SYSTEMIC INSECTICIDES INCLUDING THEIR USE FOR VIRUS CONTROL

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SYSTEMIC INSECTICIDES AND VIRUS CONTROL IN POTATOES

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Some of the best districts producing table-stock or ware potatoes are those where aphids are numerous and where aphid-transmitted viruses spread readily. Infected plants yield little, so the potato stocks have to be renewed annually, or every few years, with stocks from other districts where aphids are few.

Buying new seed tubers is expensive, particularly when the ware area is distant from seed-growing areas; even in England, which is near two of the best seed-producing areas, Scotland and Ireland, the cost of new seed tubers may account for one-third of the total cost of growing a ware crop. The spraying experiments and farm trials, organized from Rothamsted during the last 14 years, had the aim of prolonging the useful life of potato stocks in England.

Preventing the spread of virus by killing insect vectors is a rather different problem from preventing the plants being damaged directly by insect pests; the epidemiology of the diseases concerned must be considered before the experimental results can be understood. Similarly, differences in epidemiology must be allowed for before attempting to apply insecticide control in areas other than England.

Virus Spread

The two viruses, leaf roll and potato Y, that cause potato stocks to degenerate rapidly in England are both aphid-transmitted. The ways in which aphids transmit the viruses are important in relation to insecticidal control. Aphids can pick up virus Y in a few seconds and transmit it immediately to healthy plants on which they feed briefly. In contrast they must not only feed much longer to acquire leaf roll virus, but they also take a day or more to become infective after they have acquired the virus. Most residual insecticides fail to incapacitate aphids in less than an hour, and therefore do not completely prevent the spread of virus Y, whereas they have up to a day to kill vectors of leaf roll virus before they become infective. There is some decrease in the spread of Y because the insecticides greatly decrease the numbers of aphids, but to prevent its spread, a persistent insecticide is needed which incapacitates aphids so rapidly that they do not move away from a treated plant.

Of the several species of aphids infesting potatoes in England, Myzus persicae (Sulz.) is the most important vector of viruses; although numerically many fewer, the winged individuals spread virus much more than do the wingless bulk of the population. M. persicae has a very wide host range and usually overwinters in England as living insects both in the open and under shelter. It is, therefore, usually able to infest potato plants as soon as these emerge above ground in late spring. The numbers that reach potatoes depend on the weather and the activity of aphid predators and parasites. The aphids will have come from hosts other than potato, and because no overwintering alternate hosts of potato viruses are known in Britain, the aphids will usually be uninfective when they arrive.

Seed certification schemes ensure that most potato stocks planted for the first time in ware-growing areas contain few infected tubers, but these are scattered in the crop and virus is spread from them to nearby plants by the colonizing winged aphids, usually early in the season. Potatoes are most susceptible to infection when young, and the leaf roll virus is also most readily acquired by aphids from the diseased plants early in the season. Consequently, most spread of viruses usually occurs during May and June. The extent of virus spread depends on the number of infected source plants and the number and activity of the aphids, but the number of diseased plants seldom increases more than ten-fold in one season and stocks of many varieties can usually be kept safely for two years without any measures to check the spread of virus diseases.

Aphids usually leave potato plants as these begin to mature, during July and August, and some of the insects that have been feeding on diseased plants may alight on and infect plants in other potato crops, ofetn infecting initially healthy stocks. Usually fewer than 1% of plants in a previously healthy crop are infected in this way, but occasionally many aphids may arrive from a badly infected crop and infect as many as 80% of plants. Aphids retain virus Y for a few hours at most, but those carrying leaf roll virus may remain infective for the remainder of their lives, so leaf roll is more likely to be carried long distances from crop to crop, and the relatively poor control of Y is less important than it at first appears to be. There is little or no spread late in the season from plants already infected to others within the same crop.

Effectiveness of Different Insecticides

Experiments (Broadbent et al, 1960) have shown that no insecticide, contact or systemic, acts quickly enough to prevent aphids that are already infective when they arrive in a crop from infecting some of the plants they first feed on; therefore it is useless to try to prevent infected aphids bringing viruses into healthy stocks by spraying the plants with insecticides in midsummer; at best, using quick-acting insecticides, the number of infected plants may be decreased slightly. A much more effective way of preventing the infection of healthy stocks is to spray all crops containing infected plants once or twice before the aphids leave them, so destroying the infective aphids at their source.

Any effective aphicide, contact or systemic, that prevents aphids from colonizing the plants, kills non-viruliferous insects before they can become infective with leaf roll virus, and prevents the spread of this virus within the crop. (Broadbent et al. 1956, 1958) Although no insecticide acts quickly enough to prevent the spread of virus Y, treatment of crops usually decreases this by 50-75% because the aphids are incapacitated before they can visit as many plants as unaffected aphids.

To prevent spread between plants within a crop the insecticides have to be applied as soon as the plants emerge through the ground, and as a practical compromise it is recommended that the first spray should be applied when about 80% of the plants have emerged. The plants are then growing rapidly and a second spray should be applied about ten days later, followed by two more at intervals of two weeks. Thus the plants are protected for about the first two months of growth, during which time most spread occurs.

Most of the experiments have been made with DDT, which is effective when spraying is done with overhead and underleaf lances and is begun before aphids start to colonize the plants. It tends to be less effective in hot than cool weather and fails to kill all the aphids on newly produced shoots or on mature leaves when spraying is by overhead lances only. When a mature crop is being sprayed for the first time, even if underleaf lances are used, it takes a long time to kill all the aphids with DDT. Therefore the first spray at least should be with a systemic insecticide, such as demeton-methyl, phorate or dimethoate, and such insecticides should be used also for any single spray to clear the plants of aphids in midsummer.

The removal of infected plants (roguing) does not decrease disease incidence in unsprayed crops in ware-growing areas because much spread of virus, specially leaf roll, usually happens before symptoms are recognizable. When virus spread is limited by spraying, roguing has enabled stocks to be kept even longer than by spraying alone. Roguing a large ware area is an arduous task, however, and growers may prefer to spray and rogue a small area grown specially for seed, although this is slightly more costly than saving seed from the ware crop.

Recent Work with Systemic Insecticides

Stocks of potatoes have been kept with a low incidence of disease in many parts of England for three to five years when sprayed (Broadbent et al. 1960) some with and some without roguing, and a stock of early potatoes was kept productive for eight years in Hampshire. Although detailed costing (Broadbent et al. 1957) has shown that home-produced seed costs much less than 'imported' seed in most years, and with early varieties has the additional economic advantage of producing an earlier crop, few growers have yet adopted the method because they find spraying four times irksome and difficult in wet or windy weather. The passage of machinery applying the later sprays also damages the plants, but the loss of yield so caused is sometimes balanced by an increase in yield because spraying prevents damage by feeding aphids and other insects (Broadbent et al. 1958).

In an attempt to lessen the work and damage by tractor-drawn sprayers, experiments are being done with systemic insecticides applied either to the tubers or in the drills at the time the tubers are planted (Burt et al 1960). Preliminary work has shown that menazon sprayed on the tubers, and dimethoate, phorate or thiodemeton distributed in the drills, are absorbed through the roots and pass into the foliage and may prevent aphid colonization for most of the growing season. In an experiment with early potatoes in Hampshire this year, for instance, the numbers of wingless potato aphids on 100 leaves on 8 June, twelve weeks after planting were

	Total	M. persicae
Untreated	930	418
dimethoate ($4\frac{1}{2}$ lb/acre	99	63
menazon (1.3 lb/acre or 0.8 lb/ton seed)	49	26
phorate ($4\frac{1}{2}$ lb/acre)	0	0
thiodemeton (1 lb/acre)	0	0

(all rates are for active ingredients)

In two previous experiments dimethoate gave as good control as other compounds and in 1960, when applied to the drills at planting at 4 lb per acre, it checked aphids and virus spread better than DDT sprayed five times at 2 lb per acre per application. Some of the systemic insecticides delayed emergence, but when applied at rates just sufficient to control aphids, they depressed yields only slightly.

Further work needs to be done before these methods can be recommended to growers. Optimum rates of application must be determined and, although toxic residues in the tubers when the insecticides are applied at normal rates are very small, experience in a wider range of conditions may be required before tubers from treated crops can be sold for eating. The worst risk to consumers would probably arise from accidental overdosing by growers, and it is desirable, therefore, that ware crops should be treated with those compounds least toxic to mammals. In crops grown specially for seed the residue problem does not arise.

It will also be necessary to find out how soon soil-applied insecticides enter the leaves, for preliminary tests showed that aphids may not be killed during the first week after the shoots emerge. This will not matter with early potatoes because they usually emerge before aphids are flying, but it may be necessary to spray main crops once when they emerge during May.

We, and our colleague G. D. Heathcote, are now working on other problems, and our last potato experiment will be done in 1962. Perhaps N. A. A. S. Officers and the firms marketing the insecticides will continue the work and persuade growers that it will pay them to control virus diseases so that they can retain their stocks of potatoes for a year or two longer than is now customary.

References

BROADBENT, L., BURT, P.E. and HEATHCOTE, G.D. (1956). Ann. appl. Biol. 44, 256.

BROADBENT, L., BURT, P.E. and NIX, J.S. (1957). N.A.A.S. Quart. Rev. 38, 144.

BROADBENT, L., BURT, P.E. and HEATHCOTE, G.D. (1958). Proc. 3rd Conf. Potato Virus Diseases, Lisse-Wageningen, 91.

BROADBENT, L., HEATHCOTE, G.D. and BURT, P.E. (1960). Eur. Potato J. 3, 251.

BURT, P.E., BROADBENT, L. and HEATHCOTE, G.D. (1960). Ann. appl. Biol. 48, 580.

CONTROL OF SUGAR-BEET YELLOWS

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The grower wants to produce as much sugar per acre as possible, as cheaply as possible. These truisms should be kept in mind when considering the control of virus yellows in sugar beet crops. The objective is the control of yellows in so far as it gives an economic increase in sugar yield.

Three features of the disease are important in relation to control by systemic insecticides. First, the disease is spread mainly by Myzus persicae; secondly, the prevalence of virus sources in spring greatly influences the incidence of the disease; thirdly, the earlier a plant is infected during its growth, the less sugar it produces. Let us examine these three points, vectors, virus sources and yield losses, in more detail.

The importance of M. persicae as a vector of yellows has been demonstrated in several ways. Controlled experiments show its greater efficiency than other species of aphids in transmitting the virus. From data collected in field surveys over nine years, Watson and Healey (1951, 1953) showed that the incidence of yellows was directly related to trap catches of winged M. persicae. Surveys made each year by the British Sugar Corporation since 1946 clearly show that yellows is severe when green aphids are numerous and early on sugar beet, and that the incidence of yellows is not related to the prevalence of black aphids. When sugar beet in the field are examined in May and early June, occasional green aphids of several species are found on them. These may be important field vectors but M. persicae usually soon outnumber them, and as their numbers during the early stages of infestation of sugar beet are probably correlated with those of M. persicae, a comprehensive count of green aphids seems a good guide to the prevalence of M. persicae. Undoubtedly exceptions occur, as for instance when sugar beet are heavily infested in May with Myzus ascalonicus or with Macrosiphum enphorbieae. Such infestations are not necessarily followed by yellows.

We do not know whether the vagrant winged aphids of the many species that visit sugar beet, but do not start colonies on it, are ever important as vectors. They may spread yellows in those fields or districts, encountered occasionally, where yellows becomes severe although green aphids on the plants were always few. In general, however, the appearance and increase of M. persicae on sugar beet is a reliable indication that yellows will follow.

Yellows virus persists in aphids for only a matter of hours, so the M. persicae which infect sugar beet must have fed on yellows-infected plants a short time before. Some potential sources of viruliferous aphids are obvious, for the plants can be seen to have yellows and winged M. persicae; for instance, seed crops of beet and mangold, garden crops of seakale beet, ground-keeping plants of all cultivated Beta species, wild beet in coastal districts, the sprouts of clamped mangolds and red beet. Some of these are of local importance only. Measures have been taken to deal with others such as seed crops. Aphid-infested mangold clamps are important because they are ubiquitous and a potent source of winged viruliferous aphids over a long period in the spring. A practical method of dealing with them is much needed.

The role of weeds as virus sources needs further investigation. For several years we have placed aphids collected in April and May from weeds growing near beet fields on to sugar beet in the glasshouse. Occasionally mild and ephemeral yellowing develops on the beet. The only aphids which produce symptoms of sugar beet yellows virus are those from Beta species - e.g. stecklings, groundkeepers, mangold shoots. Are the mild yellowings of any importance? Does the sugar beet mild yellows virus (SBMYV) which Russell (1958) has shown to be so prevalent in English beet crops, originate from weeds?

The obvious spread of yellows to crops surrounding a source of viruliferous aphids will give a clear impression of its local importance, but may give a false impression of its direct importance to crops further afield. The deposition of aphids will be inversely proportional to at least the square of the distance if not the cube or a higher power. Thus aphids moving directly from a source to a crop more than a mile or so away are unlikely to infect more than an occasional plant per acre.

In some years, especially after a hard winter, most M. persicae found on beet during early summer occur on the few plants with yellows, and most of the crop is uninfested. M. persicae thrive and multiply better on plants with yellows than on uninfected plants, and they produce more alatae. (Baker, 1960) The aphids on such plants are probably the progeny of the winged aphid that infected the plant. They spread the virus to neighbouring plants and the winged aphids they produce will infect plants still further afield. I give this explanation of the course of development of yellows outbreaks so often seen - occasional infected plants in June, patches in July and an explosive development throughout the whole crop in August. This, though, is not invariable. Sometimes the crop can become yellow rapidly in June and July. The concentration of aphids on plants with yellows suggests that most of the winged aphids arriving early in the crop carry yellows virus, and these infect the plants and start the colonies. Field observations suggest that their likely source, after a hard winter, is clamped mangolds. An alternative explanation is that M. persicae not carrying yellows virus are seldom able to establish colonies on healthy sugar beet, which is supported by glasshouse experience; a third explanation is that sugar beet with yellows attract more aphids.

Eliminating the spring sources of virus and aphids will avoid early 'blanket' infection of neighbouring young root crops, but will never be so effectively accomplished as to prevent all infections. So long as a few plants get infected in young root crops, severe outbreaks may develop during favourable springs and summers, unless spread in the root crop can be otherwise controlled.

Experiments in the 1950's (Hull, 1960) established that the loss of sugar yield is proportional to the period, within the limits of infection times in the field, during which a plant has yellows. About 4½% of the potential sugar yield is lost for each week a plant shows yellows symptoms up to the middle of October. Thus plants with yellows at the end of June lose 60%, July 45%, August 27%, and at the end of September 9% of their sugar yield.

These losses apply to April-sown beet infected with a virulent strain of sugar beet yellows virus. They do not necessarily apply to infection with other strains or mixtures of viruses which are common in the field. Nevertheless, the total loss caused by the disease in Great Britain calculated from this figure agrees reasonably well with the loss calculated by other methods. (Hull, 1959).

Plants in the field develop yellows at different times so the experimenter is faced with the problem of getting a single figure for assessing the efficacy of his treatments. The count of infected plants at the end of August includes all those suffering the worst yield depression; a calculation of the 'infected plant weeks' from a series of counts at monthly intervals gives a figure proportional to the yield loss. The best assessment, although the most laborious, is to determine yields. Insecticide treatments may have other effects than controlling yellows; for instance, the direct feeding damage of vectors may be controlled; and infections caused by many vectors may have a different effect on yield from those caused by few.

Spraying with systemic insecticides has proved useful, in conjunction with other measures, for controlling yellows in stecklings. In stecklings, <u>prevention</u> of infection is essential; delaying infection is not enough. Viruliferous alate aphids invading stecklings in August and September will infect them with yellows even if they are sprayed at weekly intervals. Other measures, such as isolation or sowing under cover crops, must be taken to protect the stecklings while winged aphids are numerous.

The risk of direct infection by winged aphids usually decreases later in the year; late-sown stecklings have fewer plants with yellows than early sown ones, but do not grow big enough to transplant. Seed crops might, however, be sown in late August or September to grow on <u>in situ</u>. An improved method of seed growing may come from late sowing combined with protecting the seedlings against aphids, right from emergence, by seed or soil treatment with systemic insecticides.

Systemic insecticides have proved of immense value in controlling yellows in root crops. Field experiments show that a spray gives a worthwhile yield increase in crops where more than 20% of unsprayed plants develop yellows by the end of August. The more severe the yellows attack, the greater the increase in yield from spraying. On average, an early spray increases yield more than a late one and two sprays are only slightly better than one. But the best time to spray differs greatly in different seasons and districts. When aphids arrive early, an early spray is essential, and a late one may be useless. Conversely, when aphids are late, an early spray may be useless. When aphid infestation persists, two or even more sprays may be economically worth while. Experience shows that sprays at high gallonage are better than those at low, and that spraying is ineffective in windy, hot sunny weather.

The average increase in sugar yield from spraying is about 12%, but increases of 30-40% are common and the record is over 100%. Because the time of spraying is important, growers need to know when to spray. Following discussions by the Virus Sub-Committee of the International Institute of Sugar Beet Research, spray-warning schemes suited to their own circumstances were arranged in France, Belgium, Holland, Germany and Great Britain, and information on the development of aphids and issue of spray warnings are exchanged between the countries.

In England we try to assess in March the probable need for spraying from observations of aphids on winter hosts. A summary of the information collected is sent in bulletins to the British Sugar Corporation agricultural staff, to the National Agricultural Advisory Service and others. Spray warnings are sent to beet growers by the sugar factories when daily counts of aphids on sugar beet, made by the British Sugar Corporation fieldmen, indicate that green aphids are clearly beginning to multiply. Individual growers, all those in a fieldman's area or all in a factory's area, may be sent warnings according to the pattern of aphid infestation detected by the fieldmen's counts. An arbitrary figure of 0.25 aphids per plant is taken as the danger point, but other factors are taken into account, such as, the proneness of a district to get yellows, the incidence of yellows the previous year, the prevalence of virus sources, the suitability of the weather for spraying and for aphid development, the rate at which aphids are increasing, and the stage of development of the crop. More factual information is required to relate the fieldmen's aphid counts to the optimum time to spray, and we propose to experiment to this end.

In each of the five years the spray warning scheme has been in operation, we have had conditions favouring aphids and yellows in the spring, and spray warnings have been sent to growers in most beet growing areas. The acreage sprayed has been considerable - 100,000 in 1957 and 1958; 180,000 in 1959; 220,000 in 1960; and 330,000 in 1961. Some growers are still reluctant to spray solely because of the reported presence of a few green aphids which they cannot find, but are quite happy to do so when they see an infestation of black aphids. Time and experience will doubtless improve the warning scheme and also make growers understand the need to take early action.

The scheme has been adversely criticised on two counts, which are mutually contradictory. One criticism is that infestation varies so much from field to field that growers are being advised to spray fields where there are no aphids to kill; the other is that the scheme is attempting to be too refined and that growers should simply be advised to put on three sprays at fortnightly intervals each year as a routine.

I think it is wise to take the intermediate course. We are aiming to control yellows, not aphids, as pests. To control yellows the development of M. persicae infestation must be anticipated - hence spraying is advised when the infestation clearly begins to build up on sugar beet. As past experience shows that, when conditions favour spread of yellows, most fields in the affected area suffer, all farmers should be advised to spray whether or not their field is infested at the time. The weather may turn against aphids after the spray warning, and little yellows develop in crops whether sprayed or not - an inevitable risk until the weather the coming month can be predicted. The threat that yellows would be severe in each of the last five springs has encouraged the idea of routine spraying. Of the ten pre-spraying years, 1947-1956, in only two were more than 100,000 acres with over 20 percent of plants infected at the end of August (the criterion of whether spraying is justified); in five fewer than 35,000 acres would have responded to a spray. As well as this seasonal variation in incidence, the geographical distribution of yellows differ each year. A few areas get yellows almost every year and sensible growers in them spray as a routine. Since 1950, sugar beet have been infested late with green aphids in six years, early in five, and very early in one. When, therefore, should routine spraying start? The early infestations were 1952 and the five years 1957-1961 - perhaps we are due for some years of late infestation, and if routine spraying were recommended in all areas, growers would soon tire of spraying to no effect. We must not destroy predators and parasites or hasten the selection of spray-resistant aphids by unnecessary spraying. For these reasons growers should be told when to spray each year.

Each year has confirmed that spraying at the time of the warning has increased yield. Comparison of sprayed and unsprayed crop shows that spraying halves the incidence of yellows on average. The incidence of yellows in unsprayed fields has probably also been decreased by spraying such a large proportion of the acreage (up to 95%) in some areas. Evidence of this effect comes from the early spraying experiments when the unsprayed plots on the outside of the experiments had more plants with yellows than the unsprayed plots surrounded by sprayed ones. I think we can justifiably claim that spraying, with the other technical developments, is responsible for the record yields which have recently followed each other year by year.

The serious incidence of yellows in 1961 has raised doubts in some minds about the efficacy of spraying. In other years, such as 1957, when yellows has been severe, all plants on the sprayed plots have had yellows by September, but spraying has nevertheless increased yield by delaying infection. If the estimated yield this year is actually achieved it will be the second best ever obtained; without spraying yellows would have been of record severity and the yield would have been very much lower.

One striking feature this year is the frequency with which the incidence of yellows may be slight, say, 5 percent, in one field, and 100 percent in a neighbouring field, even when both have been sprayed. This erratic distribution has often been seen before the days of spraying, years when yellows incidence was moderate. Factors such as sowing date, plant population, soil fertility, variety and soil type, can greatly influence yellows incidence when it is 'marginal'; spraying changed 1961 from a 'severe' to a 'marginal' yellows year. The low yellows incidence crops are those sown early, well grown, with a high plant population.

Developments in seed dressing, granular formulations and soil treatments with systemic insecticides, will no doubt influence the nature of future control measures. Seed treatments are an attractive, easy control measure, but their effects do not usually persist long enough to replace the control now obtained by spraying. If, however, the sugar beet crop itself is an important source of the viruliferous winged aphids, seed treatment, or an early soil treatment may kill the few aphids that come from the winter sources and initiate colonies on the sugar beet crop.

References

BAKER, P.D. (1960). Ann. appl. Biol. 48, 384.
HULL, R. (1959). Report of I.I.R.B. 22nd Winter Congress, Brussels, 270.
BAKER, P.F. (1960). Ann. appl. Biol. 48, 384.
RUSSELL, G E. (1958). Ann. app. Biol. 46, 393.
WATSON, M.A. et al. (1951). Ann. appl. Biol. 38, 734.
WATSON, M.A. and HEALY, M.J.R. (1953). Ann. appl. Biol. 40, 38.

COMPARISONS OF APHICIDES, ESPECIALLY GRANULAR SYSTEMICS, FOR CONTROL OF BEET YELLOWS

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In the years 1954 to 1959 Hull (1960) tested the timing of demeton-methyl sprays to control aphids and yellows and assessed the yield response. Since 1957, on average, 227,000 acres of sugar beet have been sprayed annually to control both direct damage by aphids and especially the spread of yellows, the insecticides most used being demeton-methyl, dimethoate, fluoroacetamide and phosphamidon. (Dunning, 1961). These and other commercial and experimental aphicides have been compared in field trials since 1957 and in the glasshouse in 1960 (Dunning, 1959; Dunning and Winder, 1960, 1961).

Seed dressing formulations of systemic insecticides, such as phorate and thiodemeton, have been tested since 1957. Carbon-based seed-dressings of phorate and thiodemeton gave some control of aphids and yellows but were almost always phytotoxic (Dunning, 1960; Dunning and Winder, 1961).

In 1958 granular formulations of phorate and thiodemeton were tested in the field as soil treatments and later as foliage treatments, a technique reported to give good control of *Myzus persicae* in April/May applications on fall-planted sugar beet in California (Reynolds *et al.*, 1960). The dosage, phytotoxicity, methods and timing of application of phorate and thiodemeton granules have been tested for several years, and the effects compared with demeton-methyl sprays. These results will be reported elsewhere. In this paper experiments made in 1961 are described which tested the size and concentration of granules, their placement by machine, and compared their effect with the same amount of insecticide applied as a spray.

Aphid control was assessed where possible but more attention was given to assessing yellows incidence and especially the effect of the treatments on yield. The number of aphids per plant at a particular time were averaged for the treatment from counts of all aphids on a random sample of plants in each plot. Yellows incidence was obtained at intervals during the season by rapid visual assessment on as many plants as possible; these results have been converted into infected-plant-week totals* and then expressed as a percentage decrease in incidence of yellows for each treatment. Yield was determined by lifting suitable samples, topping, washing, weighing, determining sugar percentage by polarimeter, and hence sugar yield per acre.

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* $4\frac{1}{2}$% of this total gives the calculated percentage loss of potential yield (Watson, *et al.*, 1946).

Granule Placement

The first trials with granules tested them either broadcast and harrowed into the seedbed immediately before drilling, or drilled mixed with the seed.

Broadcasting the granules entailed using 2-3 lb of insecticide per acre but was reasonably effective in controlling yellows and increasing yield (Dunning, 1960); drilling the granules with the seed produced intolerable phytotoxicity at dosages which controlled aphids; increased granule size decreased phytotoxicity (Dunning and Winder, 1961). An extensive trial in 1959 with an experimental placement drill showed that granular demeton-methyl, dimefox, dimethoate, phorate and thiodemeton were non-phytotoxic at rates of up to 4 lb active ingredient when placed 2" to one side of the seed and slightly deeper; when placed in the row with the seed they caused damage unless used at 1 lb active ingredient per acre or less. The single-row plots, 30' long, did not permit satisfactory aphid counts, but seven weeks after drilling on 1 May the side-placed treatments had an aphid infestation similar to that of the equivalent in-row treatments which suggests that side placement should be an effective, as well as non-phytotoxic, method to test in further trials. Dimefox gave the best control of aphids, followed by thiodemeton, but differences in the effect of the insecticides were small.

In 1961 different amounts of thiodemeton granules were side-placed into the soil with a 'Gandy' granule applicator fitted with special coulters, either at the time of drilling or of steerage hoeing. These treatments were compared with a demeton-methyl spray, and with thiodemeton granules applied, by the 'Gandy' mounted on the steerage hoe, onto the foliage so that some of the granules were retained on the plant and the remainder fell onto the soil in a 4' band. The trial was at Dunholme on limestone soil, plot size being 8 rows x 52' (1/66 acre) with 4 replications of 6 treatments (Table 1, Figures 1 and 2).

The 32 oz rate of thiodemeton, side-placed at drilling time on 15 April, gave poorer aphid and yellows control but much better yield increase than the 8 oz rate. Results for the two rates have been averaged in Figures 1 and 2. The thiodemeton foliar top-dressing at 16 oz active ingredient per acre and the demeton-methyl spray, applied on 6 and 7 June respectively, gave rapid aphid control. The former was the more persistent and gave considerably greater yellows decrease and the only significant sugar yield increase. Thiodemeton granules side-placed into the soil at the same rate and time acted more slowly but gave the most persistent aphicidal action and nearly equalled the demeton-methyl spray in yellows decrease and sugar yield increase. Only 1.3" rain fell between the drilling treatments on 15 April and the remaining treatments on 6-7 June, but 0.6" fell during the following week. Maximum temperature on 6-7 June was 72° F.

Granule Size and Concentration of Active Ingredient

Foliar top-dressings with granules of different sizes and concentrations were compared in a field trial on limestone soil at Dunholme. The various thiodemeton and 0.5oz* menazon granule formulations were all applied at 16 oz active ingredient per acre. They were distributed, from hand-shaken perforated tins, in dry breezy air conditions and a temperature of 75°F. on 16 June. An experimental product, CR5331, at the same 16 oz rate and a demeton-methyl spray at the standard 7 oz rate were also tested. The plants averaged $8\frac{1}{2}$" diameter. The nine treatments were replicated four times on plots 30' x 8 rows (1/115 acre) (Table 2).

All treatments except menazon controlled black and green aphids within three to four days. Subsequently black aphid numbers were variable, but CR5331 clearly gave the best kill and persistence. In the control of green aphids, mainly M. persicae, menazon was again inferior to demeton-methyl spray. The large sized 5% thiodemeton granules (formulation 4909a) gave inferior aphid and yellows control and increased yield less than the normal-sized 5% granules (formulation 4909).

In the case of concentration comparison, 10% thiodemeton was superior to the 5% and 2.5% formulations in aphid control and yellows decrease, but inferior in yield increase. The higher concentration granules could not be applied as uniformly as the lower concentrations. The CR5331 granules controlled yellows well and gave the highest and the only significant yield increase.

Foliar Application Rates of Granules and Sprays

The efficacy of granules applied to the foliage may well be due to the high application rate per acre adopted and this was tested in a field trial at Broom's Barn Experimental Station, near Bury St. Edmunds. The sprays were applied on 26 May in a 7" band over the row at 2 oz a.i./acre, and at 24 oz a.i./acre to compare exactly with the granule treatments. Except for menazon (12.5 oz), these were applied at 24 oz a.i./acre to the foliage and adjacent soil in a band of the same width, on the 28 May, using perforated tins. The twelve treatments were replicated four times; plots were 60' x 18 rows (1/24 acre). Application rates of active ingredient per acre are given in Table 3; the 2 oz band-spray rate was the equivalent, on the plants, of an overall spray of 6 oz, approximately the normal commercial rate; in overall spraying with systemics the material falling on the inter-row soil is presumably wasted.

There were few Aphis fabae on 14 June and the counts made have little significance except to show that phorate and thiodemeton granules gave the best control. All treatments, except phorate spray at the 2 oz rate, controlled the more numerous green aphids well; phorate and dimethoate sprays and granules gave excellent control at the 24 oz rate. Menazon granules at 12.5 oz controlled green aphids better than the spray at 2 oz.,

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* The 5.0 % menazon granules proved on analysis to contain only 2.6 oz and, therefore, only 8.3 oz a.i. were actually applied.

but not as well as at 24 oz.* Yellows counts are summarized as infected-plant-week decreases in Table 4, and show treatment effects paralleling the aphid counts. Phorate granules at 24 oz a. i. /acre were slightly better than the spray at the same rate.

Each insecticide as a spray at the 24 oz rate gave slightly better sugar yield than the granule formulation. The plants had seven leaves when treated, still rather small for ideal granule retention.

Foliar Top-dressing with Granules by Machine

All trials of foliar top-dressing with granular systemics have been on relatively small plots and, except in Trial I above, the granules were applied from perforated tins shaken by hand. Machine application, when combined with tractor-powered row-crop work, should be more accurate and uniform.

In co-operation with G D. Heathcote, a 5 x 5 latin square trial was made at Broom's Barn comparing time of demeton-methyl spraying with foliar top-dressing of granular phorate. The plots were 70' x 36 rows (1/10 acre). The demeton-methyl was applied by the farm's tractor-drawn sprayer and the 10% phorate granules, at the rate of 13.7 lb (22 oz a.i.) per acre in a 2" band above the row, by a 'Horstine Farmery' granule applicator, mounted on the A share frame behind a tractor carrying the 5-row underslung hoe.

Control plots had 4.1 green aphids per plant on 24 May, 5.2 on 15 June and 9.2 on 29 June. Singling was completed by 25 May, when the plants had six leaves.

Phorate granules controlled yellows better than either the early or late sprays, but less well than the two sprays together. The granules gave the only significant increase in yield. (Table 4). Visual scoring by two independent observers on 1 August showed the phorate treated plots to be slightly greener in general appearance than those that had been sprayed twice.

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* Other trials in 1961 show clearly that the menazon spray formulation, a dispersible powder, used in this trial was much inferior to a liquid formulation with improved wetting properties and smaller particle size.

Discussion

The results of the above and other trials comparing thiodemeton granules applied to the foliage and demeton-methyl sprays are summarized below.

% decrease in infected-plant-week total

Year	No. of trials	Thiodemeton granules	(average no. of oz. a.i./ acre)	One demeton-methyl spray	Two demeton-methyl sprays
1960	4	57.8	(30.0)	49.4	-
1961	7	51.3	(21.7)	30.2	-
1960-61	11	53.2	(24.7)	36.0	-
1960-61	4	58.4	(26.0)	49.3	61.8

Foliar top-dressing with granular thiodemeton controlled yellows much better than did a demeton-methyl spray, especially in the 1961 trials. Two field trials in 1960 and two in 1961 (not reported in this paper) included two times of spraying with demeton-methyl, which approximately equalled thiodemeton top-dressing in decrease of yellows incidence.

The relative contribution to this result of the small proportion of granules remaining on the plant and the large proportion falling on the soil is unknown, but the former is probably by far the more important and hence the effect of soil type on this method of application is likely to be small. Application to foliage, some falling on the soil, was compared in 1959 with application to the soil surface near the plants; the former gave significantly better control of yellows. The National Institute of Agricultural Engineering tested these two treatments in 1961 and obtained the same result.

Granules are retained well by the rosette of sugar beet foliage provided the plants are large enough; the larger the plant, the greater the proportion of granules retained and the more efficient the control of black and green aphids compared with low or medium volume sprays.

In one 1959 trial thiodemeton applied at 48 oz a.i./acre to the sugar beet foliage gave lighter patches of green on the leaves where granules had lodged in hollows. The 10% thiodemeton granules in Trial II gave the best control of yellows but less yield than three other granule treatments - the 10% granules may have been slightly phytotoxic. Again, in Trial III, phorate and dimethoate granules controlled yellows slightly better than sprays at the same 24 oz rate, yet sprays of both materials gave the greatest yield increase.

Dry plants are preferred for applying granules in California, so that granules do not adhere to the leaf surface (Reynolds, et al., 1960); all our applications were made in dry conditions and almost invariably in temperatures of 60-80° F with some wind. The mode of action is probably fumigant in the first case, especially in still weather and when the plants are large. Unpublished results of laboratory tests by Fisons Pest Control Limited in 1961 demonstrated the highly toxic nature of the vapour from 5% phorate and thiodemeton granules. Bean plants infested with Megoura viciae were placed in a muslin-covered glass cage together with a dish of granules; phorate and thiodemeton gave complete control of aphids within 24 hours, whilst control was insignificant with the much less volatile materials dimethoate and schradan. Control by phorate and thiodemeton may have been due to fumigant or systemic action since, following 24 hours caging with a disk of granules, the bean plants showed marked residual aphicidal action after removal of the granules.

Granules retained by the plant, mainly in the leaf axils, are probably moistened by dew, and dissolved material is absorbed and translocated in the plant. Contact action is likely to be of minor importance. Menazon has low volatility and solubility, which may explain the comparatively poor results given by the granule formulations in Trials II and III above, although the lower rate of application must also be considered. Dimethoate granules in trial III controlled aphids well and this was most probably by systemic action, being a fairly soluble material.

Further experimentation with foliar top dressing is justified by the good results achieved in 1960-61, especially from the machine application in Trial IV, but the results of Trial III suggests that an equivalent rate of application in spray formulation would give equally good results. Economics and toxic hazards must be considered, also the possibility of beneficial insects being more harmed by sprays than by granules.

Trials in Germany demonstrated the longer aphicidal effect of higher than lower rates of demeton-S-methyl and demeton-S-methyl sulfoxide (800 ml v 400 ml/ha - whether a.i. or formulated product not stated) but did not determine the effects on yellows incidence or yield, (Kolbe, 1960). The effect of a treatment on yellows incidence and subsequent yield is compounded from many factors - not only the speed, completeness, and persistence of aphicidal action, against both green and black aphids as vectors and direct pests, but also disturbance of viruliferous aphids, effects on beneficial insects, and especially the timing of treatment in relation to the period of invasion by viruliferae.

Predators can certainly be an important factor in determining the degree of aphid control achieved by insecticides applied to sugar beet foliage. Placing systemic insecticide in the soil, apart from being fundamentally sound, should give maximum integration of chemical and biological control, the need for which has been stressed by many authors, especially Ripper (1957).

Many factors influence the results from soil application, as discussed by Burt et al. (1960), but their trials used very high rates of insecticide formulated with activated carbon. Sylvester et al. (1961) placed thiodemeton (1.03 lb a.i./acre) 7 inches to one side of the row and 5 inches deep, two weeks before foliar top-dressing on 2 April. The former was ineffective for a month in controlling aphids and remained inferior in aphid control and yield increase to the latter. We experimented with much closer and shallower side-placement, and results in Trial I were quite promising. Side placement can avoid the excessive use of insecticide but may not be as effective as when more uniformly distributed in the soil. However, broadcast application necessitates pre-sowing treatment, whilst timing of side placement is more adaptable.

Side-placement at drilling time is too early for most root crops, although it may be suitable for stecklings. In any case, the mechanical difficulties of attaching soil-placement coulters to precision drills are considerable, especially because the seedbed must not be disturbed. Mounting a granule applicator with soil-placement coulters on a steerage hoe is feasible (Trial 1), and mechanical improvements should enable the granules to be placed in various positions relative to the plant in future trials. The first steerage hoeing is likely to be the most suitable time to apply the materials and the fact that aphicidal action will not be immediate is unimportant (Figs. 1 and 2); soil type and moisture, placement position and physical properties of the material, are likely to affect the results considerably.

Summary

Phorate and thiodemeton are phytotoxic to sugar beet when used as seed dressings; granular formulations of these and other systemics enabled experimentation with soil and foliage application.

Foliar top-dressing by hand or machine gave the best aphid and yellows control, and yield increase, approximately equalling two demeton-methyl sprays. The possible mode of action is discussed. Large granules of thiodemeton were less efficient than small, and granules of high concentration gave better aphid control but poorer yield than low concentration granules. Sprays and granules of both phorate and thiodemeton, all applied to the foliage at the same rate of active ingredient per acre, gave similar results.

Thiodemeton granules side-placed at drilling time controlled aphids poorly, but decreased yellows incidence and increased yield. Side-placement after singling gave delayed, but eventually better, aphid control than did demeton-methyl sprayed at the same time.

Acknowledgements

We are grateful to Miss Marie Wolfe for field and laboratory assistance throughout this work, to Dr. G. D. Heathcote for the results of his 1961 trial, to Mr. J. H. A. Dunwoody for statistical analyses, and to the manufacturers for the supply of materials, information and machinery.

References

BURT, P.E., BROADBENT, L. and HEATHCOTE, G. D. (1960). Ann. appl. Biol. 48, 580.
DUNNING, R. A. (1959). in Rep. Roth. Exp. Stn. for 1958, 193.
DUNNING, R. A. (1960). I. I. R. B. 23rd Winter Congress Report. 429.
DUNNING, R. A. (1961). Che. & Ind. p. 101.

DUNNING, R.A. and WINDER, G H (1960). in Rep. Roth. Exp. Stn. for 1959, p.219.
HULL, R. (1960). Brit. Sugar-beet Rev. 28, 113, 132.
KOLBE, W. (1960). Hofchen-Briefe, 13, 150.
REYNOLDS, H.T., FUKOTO, T.R. and PETERSON, G.D. (1960). J. econ. Ent. 53, 725.
RIPPER, W.E. (1957). Advances in Pest Control Research 1, 305.
SYLVESTER, E.S., BURTON, V.E. and FERRY, G.C. (1961). J. econ. Ent. 54, 758.
WATSON, M.A., WATSON, D.J. and HULL, R. (1946). J. Ag. Sci. 36, 151.

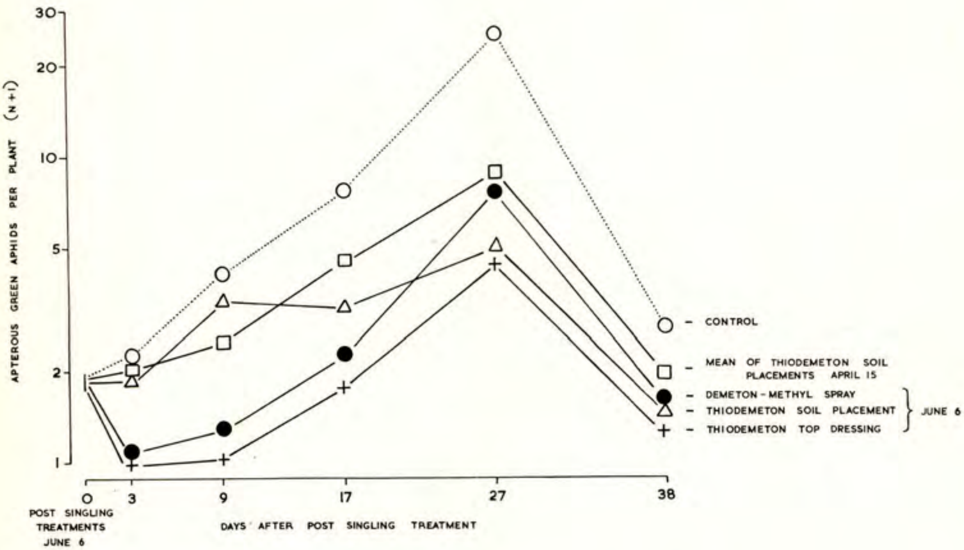

FIG. I APTEROUS GREEN APHIDS PER PLANT (N+I) AT INTERVALS AFTER TREATMENT IN TRIAL I. SEE TABLE I FOR FURTHER DETAILS OF TREATMENTS.

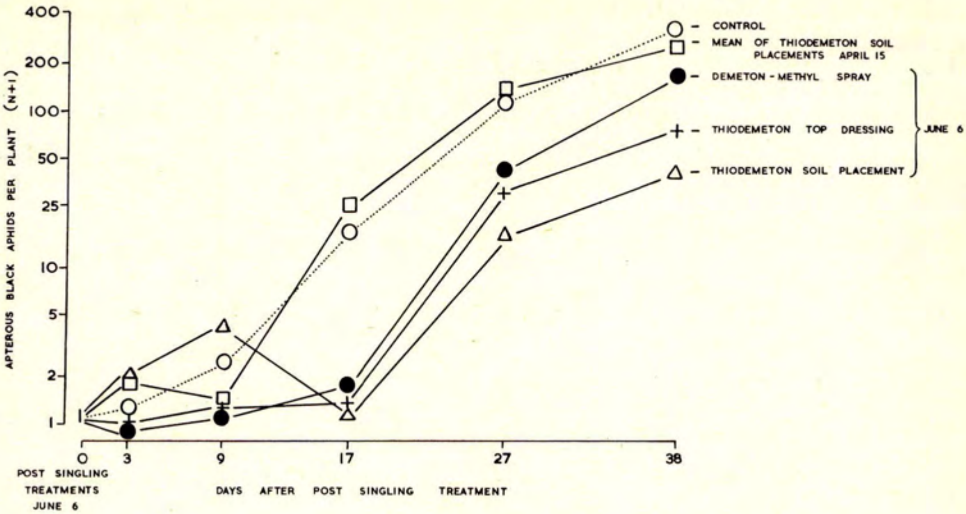

FIG. 2 APTEROUS BLACK APHIDS PER PLANT (N + I) AT INTERVALS AFTER TREATMENT IN TRIAL I. SEE TABLE I FOR FURTHER DETAILS OF TREATMENTS.

Table 1 Comparison of thiodemeton granules (4909b - 2.5%), side placed and top dressed, with demeton methyl spray.

Treatments (oz a.i./acre)	Yellows Incidence.					Yield		
	% Infection (angles)				% decrease in infected-plant week totals	Weight of washed beet (tons/acre)	% Sugar	Weight of sugar (cwts/acre)
	13 July	24 July	16 Aug.	4 Sept.				
Control	11.4	19.1	58.2	62.9	0	12.38	15.1	37.5
Demeton methyl spray on 7 June (7oz in 45 g.p.a.)	7.5	11.3	41.0	54.5	25.2	13.89	15.3	42.4
Thiodemeton placed 4" to one side of seed & 2" deep at drilling time on 15 April (8 oz)	6.5	8.7	40.4	55.4	23.2	12.47	15.4	38.4
" (32 oz)	10.9	16.6	44.5	54.8	20.6	13.94	15.4	43.1
Thiodemeton applied as foliar top dressing on 6 June (16 oz)	6.3	9.4	37.4	45.9	40.7	14.66	15.3	44.8
Thiodemeton placed 4" to one side of singled plants & 1" deep on 6 June (16 oz)	8.9	13.2	42.5	54.3	23.7	13.09	15.5	40.4
S.E. per treatment mean. ±	1.8	2.5	3.5	2.6		0.62	0.2	2.2
L.S.D. (P=0.05)	5.5	7.5	10.5	8.0		1.85	0.6	6.5

(For aphid populations see Figures 1 and 2)

Table 2 Effect on granule size and concentration of active ingredient on aphid numbers, yellows incidence and yield increase.

Treatments (oz a.i. /acre)	Numbers of apterous aphids per plant								Yellows Incidence					Yield		
	Black				Green				% Infection (angles)				% decrease in Infected-plant-week totals	Weight of washed beet (tons/acre)	% Sugar	Weight of sugar (cwts/acre)
	19-20 June	27 June	4 July	18 July	19-20 June	27 June	4 July	18 July	13 July	24 July	17 Aug.	5 Sept.				
Control	0.78	9.19	33.78	257.73	3.13	4.94	6.55	0.25	7.8	12.6	43.9	62.0	0	13.37	15.4	41.3
Demeton methyl spray at 40 g.p.a. (7 oz)	0.13	4.19	34.50	220.03	0.15	0.75	2.35	0.15	13.0	15.8	43.7	59.4	1.9	12.79	15.7	40.1
Menazon granules 0.5% (16 oz)	2.33	5.88	92.23	234.50	2.50	2.47	4.85	0.18	4.4	9.5	39.9	55.1	16.5	13.24	15.7	41.7
Menazon granules 5.0% (8.3 oz)	2.13	2.31	40.25	219.05	2.00	1.47	2.55	0.15	8.0	11.9	43.4	60.3	3.5	12.65	15.8	40.1
Thiodemeton granules 4909b - 2.5% (16 oz)	0	1.38	30.03	119.73	0	0.31	1.58	0	6.7	11.3	32.9	47.4	31.9	15.35	16.4	50.1
Thiodemeton granules 4909 - 5% (16 oz)	0.03	1.34	41.48	125.03	0.13	0.34	1.70	0	9.2	10.6	31.5	44.7	37.5	15.43	16.3	50.2
Thiodemeton granules 4909a - 5% (16 oz)	0.20	6.00	36.43	146.88	0.58	0.84	1.73	0.03	5.4	5.5	33.3	52.3	25.7	13.83	16.1	44.6
Thiodemeton granules 5127 - 10% (16 oz)	0	1.66	30.88	104.58	0.03	0.38	0.88	0	4.0	6.0	27.5	44.1	43.0	14.31	16.2	46.3
CR5331 - 5% (16 oz)	0	1.91	24.25	58.20	0.10	0.34	1.05	0.03	3.0	7.8	32.9	44.4	39.0	15.93	16.3	51.8
S.E. per treatment ± mean.									3.1	3.8	4.3	3.8		0.85	0.25	3.24
L.S.D. (P = 0.05)									9.0	11.2	12.6	11.0		2.48	0.7	9.5

7 days before treatment there were 1.63 black and 0.28 green apterous aphids per plant, whilst at the time of spraying on 16 June there were 1.35 black and 3.00 green.

Table 3 Comparison of granule and spray application

Treatment * (oz active ingredient per acre)	Nos. of apterous aphids per plant on 14 June **		Yellows incidence ***				Yield		
	Black	Green	% Yellows (angles)			% decrease in i.p.w.	Weight of washed beet (tons/acre)	% Sugar	Weight of sugar (cwts/acre)
			10 July	1 Aug.	25 Aug.				
Control	1.38	5.19	13.3	54.9	61.2	0	14.89	15.2	45.3
Demeton methyl spray (2 oz)	1.38	0.62	4.9	29.9	48.6	37.3	16.25	15.0	48.6
Phorate spray (2 oz)	2.03	4.97	10.5	48.8	63.9	0.4	14.60	15.0	43.7
Phorate spray (24 oz)	1.00	0.14	3.6	20.5	40.3	55.9	17.42	15.6	54.1
Phorate granules 10% (24 oz)	0.22	0.19	2.7	19.5	38.0	60.3	17.40	15.5	53.8
Thiodemeton granules 5% (24 oz)	0.30	0.05	2.5	14.8	30.0	73.6	17.50	15.6	54.7
Menazon spray (2 oz)	0.86	2.19	4.0	36.6	54.0	24.4	16.28	15.2	49.3
Menazon spray (24 oz)	1.43	0.24	4.3	23.0	42.9	50.5	17.15	15.1	51.7
Menazon granules 5% (12.5 oz)	0.84	0.89	5.6	33.4	51.8	30.0	15.90	15.1	48.0
Dimethoate spray (2 oz)	0.54	1.78	5.2	35.8	55.8	22.3	15.62	15.0	46.7
Dimethoate spray (24 oz)	2.00	0.08	2.3	19.8	37.8	60.1	17.74	15.7	55.6
Dimethoate granules 6.9% (24 oz)	1.19	0.08	3.5	19.2	38.0	60.2	17.22	15.6	53.7
S.E. per treatment mean. ±			1.8	3.9	3.1		0.50	0.21	1.86
L.S.D. (P = 0.05)			5.1	11.3	8.9		1.45	0.6	5.4

* All sprays applied at 20 g.p.a. actual, but band-sprayed 1/3 of row width and therefore equivalent on plants to rate of 60 g.p.a. overall spraying.

** Pretreatment population 0.51 and 2.64 per plant respectively on 24 May.

*** A final count of the number of plants with yellows on 27 September showed an apparent decrease in incidence and has been neglected in the calculation of the infected-plant-week total.

Table 4 Comparison of demeton methyl spray and machine applied phorate granules.

Treatment	% decrease in infected-plant-week totals	Weight of washed beet (tons/acre)	% Sugar	Weight of sugar (cwts/acre)
Control	0	16.0	15.0	48.0
Demeton methyl spray 19 May. (7 oz. a.i. in 70 g.p.a.)	21.8	16.9	15.1	50.8
Demeton methyl spray 15 June (7 oz. a.i. in 25 g.p.a.)	21.2	17.1	14.9	51.2
Two demeton methyl sprays. (as above)	28.7	18.0	15.1	54.4
Phorate granules applied in a 4" band on the foliage 25 May. (22 oz. a.i./acre)	24.3	18.5	15.3	56.6
S.E. per treatment mean.		±0.65	±0.28	±2.30
L.S.D. (P=0.05)		2.00	0.86	7.09

Appendix:

Insecticides used in 1961 field trials and some details of their formulation

Demeton-methyl: 58% W/V miscible liquid.

Dimethoate: 6.9% granules <0.5-4.0 mm. diameter
30% W/V miscible liquid.

Menazon: JF 903 0.5% granules 0.5-1.67 mm. diameter *
JF 938 2.6% " 0.5-1.67 mm. "
JF 703 70% dispersible powder.

Phorate: 10% granules <0.5-1.50 mm. diameter
48.2% W/V experimental miscible liquid

Thiodemeton: 4909 5% granules 0.5-1.5 mm. diameter *
4909a 5% granules 3-4 mm. diameter
4909b 2.5% granules 0.5-1.5 mm. diameter
5127 10% granules 0.5-1.5 mm. diameter

CR5331: 5% granules 0.85-1.4 mm. diameter *

Particle sizes of Granular Insecticides used in the 1961 trials

Material	Percentage by weight of each fraction								
	Less than 0.5 mm.	0.5-1.0 mm.	1.0-1.5 mm.	1.5-2.0 mm.	2.0-3.0 mm.	3.0-4.0 mm.	4.0-5.0 mm.	5.0-6.0 mm.	6.0-8.0 mm.
Dimethoate 6.9%	5.5	11.0	25.5	31.0	22.0	4.0	-	-	-
Menazon 2.6% JF 938**	1.5	9.0	38.0	42.0	10.0	trace	-	-	-
0.5% JF 903	1.0	10.0	45.0	36.5	7.0	trace	-	-	-
Phorate 10% ***	31.0	67.0	1.5	trace	-	-	-	-	-
Thiodemeton 5% 4909	19.5	29.0	43.0	7.5	trace	-	-	-	-
5% 4909a	0.5	1.0	1.5	3.0	6.5	53.0	31.5	2.5	trace
2.5% 4909b	17.0	32.5	32.5	17.5	trace	-	-	-	-
10% 5127	17.5	29.5	34.5	18.5	trace	-	-	-	-
CR5331 5%	1.5	9.0	70.0	19.5	-	-	-	-	-

* manufacturers data.

** JF 938 applied as 5% granules, but subsequent analysis by the manufacturer showed it to contain 2.6% menazon. The amounts of active ingredient applied have been amended throughout the paper.

*** based on one sample only.

THE CONTROL OF SUGAR-BEET VIRUS YELLOWS WITH PHORATE GRANULES

by C. D. Lindley
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Summary

Work is described with phorate, a new organo-phosphorus systemic insecticide, applied as a granular formulation for the control of virus yellows in sugar beet.

It was more effective in controlling aphids when applied topically to sugar beet plants than as a sideband placement. Field experiments carried out over three seasons have shown that a topical application gave excellent and persistent reduction of aphids, reduced the incidence of virus yellows and increased the yield of sugar.

The persistence varied with the rate of application, 1 lb a.i. per acre being effective for approximately 2 weeks, 2 lb for 3 to 4 weeks and 3 lb for 5 weeks.

No detectable residues of phorate (<0.02 p.p.m.) were found in leaves or roots at harvest following the application of 3 lb a.i. per acre.

Introduction

The use of systemic insecticides on sugar beet for the control of aphids and consequent reduction of virus yellows has become standard practice in many areas of England. The British Sugar Corporation have developed a spray warning scheme advising farmers when to spray. In many cases two or even three applications are required to effectively protect the plants during the period of aphid migration and build-up.

The work with topical applications of granulated phorate by Reynolds, Fukuto and Peterson (1960) in California was observed by the author during 1957. They found that phorate persisted in the plants for several weeks and was superior to spray applications of demeton for the control of aphids, leaf-hoppers and mites. There were, however, considerable differences between conditions in California and those normally found in the United Kingdom. In California the plants had dense foliage at the time of application. The aphids were not vectors of a virus disease and irrigation is essential in the cultivation of the crop. .Nevertheless, there seemed to be good reason for investigating the topical application of granulated phorate on sugar beet in the United Kingdom and trials began in 1959.

Materials and Methods

An 8% formulation of phorate on attapulgite granules was used in 1959, diluted to 5% with brick dust. In one trial a comparison with 5% phorate on attapulgite granules was made. Subsequent trials were carried out with the United States commercial 10% phorate on attapulgite granular (24-48 mesh) formulation.

Replicated small plot trials were made in 1959 and 1960, and unreplicated large plot (grower) trials in 1961. Application of granules was made with a Bean seed drill in 1959, and in 1960 with a Gandy granular applicator mounted on a wheelbarrow type frame and propelled by hand. Application on the grower trials in 1961 was made with a Farmery "Micro-Band" granular applicator mounted on a steerage hoe. The plot size was $\frac{1}{2}$ to 1 acre. The spray application of demeton-methyl in the replicated trials were made at 20 gallons per acre.

The design of the small plot trials was a randomized block with fourfold replication, the plot size being 18 to 30 rows wide and 20 yards long. Counts of apterous green aphids were made on between 10 and 20 plants per plot selected at random. Counts of the plants showing symptoms of virus yellows were made on 500 to 1,000 plants per plot. The number of infected-plant-weeks was calculated from the sum of products over successive dates of observation of the number of plants infected and the interval of time between the date of observation and mid-October. The percentage loss of potential yield was calculated on a $4\frac{1}{2}$% loss for each week the plant shows symptoms of virus yellows up to mid-October (Watson, Watson and Hull 1946).

Yields were estimated by lifting nine 30' lengths of rows per plot. Two 28 lb samples of beet were sent to the local British Sugar Corporation factory for estimation of dirt tare and the percentage of sugar.

The residue analyses were carried out using the Laws and Webley method (1961) for determining organo-phosphorus insecticides.

Results

Two trials were laid down in 1959 to compare application of phorate granules in a narrow band on top of the plants (topical) and in a band just below soil level approximately 2 inches to one side of the plants (sideband) with two sprays of demeton-methyl applied 15 days apart. Both trials gave similar results, and the figures for one are given in Table 1.

Table 1 Comparison of Phorate Granules with Demeton-methyl Sprays - 1959

Treatment (a.i./acre)	Date of treatment	Apterous green aphids per 10 plants			% Plants with virus yellows
		26/5	10/6	23/6	30/7
Phorate sideband 1.0 lb	14/5	4.2	17.0	165.0	39.0
Phorate sideband 2.0 lb	14/5	3.7	11.0	87.0	23.8
Phorate topical 1.1 lb	14/5	0.7	2.5	34.7	17.4
Demeton-methyl 7 oz	26/5 & 10/6	-	2.5	4.2	13.2
Control	-	9.7	34.2	1060.5	63.4
Least Significant Difference					
P = 0.05					19.5
P = 0.01					26.9

Sideband application of phorate at 1 or 2 lb did not give as effective a control of aphids as a topical application at 1 lb. The latter treatment gave good initial kill and a count on 10th June showed there were as many aphids 27 days after application as on the demeton-methyl spray 15 days after application. A second spray of demeton-methyl was applied on this date resulting in a lower aphid count on 23rd June than on the phorate plots.

A virus yellows count on 30th July confirmed the superiority of the topical application of phorate to the sideband method. The plots sprayed with demeton-methyl contained less virus infection than the phorate treatments, reflecting the better aphid control in June.

In the second trial the 5% attapulgite formulation was marginally but not significantly inferior to the 8% attapulgite formulation diluted with brick dust, both being used as topical application.

As a result of these experiences, it was decided in 1960 to investigate the effect of different rates and times of application of phorate granules. Three trials were laid down, one near Guildford, one near Mildenhall and one near Ipswich. Results are shown in Tables 2, 3 and 4.

Table 2 Comparison of Topical Application of Phorate Granules with Demeton-methyl Sprays at Guildford Site. 1960.

Treatment (a.i. per acre)	Date of treat-ment	% Plants infested apterous green aphids				Infected-plant-weeks *	% Decrease inf.-plant-weeks from Control	Yield of sugar (cwt/acre)
		27/5	1/6	24/6	1/7			
Phorate 1.0 lb	27/5	-	0	20	43	857	17.7	59.1
Phorate 2.0 lb	27/5	-	1	23	37	693	33.5	65.0
Phorate 3.2 lb	27/5	-	1	18	13	564	45.9	70.2
Demeton-methyl 7 oz *	27/5 & 13/6	-	1	8	35	640	38.5	62.1
Control	-	60	68	48	73	1041	-	51.6
Least Significant Difference P = 0.05						102		6.0
P = 0.01						143		8.3

* Calculated from virus yellows counts 1/7, 3/8 and 5/9.

Table 3 Comparison of Topical Application of Phorate Granules with Demeton-methyl Sprays at Mildenhall Site. 1960.

Treatment (a.i./acre)	Date of treat-ment	% Plants infested apterous green aphids					Infected-plant-weeks *	% Decrease inf.-plant-weeks from Control
		25/5	31/5	7/6	17/6	7/7		
Phorate 1.2 lb	18/5	0	0	10	16	53	194	35.3
Phorate 2.0 lb	18/5	0	1	8	3	55	175	42.7
Phorate 3.3 lb	18/5	0	1	4	3	32	115	61.7
Phorate 2.2 lb	25/5	-	0	1	4	45	166	44.7
Demeton-methyl 7 oz *	25/5 & 7/6	-	0	4	0	55	147	50.9
Control	-	34	19	18	24	83	300	-
Least Significant Difference P = 0.05							90	
P = 0.01							124	

* Calculated from virus yellows counts 27/7 and 6/9.

Table 4 Comparison of Topical Application of Phorate Granules with Demeton-methyl Sprays at Ipswich Site. 1960.

Treatment (a.i. /acre)	Date of treatment	% Plants infested apterous green aphids				Infected-plant-weeks *	% Decrease inf.-plant-weeks from Control
		26/5	31/5	14/6	30/6		
Phorate 2.0 lb	11/5	0	3	10	38	144	29.9
Phorate 2.0 lb	19/5	0	8	8	48	159	22.6
Phorate 1.1 lb	26/5	-	0	13	58	125	39.0
Phorate 2.0 lb	26/5	-	0	4	47	107	47.8
Demeton-methyl 7 oz *	26/5 & 14/6	-	0	11	20	121	40.9
Control	-	6	15	21	42	205	-
Least Significant Difference P = 0.05						52	
P = 0.01						72	

* Calculated from virus yellows counts 26/7 and 31/8

Phorate granules gave a good initial kill of aphids at all rates at the three sites. The persistence varied with the rate and the time of application, 1 lb being effective for approximately 2 weeks, 2 lb for 3 to 4 weeks and 3 lb for 5 weeks.

At Ipswich, phorate applied on 26th May appeared to persist longer than the same rate applied on the 11th or 19th. This may have been due to the fact that more granules were retained on the foliage of the plants when they were larger. At this site many Coccinellid predators were present. Their distribution was affected by the treatments and they were responsible for some of the anomalous results of the aphid counts. The aphid counts show that each application of demeton-methyl persisted for 10 to 14 days, and that some reinfestation occurred between the two applications.

Rainfall was low following the application of phorate at all sites. At Guildford no rain fell for 11 days after application, followed by one inch in the next week. At Mildenhall there was no rain between 15th May and 5th June, but over one inch fell in the next four days. Conditions at Ipswich were similar except that only about half an inch fell between 6th and 10th June.

All treatments at Guildford gave a significantly higher yield of sugar per acre over the control. The increase with phorate at 1 lb was 7.5 cwt/acre, 2 lb 13.4 cwt/acre, and 3.2 lb 18.6 cwt/acre compared to an increase of 10.5 cwt/acre with demeton-methyl. The yield with phorate at 3.2 lb was significantly greater than with 1 lb phorate or demeton-methyl.

At Mildenhall there were fewer aphids on two of the phorate treatments on 17th June than on 7th June, although the numbers on the untreated had risen. Perhaps the rain facilitated uptake of phorate by the plants on these treatments three weeks after application.

The reduction in the amount of virus yellows in general reflected the degree of aphid control shown by each treatment, 1 lb of phorate giving a mean reduction of 31%, 2 lb of 42%, and 3 lb of 54%, compared to a reduction of 43% with two sprays of demeton-methyl.

At Ipswich, application on 26th May gave a better control than either on 11th or 19th May, but at Mildenhall there was no difference between application on 18th or 25th May.

In 1961 fifteen unreplicated grower strip trials were carried out to obtain information on the efficiency of different rates of phorate granules applied with a new type of grannular applicator under conditions of grower usage. The remainder of each field was sprayed by the farmer but in seven trials this was carried out several weeks after the spray warning was received. In five trials, two sprays were applied with an interval of approximately 3 weeks.

At eight sites two or more rates of phorate were used, and at four of these, three rates were compared. Results are given in Tables 5 and 6.

Table 5 Comparison of Two Rates of Phorate in Eight Grower Trials. 1961

Treatment	Range of rates (a.i./acre)	Mean rates (a.i./acre)	Mean number infected-plant-weeks*	% Loss of potential yield
Phorate	1.25 - 1.4 lb	1.34 lb	102.3	4.6
Phorate	1.7 - 1.9 lb	1.79 lb	98.4	4.4
Demeton-methyl	7 oz per ⁜ application	-	155.3	7.0

⁜ 1 application at 5 sites
2 applications at 3 sites

* Calculated from virus yellows counts in mid-July, mid-August and mid-September.

Table 6 Comparison of Three Rates of Phorate in Four Grower Trials. 1961

Treatment	Range of rates (a.i./acre)	Mean rates (a.i./acre)	Mean number infected-plant-weeks *	% Loss of potential yield
Phorate	1.3 - 1.4 lb	1.35 lb	71.8	3.2
Phorate	1.7 - 1.8 lb	1.75 lb	61.3	2.8
Phorate	1.9 - 2.5 lb	2.1 lb	42.7	1.9
Demeton-methyl	7 oz per ‡ application	-	146.9	6.6

‡ 1 application at 3 sites
2 applications at 1 site

* Calculated from virus yellows counts in mid-July, mid-August, and mid-September.

Phorate gave effective control of virus yellows in the grower trials and the higher rates of application were slightly more effective than the lower rates. It was more effective than sprays of demeton-methyl but this was largely due to the fact that in certain trials only one application of demeton-methyl was made, this sometimes being badly timed.

The mean number of infected-plant-weeks for all rates of phorate at all sites was 128 compared to a figure of 184 for the spray treatments. The calculated loss of potential yield was 5.8% for phorate and 8.3% for the sprays.

The amount of phorate in the leaves of plants following application at 2 lb per acre was 3.3 p.p.m., after 7 days, 0.5 p.p.m. after 14 days and 0.033 p.p.m. after 28 days in one experiment.

No detectable residues ($<$ 0.02 p.p.m.) were found in leaves seven weeks after treatment with 3 lb per acre and in leaves or roots at harvest.

Discussion

These experiments have shown that a topical application of phorate to sugar beet will give a high initial aphid kill and will persist for several weeks, resulting in a reduced virus yellow incidence. The yield of sugar was measured in only one of these experiments and this confirmed that a reduction of virus incidence was associated with an increased yield.

A comparison of the effect of different rates of phorate shows that there is a greater reduction of yellows at the higher rates, due to their longer persistence. The difference between the reduction obtained at 2 lb per acre and at 3 lb is only worthwhile if a severe aphid attack occurs (e.g. Guildford, Table 4) when the increased yield more than pays for the extra cost of treatment. When there is a less severe infestation (e.g. at other sites, Tables 3, 4, 5 and 6), the extra cost would not be justified.

One application of phorate at 2 lb per acre has generally given as good a control of virus yellows as two sprays of demeton-methyl.

The comparative figures for the control of virus with phorate and demeton-methyl in the grower trials must not be over-estimated for reasons explained previously. These trials are of value in giving additional data on the efficiency of different rates of phorate, and this type of experiment was felt to be a necessary step between replicated small plot experiments with the material and its commercial use by the farmer.

A considerable acreage of sugar beet is annually sprayed twice and the results in certain of the grower trials indicated that at least in 1961 this figure could profitably have been greater. Since it is extremely difficult to forecast the severity of virus yellows at the time of application, it may be advisable to use 1.5 lb to 2 lb of phorate as a routine protectant against a moderate attack.

Experiments carried out on the timing of phorate applications have given some evidence that the persistence is reduced when application is made to small plants (i.e. at 2 to 6 true leaf stage) compared to its use on larger plants. In many of the grower trials in 1961, phorate was applied before the spray warning had been issued, giving a greater reduction of virus than the sprays. Phorate should not therefore be applied to small plants unless aphids are present, but it could usefully be applied once the plants were past the sixth leaf stage if the spray warning had not been received.

It has been shown that granular phorate can be applied commercially to sugar beet by an applicator mounted on a steerage hoe during routine cultivation. There will therefore be little additional application cost to the farmer.

Reynolds et al (1960) suggested that the insecticidal toxicity of phorate applied topically to sugar beet is largely a combination of fumigant and systemic activity. Observations at one site in 1960 showed that the aphids had begun to fall off the leaves onto the ground within 4 hours of applying phorate, and no live aphids were found after 18 hours. This is evidence of fumigant action. The amount of phorate recovered from the leaves shows that uptake can be rapid and that systemic action is likely to contribute to aphid toxicity.

References

LAWS, E.Q. and WEBLEY, D.J. (1961). Analyst, 86, 249.

REYNOLDS, H.T. FUKUTO, T.R. and PETERSON, G.D. (1960). J. Econ. Ent. 53, 725.

WATSON, M.A., WATSON, D.T. and HULL, R. (1946). J. Agric. Sci. 36, 151.

Acknowledgements

The writer wishes to thank Dr. A. Dunning, Rothamsted Experimental Station, for his advice and encouragement with this work, and many members of the staff of the British Sugar Corporation Limited for finding the experimental sites.

The co-operation of many farmers is also gratefully acknowledged.

FIELD TRIALS WITH THIODEMETON FOR THE CONTROL OF APHIDS ATTACKING SUGAR-BEET, POTATOES AND BRASSICAS

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Following the development of organophosphorus systemic insecticides which are absorbed by leaves and the root system of plants, the possibilities of applying suitable formulations of them to the seed and soil were studied and reported by various workers (Unterstenhöfer 1957a, b; David and Gardiner 1955). Their results have indicated the possibilities of controlling aphids on a number of crops including sugar beet, potatoes and brassicas, using systemic insecticides as seed dressing and granular formulations, the latter being either applied to the soil or as top dressing on to the growing crop.

Our own trials work from 1958 - 1961 was done primarily with thiodemeton (Schrader, 1950), the proposed common name for OO-diethyl-S-2-(ethylthio)ethyl phosphorodithioate. Thiodemeton is a clear oily liquid with a strong odour. The volatility at 20° C. is 2.7 mg/m^3. It is only slightly soluble in water and fairly resistant against hydrolysis up to a pH of 8. The acute oral toxicity on male rats is 12.5 mg/kg, on female rats 2.6 mg/kg and on male guinea pigs 10.8 mg/kg. The dermal LD_{50} of a 50% thiodemeton carbon powder is 70 mg/kg. In our trials work from 1958 - 1961 we were using 2.5%, 5% and 10% granular formulations of thiodemeton, a 5% granular formulation of demeton-S-methyl sylphoxide and a 50% thiodemeton seed dressing. The top and side dressing applications of thiodemeton were in most cases compared with spray treatments using emulsifiable concentrates of demeton methyl, demeton-S-methyl and demeton-S-methyl sulphoxide.

Trials with thiodemeton on sugar beet

Much valuable work on the control of M. persicae and A. fabae, both carriers of Virus Yellows of sugar beet, has been done in the last 10 years in this country (Hull, 1956; 1958; Gates, 1959) using systemic sprays. The prime object of our trials on sugar beet was to compare the effect of various thiodemeton formulations on these two aphid species and the incidence of Virus Yellows in comparison with spray treatments.

In 1958, a 50% thiodemeton seed dressing was included in a replicated trial on sugar beet. Rubbed and graded seed was sown at a rate of 14 lb per acre on the 16th April, dressed with $\frac{1}{2}$-oz, 1 oz and $1\frac{1}{2}$ oz of thiodemeton seed dressing per lb of seed. Demeton-methyl at a rate of 7 oz per acre and demeton-S-methyl at 3.3 oz per acre were sprayed on the 20th May and 18th June. The total numbers of aphids on 20 leaves were recorded on 30th June. On the 9th May, about 8 days after emergence of the untreated plots, the emergence of all plants was scored, no emergence being graded as 0, even emergence as 5. The results are given in Table 1.

Table 1

Treatment	Total No. aphids per 20 plants	Grading of Emergence
Thiodemeton seed dressing		
$1\frac{1}{2}$ oz	48	0.75
1 oz	11	1.50
$\frac{1}{2}$ oz	18	2.50
Demeton-methyl	1	4.5
Demeton-S-methyl	5	4.25
Control	107	4.25
5% L.S.D.	71	1.07

These results, indicating good aphid control but an undesirable degree of phytotoxicity, are in line with those reported by other workers (Dunning, 1960, 1961; Steudel et al., 1959). Consequently work with thiodemeton seed dressing was discontinued and a thiodemeton 5% granular was used in a replicated trial in 1960 at Rowhill Experimental Farm, Kent. It was applied by hand on top of the seed at sowing time (1st April) at a rate of 20 lb per acre, i.e., 1 lb active ingredient per acre. The seed rate was 14 lb per acre and the plots were 1/35 of an acre. Demeton-methyl at 7 oz per acre and demeton-S-methyl sulphoxide at 3.3 oz per acre were sprayed on the 17th June.

The aphid infestation on the 9th July in the various plots given in Table II is expressed as number of green aphids per leaf, whilst for black aphids a scoring system was used grading the degree of infestation from 0 - 4, an index figure being arrived at by multiplying the score value with the number of leaves in each score category. An assessment of Virus Yellows incidence was carried out on the 20th August, 1960 and the weight of topped beet was determined at harvest time.

Table 2

Treatment	Green aphids/ leaves		Black aphids/20 leaves (degree of infestation)	Virus Yellows in %.20.8.60.	Topped beet (Total) lb
	Winged	Apt.			
Thiodemeton 5%	0.4	4.8	11.8	38.5	3804
Demeton-methyl	0.4	5	12	44	5619
Demeton-S-methyl sulphoxide	0.6	5.4	10.6	40	5520
Control	0.2	8.6	43.6	68	5263
	not significant		5% L.S.D.	5% L.S.D.	5% L.S.D.
			11.4	17.6	1113

Despite the fact that the thiodemeton treatments had given good control of Virus Yellows they were lower in yield than the control or the spray treatments and it must be assumed that this reduction was due to phytotoxicity. It was, therefore, decided to discontinue work with this form of application and, in the 1961 trials, to experiment on the application of thiodemeton 5% and 10% granulars as a top dressing, i.e., on to the leaves of sugar beet plants at singling time. Promising results in this country with this type of treatment were first reported by Dunning (1961) who found thiodemeton, applied as top dressing at $1\frac{1}{2}$ lb active ingredient per acre, slightly more efficient in aphid and Virus Yellows control than two demeton-methyl sprays.

It was the aim of our field trials to compare granular formulations of thiodemeton and to a limited extent of demeton-S-methyl sulphoxide under different conditions in Virus Yellows areas. In the larger scale trials we tried to obtain, at the same time, information on the possibilities of applying granular formulations under field conditions with suitable applicators, attached to steerage hoes. By this technique two operations, i.e., insecticide application and hoeing could be combined, a point pertinent to the spring mechanization of the sugar beet crop.

The following account refers only to a cross section of the replicated trials, because space precludes the inclusion of full results of 10 trials in 7 different sugar beet factory areas.

Trial on sugar beet at Rowhill Experimental Farm, Kent

Layout: Randomized block; 1/50 acre plot size. The date of application of thiodemeton was 3rd June and of spray treatments 7th and 22nd June. The rates were thiodemeton 5%: 20, 30 and 40 lb per acre applied as top and side dressing; 5% demeton-S-methyl sulphoxide granular: 20 lb per acre; and demeton-S-methyl sulphoxide: 3.3 oz per acre.

Aphid counts were done on the 6th June and 17th June, whilst the incidence of Virus Yellows was assessed on the 28th July. The results are given in Table 3 where for black aphids the degree of infestation is given using the scoring method described above.

Table 3

Treatment		Aphids per 30 plants				Virus Yellows % 28th July	Root Yield (tons per acre) **	Sugar content in %
		6th June green	6th June black	17th June green	17th June black			
Thiodemeton	20 lb	1	1	2	9	22	14.1	13.7
5% top	30 lb	1	0	10	9	20	12.2	13.0
dressing	40 lb	6	0	6	0	15.3	13.3	13.3
Thiodemeton	20 lb	33	2	18	27	29.7	13.8	12.7
5% side	30 lb	17	0	23	1	24.7	13.2	13.5
dressing	40 lb	102	0	16	3	25.3	12.5	13.1
5% demeton-S-methyl sulphoxide top dressing		5	9	5	1	29	12.3	13.3
Demeton-S-methyl sulphoxide		not counted		2	1	25.7	12.4	13.6
Control		280	111	148	147	56.3	9.1	13.0

** (estimating 5% dirt tare)

As far as Virus Yellows incidence is concerned the 5% L.S D. between any two means is 15.5 whilst for the root yields the 5% L.S.D. is 2.05 tons.

Ipswich Trial

The layout was 2 x replicated plots 190 yd long and 10 rows wide. The dates of spray treatments were 10th May and 15th June, applied by field sprayer, and that of granular application 10th May, applied by Noble applicator attached to a Ford-Ferguson hoe.

The granular materials were, in this and the following trials, applied as top dressing, i.e., directed to the plants at the 6 leaf stage in a 3" band, a small portion being retained by the plants, the remaining granules falling on to the ground. Results of aphid and virus assessments are given in Table 4.

Table 4

Treatment	pre-appl. green	pre-appl. black	Aphids per 30 plants 31.5 green	31.5 black	21.6 green	21.6 black	Virus Yellows % 18.8.	16.8.
Thiodemeton 5% 20 lb			29	15	33	1045	25.5	33.2
Thiodemeton 5% 30 lb			39	31	18	706	26	38.6
Thiodemeton 10% 15 lb	18	27	15	41	46	1777	17	26
Demeton-methyl twice, 7 oz			7	37	1	70	11	21.8
Control			225	74	472	2328	48	60

Bury St. Edmunds Trial

The layout was 2 x replicated plots 100 yds long and 10 rows wide. The dates of spray treatments were 28th May, 26th June (field sprayer, band sprayed). Granules were applied on 12th May with a Noble applicator attached to Ferguson hoe. Results are given in Table 5.

Table 5

Treatment	Aphids per 30 plants 3.6 green	3.6 black	26.6 green	26.6 black	Virus Yellows % 19.7	15.8	15.9
Thioderheton 5% 20 lb	4	0	24	1551	4	6.3	20.6
Thiodemeton 5% 30 lb	11	16	19	696	2.7	8.9	23.3
Demeton methyl 3.3 oz/acre	2	1	5*	36	1.8	7	20.6
Demeton-S-methyl sulphoxide $1\frac{1}{2}$ fl. oz/acre	0	10	33**	45	1.6	6.3	17.6
Control	64	14	101	876	11.4	27.25	40.3

* 1 hour after spraying
** Just before second spray

Spalding Trial

The layout was 2 x replicated plots 230 yds long and 10 rows wide. The dates of spray applications were 25th May, 17th June, and of granular application 24th May; with a **Noble** applicator on Leverton hoe. Results are given in Table 6.

Table 6

Treatment	pre-appl. green black		Aphids per 30 plants 29th May green black		15th June green black		4th July green black		Virus Yellows % 1 Aug.	24 Aug.
Thiodemeton 5% 20 lb			1	0	36.5		207	121	8.1	20
Thiodemeton 5% 30 lb			0	0	13		126	68.5	3	10
Demeton-methyl 7 oz a.i.	14	0.6	0	0	11		60	17	1.25	8.25
Demeton-S-methyl sulphoxide 3.3 oz a.i.			0	0	23		53	24	1.25	10
Control			14	6	103		469	231	15.5	39

Whilst Tables 4 - 6 refer to aphid and virus control in the Bury St. Edmunds, Ipswich and Spalding trials, we summarize in Table 7 information from the three trials in question, giving average results in terms of percentage decrease of infected plant weeks, sugar content and sugar yield.

Table 7

Treatment	% decrease infected plant weeks	Sugar content %	Sugar yield (cwt/acre)
Thiodemeton 5% 20 lb per acre	43	15.8	68.0
Thiodemeton 5% 30 lb per acre	45.8	15.2	64.8
Demeton-methyl (two applications)	61.9	15.7	73.1
Control		15.3	61.5

Trials with thiodemeton on potatoes

In 1960 a small scale replicated trial was carried out at Rowhill Experimental Farm, primarily to compare the effect of a thiodemeton treatment with four spray applications of demeton-S-methyl sulphoxide on four species of aphids.

The layout was a 4 x 4 Graeco-Latin square. Each plot was approximately 23 x 23 sq.ft., consisting of ten rows each containing 15 plants. Wide strips of unsprayed guard rows separated the plots one from another, and also surrounded the whole experimental area.

The variety was Majestics planted 28th April, 1960 with Best Scotch "SS" grade seed.

The following three treatments were compared: (1) thiodemeton 5% granules at 20 lb per acre, sprinkled on to the potatoes in the furrow at planting time; (2) demeton-methyl 7 oz in 60 gallons per acre; (3) demeton-S-methyl sulphoxide 3.3 oz in 60 gallons per acre.

Thiodemeton 5% was applied once only at planting. The sprays were applied on the 10th June, 1st July, 21st July and 3rd August.

Results

Four aphid species were concerned: Myzus persicae (M.p.), Aphidula nasturtii (A.n.), Aulacorthum solani (A.s.), Macrosiphum solanifolii (M.s.)

Twelve leaves (four top, four middle, four bottom) randomly chosen, were examined on each plot. In addition the crop was examined from time to time between these samplings to see if reinfestation had started.

On 11th June no aphids were found on the leaves from the treated plots but seven apterates of undetermined species were counted on the control sample. In counts on 17th - 20th June again no aphids were seen on the treated samples but a total of 25 apterates were found, as follows: M.p. 5; A.s. 1; A.n. 9; M.s. 10.

On 19th July the only aphids present on the treated leaf samples were two apterates (M.p.) on the demeton-methyl plots; 33 aphids were found on the control leaves, consisting of apterates of M.p. 1; A.s. 1; A.n. 24; Aphis fabae seven of which one was winged.

The assessments of 29th and 30th July are given in Table 8.

Table 8

Assessment of aphids on 29th and 30th July

Aphid Species		Aphids on 48 leaves			
		Thiodemeton	Demeton-methyl	Demeton-S-methyl sulph.	Control
M.p.	Apt.	1	0	20	35
	Wngd.	2	2	0	3
A.s.	Apt.	0	5	1	3
	Wngd.	0	0	0	0
A.n.	Apt.	0	14	9	45
	Wngd.	0	2	1	0
M.s.	Apt.	1	14	6	17
	Wngd.	0	1	0	4
Total	Apt.	2	33	36	100
	Wngd.	2	5	1	7

There was a reduction in yield from the thiodemeton plots compared with the other treatments and the control, a reduction involving the average size of the tubers and not their number. The estimated number of tubers in the thiodemeton plots was 1,722, in the demeton-methyl plots 1,694, the mean tuber weight being 0.312 lb and 0.395 lb.

It can be seen that the thiodemeton soil application kept the potatoes virtually free from aphids from the end of April to at least the beginning of August (when the aphids disappeared from the untreated potatoes). This result agrees with the results obtained by Burt and Heathcote (personal communication) who found that in a replicated trial at Efford Horticultural Experimental Station thiodemeton 5% granular applied at planting time on early potatoes kept them virtually free from aphids until harvest time.

Unfortunately it was not possible to arrange for a proper assessment of virus incidence in 1961 at Rowhill Farm. Küthe (1961), however, reports that a treatment at planting time with thiodemeton 5% at a rate of 0.5 and 1 gr. tuber reduced effectively the spread of leafroll virus.

Trials in thiodemeton on brassicas

At Rowhill Farm, demeton methyl, demeton-S-methyl sulphoxide and a 2.5% granular formulation of thiodemeton were applied on spring cabbages on the 17th July, 1961 in order to assess their effect on *Brevicoryne brassicae*. The liquids were applied by means of an Oxford Precision Sprayer whilst the granules were applied by hand in one case as top dressing and in another as side dressing, i.e., directed on to the soil near the base of the plants. The trial was replicated three times, each plot consisting of 40 plants. At the time of application the plants were heavily infested with Mealy Cabbage aphid. To assess the results 8 plants per plot were inspected on the 2nd August, 1961 and the degree of infestation scored separately on inner and outer leaves. The following scoring was used:

0 = nil aphids
1 = 5 - 15 aphids
2 = 15 - 50 aphids
3 = 50 - 200 aphids
4 = 200 +

To arrive at the degree of infestation the score value was multiplied with the number of plants/leaves in each grade and Table 9 gives the results as mean values per 8 plants.

Table 9

	Degree of aphid infestation after 17 days	
	Inner leaves	Outer leaves
Thiodemeton 2.5% granular top dressing 60 lb/acre	1.4	0.6
Thiodemeton 2.5% granular side dressing 60 lb/acre	6	6.6
Demeton-methyl 9.3 oz/acre	1.4	0
Demeton-S-methyl sulphoxide 4.4 oz/acre	4	0.6
Control	24.6	18.6

In another trial in Suffolk, thiodemeton 5% and a 5% granular formulation of demeton-S-methyl sulphoxide were applied as top dressing by hand on Brussels sprouts on the 30th July, 1961. Demeton methyl and demeton-S-methyl sulphoxide applied as spray served as comparison. There were three replicates, the individual plot size being 1/100 acre.

The effect against Mealy Cabbage aphid was assessed 4 and $6\frac{1}{2}$ weeks after application, grading the infestation in hearts and on the outer leaves separately, thus arriving at an index figure for the degree of aphid infestation as at Rowhill Farm. Ten plants per plot were scored and the results in Table 10 represent the mean of the three replicates.

Table 10

Treatment	Degree of aphid infestation			
	4 weeks after application		$6\frac{1}{2}$ weeks after application	
	hearts	outer leaves	hearts	outer leaves
Demeton-S-methyl sulphoxide granular 5% at 20 lb/acre	4	0	1.3	15.3
Thiodemeton 5% at 20 lb/acre	0	0	0.3	2.3
Demeton-methyl 9.3 oz	5	3	6	20.3
Demeton-methyl 18.6 oz	5.3	4	2.3	21.7
Demeton-S-methyl sulphoxide 4.4 oz	5.6	3.3	6.3	20.7
Control	9	5	5	24

A similar trial was laid down in Bedfordshire on the 17th July, on Brussels sprouts, the plot size being 1/100 acre. The treatments were 3 times replicated. In this trial a higher rate of thiodemeton 5%, namely 40 lb per acre, and a 5% granular formulation of demeton-S-methyl sulphoxide was included. The results were assessed as in the Suffolk and Rowhill trials, 2, 4 and $6\frac{1}{2}$ weeks after treatment and are given in Table 11.

Table 11

Treatment	Degree of aphid infestation					
	after 2 weeks hearts	outer leaves	after 4 weeks hearts	outer leaves	after $6\frac{1}{2}$ weeks hearts	outer leaves
Thiodemeton 5% at 20 lb	1.6	0	3.3	0	10	9.6
Thiodemeton 5% at 40 lb	0.6	0	1.6	0	8	7
Demeton-S-methyl sulphoxide gran. 5% 20 lb	5.3	0	5	0	8.3	16.3
Demeton-methyl	0.6	0	5.3	0	12	27
Demeton-methyl	0.3	0	4.6	0	11.6	25
Demeton-S-methyl sulphoxide 4.4 oz	1	0	3.3	0	12	27.3
Control	8.3	0	16.6	0	15	34

Summary and Discussion of Results

(a) Sugar beet

The application of granular formulations of thiodemeton as top dressings to young sugar beet plants in May has, by controlling M. persicae and A. fabae, reduced the incidence and slowed down the spread of Virus Yellows as judged by virus counts taken in July and August from replicated field trials in different areas. Only small differences could be observed between the 20 and 30 lb rate of thiodemeton 5%, and it is doubtful whether they were significant.

In the Rowhill trial a thiodemeton top dressing was slightly better than two demeton-methyl sprays judged by the virus counts at the end of July, whilst at the Ipswich and Spalding trials two spray treatments appeared superior in terms of virus control. In the trial at Bury St. Edmunds the difference between two spray treatments and one thiodemeton top dressing was small and probably not significant.

In those trials where 1 and 2 demeton-methyl spray applications were compared two treatments had given slightly better virus control than one, which is in line with previous findings.

The yield data available so far show that top dressing applications of thiodemeton granules and spray treatments with demeton-methyl and demeton-S-methyl sulphoxide resulted in considerable increases, both in root weight and sugar content, compared with the untreated controls.

In the Rowhill trial, where the largest yield response was recorded, the 20 lb rate of thiodemeton 5% applied as top dressing gave the highest yield, although it did not differ significantly from the yields obtained with the other granular treatments including side dressing applications of thiodemeton 5% and the yields of the plots sprayed twice with demeton-S-methyl sulphoxide and Bayer 4895 (fenthion).

In the field trials at Bury St. Edmunds, Ipswich and Spalding the 20 lb rate of thiodemeton 5% has increased the sugar yield per acre by 10.5%, whilst two sprays with demeton-methyl resulted in an increase of 18.6%. The recorded increases in sugar content range between 0.2% and 0.8% following thiodemeton treatments, and between 0.2% and 0.6%. In interpreting the results it must be remembered that for thiodemeton the trials conditions were more severe, considering that large scale application of granules with applicators attached to farmers' machinery was done for the first time in 1961. Although valuable experience was gained, the application of the granules was not always as perfect as we would have wished.

In the trial at Rowhill, a side dressing treatment of thiodemeton had a slower effect on the aphids than the top dressing treatment carried out at the same time. This is probably due to the fact that absorption of thiodemeton by the roots was relatively slow, especially under the dry weather conditions prevailing.

The 5% granular formulation of demeton-S-methyl sulphoxide was, at equivalent rates, nearly as effective as thiodemeton 5%, but further trials work is needed to fully evaluate the biological efficiency of this formulation.

Little information is available on the way in which thiodemeton acts on aphids when applied as top dressing. We can only assume that the initial effect on aphids is due to fumigant action following the release of thiodemeton from the granules under the influence of moisture. Penetration into the leaves probably takes place which, assisted by root absorption, produces a systemic effect and is thought to be responsible for the relatively long lasting effect on aphids. After absorption thiodemeton is, within the plant, converted into metabolites by oxidation, firstly of the mercapto sulphur and later of the thiono sulphur (Metcalfe et al., 1957).

The effect of the thiodemeton top dressings on aphids lasted for about 3 - 4 weeks but even 6 weeks after the treatment there was still a notable reduction in aphid numbers compared with the untreated control. In years with very early and prolonged aphid infestation it might be advisable to apply a systemic spray at the time when the effect of the granular applications begins to wear off, particularly if black aphids build up.

Whilst there is a rapid knockdown of aphids following spray treatments with demeton-methyl and demeton-S-methyl sulphoxide it will take somewhat longer under field conditions before top dressing applications with thiodemeton become fully effective, a fact which should be borne in mind as far as timing of granular applications is concerned. It is felt that the relatively long persistence of thiodemeton would allow an application to be made before aphid infestation starts, thus reducing the early virus infections which are particularly dangerous.

(b) Potatoes

The long lasting effect of thiodemeton on aphids when applied at planting time is encouraging and it is likely that this type of treatment, when combined with roguing, should control the spread of leafroll satisfactorily. This is indicated by Burt, Broadbent and Heathcote (1960) and has been found to be true in the trials carried out by Küthe (1961). Growing on tubers from our 1961 trial at Rowhill and assessing the virus in 1962 should provide own information on this point.

If thiodemeton is to be used for seed production on potatoes the reduction in tuber size observed in the 1960 Rowhill trial might not be a disadvantage. Observations during this season have so far not indicated any adverse effect of thiodemeton on the growth of potatoes. In our trials the thiodemeton was sprinkled by hand along the furrows at planting time and the results suggest that the expanding root system can also absorb the thiodemeton at some distance from the tuber. However, as Burt, Broadbent and Heathcote (1960) point out more basic knowledge about the behaviour of granular systemics in the soil and the effect of soil conditions and plant growth on rate of up-take is required.

(c) Brassicas

In the three trials reported thiodemeton was applied by hand as a top dressing and gave good control of Mealy Cabbage aphids which at the time of application were established in the hearts - a problem which is always difficult to deal with systemic sprays. It is likely that some of the granules of the top dressing are retained in the hearts where they might kill aphids by fumigant action and later by systemic action following leaf absorption. The longer residual effect of the thiodemeton application in comparison to the spray treatment is noteworthy in this connection.

There was no significant difference between the low and the high rate of thiodemeton 5% used in one of the trials and the results obtained in the Rowhill trial showed that good aphid control could also be obtained with an application of a 2.5% granular formulation of thiodemeton.

In the Rowhill trial a top dressing application was more efficient than the side dressing application. A double rate of demeton-methyl improved the control of Mealy Cabbage aphid, but not significantly.

The 5% granular formulation of demeton-S-methyl sulphoxide was less efficient in controlling Mealy Cabbage aphid, which might be due to the lower vapour pressure of this compound.

The results obtained with thiodemeton top dressing in the 1961 small scale trial are encouraging enough to justify larger scale trials next season when preferably the granules should be applied by suitable machinery.

Acknowledgements

We wish to convey our thanks to the British Sugar Corporation and their field staff who have assisted in finding sites for trials and in assessing the results. Thanks are also due to many farmers who have kindly co-operated in our trials with granular systemic insecticides.

References

BURT, P. L., BROADBENT, L. and HEATHCOTE. G. D. (1960) Ann. appl. Biol. 48, 580.
DAVID, W A. L. and GARDINER, B. O. C. (1955). Ann. appl. Biol. 43, 594.
DUNNING, R. A. (1960). 23rd Winter Congress of I. I. R. B., Feb. 1960.
DUNNING, R. A (1961). Chem. & Industry, p. 101.
GATES, L. F. (1959). Ann. appl. Biol. 47, 492.
HULL, R. (1956). J. Sci. Food Agric., 7, supplement.
HULL, R. (1958). Agriculture, 65.
KÜTHE, K. (1961). Z. Pflanzenkrankheiten, 68, 209.
METCALF, R. L., FUKUTO, T. R. and MARCH, R. B. (1957). J. Econ. Ent. 50, 338.
SCHRADER, G. (1950). D. B. P. 836349.
STEUDEL, W., HEILING, A., HANF, E. (1959). Z. angew. Ent. 44, 387.
UNTERSTENHÖFER, G. (1957a). Z. f. Pflanzenkrankheiten, 64, 619.
UNTERSTENHÖFER, G. (1957b). Proc. IV Intern. Crop Protection Congress, Hamburg, 1243.

THE USE OF DIMETHOATE FOR CONTROL OF SUGAR-BEET VIRUS YELLOWS IN GREAT BRITAIN

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Dimethoate (00-dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate) was shown, early in its development, to move systemically within plants, and to have a contact LD 50 for Megoura viciae of 5 ppm. The acute oral toxicity to female white rats of very pure dimethoate is 600-700 mg/kg (though laboratory and technical grades are 2-3 times as toxic) (Sanderson and Edson, 1959; Casida and Sanderson, 1961). Dimethoate is therefore a systemic aphicide with a high insecticidal activity, and comparatively low mammalian toxicity. It is, in fact, the first systemic organophosphorus insecticide to be excluded from the list of Scheduled Poisons or Scheduled Substances used in agriculture in England.

The first field trials in Great Britain with dimethoate for control of aphids were conducted in 1957. The work which has been subsequently undertaken in Great Britain for control of Myzus persicae and virus yellows was summarised by Geering and Abel (1961). This report reviews all experimental information available to the present time.

In 1958, trials on sugar beet were designed to assess dimethoate for (i) the control of aphids, i.e. Myzus persicae and Aphis fabae, (ii) its effect on the spread of virus yellows, and (iii) yield effects resulting from control of virus yellows. It is now generally recognised in Great Britain that M. persicae is the more important aphis requiring control, because the greater annual loss of crop results from the spread of virus disease by this species.

At eight sites in East Anglia, latin square trials indicated that the optimum dosage of dimethoate was 4.8 oz/acre. A single spray application in a volume of 40 gal/acre of water was made at each site, the timing being determined by the level of aphid population. The aim was to apply sprays when the spray warning was received from the local sugar beet factory. Unfavourable weather, however, prevented the best timing at all sites.

In the accompanying figure, the result of spraying at the optimum time at Long Melford is illustrated and shows a suppression of the population of M. persicae throughout its period of activity. At some sites the aphis population remained low throughout the season, but where populations were higher, control of M. persicae was demonstrated during a period of 14-20 days following the single spray of dimethoate.

Virus incidence was recorded from mid-July until the end of September. The percentage infection with virus yellows in early September is shown in Table 1. At sites 7 and 8, virus incidence was low, due to very low populations of M. persicae. Sites 5 and 6 showed just over 40% and 30% virus infection on the controls, but these were localities where the spray was applied too late to prevent spread of the virus. Consequently, analyses showed that significant reduction in virus incidence was only obtained at sites 1-4.

Table 1 Virus Yellows Control : 1958
% Infection on 8th and 9th September

SITE	TREATMENTS	
	Control	Dimethoate 4.8 oz a.i./acre
1. Long Melford	55.2	27.3
2. Shelford	85.3	77.2
3. Kennett	58.6	41.5
4. Gayton	24.9	11.0
5. Booton	41.6	38.2
6. Maldon	33.5	32.1
7. Elsing	13.0	9.6
8. King's Lynn	11.9	7.8
Means	40.5	30.6

L.S.D. for means = 4.99

Yield records were then taken on the four sites where significant reductions in yellows incidence were demonstrated, i.e. Table 1, sites 1-4. These are presented in Table 2, where it will be seen that significant yield increases were obtained at sites 1-3, but not at site 4 (Gayton), where the controls showed the lowest virus infection (24.9%) of the group.

Table 2 Yields in tons per acre : washed roots

SITE	Control	Dimethoate	Recorded increase	L.S.D.
1. Long Melford	15.63	17.59	1.96	± 1.43
2. Shelford	19.24	23.09	3.85	± 2.26
3. Kennett	17.56	19.57	2.01	± 0.99
4. Gayton	26.01	24.44	NIL	N.S.

There were no significant differences in sugar content between treated and untreated crops, at any of the four sites where beet was harvested.

The 1958 results served to show: (a) that a single spray of dimethoate can control virus yellows and increase yield of roots and hence sugar; (b) that correct timing of the spray application is required in order to achieve optimum virus control.

In 1959, when very heavy outbreaks of black aphis, A. fabae, occurred, yield response to spraying with dimethoate and other systemics was attributable to control of both virus yellows and black aphis. Results of trials conducted in 1959 by Dunning (1960) have shown that single sprays of dimethoate increased sugar yield by 59% in one trial, and by 129% in another. Hull (1960a) reporting yield trials from 15 factory areas in 1959, shows that over all sites the average yield increase from a single or double spray of systemic insecticide was 26%. At one site, viz. Ipswich, dimethoate was sprayed (Hull, 1960b). This is in an area where virus incidence is generally severe, and an exceptional response to spraying could be anticipated, if successful, in 1959. At this site a single spray of dimethoate increased sugar yield by 36%.

Recent experimental work has mainly reported comparisons of different aphicides for virus control. During 1959 and 1960, Parry Williams (1961) compared a range of systemic aphicides for control of aphids and virus yellows. In 1960, he showed that dimethoate at 6.4 oz a.i./acre gave satisfactory control of green and black aphids, and significantly reduced the incidence of virus yellows.

Hull (1961) summarised results from 5 trials which tested a single application of various insecticides, including dimethoate, for control of aphids and yellows. At Cambridge, none of the chemicals reduced virus incidence. At Spalding, only slight reductions were recorded, while at Peterborough slight increases in virus incidence resulted from single spray applications. At Dunholme, all treatments except one decreased virus incidence. Near Lincoln, a low level of virus attack was decreased. Within these variable conditions of response, i.e. decrease in virus incidence in 3 out of 5 sites, dimethoate showed an average decrease in yellows incidence of 15%.

Where the aim is to control virus yellows by a single spray application, correct timing in relation to aphis populations is of great importance. This was particularly apparent in 1958, when at Shelford, Booton and Maldon (Table 1), sprays were applied too late for optimum effect. During 1961, Dunning has examined the effects of early mangold fly sprays on subsequent yellows infection. His results (unpublished) justify a closer examination of the effect of an early application of dimethoate at a reduced dosage, e.g. 1.2 oz/acre as recommended for control of Pegomyia betae.

References

CASIDA, J.E. and SANDERSON, D.M. (1961). Nature, 189, 507.

DUNNING, R.A. (1960). Rept. Rothamsted Exp. Stn., 1959. 191.

GEERING, Q.A. and ABEL, A.L. (1961). Proc. 24th Winter Congress, I.I.R.B. (in press).

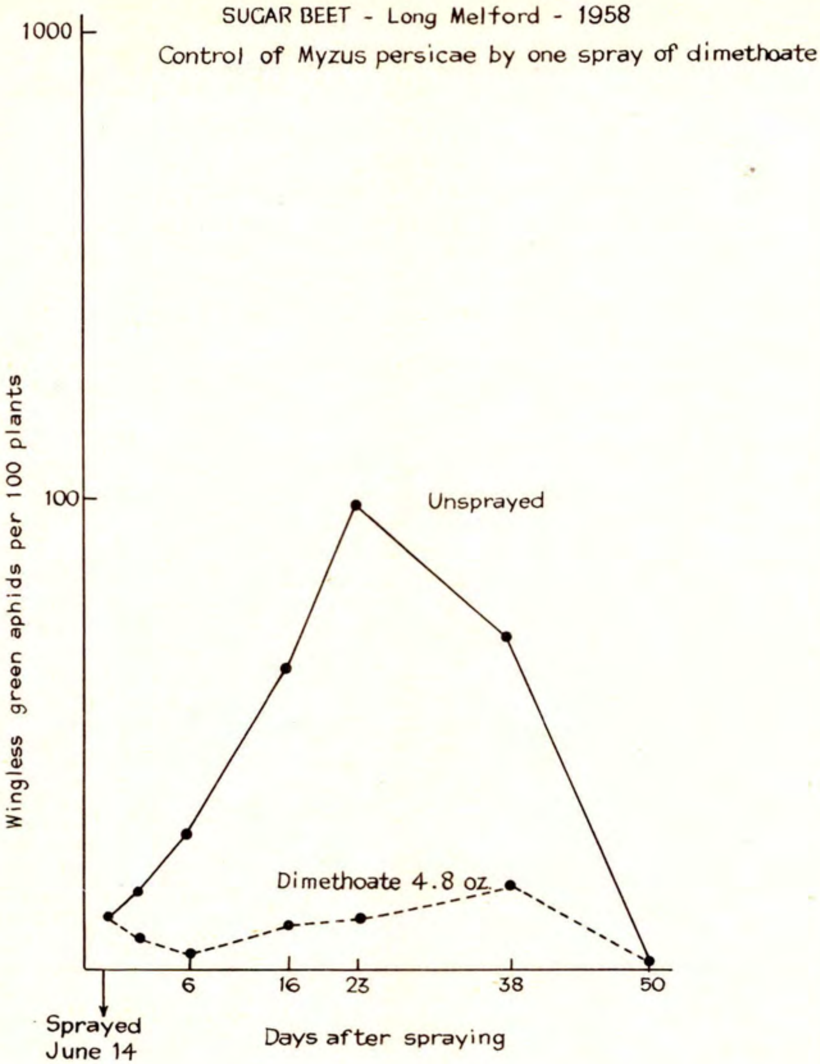
HULL, R., (1960a). Rept. Rothamsted Exp. Stn., p. 188.

HULL, R. (1960b). Brit. Sugar Beet Review, p.113.

HULL, R., (1961). Rep. Rothamsted Exp. Stn. 1960. p.219.

PARRY WILLIAMS, J.R. (1961). "Biological Studies and Observations Concerning the use of Commercial Insecticides Against Sugar Beet Aphids". Thesis for M.Sc., University of Durham (in preparation).

SANDERSON, D.M. and EDSON, E.F. (1959). J. Pharm. and Pharmacol. 11, 721.


SUGAR BEET - Long Melford - 1958
Control of Myzus persicae by one spray of dimethoate
1000
100
Wingless green aphids per 100 plants
Unsprayed
Dimethoate 4.8 oz.
6
16
23
38
50
Sprayed
June 14
Days after spraying

A PROGRESS REPORT ON THE CONTROL OF APHIDS IN MANGOLD CLAMPS BY METHYL BROMIDE FUMIGATION

by

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In England Broadbent et al. (1949) showed the importance of mangold clamps as sources of viruliferous aphids. In Denmark, Germany, Holland and Belgium also, aphid-infested clamps are considered to be one of the main soucres of yellows virus in the spring. The field staff of the British Sugar Corporation surveyed the incidence of aphids in mangold clamps in beet-growing areas at the beginning of April and of May 1948-57 (Hull, 1955). Over this ten-year period the average number of clamps per square mile ranged from 1 to 2.1 in April, and 0.4 to 0.9 in May, with 5-53% and 11-62% of clamps infested with aphids in the two months respectively. A similar survey over 855 square miles in late April, 1961 covered 2,750 farms; of these 1,482 grew mangolds, red beet or fodder beet, and 962 still had clamps of which 443 were aphid-infested. The aphids on shoot samples from 123 infested clamps were identified in the laboratory; 63% of the samples contained *Myzus persicae*, 2% *M. ascalonicus*, 3% *Macrosiphum euphorbiae*, (*M. solanifolii*), 9% *Aulacorthum solanii*, 96% *Rhopalosiphoninus staphyleae*, and 17% *R. latysiphon*.

Methods tried so far for dealing with aphid infested clamps in the spring have proved impracticable or have given erratic results. Infestation can be decreased by careful topping in the autumn, but pre-harvest spraying with demeton-methyl proved unreliable (Dunning, 1961b). Neither measure controls *Rhopalosiphoninus* spp. A direct control of aphids in clamps in the spring is desirable because the whole crop would then not need to be treated, but only clamps found to be infested. Such a method could be recommended as a worth-while investment to individual beet growers, for although the effect of infested clamps can extend widely, they are most obvious and damaging to crops growing near to the clamps.

The susceptibility to methyl bromide of many species of aphids, including those that infest clamped mangolds, has been found to be very high in laboratory tests. Both in the laboratory and in 'microclamps', doses considerably in excess of the LD 99 for aphids caused no damage to several varieties of mangolds except to kill the unwanted sprouts (Dunning, 1961a). Fumigation of infested clamps therefore appeared to be a promising control method and was tested in clamps in Lincolnshire, Cambridgeshire and Suffolk.

Methyl bromide fumigation under sheets is widely used to control insects in many stored products. Workers at Imperial College, in conjunction with those from the Plant Pathology Laboratory of the Ministry of Agriculture, have adapted this method to disinfest various kinds of plant material, with which uniform distribution of gas is important. The principles so developed have been applied to the fumigation of mangold clamps.

In March-May of 1960 and 1961, 11 clamps were fumigated for periods of 2-17 hours. Clamp volumes ranged from 600 to 8,000 cu.ft., and the coverings were of loose or baled straw, sometimes with soil as well. A 10/1000" unsupported polythene sheet was used for the majority of tests. The efficacy of treatment was assessed by determining the amount of methyl bromide in gas samples taken during fumigation and airing, and by examining mangold sprout samples for live and dead aphids at intervals after the fumigation. All clamps were freed or very nearly freed from live aphids by fumigation. The work is continuing and will be published in full later.

References

BROADBENT, L., CORNFORD, C.E., HULL, R. and TINSLEY, T.W. (1949). Ann. appl. Biol. 36, 513.
DUNNING, R.A. (1961a). Rep. Rothamst. Exp. Stn. 1960, p.217.
DUNNING, R.A. (1961b). Chem. & Industry. p.101.
HULL, R. (1955). Mangold clamps and sugar beet growers. Brit. Sug. Beet Rev. 23, 123.

Discussion

Q. Mr. G. D. Brenner

What type and grade of granules have been used in the field applications?

A. Dr. Dunning

There are two answers I can give. One is to refer you to the table in the paper which includes a lot of information on the size of the granules used. Secondly, we have some samples and I will put these here for everyone to see. So far as the formulation is concerned I will have to refer you to the manufacturers. Is that all right?

Q. Dr. M. A. Phillips

Whilst it is clear that granular insecticides do act, the mode of action needs to be investigated. It is difficult to accept without proof that there can be any fumigant action in the field and systemic action appears to have been demonstrated by residue analysis. What we would like to know is how the material gets into the plant system. Some of these granular materials which we have analysed appear to contain about 5% active material + about 95% Fullers earth or similar substance and no surface active agent or very little.

A. Dr. Dunning

We can say a little about this. Fisons Pest Control very kindly allowed me to refer to some unpublished results of trials. These showed that, in a cage, granules of phorate and thiodemeton have fumigant action. They also showed that a plant will absorb the vapour under these conditions because after the removal of the granules the plants still showed systemic insecticidal activity. They also showed very clearly that if you put these granules in a dish under the plant in the field there is no effect whatsoever. With phorate and thiodemeton granules going on to the plant in the field you will probably get some local fumigant action (this was demonstrated by Lindley in his field trials with phorate) but I do not feel that it is the most important mode of action. This is much more likely to be local absorption through the leaf and petiole - dimethoate granules gave good green aphid and yellows control in Trial III, but this material shows negligible fumigant action in a cage (Fisons Pest Control unpublished results).

Q. Dr. James B. Loughnane

At what stage in the storage period was menazon applied to the potato tubers?

A. Dr. Broadbent

My remarks referred to the soil-applied granular insecticides and not to menazon. This material was sprayed on to the tubers immediately before planting. Granular insecticides are often not fully effective until a few days after the potato plants emerge through the soil. The time presumably depending on root growth and distribution of insecticide in the soil. Mr. Newman has been doing some work with menazon. Perhaps he can inform us.

Mr. J. F. Newman

In the field, the shoots from menazon treated tubers are toxic to aphids as soon as they emerge from the soil. Tuber treatments are usually applied at, or shortly before planting, but in some cases treatments were made in the chitting house in the proceeding autumn. In all cases, aphid control on the shoots was effective as soon as they emerged from the soil. In the experiments so far made, menazon does not seem to be translocated into the shoots before the tubers are planted.

Summing up - Mr. F. C. Bawden

Given the answers to two questions about the behaviour of an aphid-transmitted virus, it is usually possible to forecast whether spraying with an insecticide is likely to check its spread significantly. The questions are: does it spread mainly from infected to healthy plants within a crop?; can its vectors infect a healthy plant immediately after feeding briefly on an infected one? When the answer to the first is yes and to second no, spraying is likely to be effective, but not when they are the other way round. However, only field experiments can show whether benefits from spraying are economically worth while, establish what to spray with and when to spray. An insecticide may be valuable in one crop but not in another against viruses that have a common vector and behave very similarly. For example, DDT checks the spread of potato leaf roll but not of sugar beet yellows, although both are transmitted by the peach-potato aphid. Systemic insecticides can be expected to be most generally useful, and applying these to the soil at planting time promises to obviate the need to time the first spray as accurately as now must be done to ensure the maximum benefit from spraying. We have had evidence today of notable advances in controlling some virus diseases by attacking the insect vectors, and there is promise that these represent only the beginning of what will become possible.