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SUGAR BEET, AND ITS PEST AND VIRUS PROBLEMS, IN ENGLAND

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Summary Data are given on sugar-beet crop production in England, especially the changes in cultural practices that influence pest and disease damage to the crop, and on pesticide usage. The main current problems are the eating of seed by wood mice (*Apodemus sylvaticus*), damage to seedling establishment by soil-inhabiting arthropods, grazing of seedlings by birds and mammals and, especially, aphids and virus yellows.

Soil-inhabiting pest damage can largely be controlled but treatments are becoming increasingly expensive. Yellows control by conventional foliage-applied materials against the aphid vectors has been less satisfactory in 1974 and 1975 than previously; this has been due partly to the aphids' increasing resistance to organophosphorus insecticides. Non-organophosphorus, seed-furrow-applied granular pesticides seem to be an answer but the justification for their widespread prophylactic use needs consideration.

Résumé Nous avons donné les renseignments au sujet de la culture des betteraves industrielles en Angleterre, surtout en ce qui concerne les changements dans la culture qui peuvent influencer les dégâts au recolt par les parasites et les maladies, et aussi sur l'usage des pesticides. Les plus graves problèmes, actuellement, sont les pertes des graines a cause des campagnols (Apodemus sylvaticus), la réduction des populations á la levée par les arthropods souterrains, la jaunesse et ses vecteurs.

Nous avons les traitements satisfaisants contre les parasities souterrains, mais les produits utilisés devient de plus en plus chers. Le control des vecteurs de la jaunesse par les traitements conventionnels sur les feuilles, était moins éfficace en 1974 et 1975 qu'auparavant; c'est partialement, au moins, à cause de la résistance croissante des pucerons aux insecticides organo-phosphoriques. Il semble que les produits micro-granulés d'autres formulations que l' organophosphor appliqué au lit de germination donneront les meilleurs résultats, mais le justification pour leur emploi étendu prophylactique doit être examiner.

INTRODUCTION

An international survey, under the aegis of the International Institute for Sugar Beet Research (Institut International de Recherches Betteravières - I.I.R.B.), recorded sugar beet pest and disease damage, and pesticide usage, in twenty European countries in 1968-70 (Dunning, 1972). Since then, some pest and disease problems have changed in England, especially because of continued changes in cultural practices (Dunning, 1971) and the development of aphid resistance (Dunning & Winder, 1975; Needham & Devonshire, 1975), and new pesticides have become available (Dunning & Winder, 1973b).

This paper gives current data on changes in sugar-beet crop culture that affect pest and disease damage, on the damage that occurs and the pesticides used, and discusses the implications.

THE SUGAR-BEET CROP

In England sugar beet is grown only under contract to the British Sugar Corporation (B.S.C.) who process it at their seventeen beet sugar factories, which are distributed mainly throughout the eastern arable area. National annual consumption of sugar is about 2.64 million t (2.6 million ton); in an average season home-grown sugar meets about one third of the national need, the remainder being largely met by the refining, at ports, of imported raw cane sugar. About 202,000 ha (nearly 500,000 ac) of sugar beet is currently grown in this country with considerable seasonal variations in yields (Table 1). The announced intention to provide half of the national sugar requirement from home-produced beet would require about 263,000 ha (650,000 ac) to be grown within the present factory catchment areas.

Table 1

Sugar-beet yields, 1970-74

Year	Wt of roots (t/ha)	Sugar content (%)
1970	35.9	17.0
1971	43.5	16.6
1972	34.6	17.0
1973	39.4	15.9
1974	25.2	15.5

CHANGES IN HUSBANDRY OF SIGNIFICANCE TO PEST AND DISEASE DAMAGE

Soil types A 1974 survey estimated the proportion of the sugar-beet crop grown on different soil types (Table 2). The extreme weather conditions of 1974 and 1975 caused sowing and harvesting difficulties on soil with a high clay content; as a result, there is a tendency for acreage to increase on the lighter soil types at the expense of the heavier.

Rotation and crop distribution Except when following a grass ley of at least 3 years, it is a contract condition that sugar beet may only be grown on land which has not grown any crops that are hosts of the beet cyst eelworm (*Heterodera schactii*) during the two previous years; on land known to be infested with beet cyst eelworm a longer rotation is enforced by the Ministry of Agriculture. The enforced rotation decreases damage by pygmy beetle (*Atomaria linearis*) (Jones and Dunning, 1972) and probably by other pests and diseases. Sugar beet usually follows two straw crops in this country and four-course rotations are the average in most areas. Most of the crop is grown on the eastern arable side of the country from Yorkshire to the Thames, particularly in Norfolk, Cambridgeshire and south Lincolnshire, where it exceeds 10% of the total arable acreage (Fig. 1).

Table 2

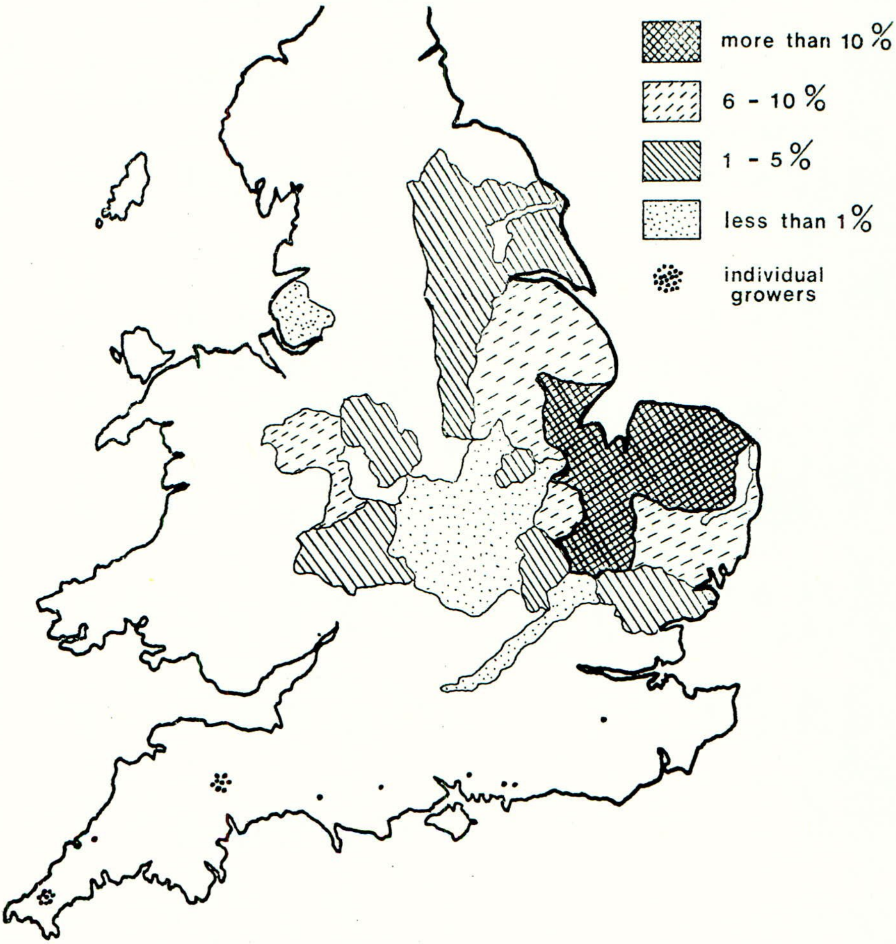
Incidence of sugar-beet growing on the different soil types

Soil type	% of National Crop
Loamy Coarse Sand	4.3
Loamy Sand	4.0
Loamy Very Fine Sand	3.6
Coarse Sandy Loam	7.5
Sandy Loam	31.6
Very Fine Sandy Loam	6.4
Loam	7.2
Silt Loam	6.6
Sandy Clay Loam	14.5
Clay Loam	7.4
Clay	1.6
Light Peat	1.6
Loamy Peat	1.8
Peaty Loam	1.5
Organic Mineral	0.3
Others	0.1

Fig. 1

Distribution of sugar-beet acreage

(expressed as a % of the total arable acreage)



Seed and seed spacing, and plant populations Although sugar beet was first introduced into this country as a labour-intensive crop to help the unemployment situation of the 1920s and 1930s, the ever-increasing shortage and cost of hand labour since the second world war has concentrated recent research effort on the task of growing the crop without hand work; progress to this end since 1960 is shown in Table 3.

Table 3

Changes in methods of establishing the crop, 1960-1975

Year	Precision Drilled*	Planted to Stand**	Monogerm Seed Used	Pelleted Seed Used	Herbicide Used
	Percent of crop acreage				
1960	24	-	-	-	-
1961	35	-	-	-	5
1962	46	-	-	-	9
1963	58	-	-	-	13
1964	65	-	-	1	18
1965	74	-	1	3	35
1966	86	1	6	16	47
1967	90	4	14	28	64
1968	95	12	26	43	71
1969	100	19	43	60	77
1970	100	30	63	83	85
1971	100	32	66	88	90
1972	100	35	64	91	91
1973	100	39	67	94	95
1974	100	52	74	97	96
1975	100	65	86	99	98

* i.e. using drills that space each seed at a predetermined distance.

** seeds spaced at 12.5 cm or more apart, with the object of no further plant-spacing work by hand or machine.

Precision drilling was the first major step to decreasing the number of seeds sown, and was associated with mechanical processing of the seed to improve its precision spacing and monogermity. The introduction of genetic monogerm seed, which necessitated the use of pelleting to improve precision spacing, enabled rapid progress to be made in 'drilling to stand', i.e. spacing the seeds at 12.5 cm or greater, with the object of establishing a seedling population of about 75,000/ha (30,000/ac) without any hand or machine work. In practice, the seed numbers sown are about 50% more than the desired plant numbers on the assumption that average plant establishment will be 66% of the seeds sown (despite a minimum laboratory germination of 90%) but it varies considerably; far too many seedlings may grow, necessitating hand work to thin them to the desired plant population, or too few may establish and lead to a yield loss, especially because such thin and irregular crops are subject to pest and disease damage.

Developments in the methods of establishing sugar-beet stands were reviewed by Hull & Jaggard (1971), and changes in seedling populations by Dunning (1971); more recent trends are shown in Tables 3 and 4, and indicate the rapid progress that is being made. This is as a result of economic necessity rather than choice but, despite the hazards of planting-to-stand, it is proving successful (Table 4), especially because of the increased attention to crop husbandry and perhaps because of more and better pesticides (Table 7).

Table 4

Sowing date, Seed spacing and Plant population, 1968-1975

Year	Mean sowing date	Mean seed spacing	Mean plant population/ha
1968	2 April	7.6 cm (3.0 in)	68,113
1969	15 April	8.9 cm (3.5 in)	66,863
1970	19 April**	10.4 cm (4.1 in)	65,805
1971	3 April	10.7 cm (4.2 in)	68,697
1972	6 April	10.7 cm (4.2 in)	70,115
1973	28 March	11.7 cm (4.6 in)	69,233
1974	4 April	13.0 cm (5.1 in)	63,104*
1975	18 April**	13.5 cm (5.3 in)	68,697

* Seedling establishment abnormally low because of drought after sowing.

** Sowing date abnormally late because of excessive rain in March/April.

Sowing date Early sowing is essential for maximum yield (Hull & Webb, 1970) and growers continue to respond to encouragement to sow earlier but are sometimes thwarted by the weather; planting-to-stand means there is no longer the need to delay some sowings so that hand singling can cope with the work. Mean sowing date varies considerably with season but, in general, is now in late March rather than early April (Table 4). Too early sowing runs the risk of the plants bolting but one of the objectives of breeders is to improve bolting resistance, so as to enable even earlier sowing. The trend to earlier sowing is likely to continue but is likely to produce greater loss of seed to wood mice because of slower germination, greater seedling losses to pests such as springtails (*Onychiurus* spp.) because of slower root growth (Baker & Dunning, 1975), and greater grazing damage by birds and mammals because of slower leaf growth (Dunning & Green, 1975).

Herbicide usage Elimination of hand work by precision drilling of monogerm seed at wide spacing depends on effective weed control. The use of herbicides continues to increase (Table 3). To avoid the necessity of inter-row cultivation, which itself can lead to further weed seed germination, there is likely to be a gradual move to overall rather than row-band treatment. Total weed control is the objective, leaving only the desired 75,000 beet seedling/ha, but it runs the risk of increased pest damage because many of the sugar-beet pests normally feed also on weed seedlings. Field trials tested herbicide v no herbicide on sites with soil-inhabiting pests such as millepedes, wireworms and springtails; despite usually small numbers of weed seedlings on the untreated plots, root damage by pests was increased or unaffected, but never decreased, by herbicide treatment and seedlings on treated plots were consistently smaller (Baker, 1975), probably as a result of phytotoxicity. Where weeds were not removed until June 3rd from plots in trials at Broom's Barn in 1971, subsequent virus yellows incidence was halved (Dunning & Winder, 1973a).

Wild beet have increased in the last few years and are now a serious weed problem in some fields (Longden, 1975); if they are not controlled, they may harbour pests and diseases throughout the rotation.

PEST AND DISEASE PROBLEMS

Byford (1975) reviews the present status of fungal diseases of sugar beet, Jones & Dunning (1972) indicate the relative importance of the crop's pests, Dunning (1975) records incidence of arthropod pest damage to the crop from 1947 to 1974, and Dunning (1974) and Dunning & Green (1975) consider bird damage. In addition, each year the Broom's Barn Section of the Rothamsted Annual Report comments on pest and disease incidence and damage.

Under the terms of the B.S.C's contract with the grower crop failures are permitted to be ploughed up, and usually resown to sugar beet, only after inspection by a member of their agricultural field staff. Records of the causes of crop failure in 1973 to 1975 are given in Table 5, and indicate the seasonal variation in crop problems. Smaller, proportionate areas failed and were not resown, and much larger areas were damaged to varying degrees.

Table 5

Causes of sugar-beet crop failure, 1973-75

Cause	Area resown (ha)		
	1973	1974	1975
Wireworms	13	2	9
Pygmy beetle	57	16	1
Millepedes	47	7	16
Symphylids	66	-	27
Slugs	7	-	34
Flea beetle	2	-	-
Beet leaf miner	4	-	-
Leatherjackets	6	-	66
Wood mouse	5	1026	24
Rabbit	1	9	4
Pheasant	3	25	-
Wood pigeon	1	31	-
Skylark	38	386	47
Partridges	1	20	-
House sparrow	14	11	5
Birds (not specified)	50	149	11
Blackleg	6	-	-
Herbicide damage	216	44	63
Wind damage	4674	187	1115
Soil capping	95	4	221
Frost	72	18	5
Several	259	1128	170
Total rainfall, March-May (mm)	134	60	171

Virus yellows, transmitted by aphids, especially the peach-potato aphid (*Myzus persicae*), is the most damaging of all the pest and disease problems of the crop.

After 11 years of low incidence, it became rather prevalent in 1973 and was more prevalent in 1974 than in any year since records started in 1948; in 1975 incidence was again high at the end of August (Table 6).

Table 6

Estimated % virus yellows infection at the end of August, 1948-1975

(Specific field counts: see Hull, 1968)

1948	-	18	1958	-	14	1968	-	4
1949	-	48	1959	-	16	1969	-	2
1950	-	14	1960	-	16	1970	-	2
1951	-	4	1961	-	21	1971	-	1
1952	-	22	1962	-	2	1972	-	2
1953	-	6	1963	-	2	1973	-	11
1954	-	9	1964	-	2	1974	-	66
1955	-	7	1965	-	5	1975	-	37
1956	-	3	1966	-	6			
1957	-	45	1967	-	5			

An alternative assessment of the relative importance of pests and diseases is to consider the treatments applied by growers for the control of those problems for which materials are available and recommendations made. The British Sugar Corporation collect this data by two methods. On the completion of sowing, growers return a form giving details on sowing date, seed spacing, etc., including pesticides applied before or during sowing and the purpose for which applied (see Cooke, 1975). Also, during the growing season the B.S.C. fieldstaff each interview ten growers, picked at random from the contract numbers by the computer, and record crop statistics. The sample, 5% of the total crop area, provides data on materials used for control of the main pests, but is unreliable for minor uses and these have been omitted from Table 7.

DISCUSSION

The main pest and disease problems of the crop are the eating of seed by wood mice, the grazing of seedlings by birds and mammals, soil-inhabiting 'insect' damage to seedling establishment, and virus yellows; beet cyst eelworm causes very little actual crop damage because of the control by rotation, but this rotation imposes limits on the offtake of sugar beet from the most productive soils. Growers accept that the rotation is necessary and complain mainly about the above four problems. However, the continuation of the B.S.C's strict rotational control on all soils, irrespective of type, water supply and location, may need reconsideration in the light of experience and current conditions.

The vertebrate pest problem is not a new one but has increased in significance because of the changes in methods of establishing the crop. Studies are in progress (Green, 1975; Dunning & Green, 1975) to understand better why damage occurs and to devise means by which it can be avoided.

Table 7

Pesticides applied during the season and pest or disease to be controlled: survey of 5% of crop area, 1975

Material*	Primary pest or disease to be controlled (1-5: area treated in decreasing order)					% of surveyed acreage
	Docking disorder	Millepedes	Other soil-inhabiting pests	Flea beetle	Aphids or virus	
Aldicarb	3	4	2	5	1	26.7
Oxamyl	4	3	2		1	1.3
Gamma BHC		2	1	3		6.5
DDT			2	1		1.1
Demephion					1	1.1
Demeton-S-Methyl					1	81.7
Dimethoate					1	16.2
Formothion					1	3.8
Oxydemeton-Methyl					1	3.8
Phosphamidon					1	4.1
Phorate					1	4.1
Pirimicarb					1	16.9
Thiometon					1	2.7
% of Surveyed acreage	2.6	4.5	5.1	0.9	86.0	

* Telone or DD, disulfoton, menazon, metaldehyde and methiocarb also used but each on less than 1% of surveyed acreage.

The gradual increase of seed spacing distance that has been occurring for many years, now being taken to the ultimate practice of planting-to-stand on 65% of the crop in 1975, has not been paralleled by a general increase in insect pest damage to seedlings. Damage by wireworms, beet flea beetle and beet leaf miner declined over the years 1947 to 1974, probably due to the use of insecticides. However, damage by millepedes and symphylids appears to be increasing (Dunning, 1974); this may be as much due to increased awareness as to the changes in crop agronomy. Nevertheless, planting-to-stand is a relatively hazardous process and growers are anxious for maximum protection from seedling pests; a prophylactic seed treatment is considered essential (Dunning & Winder, 1971). In fields where soil-inhabiting pest damage is expected, because of rotation or previous history, growers also apply pesticide overall to the soil (½-1 kg/ha gamma BHC, worked into the seedbed) or in the seed furrow during drilling (¼-1 kg/ha aldicarb or oxamyl). The latter treatment is much more expensive but gives bonus in controlling foliage pests early in the season.

Without doubt one of the biggest problems facing the sugar-beet grower is how to control virus yellows. After more than a decade of low infection level, attributed at least in part to the efficiency of the Spray Warning System and the materials used, yellows increased in 1973 and was more in 1974 than in any year since records started in 1948; virus yellows has again been widespread and severe in 1975, despite a more intensive insecticide programme than ever before. The weather pattern of these three years has been abnormal; virus-infected plants overwintered successfully in the mild conditions and the hot, dry early summers encouraged large aphid infestations. Furthermore, the wilting of the beet plants was not conducive to uptake and trans-location of systemic insecticides. Despite these factors, aphid control was unsatisfactory and resistance to organophosphorus sprays is implicated. The resistance that occurred in 1974 has been recorded (Dunning & Winder, 1975; Needham & Devonshire, 1975) and further evidence for its occurrence in 1974 and 1975 is presented at this Conference.

Trial results suggest that relatively small differences in efficiency of Ministry Approved aphicides are greatly magnified under adverse conditions. Because the B.S.C. gives positive advice to sugar-beet growers on materials to use, and when to use them, a new series of trials are in progress to compare the efficiency of currently Approved spray materials; results available will be presented at the Conference. Radical changes in advice on materials to use is likely and, in addition, advice will be given that it is essential to ring the changes between materials of different chemical groups.

The Spray Warning Scheme (Hull, 1968) aims to advise use of aphicides, to control virus yellows, when and where necessary. Calendar spraying, or any other prophylactic schemes have been discouraged because the risk of aphid resistance has always been foreseen. Despite this care, resistant aphids are now widespread, although by no means universal.

What should the advice be on the use of seed-furrow-applied oxime carbamates ? Aldicarb and thiofanox give persistent control of aphids until about mid-June but the control of yellows is usually no better than one or two sprays of an efficient aphicide. However, although the granule treatment is expensive it is convenient and, certainly with aldicarb, efficient in controlling Docking disorder and damage by soil-inhabiting pests; moreover, the increase in sugar yield given is often better than would be expected from the pest and disease control achieved. Thus, when aldicarb became available in 1975 it found a ready market and its continued use seems assured. But for how many years; will not aphid resistance develop ? Advice must take cognizance of these problems, and progress should be cautious until further studies have been made.

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FUNGAL DISEASES OF SUGAR BEET IN ENGLAND AND THE PROSPECTS FOR THE USE OF FUNGICIDES

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Summary The use of fungicides on the sugar-beet crop in England is reviewed. All seed is treated against Phoma betae by the ethyl mercury phosphate (EMP) steep process, but an alternative treatment is being sought urgently. Maneb and captafol slurries and TCMTB liquid have not been as effective as EMP steep in field trials. Aphanomyces cochlioides causes some seedling losses but fenaminosulf used to control it gave no yield increase. Ramularia leaf spot defoliates some beet-seed crops and was effectively controlled by fentinhydroxide or benomyl sprays, but these did not increase yield enough to justify general treatment. Fungicide sprays against powdery mildew increased yield of both root and seed crops, but this disease requires further study as does Alternaria sp., an important secondary pathogen on yellows-infected plants. Fungicides applied to the soil before drilling or in July did not control violet root rot.

INTRODUCTION

Some 27 species of fungi and 3 bacteria occur as primary or secondary parasites on sugar beet in England (Hull, 1960). However, few fungi cause generally known, or occasionally widespread diseases and there are only six diseases and one secondary parasite that have appeared important enough to justify investigations of the possibility of control with fungicides. At present, fungicides are only used as a routine on sugar beet in England for seed treatment and to control downy mildew in stecklings (first-year seed plants). Recent experimental work has tested the possible value of other fungicide applications to the crop.

SEEDLING DISEASES

Seed-borne fungi Potentially the most important cause of beet seedling blackleg in England is Phoma betae. Favoured by the wet weather in late summer common in England, this fungus often infects seed clusters. With low seeding rates, avoidable seedling losses due to disease cannot be tolerated, so the most effective treatment must be used against P.betae. Since 1961, sugar-beet seed used in England has been steeped in ethyl mercuric phosphate solution (EMP Steep - Byford, 1963). This effectively controls P.betae and has an additional beneficial effect because the germination capacity of some seed lots is improved independently of disease control.

However, the treatment is costly, EMP is very toxic, and seed must be regraded after treatment, with large losses in some seed lots. Furthermore, the use of organo-mercury seed treatments has been criticised on environmental grounds, and they are being superseded by non-mercurial treatments on other crops and on sugar beet in other countries. Thus in addition to the desirability of finding an easier, cheaper and safer treatment, there is also the possibility that the use of mercury may be banned, or that the chemical itself may cease to be available.

The search for an alternative treatment was initiated even before EMP steep was adopted commercially, and still continues. Other liquid organo-mercury treatments, including EMP as a mist or spray were tested and rejected as being less effective or potentially phytotoxic (Byford, 1963; 1971). Many non-mercurial treatments have been screened in small plot trials, and the most promising have been tested in the field. The first material tested was maneb, which when applied as a slurry at 1% of seed weight gave emergence comparable to EMP steep in trials in 1969 and 1970 (Byford, 1972). Subsequently, captafol and TCMTB have been tested (Table 1) but the results have been disappointing compared with EMP steep.

Table 1

Effect of fungicide seed treatment on sugar-beet seedling emergence

Seedling emergence as percentage of seeds sown

	1973	1974	1975
No. of trials	17	16	14
No fungicide	44.8	43.8	45.3
EMP steep	55.9	52.6	56.3
1.1% Maneb	50.4	50.9	50.9
0.64% Captafol	49.7	49.5	48.9
0.08% TCMTB	50.0	-	-
0.1% TCMTB	-	49.4	49.1
0.12% TCMTB	48.9	-	-
0.15% TCMTB	-	-	49.2

Soil-borne fungi These are of limited importance as causes of beet seedling disease in England. Protectant fungicides applied to EMP-steeped seed gave no benefits when the seed was sown at randomly-selected sites (Byford, 1972). Only *Aphanomyces cochlioides*, which is widely distributed in England, sometimes causes localised seedling losses, usually in late-drilled or re-drilled crops (Byford, 1975a). It is effectively controlled by fenaminosulf, but in a series of trials at sites where *A.cochlioides* occurred, no significant improvement in yield was obtained from fenaminosulf applied in the seed pellet, even when a moderate attack of blackleg was controlled (Byford & Prince, 1976). As only a few acres of crop are affected by *A.cochlioides* in most years, it was concluded that the use of cultural practices to avoid infection or to minimise possible losses when there was a danger of infection was more economic than chemical control measures.

LEAF DISEASES

Downy mildew (Peronospora farinosa s.sp. betae). This disease is most prevalent in beet crops in areas where beet seed is grown. The fungus overwinters only on living beet plants and, although it can survive on groundkeepers in fields or old clamp sites, surveys have shown a close association with seed crops (Byford & Hull, 1967). As it has been scarce in both seed and root crops since 1967, it currently causes little anxiety. However, its absence has been largely the result of unfavourable weather and, as some of the new, high yielding, yellows-resistant varieties are relatively susceptible, it could become important again given favourable weather.

The disease can be checked by fungicide sprays (Byford, 1966), but for maximum effect a spray programme must be started before the disease is established. Since the disease is very sporadic in its incidence, prophylactic spraying cannot be recommended except on seed crops, which cover a limited area and are subject to an inspection scheme under which downy mildew-infected crops can be rejected. The main controls used against this disease must be hygiene, separation of root and seed crops, and use of resistant varieties. To the last end, a downy mildew nursery has been established in co-operation with N.I.A.B. where varieties can be tested and breeding material screened on a field scale for susceptibility to the disease.

Leaf spot Happily for British farmers, leaf spot due to Cercospora beticola, a major disease problem in hot, humid climates, is only rarely found here. Leaf spot due to Ramularia beticola is better adapted to our relatively cool summers. This fungus can cause losses in root crops in S.W. England, where Hull (1960) reported significant yield increases from both fungicide sprays and the use of resistant varieties. However, it only rarely causes defoliation in the main root crop areas of Eastern England, and control measures against it are not contemplated.

Scott (1969) reported R.beticola defoliating beet-seed crops in the Cotswolds, and subsequent surveys (Byford, 1975b) showed that the disease was general in the Cotswolds and Upper Thames valley, common in Lincolnshire, but rare in other seed-growing areas. A series of experiments was started to determine whether sprays applied to control leaf spot would increase yield. Trials on crops in the Cotswolds compared fentinhydroxide and benomyl, and others in Huntingdonshire and Lincolnshire compared three, two or one application of fentinhydroxide in May (Tables 2 and 3).

Leaf spot was controlled most effectively in the Cotswolds, but the average yield increase from spraying was higher in Lincolnshire. However, in 11 trials sprays increased yield on average by only 3%, which was small in comparison with the variance of the trials. In a few trials, large yield increases were obtained but the reason for this could not be determined and it is not possible to predict crops where large responses to spraying may occur. Although sugar-beet seed is a high value crop and a yield increase of 3% following a single aerial spray would show a profit, it is not possible to make a general recommendation to spray on the basis of these results. Cultural factors such as time of sowing and harvesting and fertiliser usage have a much greater effect on seed yield.

Powdery mildew (Erisyphe betae) In dry seasons, powdery mildew is usually widespread in England in late August and September but the extent to which it causes loss of yield is uncertain. Russell (1971) reported that fungicide sprays to control powdery mildew had increased yield by 4-5% on average, and by up to 12% in a susceptible variety, while Byford (1975c) reported a 10% yield increase when powdery mildew was controlled in a sugar-beet seed crop.

Table 2

Effect of fungicide sprays on Ramularia leaf spot incidence in sugar-beet seed crops

Sprays applied in May; percentage leaf spot on mid-stem leaves in the second half of July

Year	County	Unsprayed	fentinhydroxide at 0.67 kg ai/ha			benomyl at 0.28 kg ai/ha	
			1 spray	2 sprays	3 sprays	1 spray	3 sprays
1968	Oxon	9.9	2.2***	2.0***	0.9***	-	-
1969	Oxon	2.9	0.4**	0.3**	0.3**	0.3**	0.2**
	Lincs a	9.0	2.9***	1.4***	1.3***	-	-
	Lincs b	2.9	2.3	1.3	1.6	-	-
1970	Oxon	7.4	0.9***	0.8***	0.2***	0.1***	0.2***
	Hunts	0.2	0.1	0.03	0.04	-	-
	Lincs a	0.3	0.03*	0.01*	0.01*	-	-
	Lincs b	0.1	0.03	0.01*	0.01*	-	-
1971	Hunts	negligible, not assessed					
	Lincs a	6.8	4.4**	3.0***	2.7***	-	-
	Lincs b	8.9	5.9**	3.2***	2.8***	-	-
1972	Oxon	8.3	0.8***	0.4***	0.6***	-	0.2***

Significantly different from unsprayed at * = $P<0.05$; ** = $P<0.01$; *** = $P<0.001$

Table 3

Effect of fungicide sprays on sugar-beet seed yield

Sprays applied in May; seed yield t/ha

Year	County	Unsprayed	fentinhydroxide at 0.67 kg ai/ha			benomyl at 0.28 kg ai/ha	
			1 spray	2 sprays	3 sprays	1 spray	3 sprays
1968	Oxon	3.06	3.18	3.51	3.45	-	-
1969	Oxon (i)	3.78	3.92	4.13	4.30*	3.92	3.80
	Lincs b	4.24	4.29	4.53	4.51	-	-
1970	Oxon	4.94	5.15	4.51	4.24	4.27	4.72
	Hunts (ii)	3.73	4.06	4.07	4.11*	-	-
	Lincs a	5.91	6.53*	6.34	6.01	-	-
	Lincs b	4.07	3.97	3.86	4.22	-	-
1971	Hunts	3.29	3.18	3.00	2.92	-	-
	Lincs a	3.71	3.75	3.31	3.42	-	-
	Lincs b	2.94	3.44*	3.69**	3.44*	-	-
1972	Oxon	4.03	3.99	4.21	4.20	-	4.31

(i) Increase in seed yield mainly due to controlling Phoma stem rot, not leaf spot.

(ii) Heavily infected with powdery mildew in July, little leaf spot.

Significantly different from unsprayed at * = $P<0.05$; ** = $P<0.01$

In recent experiments at Broom's Barn with fungicides applied in August and September to control leaf fungi and maintain leaf area in the early autumn, although top yield has been increased in most years, root yield has only been increased by spraying when powdery mildew was prevalent. Table 4 shows the effect of fentinhydroxide and benomyl sprays on sugar yield when powdery mildew was prevalent.

Table 4

Effect of fungicide sprays in August/September on sugar yield of sugar beet

Sugar yield t/ha

Year	Unsprayed	fentinhydroxide		benomyl		mildewicide	
		1 spray	3 sprays	1 spray	3 sprays	1 spray	3 sprays
1972	8.91	-	9.82	-	9.57	-	-
1973 a	8.69	-	8.82	-	-	8.99	8.84
1973 b	8.42	8.96	8.90*	-	-	9.06	-
1974	7.82	8.31	8.24	7.92	8.34	7.81	7.61

fentinhydroxide applied at 0.67 kg a.i./ha

benomyl applied at 0.28 kg/ha in 1972 and 0.42 kg/ha in 1974

mildew-specific fungicides used

(a) 1973 chloraniformethan at 0.53 kg a.i./ha

(b) 1974 'Bayer 6660' at 0.25 kg a.i./ha

* = only 2 sprays applied

The problem of powdery mildew is one that merits further investigation, to confirm that controlling it can give worthwhile yield increases, to determine how widespread, severe and frequent are its attacks, and whether these can be forecast from weather or other data.

Alternaria An Alternaria species resembling A.tenuissima causes necrotic lesions on the leaves of beet plants infected with beet mild yellowing virus. Russell (1965 and 1966) reported that fungicides applied to control Alternaria could decrease the yield loss following infection with virus yellows by up to 30%, increasing the yield of infected plants by 20%. In the years of low yellows incidence from 1961 to 1972, work with Alternaria on virus yellows-infected plants concentrated on breeding for resistance. However, the exceptional outbreak of yellows in 1974 has focussed attention on this problem. If Russell's results, obtained on artificially yellows-infected plants, can be repeated in naturally-infected crops, then Alternaria is the only fungus which, in some years, causes major economic losses to sugar beet in England. Further investigation of this problem seems necessary.

ROOT DISEASES

Several fungi can cause rots of sugar-beet roots in the field or in storage, of which only violet root rot (Helicobasidium purpureum) has been studied in this country. Hull and Wilson (1946) reported on its occurrence in England from 1936 to 1943 and investigated the factors that favour its development. Cooke et al. (1969) reported that violet root rot was controlled by soil fumigation with D-D, but Darpoux and Lebrun (1961) reported unsuccessful attempts to control it with soil-applied fungicides. In 1969, a carrot crop on a light peat soil at Burwell, Cambs, which was very heavily infected with violet root rot, was ploughed in, and soil-applied fungicides to control the disease in sugar beet were tested in 1970 and 1971.

In the first experiment, mebenil, benomyl, carboxin Hg, quintozene and thiram were sprayed on the soil surface and worked in before drilling. In September, mebenil and benomyl at 12.6 kg/ha had slightly decreased infection and several of the treatments gave a non-significant yield increase, but no effect on violet root rot incidence or yield was detected in December. The next year, quintozene, mebenil and BAS 3191 were worked in shortly before drilling or sprayed onto the soil along the rows in July, but none of these treatments decreased infection or increased yield.

In further experiments, it was found that the main development of violet root rot infection in sugar-beet roots occurred in August, September and October and it was concluded that soil-applied fungicides fail to control H.purpureum because they have become inactive before this period of fungal activity and infection.

CONCLUSIONS

Recent investigations have shown that no fungus, except perhaps Alternaria sp., presents a disease problem on sugar beet in England of major economic importance. An important factor in this favourable situation is the comparative resistance of all our commercial sugar-beet varieties to most of the pathogenic fungi that occur here. Genetically variable plant breeding material shows differences in susceptibility to such diseases as rust and Ramularia leaf spot much greater than are encountered in commercial crops. The first line of defence against these diseases must, therefore, be to ensure that undue susceptibility to minor diseases is not inadvertently introduced into new varieties.

From the manufacturers' point of view, the prospects for fungicide usage on sugar beet in England are not good. All seed will continue to be treated with EMP or a substitute, which ensures a market for enough product to treat about 500 t of seed. Doubtless many steckling beds will continue to be treated against downy mildew - probably about 800 ha, but large-scale use of fungicides on the crop seems unlikely unless current work on powdery mildew or Alternaria gives unexpectedly encouraging results.

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FIELD TRIALS IN SUGAR-BEET MADE WITH THIOFANOX IN THE UNITED KINGDOM IN 1975

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Summary The insecticidal properties of thiofanox have been investigated in extensive field trials in the major sugar-beet growing areas in the United Kingdom in 1975. Thiofanox, at a rate of 0.8 kg a.i./ha, applied in the seed furrow controlled green aphids (*Myzus persicae*) and black aphids (*Aphis fabae*), and considerably reduced the incidence of virus yellows. Thiofanox is not phytotoxic at the rate of 0.8 kg a.i./ha, with a safe margin in most of the soils. Therefore, thiofanox at 0.8 kg a.i./ha is a suitable material for application with sugar-beet seed to control aphids and yellows.

Résumé Les propriétés insecticides du thiofanox ont été étudiées au cours de divers essais en plein champ à répétitions dans les principales régions de culture de betterave à sucre en Grande-Bretagne. Le thiofanox appliqué dans la ligne de semis à la dose de 0.8 kg m.a./ha a montré une excellente efficacité contre les pucerons verts (*Myzus persicae*), les pucerons noirs (*Aphis fabae*), et a très nettement diminué la jaunisse parasitaire. Le thiofanox a prouvé sa sélectivité à la dose de 0.8 kg m.a./ha. Par suite, le thiofanox à la dose de 0.8 kg m.a./ha en traitement localisé des semis de betteraves est un produit efficace contre les pucerons et la jaunisse parasitaire.

INTRODUCTION

At the present time, sugar-beet growers are faced with the situation where "virus yellows" severely reduces sugar yields in most sugar-beet growing areas of England. Considering the success of thiofanox as an aphicide in trials undertaken in 1973 and 1974 (Schauer, 1973; Schauer and Pauwels, 1975), extensive field trials were established to study a wider range of dosages. This paper summarizes the efficacy data obtained from the major sugar-beet areas of England. This paper includes all counts and assessments made at seven sites up to 15th September 1975. Yield data cannot be presented in the text, but yield increases in 1974 trials were related to virus yellows reduction (Schauer and Pauwels, 1975; Schauer, 1975; Dunning and Winder, 1974). Sugar yield data will be presented at the Conference.

METHODS AND MATERIAL

Sugar-beet fields known to have previously suffered pest damage were selected [symphylids (*Scutigerella sp.*), aphids (*Myzus persicae* and *Aphis fabae*)]. Thiofanox (also known under the commercial name of DACAMOX 5 G) is formulated on a clay based granule to give 5 % of a.i. The standard pesticide used in all the trials was aldicarb applied as a 10 % granular formulation. In-furrow applications were made with the standard Horstine Farmery granule applicator at all sites. The granules were applied in close contact with the sugar-beet seeds over a small band of 2-3cm width. Depth of drilling was set at 2.5cm. All sites were sown with the same pelleted seed variety, free of any insecticide treatment. Because of the very dry weather conditions in May some trials were discarded.

The effects of the treatment were assessed by counting the emergence of 10 m of crop row per plot. Aphids counts were made on 20 leaves per plot (2 leaves/plant). Virus yellows infection was expressed as the percentage of affected plants per plot. After collation, treatment effects on virus yellows incidence were converted to a single figure using the method recommended by Broom's Barn Experimental Station. The method involves the totalling of individual assessments to give a figure for infected-plant-weeks. Yellows counts were made on 15th September. This figure gives a clearer impression of the effect of treatments in reducing virus yellows by expressing results as a percentage reduction in the disease. Details of the trial sites are given in Table 1.

RESULTS

All assessments are recorded in Tables 2, 3, 4, and 5. Seedling establishment was assessed at only five sites as the very late sowing caused erratic seedling emergence at sites 5 and 7 (Table 2). The mean emergence in the control plots is given at the bottom of Table 2. Seedling establishment was not quite satisfactory due to the bad climatological conditions and late sowing.

In general, all insecticide treatments increased the percentage of seedlings emerging. However, the higher dosages of thiofanox slightly reduced plant stand in sandy soils (Sites 2 and 3). Symphylids (Scutigerella sp.) were present in large numbers at Site 4, and it can be concluded that the increased plant stands were due to the control of these pests.

Evaluations of the control of green aphid (Myzus persicae) were made at five sites and for black aphid (Aphis fabae) at three sites. The results summarized in Table 3 demonstrate that all treatments greatly reduced the population of Myzus persicae. Thiofanox at 0.8 kg a.i./ha provided better green aphid control than did aldicarb at the same rate. Data presented in Table 4 show that all treatments provided excellent control of Aphis fabae. The number of aphids per 20 leaves per plot are given under the control.

The evaluation of virus yellows incidence was made at five sites (Table 5). All insecticide treatments reduced virus infection. Results of applying thiofanox and aldicarb at 0.8 kg a.i./ha were slightly in favour of thiofanox. Thiofanox at 1.2 kg a.i./ha provided the greatest reduction of virus yellows infection, approximately 20 %, but did not decrease considerably the incidence in comparison with the two lower rates.

CONCLUSIONS

Thiofanox, at a rate of 0.8 kg a.i./ha, effectively controlled M. persicae and A. fabae, and reduced the incidence of virus yellows. There is evidence to suggest that, when applied directly with the beet seed, the optimal rate may be even lower than those tested. In the field, we recommend a rate from 0.4 kg/ha in sandy soils to 0.8 kg/ha on heavier soils, especially where virus yellows is a problem.

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TABLE 1

Details of seven trial sites

N°	Site	Soil type	% organic matter	Sowing date
1	Gamlingay, Cambridgeshire	Fine sandy loam	1.7	28 April
2	Beechamwell, Norfolk	Calcareous loamy sand	1.9	21 April
3	Swaffham, Norfolk	Loamy sand	2.8	8 April
4	Thorney, Cambridgeshire	Organic silt loam	14.2	1 May
5	Holme Fen, Cambridgeshire	Sandy peat	53.9	19 May
6	Brampton, Cambridgeshire	Fine sandy loam	2.0	29 April
7	Little Stukeley, Cambridgeshire	Sandy clay loam	3.2	23 May

TABLE 2

Seedling establishment at five trial sites as % of control

	Treatments	Dosage kg a.i./ha	Sites 1	2	3	4	6	Average
1.	Control ⁚		100	100	100	100	100	100
2.	Thiofanox	0.40	143	113	101	138	106	120
3.	Thiofanox	0.80	118	97	94	115	102	105
4.	Thiofanox	1.20	105	87	81	141	100	103
5.	Aldicarb	0.82	118	106	101	128	102	111
⁚	Mean emergence in control (plants/40 m)		44	63	57	33	40	

TABLE 3

Percentage of *Myzus persicae* killed

	Treatments	Dosage kg a.i./ha	Sites 1	4	5	6	7	Mean
1.	Control ⁜		150	783	81	383	27	
2.	Thiofanox	0.40	96.7	41.7	3.5	92.8	57.2	58.4
3.	Thiofanox	0.80	98.5	72.2	70.7	96.9	88.2	85.3
4.	Thiofanox	1.20	97.2	75.3	77.9	95.9	79.5	85.1
5.	Aldicarb	0.82	93.3	65.4	65.6	96.0	63.9	76.8
	Days after drilling		65	65	41	76	55	

⁜ Number of aphids per 20 leaves/plot

TABLE 4

Percentage of *Aphis fabae* killed

	Treatments	Dosage kg a.i./ha	Sites 1	4	6	Mean
1.	Control ⁜		38	293	14	
2.	Thiofanox	0.40	99.9	96.5	81.9	91.7
3.	Thiofanox	0.80	97.5	90.9	88.6	92.3
4.	Thiofanox	1.20	98.3	97.3	91.7	95.7
5.	Aldicarb	0.82	100	95.5	93.3	96.2
	Days after drilling		65	65	76	

⁜ Number of aphids per 20 leaves/plot

TABLE 5

Virus yellows incidence at five sites

	Treatments	Dosage kg a.i./ha	Sites 1	2	3	6	7	Mean
1.	Control		42	77	26	83	77	50.8
2.	Thiofanox	0.40	28	73	17	73	70	43.5
3.	Thiofanox	0.80	27	71	10	78	70	42.6
4.	Thiofanox	1.20	28	71	13	74	65	41.8
5.	Aldicarb	0.82	34	80	18	77	72	46.8
	Days after drilling		140	147	160	140	125	

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RECENT EXPERIENCES WITH TERBUFOS*

AGAINST SUGAR BEET PESTS IN EUROPE

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Summary Experimental work with the new organo-phosphorous soil insecticide, terbufos, has increased in Europe in the last two seasons.

Terbufos has shown good to excellent consistent control of a wide range of sugar-beet pests, including *Atomaria linearis*, *Chaetocnema tibialis*, *Agriotes* spp., *Blaniulus guttulatus*, *Pegomya betae*, *Aphis fabae*, *Scutigerella immaculata* and *Cleonus mendicus*. *Ditylenchus dipsaci* has also been well controlled at several trials. The rate needed depends largely on the method of application, on pest complex expected and on local conditions, and ranges from 150-2000 g a.i./ha. The low rate of terbufos was applied in the seed furrow.

Terbufos remains active for some 6-12 weeks, according to the dosage, giving ample protection against seedling pests, and frequently reduces the damage caused by insects which attack later.

Terbufos causes little damage to sugar-beet and is markedly superior to phorate in this respect.

* Marketed as COUNTER ^{R}, a trademark of the American Cyanamid Company

INTRODUCTION

The results of trials with terbufos (AC 92100) were first discussed by Fagan (1973) when American and initial European results with the compound were presented. Dunning and Winder (1973) also presented encouraging data from their sugar-beet work in the United Kingdom.

Since then, extensive trial programmes have been undertaken in some twelve European countries. Main efforts have been devoted to trials in sugar-beet and maize, but potatoes, carrots, brassicae and other vegetable crops have also been included.

Work in the last three years, i.e. 1973-1975, has included trials to determine optimum dosages and most suitable methods of application, and has included both replicated and unreplicated trials on farms.

Sugar-beet seedlings are attacked by a range of pests. The incidence of many of these pests is highly variable, sporadic or associated with particular circumstances. Much of the damage that these arthropods cause is often done prior to it being obvious in the field and when it is too late to treat by a routine spray or dusting. The level of damage during an outbreak can, however, be very severe and can result quite easily in a total crop failure, and it is with this background in mind that one must set out to develop soil insecticides for the sugar-beet crop.

METHODS AND MATERIALS

The work reported, mostly from Italy, France, and the U.K., covers a range of pests. Results from randomized block, Latin square, incomplete block or multifactorial trials only are discussed, in all cases a minimum of four replications were used. Application methods used included broadcast, in furrow, banded just in front of the drill coulter ("bow-wave") and banded just after the seed is sown but prior to compression ("fish-tail").

Some of the early trial applications were made by hand, most of the recent work, including all the (not discussed) unreplicated demonstration tests, has been carried out using a wide range of commercially available granule applicators.

Statistical data has been omitted from many of the results presented for several reasons but mainly because only a summary of available data is presented.

RESULTS

Soil Insects

a) Experiments in France. Soil insect pests cause significant damage in France and crops are treated with insecticide against them as a routine. The important pests include:- Atomaria linearis (pigmy beetle), Blaniulus guttulatus (millipedes), Agriotes spp. (wireworms), Scutigerella immaculata (symphilids), Pegomgia betae (mangold fly), and aphids. Nematodes are also a problem.

To combat such a wide range of pests, it is essential to have a compound with a wide activity spectrum. In this respect, terbufos is outstanding. An infurrow treatment of 150-200 g a.i./ha has normally offered excellent protection against these problems, except possibly S. immaculata and nematodes where a higher rate gives better performance. Efficacy has been consistent from region to region with terbufos, and also from season to season.

It is important to note that the results given below are from sites where one particular pest was abundant, however some of the effects of terbufos or the other pesticides may have been on other pests in those soils.

Summarised data from eight trials with heavy Agriotes spp. infestations are presented in Table 1.

Table 1

Efficacy of terbufos in Agriotes-infested soil, the results expressed as a percentage of sugar-beet seedlings established 30-45 days after sowing compared with untreated plots in 1974. (Data Procida, Sedagri)

Product	Application Method	Rate g.a.i./ha	Mean (8 trials) % seedlings established
Terbufos 2G	In-furrow	150 - 165*	187
Terbufos 2G	In-furrow	200 - 300	199
Terbufos 5G	Bow-wave	400 - 425	193
Carbofuran 5G	In-furrow	600 - 930	177
Aldicarb 5G	In-furrow	750	119**

* - Dosage range according to actual rate from machine in field.

** - from 5 sites only.

From this data, it can be seen that terbufos (at a dosage some four times lower) gives equal or slightly better control of Agriotes spp. than carbofuran or aldicarb.

Results of trials against B. guttulatus and S. immaculata were obtained from three sites in 1974. These are summarised in Table 2.

Table 2

Efficacy of terbufos in soils infested with B. guttulatus and S. immaculata, the results expressed as percentage seedlings established 30-45 days after sowing compared with untreated plots in 1974. (Data Procida, Sedagri)

Product	Application Method	Rate g a.i./ha	Mean (3 trials) % seedlings established
Terbufos 2G	In-furrow	160 - 175	108
Terbufos 2G	In-furrow	230 - 255	110
Terbufos 5G	Bow-wave	425 - 465	113
Carbofuran 5G	In-furrow	600 - 670	111
Aldicarb 5G	In-furrow	750 - 810	108

The results show little difference between treatments.

Applications in-furrow, "bow-wave" and "fish-tail" have all given good results in French trials.

Terbufos 2G has also been studied in detail at Pavant, France, against a range of soil arthropods in both 1973 and 1974. B. guttulatus was the main problem although both wireworms and a few S. immaculata were also present. Terbufos activity showed up well in this and other trials where infestation pressure have been high. Results in 1974 are presented in Table 3. Similar results were obtained in 1973.

Table 3

Efficacy of terbufos in soil heavily infested with arthropod pests at Pavant, the results expressed as percentage of plants established compared with untreated plots. (Data Procida)

Product	Rate g a.i./ha	% plant stand increase at 6 leaf stage	10 leaf stage
Terbufos 2G	165	294	301
	270	292	299
Carbofuran 5G	640	173	185
Untreated		100 (20.0 per 10m.)	100 (20.3 per 10m.)
Significant differences p = 0.05		39.6	29.8
C. of V.		12.3	9.25

Excellent results against both *A. fabae* (black aphids) and *P. betae* were obtained in trials in France in 1973-74; both insects are frequent pests in several of the important sugar-beet growing countries of Europe (Tables 4 and 5).

Terbufos was tested against *A. fabae* at Bonneil and Pavant (sites 1 and 2) in 1973, and at Boureschês, Nogental, Villebourg and St. Paterne (sites 3 - 6) in 1974.

Table 4

Efficacy of terbufos against *A. fabae* (Data Procida).

Product	Rate g a.i./ha	Number aphids/100 plants Site 1 91 DAT*	Site 2 82 DAT	Site 3 66 DAT	Site 4 59 DAT	% beet free of aphids Site 5 48 DAT	Site 6 53 DAT
Terbufos 2G	142-284	126	124	3	0	98	99
Aldicarb 5G	700-750	527	154	-	0	100	99
Carbofuran 5G	744-790	-	-	3	0	-	-
Untreated		3726	1831	1030	2860	59	65

* DAT - days after treatment

Terbufos was tested against *P. betae* at Caroy les Hernonville and Bonneil (sites 1 and 2) in 1973 and at Pavant, Bleomes and Nogental (sites 3, 4 and 5) in 1974.

Table 5

Efficacy of terbufos against *P. betae*. (Data Procida)

Product	Rate g a.i./ha	% beet with foliage free of mines Site 1 79 DAT	Site 2 80 DAT	Site 3 72 DAT	Site 4 67 DAT	Site 5 59 DAT
Terbufos 2G	142-271	99	99	100	98	93
Aldicarb 5G	688-750	100	90	100	93	94
Carbofuran 5G	744	-	-	-	-	87
Untreated		24	1	72	65	72

The influence of such results on yields is well demonstrated by data obtained from a trial at Rensucre (Nord), as shown in Table 6. (Data I.T.B. 1974)

Table 6

Influence of soil insecticide treatments on plant population, beet yield, sugar percentage and sugar yield.

Treatment	Rate g a.i./ha	Heavy Infestation* Replicates 1 and 2	Light Infestation Replicates 3 and 4
a) Plant Populations (number/ha)			
Terbufos 2G	160	52,000	53,000
Carbofuran 5G	600	45,600	46,200
Untreated		13,000	40,000
b) Yield of beet (t/ha.)			
Terbufos 2G	160	47.30	41.56
Carbofuran 5G	600	42.20	45.46
Untreated		18.16	41.30
c) Sugar content (%)			
Terbufos 2G	160	15.10	14.37
Carbofuran 5G	600	14.24	13.54
Untreated		12.36	14.37
d) Yield of sugar (t/ha.)			
Terbufos 2G	160	7.14	5.97
Carbofuran 5G	600	6.00	6.15
Untreated		2.24	5.93

* Main pests of untreated areas were *B. guttulatus* and *A. linearis*.

b) Experiments in the United Kingdom. Since the report of Dunning and Winder (1973), which indicated moderate to severe infestations of *A. linearis* in 1971, 1972, and 1973 in the U.K., the last two seasons have seen probably lesser general levels of infestation, and few infestations were recorded in 20 farmer trials in 1975. Millipedes have caused little damage in these last two seasons, although aphids were numerous in 1974.

Results from two sites in the U.K. where *A. linearis* caused problems in 1974 are presented in Table 7.

Table 7

Efficacy of terbufos against A. linearis, U.K., 1974.

Product	Rate* kg a.i./ha	Plant counts 20 m row		% Roots attacked by A. linearis		% Control	
		Site 1**	Site 2	Site 1	Site 2	Site 1	Site 2
Terbufos 5G	0.5	104	110	73	37	19	35
Terbufos 5G	1.0	122	122	40	7	56	88
Terbufos 5G	2.0	116	95	15	2	84	97
Untreated		112	111	90	57		

* Bow-wave treatment, wheelbarrow microband applicator.

**1) Site: Benwich
var. Sharpes K 17 silt-loam soil, application 2.4.1974

2) Site: Nordelph
var. Monotri M 32 organic loam soil, application 1.4.1974

Good control was thus obtained, particularly at the 2.0 kg a.i./ha rate of application.

c) Results in Italy from 1972-74 showed consistently good control of Chaetocnema tibialis (flea beetles), a major problem, when terbufos was applied at rates of 1-2 kg a.i./ha broadcast and of 250-500 g a.i./ha in the furrow.

Terbufos has not always controlled late infestations of Cleonus mendicus (weevils) completely, but an application at the time of sowing has decreased the level of attack.

Results of trials at **five** sites against the two pests are summarized in Table 8.

Table 8

Efficacy of terbufos against C. tibialis and C. mendicus in sugar-beet, Italy, 1972-1974.(Data SIAPA)

Dosages (kg a.i./ha)	Distribution***	C.tibialis* DAT	Control (%)	C.mendicus** DAT	Control (%)
2.0	Broadcast	47	91.7	85	78.4
3.0			96.9		99.3
0.45	Localised	63	75.0	173	72.2
0.9			82.0		81.1
1.0	Broadcast	70	82.0	111	45.6
1.5			84.0		38.1
0.5	Localised	61	95.0	160	31.5
0.95			97.0		33.0
0.25	Localised	61	71.0	174	27.0
0.5			86.0		21.0

Site locations: Pincara (Rovigo), Fiesso Umbertiano (Rovigo), Galeazza(Bologna), Canaro (Rovigo), and Stienta (Rovigo).

* C. tibialis evaluations: based on average number of foliar erosions (50 plants/plot) in comparison with the check.

** C. mendicus evaluations: based on average number of root erosions (50 beets/plot) in comparison with check.

*** (a) broadcast by hand (soil incorporation with harrow)

(b) localised distribution by Horstine Farmery on Stanhay sowing-fertilizer machine.

More detailed results from the 1975 trials series confirm the consistency of activity of terbufos against C. tibialis.

Table 9

Efficacity of terbufos against C. tibialis in sugar-beet, Italy, 1975. (Data SIAPA)

Product	Rate kg a.i./ha	No. plants*m^2	Mean No.** erosions leaf	% Control
a) Broadcast applications (Site 1 Mirabello, Site 2 Canaro)				
Treated: 28.2.75		49 DAT	53 DAT	
Phorate 10G	3.0	12.6	6.9a ***	71.6
Untreated		12.9	24.4b	--
Terbufos 5G	2.0	11.9	4.6a	80.9
Carbofuran 5G	2.0	12.5	3.4a	85.0
Treated: 28.2.75		61 DAT	61 DAT	
Phorate 10G	3.0	8.9b	6.3a	79.5
Untreated		8.3b	31.0b	--
Terbufos 5G	2.0	9.8a	6.4a	79.4
Carbofuran 5G	2.0	8.9b	12.0a	61.4
b) Localised, in-furrow applications (Site: Canaro)				
Treated: 2.4.75.		37 DAT	37 DAT	
Carbofuran 5G	0.54	10.3a	2.3a	85.1
Untreated		8.3b	15.5b	--
Terbufos 5G	0.55	8.8ab	1.1a	92.7
Aldicarb 10G	0.61	10.1a	2.8a	81.5

* Mean number/m^2 from 50m of row/plot

** Mean calculated from 100 leaves/plot

*** a.b.c., significance data according to Duncan's New Multiple Range Test, 5% probability level.

Yield data are not yet available from this programme.

Nematodes

Activity against Ditylenchus dipsaci (stem eelworm) was also shown at a site at Etain, France. Good nematicidal efficacity has also been observed from trials work in Switzerland (not presented).

An assessment of root-crown damage at harvest is presented in Table 10. (Data: Service Agronomique Beghin-Say).

Table 10

Efficacy of terbufos against *Ditylenchus dipsaci*, Etain, 1974.

Product	Rate* g a.i./ha	% Root crowns with lesions
Aldicarb 5G	1000	7.9
Carbofuran 5G	600	26.8
Terbufos 2G	160	27.8
Chlormephos 5G	400	60.4
Untreated	-	72.4

* In-furrow application

DISCUSSION

Efficacity

The efficacity data reported on from the trials carried out in France, Italy and the United Kingdom have been supported by less extensive, but nevertheless conclusive results from other countries, some of these trials are now briefly mentioned.

Results from trials in Germany, both greenhouse and field, show excellent control of *Collembola* (springtails) by 500 or 1000 g a.i./ha of terbufos. Good control of *A. linearis* is also reported with yield increases of 17% obtained, and complete control of *P. betae* was further recorded at one site (dosage 0.025 g a.i. per m. of row). (Data: Urania).

Further data from France indicate that good control can also be obtained of the less frequent soil pests such as *Tipula paludosa* (leatherjackets) and *Tanymechus palliatus* (weevils). Results from a site at Airan, where *T. paludosa* was a main pest, showed a 112% plant stand compared with untreated, and an identical result was obtained from a site at St. Etienne where *T. palliatus* was abundant. (Data: Procida).

Selectivity

Because sugar-beet seedlings are delicate and are grown on a wide range of soils, under many different conditions, soil-applied insecticides are likely to cause some damage to them, especially if the chemical is applied in the seed furrow. The effect of terbufos on sugar-beet seedlings has therefore been closely studied in all our trials. Occasionally slight damage to beet seedlings has been caused when the pesticide was applied in the seed furrow, even at application rates as low as 300 g a.i./ha in France, but such damage is invariably outgrown without loss of yield. In-furrow applications of below 300 g a.i./ha normally offer no risk to the crop, but in-furrow applications of 500 g a.i./ha or over have occasionally resulted in some plant stand reduction, as have broadcast applications at 2.0 kg a.i./ha. In most cases, however, no damage has been caused and it seems that phytotoxicity is associated with stress situations within the plant. Such stresses can be caused by cold and wet conditions.

No phytotoxicity problems at all have been reported from Italy, where rates up to 1.0 kg a.i./ha (localised) and 3.0 kg a.i./ha (broadcast) have been extensively tested.

In the trials terbufos has shown equal or slightly superior selectivity compared to carbofuran and superior selectivity compared to phorate at effective rates.

Conclusions

We conclude from our experiments that terbufos controls a wide range of sugar-beet pests, including pigmy beetle, wireworms, mangold fly, millipedes, aphids, symphilids, weevils, springtails, flea beetles and some nematodes, while showing little risk of damage to the sugar-beet seedlings. The experiments demonstrate that the performance of terbufos under field conditions has been consistent and that very low application rates are usually adequate to give highly acceptable levels of control.

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