such aircraft as the Callair A-9, Piper PA 18A, Piper Pawnee 235B, Snow S2-D, Bell 47D and G series helicopters. This equipment will be interchangeable with existing application machinery and is likely to be suitable for conventional as well as bi-fluid spraying. Motorized and power-take-off ground equipment for brush or crop use and a knapsack sprayer also have been designed.

Since it is necessary to store and pump two discrete liquids as opposed to one liquid in conventional spraying, an aircraft adapted for bi-fluid spraying requires the addition of a second spray tank, secondary pump and the necessary plumbing as well as the mounting of the special mixing chambers. However, the amount of chemical used is at the most only one-seventh of the quantity of water used and therefore the second tank need only be of a relatively small size.

Accommodation of this tank does not present significant engineering problems. Operation of the system depends upon the accurate metering of the two phases into the mixing chambers. Since this is achieved by the use of metering discs inserted in the phase delivery lines, precise pressure control on both phases is an essential part of the equipment. In the event of mechanical failure resulting in the emission of broken emulsion with its attendant drift hazard, visual warning is given to the pilot by means of a simple electronic indicator.

CONCLUSION

It is recognized that, when pesticides in the form of aqueous solutions or emulsions are applied through conventional nozzles designed to break up the liquid into a relatively fine spray, a proportion of this spray, consisting of the very small droplets, is likely to drift away in any air movement. As the droplets travel through the air, they evaporate, become smaller, and drift still further downwind. The use of invert emulsions by the Biflon system appears to offer a practical solution to the problem of drift control.

There are several objections to the present practice of preparing emulsions before they are sprayed. One cannot be sure that the emulsion is uniform throughout. If it is not, the sprayed liquid will contain concentrations of pesticide above and below what was intended. If spraying is interrupted for some hours, the emulsion may deteriorate and when operations cease for the day there is the problem of what to do with any emulsion left over. The Biflon system circumvents these difficulties quite apart from the advantages it provides by reducing drift.

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