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HERBICIDE EVALUATION IN BRASSICA CROPS - 1968-72

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Summary Aziprotryne was the most satisfactory treatment for pre- and post-emergence application in drilled cabbage. A combined programme of trifluralin applied pre-sowing and propachlor pre-emergence was also safe and effective. Drilled cauliflower showed good tolerance to pre-emergence applications of CP 52265 (2 - chloro - N - iso propoxymethyl) 2' - 6' acetoxylidide), CP 52223 (2 chlor - N - (iso butoxymethyl) - 2' - 6' acetoxylidide and dacthal.

Dinitramine caused injury to drilled crops at doses necessary for adequate weed control. In cauliflower, greater damage occurred with surface pre-emergence applications of dinitramine than where it was incorporated prior to sowing.

Simazine was highly selective in transplanted cabbage and post-emergence in drilled crops at doses up to 1.0 lb a.i./ac. Effectiveness was increased with the addition of desmetryne, aziprotryne or prometryne.

Results with haloxydine and alachlor are also included.

INTRODUCTION

The importance of having satisfactory herbicides for use in Brassicae especially direct drilled crops has already been discussed (Cassidy 1966). Trials reported in 1968 (Cassidy and Doherty 1968) showed that propachlor and trifluralin were the most selective herbicides for drilled cauliflower, cabbage and Brussels sprouts. It was pointed out, however, that their ineffectiveness against certain weed species was a serious drawback, but that combinations of these herbicides might be worth investigating.

Evaluation of trifluralin/propachlor programmes and of a number of new herbicides in drilled crops has been carried out since 1968. Trials with simazine and other herbicides in transplanted crops have also been conducted during this period.

METHOD AND MATERIALS

Trials at Kinsealy were on a medium loam having a clay and organic matter content of 25.0% and 6.5% respectively. Sites in Mallow, Co. Cork, were also medium loams while the Carlow sites were free draining coarse sandy loams with 9 - 12% clay and 3.5 - 4.5% organic matter.

A randomised block design with 4 - 6 replicates was used in most trials but where two or three different crops were included in the one trial the design was a randomised split plot with three replicates. Plot size was 10 yds x 2 yds. Treatments were applied with a pressure retaining knapsack at a volume of 40 gal/ac. Granular formulations were applied by hand. All doses are given in lb/ac a.i.

Plant counts or number of thinnings removed were recorded. Weight of thinnings and crop yields were also taken in some trials. Weed kill was assessed by counting survivors in a number of quadrats thrown at random in each plot. At least two visual assessments of treatment effect on crop and weeds were made.

RESULTS

Drilled cabbage - 1969 Six treatments were compared for pre-sowing or pre-emergence application of three sites (A, B, C) in the Carlow area. Crops were sown in early June and pre-emergence treatments were applied seven days after sowing at Site A and after two days at the other sites. Trifluralin was applied and immediately incorporated with two runs at right angles of a tine cultivator approximately ten days after sowing.

Treatments and results are given in Table 1. Selectivity and degree of weed control of the different treatments were very similar at the three sites and because of this only the mean values for plant stand and crop and weed assessments are given in the Table.

Table 1

Effect of treatments on crop and weeds - Drilled cabbage - 1969

Treatments	Dose lb/ac	Plant stand[2] as % of control	Yield t/ac A	Assessments[1] Mean of 3 sites Crop	Weeds	% weed kill Site A S.a.	P.p.	Sp.a.	Site B Ch.a.	V.s.	S.v.
Trifluralin	1.0	112	20.2	9.8	4.8	0	53	65	86	86	0
Trifluralin + Propachlor	1.0 3.9	105	22.8	9.5	7.6	3	76	97	87	91	86
Propachlor	3.9	103	16.7	9.8	3.4	0	26	97	47	66	58
Aziprotryne	1.8	95	19.9	9.9	6.3	16	28	91	89	59	98
"	3.6	78	24.4	8.3	8.4	53	79	99	100	95	100
Propachlor + Nitrofen	2.6 1.8	102	17.7	9.9	5.2	0	47	91	63	85	66
Control (handweeded)		100	19.9	10.0	1.5	0	0	0	0	0	0
S.E. of treatment mean			0.4								
Weeds/ft^2 in control plots						1.2	3.5	4.7	3.9	2.2	0.8

[1] Rating scale = Crop : 0 (complete kill) - 10 (no damage)
Weeds : 0 (dense cover of weeds) - 10 (no weeds)

[2] Mean of 3 sites

S.a. = Sinapis arvensis. P.p. = Polygonum persicaria. Sp.a. = Spergula arvensis
Ch.a. = Chenopodium album. V.s. = Veronica spp. S.v. = Senecio vulgaris.

Except for aziprotryne at 3.6 lb, all treatments were highly selective. The double dose of this herbicide reduced plant stand by approximately 20% at all sites, but surviving plants grew very well and produced the highest yields in the trials. The excellent prolonged weed control provided by this treatment contributed largely to this result.

Following aziprotryne at 3.6 lb in effectiveness was the combination of trifluralin at 1.0 lb pre-sowing + propachlor at 3.9 lb pre-emergence. This treatment gave good control of all the weed species which occurred except Sinapis arvensis. Aziprotryne at 1.8 lb also gave satisfactory control but was not as effective against Polygonum spp.or Veronica spp. as the previous combination. Least effective treatments were propachlor at 3.9 lb and trifluralin at 1.0 lb.

Drilled cauliflower, green broccoli and cabbage - 1970 The tolerance of drilled cauliflower, green broccoli (calabrese) and cabbage to pre-emergence application of seven herbicides was examined in a trial at Kinsealy. Treatments were applied four days after sowing under moist soil conditions in late June. Crops were not allowed to mature but the fresh weight of all three was recorded two months after sowing (Table 2).

Table 2

Effect of treatments on crop and weeds - 1970 - Drilled crops

Treatment	Dose lb/ac	Plant wt. as % of standard[1] A	B	C	Plant no's as % of standard[1] A	B	C	Assessments[2] Crop A	Crop B	Crop C	Weeds 26/7	Weeds 19/8	No. of weeds ft[2] V.s.	S.m.	all spp.
Propachlor	3.9	100	100	100	100	100	100	7.8	8.5	8.8	8.5	4.8	7	9	25
Aziprotryne	1.75	74	108	129	86	100	126	7.3	8.0	9.0	8.7	6.3	5	7	18
Haloxydine	0.5	95	102	82	108	98	90	7.7	8.3	8.5	8.0	5.5	4	3	13
"	1.0	83	101	88	102	110	85	7.2	8.3	8.8	8.8	7.3	1	2	10
Alachlor	2.0	103	137	81	112	104	109	9.0	9.0	9.3	5.7	4.0	1	18	31
Dacthal	12.0	152	129	112	125	127	112	8.2	8.8	9.0	8.5	6.2	0	5	11
CP 52223	2.0	115	80	130	117	90	116	8.2	7.7	9.3	8.7	8.2	0	6	14
CP 52665	2.0	130	122	112	132	110	119	8.0	8.3	9.0	8.5	6.8	0	4	8
S.E. as % of gen. mean		35.6	22.6	30.0	18.9	17.2	15.2								

[1]Standard = propachlor [2] Rating scale as in Table 1

A = cauliflower c.v. Dominant B = green broccoli c.v. Coastal. C = cabbage c.v. Wiam
V.s. = *Veronica spp.* S.m. = *Stellaria media*

The main points which emerged from this screening test were that cauliflower was generally more sensitive to herbicides than green broccoli while cabbage was the most tolerant. Dacthal at 12.0 lb, CP 52223 (2 chlor - N - (iso - butoxymethyl) - 2' - 6' acetoxylidide) at 2.0 lb and CP 52665 (2 - chloro - N - iso propoxymethyl) 2' - 6' acetoxylidide) at 2.0 lb were the most promising herbicides for both selectivity and effectiveness. All three gave excellent control of *Veronica* spp. *Lamium purpureum* and *Sonchus oleraceus* and were more effective against *Stellaria media* than propachlor at 3.9 lb which was used as a standard in this trial. Alachlor at 2.0 lb, applied in granular form, although highly selective gave very poor weed control. Aziprotryne at 1.8 lb was safe for application to cabbage but caused severe damage to cauliflower.

Haloxydine caused yellowing in the early stages of growth in all crops and this was particularly severe at a dose of 1.0 lb in cauliflower and cabbage. Plants, however, recovered from this effect after about five weeks. Effective weed control was obtained with this treatment.

Herbicide programmes in drilled cabbage - 1970 Six herbicide programmes were compared in a trial on winter cabbage sown in early July at Kinsealy. Pre-emergence treatments were applied four days after drilling and post-emergence at the 6th leaf stage of the crop, six weeks later.

All programmes were highly selective with no significant damage occurring from either pre- or post-emergence treatments. Two of the most effective programmes were:

(1) Aziprotryne at 1.8 lb applied pre- and post-emergence
(2) Trifluralin at 0.5 lb pre-sowing + propachlor at 3.9 lb pre-emergence + aziprotryne at 1.8 lb post-emergence.

Drilled cabbage - 1971 Five treatments were applied post-emergence at the 8th leaf stage to a winter cabbage crop drilled in mid-June at Kinsealy. Aziprotryne at 1.8 lb was applied pre-emergence to the trial area and gave very successful control. As a result, few weeds were present when the post-emergence treatments were applied.

All treatments gave satisfactory prolonged weed control and there was little difference between them in effectiveness. Differences occurred in selectivity however. A mixture of nitrofen at 2.1 lb + simazine at 0.5 lb caused severe crop damage and vigour remained retarded up to harvesting. Prometryne at 0.5 lb in a mixture with simazine at 0.5 lb caused more initial scorch to the crop than aziprotryne at 1.0 lb or 1.8 lb combination with simazine at 0.5 lb. Aziprotryne at 1.8 lb on its own was particularly safe.

Drilled cabbage and cauliflower - 1972 Trials were carried out at Kinsealy in drilled cabbage and cauliflower to compare dinitramine with trifluralin. Prynachlor and propachlor were also included but the former was applied in error at double the normal dose. Dinitramine was tested both as pre-sowing incorporated and surface pre-emergence treatments and was applied at three doses. Trifluralin and dinitramine were incorporated immediately after application to a depth of 2 in. by rotovator.

The principal weeds in the two trials were *Senecio vulgaris*, *Fumaria officinalis*, *Poa annua* and *Capsella bursa - pastoris*. Treatments and results are given in Table 3.

Table 3

Effect of treatments on drilled cauliflower and cabbage - 1972

Treatment	Dose lb/ac	Cauliflower thinnings No.[1]	Cauliflower thinnings Wt[1]	Cabbage No.[1]	Assessments[2] Crop Caul.	Crop Cabb.	Weeds 18/7	Weeds 18/8	% weed kill S.v.	F.o.	P.a.	C.bp.
Prynachlor	7.8	102	213	97	4	4	4	4	93	52	100	98
Propachlor	3.9	90	164	99	3	2	7	7	79	4	77	38
*Trifluralin	1.0	114	190	119	3	2	6	7	0	87	100	0
*Dinitramine	0.25	94	174	118	4	3	6	8	49	40	92	0
* "	0.5	100	200	96	4	5	5	8	0	53	98	14
* "	1.0	93	143	85	6	7	4	7	36	75	97	54
Dinitramine	0.25	110	211	111	4	2	7	7	10	32	44	38
"	0.5	71	143	75	5	4	6	6	58	78	56	56
"	1.0	32	54	50	7	7	5	7	0	83	55	77
Aziprotryne	1.8	N.a.	N.a.	105	N.a.	2	4	4	99	68	67	85
Trifluralin + Propachlor	1.0	N.a.	N.a.	99	N.a.	3	5	5	75	68	90	89
Control	100	100	100	100	2	2	9	9	0	0	0	0
S.E. as % of gen. mean		19.4	25.6	14.1								
Weeds/ft^2 in control plots									5	4	4	3

* Incorporated pre-sowing. [1] as % of control. [2] E.W.R.C. scale 1 - 9.
N.a. = not applied.
S.v. = *Senecio vulgaris*. F.o. = *Fumaria officinalis*. P.a. = *Poa annua*
C.bp. = *Capsella bursa-pastoris*.

Prynachlor even though applied at the high dose of 7.8 lb/ac showed good selectivity in both cabbage and cauliflower. This treatment also gave excellent prolonged weed control with only F. officinalis showing some resistance.

Severe reduction in stand and vigour occurred with dinitramine at 1.0 lb in both crops particularly with the pre-emergence surface application which was more damaging than the pre-sowing incorporated treatment in cauliflower at 0.5 and 1.0 lb. Both crops recovered well from the initial injury caused by dinitramine at 0.5 lb while at 0.25 lb selectivity was only slightly less than trifluralin at 1.0 lb. Dinitramine was similar to trifluralin in degree and spectrum of weed control but was not as persistant. S. vulgaris was resistant or partially resistant to dinitramine and C. bursa-pastoris was poorly controlled where dinitramine was incorporated. Better control of C. bursa-pastoris was obtained with surface application but the opposite was the case with Poa annua.

Aziprotryne at 1.8 lb gave good weed control in cabbage with no crop damage. Satisfactory prolonged control was also obtained with the trifluralin/propachlor programme. Neither treatment gave complete control of F. officinalis.

Transplanted cabbage and Brussels sprouts - 1970 In 1970 trials were carried out on transplanted cabbage at two sites on medium loam soil in the Mallow area of Co. Cork. Treatments were applied three weeks after planting when the crops which were grown in drills were well established. Some weeds had emerged at time of spraying particularly Polygonum aviculare at Site D which had three true leaves.

Treatments and results are given in Table 4. High crop selectivity was shown by all treatments except simazine at 1.5 lb which caused a slight reduction in crop vigour and yield.

Table 4

Effect of treatments on crop and weeds - transplanted cabbage - 1970

Treatments	Dose lb/ac	Yield tons/ac Site A	Yield tons/ac Site B	Plant Stand as % of control Mean of 2 sites	Assessments[1] Crop Mean of 2 sites	Assessments[1] Weeds Site A	Assessments[1] Weeds Site B	% weed kill Site A P.av.	% weed kill Site A S.m.	% weed kill Site B P.a.	% weed kill Site B all weeds
Aziprotryne	1.75	31.8	26.7	105	9.7	7.3	9.4	31	100	97	93
Simazine	0.5	29.2	24.9	104	9.5	5.6	8.6	28	91	100	92
"	1.0	27.3	24.1	107	9.1	7.5	9.3	54	99	100	95
"	1.5	24.5	21.4	105	8.5	8.1	9.5	34	100	100	96
Simazine + Desmetryne	0.5 0.25	27.5	27.6	106	9.3	8.6	9.4	57	100	100	98
Simazine + Aziprotryne	0.5 1.75	30.9	24.6	105	9.4	8.9	9.6	57	100	100	98
Alachlor	1.5	26.1	21.5	102	9.5	1.0	0.9	5	27	51	37
Control (one handweeding)		25.3	22.6	100	9.5	0.3	0.9	0	0	0	0
S.E. of treatment mean		2.41	1.25								
Weeds/ft[2] in control plots								4	8	11	21

[1] Rating scale as in Table 1

P.av. = Polygonum aviculare. S.m. = Stellaria media. P.a. = Poa annua

Most effective control was given by the mixtures of simazine at 0.5 lb + aziprotryne or desmetryne. Simazine at 1.0 lb, 1.5 lb and aziprotryne at 1.8 lb also gave satisfactory prolonged control but at Site D no treatment provided adequate control of Polygonum aviculare. Alachlor at 1.5 lb applied in granular form was most ineffective against all species.

In the Kinsealy trials, aziprotryne, alachlor and simazine at 1.5 lb were omitted but trifluralin at 1.0 lb as an incorporated pre-planting treatment was included. Compared to the Mallow trial post-planting treatments were applied one week after planting. No damage occurred in either crop with any treatment.

Most effective control was obtained with the mixture of simazine at 0.5 lb + desmetryne at 0.25 lb and simazine at 0.5 and 1.0 lb. Although good initial control was given by desmetryne at 0.25 lb, weeds particularly Senecio vulgaris, Capsella bursa-pastoris and Stellaria media were a problem in desmetryne treated plots towards the end of the season. Similar species were also present where trifluralin at 1.0 lb was applied.

DISCUSSION

The results of this series of trials suggest that season long weed control can be easily achieved in drilled or transplanted cabbage with the range of herbicides now available. At a dose of 1.8 lb, aziprotryne proved very selective and effective either as a pre-emergence or post-emergence treatment. No damage occurred where combined pre- and post-emergence applications of aziprotryne were applied to drilled crops on a medium loam soil. The 1969 trials show, however, that damage can occur if the normal dose is exceeded pre-emergence. Previous experience (Cassidy and Doherty 1968) also indicated that crop stand can be reduced if heavy rain follows application of this herbicide. The susceptibility of cauliflower to aziprotryne was again confirmed. Indeed the greater sensitivity of cauliflower to herbicide injury as compared to cabbage was shown in the 1970 screening tests (Table 2) and highlights the problem of obtaining satisfactory chemical weed control in this crop whether direct drilled or transplanted.

Of the new herbicides tested CP 52223 and CP 52265 showed the highest degree of selectivity in cauliflower and were amongst the most effective as well. Cauliflower was also highly tolerant to dacthal at 12.0 lb and further investigations of this herbicide as a pre-emergence treatment either alone or in combination with other herbicides appear justified.

The combination of trifluralin pre-sowing plus propachlor pre-emergence gave good results in drilled crops. Where a wide weed spectrum which includes Compositae and Polygonaceae species occur this programme would appear to offer the best solution to the weed problem in drilled cauliflower or green broccoli until more selective herbicides, mixtures or combinations are developed.

Dinitramine showed no advantage over trifluralin with which it was compared either as an incorporated or a surface applied treatment. It was less selective than trifluralin at 1.0 lb at the lowest dose (0.25 lb) tested and at this dose was neither as effective or as persistent as trifluralin.

Simazine at doses up to 1.0 lb/ac gave consistently good weed control without crop injury in transplanted crops and as a post-emergence treatment in drilled cabbage on medium loam soils. More effective control was obtained where herbicides with contact action like desmetryne, aziprotryne, or prometryne were mixed with simazine. Using mixtures such as these it is possible to defer application until either transplanted or drilled crops are well established thereby reducing the risk of crop injury which might occur from simazine particularly on light soils.

Acknowledgements

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WILD OATS, WHERE NEXT?

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Wild oat is the most difficult and intractable weed problem that has faced our agriculture during the past two decades. Indeed it is the only weed that has seriously threatened our cereal system which is the corner stone of our arable agriculture. If to this is added that the problem is getting worse and that there appears to be no complete solution in sight, we have indeed a serious situation, but not, I hasten to add, one that cannot be improved. How it can be improved is very much an object of this paper.

Wild oat is surprisingly a weed about which there is an over abundance of published data. The Information Section at WRO has more than 1000 published references to *Avena* spp., yet even so, there are gaps in our knowledge. How to come to terms with such a mass of facts is in itself a problem: WRO assisted by the Home Grown Cereals Authority has initiated a new and comprehensive review of this literature. In the meantime the knowledge that so much information exists, yet control of the weed is imperfect can only add to the irritation and frustration felt by the farming community at the present time.

In this paper an attempt will be made to clarify the issues, to raise questions that ought to be discussed, to bring in a sense of realism about wild oat. I will indicate ways in which existing control measures could be modified and made more acceptable. Perhaps some will not agree with my suggestions: so be it, at least I will have stimulated thought - and this is what is needed now.

An MCPA for wild oats?

There is one issue that needs to be dismissed because it clouds our thinking and is an excuse for inactivity. Many farmers and some technologists hope for an MCPA for wild oats, that is to say a reliable, cheap (£1 per ac. or less) new herbicide that will give 100% control. I cannot see such a new herbicide in the future. To-day's complexities and costs of development mean to-day's prices as can be seen with benzoylprop-ethyl at £4.75 ac and tri-allate granules at £4.50. These costs in relation to cereal prices imply specific and purposeful use rather than regular overall application. We should remember that MCPA cost £1 to £1.50 per acre in 1953 (Holmes 1953). Allowing for the decline in the value of money this cost would be £2.50 - £3.70 to-day. Cheap control is more likely to come from better use of the materials already available. There is one reservation to this view, EEC prices for wheat at say £40 a ton could make the current herbicide prices look relatively cheap, but other costs will rise so the margin for weed control may not widen for long.

The background to the problem

Let us now turn to the increasing problem of the wild oat as it is in British Agriculture to-day. The survey evidence supports the view that the number of seriously infested fields in traditional wild oat areas is increasing, and that new infestations are appearing in areas previously considered free of the weed (Thurston

1954, Elliott et al 1968 and Phillipson et al 1972). The evidence of all this has been plain to see this past summer and has been frequently commented on in the press. What has created these trends?

The growth regulator herbicides of the 1950s and 1960s gave freedom from broad-leaved weeds in cereals. Thus liberated from a major need to rotate, farmers increased their acreages of cereals so as to reap the benefits of large scale mechanization, and the repeated growing of barley and wheat became commonplace. The widespread attitude to weed control became one wholly dependent on herbicides used almost on impulse and without thought as to long term trends in weed populations. It was true that grass-killing chemicals came available but the frequency of their use and their general performance did not match that of the broad-leaved chemicals: the result has been a progressive increase in grass weeds - couch (Agropyron repens), wild oat (Avena spp.) blackgrass (Alopecurus myosuroides) and rough-stalked meadow grass (Poa trivialis). Of these, wild oat has proved the most dangerous undoubtedly because it lacks the inherent biological weaknesses that help to limit the aggressiveness of the others in the cereal situation.

While providing an explanation for the build-up of wild oat on particular farms, repeated cereal growing cannot be blamed for the widespread movement of the weed into new areas. The key to this is provided by two pieces of information which have indicated the extent to which wild oat seed has been moving around Britain in cereal seed and straw (Elliott and Attwood 1970, Wilson 1970). If the results of the seed drill survey are averaged it can be calculated that the farmers of England and Wales sowed that Spring some 42 seeds for every acre of barley, and this has probably been occurring annually. The annual movement of straw off farms is in excess of 400,000 tons or 24 m bales, even if only a quarter of them contain the average figure of 100 seeds per bale a vast amount of seed is involved.

Table 1

Number of cereal samples collected and proportion contaminated by wild oat seed

Country	Samples: No. obtained	Samples: Proportion contaminated %
England and Wales	378	19
Scotland	122	16
Northern Ireland	120	3
United Kingdom	620	

from Elliott J. G. and Attwood P J. Tech. Rep. No. 16, ARC Weed Res. Org.

So the seed was spread and the infestations increased. Chemical industry provided two remedies in the early 1960s, barban and tri-allate. Surveys have shown that a disappointingly low proportion of infested fields have received these chemicals (Elliott et al 1968) and (Phillipson 1972). It is therefore relevant to consider their attributes in relation to wild oat control in cereals.

Table 2

Wild oat seed recovered from straw bales

Crop	Weight bale lb	Seeds recovered	Seeds per ton of straw
Oxford winter barley	46	19,360)	
	38	8,800)	680,000
	31	6,800)	
Boxworth winter barley	35	1,190)	
	34	1,250)	63,500
	31	400)	
Boxworth spring barley	47	248)	
	40	156)	960
	12	26)	

from Wilson B. J. 1970 Proc. 10th Br. Weed Control Conf. 831

Attributes of the herbicides

Tri-allate emulsifiable concentrate.

1. Because it has to be applied before the weed is visible its use calls for prior planning.
2. Special care in preparing the seedbed and incorporating the chemical quickly is necessary for maximum performance.
3. Surviving plants form normal panicles so tri-allate can be followed by hand roguing.
4. At £3.60/ac its cost is sufficient to call for specific rather than general use.

All these points make tri-allate (emulsifiable concentrate) a chemical for the farmer who has a planned system of wild oat control or eradication or one who expects heavy infestations. The granular formulation qualifies for the same comment but with the added flexibility that it can be broadcast after sowing and requires no incorporation, a considerable benefit when a large area is to be treated. The granule works as well as the emulsion in autumn but costs more.

Barban.

1. As it is applied when the wild oats have 1-2½ leaves, prior planning is unnecessary.
2. Barban's performance is dependent on crop competition after spraying in continuing the suppression of wild oat.
3. Because the stem length of surviving wild oats may be reduced by barban, roguing is difficult to carry out efficiently after its use.
4. Barban is most effective on a population of wild oats that has compact emergence. It works better on spring cereals than on those sown in the autumn because in the the latter the emergence of the weed occurs over a long period.

Put together, these attributes make barban a chemical for the farmer who does not have a planned system or whose infestations tend to be light or unexpected, and this is a situation more common with spring barley growers than with the specialist growers of winter wheat. It is a chemical for the farmer who is living with wild oat rather than eradicating it and in this context the price is relatively attractive.

Both tri-allate and barban require care in their application and even under ideal conditions they do not give 100% control. In practice farmers can encounter difficulty in meeting the exacting requirements in their application and the result is a less than optimal control. The two new materials chlorfenprop-methyl and benzoylprop-ethyl are used post-emergence. The former on barley or wheat at 2-4 leaf stage and the latter on wheat when the wild oats are tillering. These herbicides substantially extend the range of control situations, as do metoxuron and chlortoluron which can have a useful effect on wild oat although they are primarily blackgrass herbicides. There is insufficient experience as yet to comment on the general performance of these new materials. However it is possible to comment that our judgement of the performance of all the herbicides is not based on the most important criterion - their effect on seed production.

The importance of seed

A major weakness of the current use of herbicides and most cultural control measures is that they are judged on their short term performance when they ought to be judged on their effect on the wild oat population in the long term. The key to such an understanding lies with wild oat seed; its production, its movement, its dormancy and decay in the soil. It is the seed in the soil that provides the continuity of an infestation from year to year, it accounts for the rise and decline of populations and must therefore be the central target of control measures.

A failing of our present approach to wild oat control is that it studies plants and panicles and not the seed in the soil, yet the former are but a manifestation of the current season's germination of a mainly dormant population in the soil. Many research reports and most commercial literature and farmers judge wild oat control on the numbers of panicles seen in July: yet at that moment of time the panicles themselves are irrelevant; the seed they carry and will shed is what is important. Most wild oat plants manage to produce a panicle, but panicles vary enormously in the seed that they carry and shed (Bate et al 1970). We must lead farmers' eyes away from panicles so that they will concentrate on the seed.

If inflow of seed into the soil is greater than outflow then a wild oat infestation will build up: if the reverse is true it will decline. At best, decline is a slow process because there is at present no artificial way of breaking the dormancy of seed in the soil, so it is necessary to wait for natural germination or death. Because we have no means of stimulating seed outflow, all control systems depend on limiting inflow. Here is an important point to fasten on to: everything in a control programme whether it is biological, cultural or herbicidal, has to be seen in terms of its effects on seed inflow. Because the peak of germination occurs 2 - 3 years after shedding, herbicides take this length of time to show their full consequences. In wild oat control patience is a virtue. In another publication I have described my concept of the inflow and outflow of wild oat seed in soil, and the factors that contribute to both (Elliott 1972). My colleague, Mr. Cussans is constructing a computer model of the seed cycle.

Fig. 1

WILD OAT SEED CYCLE

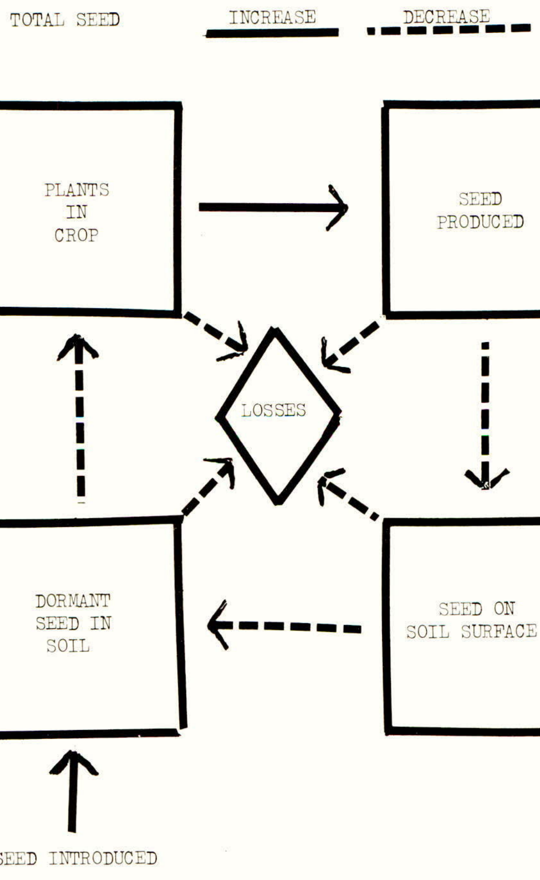


Table 3

Effect of barley population on production of wild oat panicles and seeds

Barley		Wild oat		
Seed rate lb/ac	Row width in.	Panicles/plant	Seeds/panicle	Seeds/yd^2
84	4	1.06	53.8	1706
84	8	1.19	91.0	3342
168	4	1.00	30.5	915
168	8	1.00	50.0	1500

from Bate P. G., Elliott J. G. and Wilson B. J. 1970 Proc. 10 Br. Weed Control Co 825-830.

The central issue in a control system is the inflow/outflow balance of seeds The design of a system whether it be eradication or containment can only come fro a knowledge of component effects on seed production, dormancy and death. In respect of these there are some major inadequacies in our current knowledge.

1. A study of experiments relating seed shed to plant emergence shows that the former can often be numbered in thousands/yd^2 but the latter usually occur in cereals in hundreds/yd^2. Natural causes bring a 90% reduction during the see to seedling phase of the weed's cycle. Oughtn't we to be studying this very closely in an attempt to turn 90% into 95% or 99%?

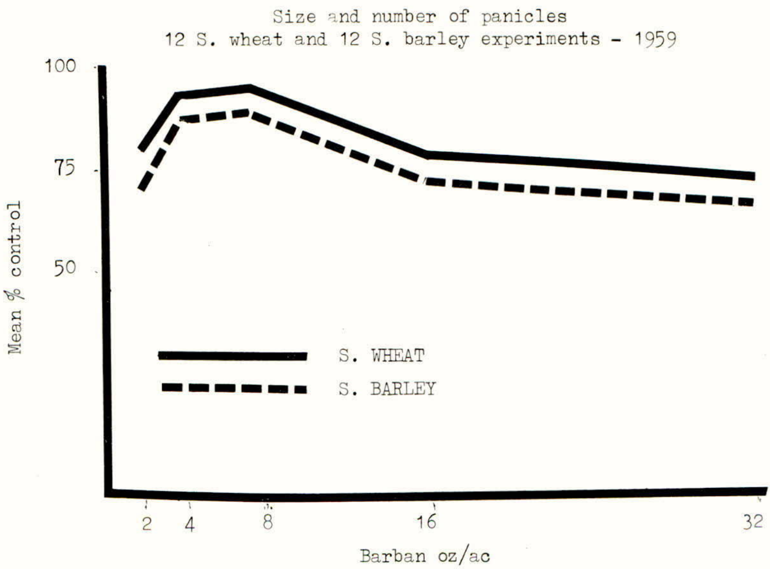
2. A difficulty in developing more effective control is our inability to encoura seed outflow by death or germination, dormancy being the main barrier. There is much interest in chemical dormancy breakers, let us hope that an effective one will be found. In the meantime more effort could be devoted to studying other influences on dormancy such as stubble burning which, according to many farmers, causes a beneficial reduction in dormancy. It has been recorded tha immature seeds tend not to be so dormant as mature seeds. One of the effects of the herbicides barban and benzoylprop-ethyl is that surviving plants are much delayed in growth and the seeds may be immature. Oughtn't we to know mu more about dormancy in relation to immaturity, and how to cause the latter?

3. We could benefit by translating our attitudes to Agropyron repens couch contr into the wild oat situation. Couch control is based on the numbers of plants the following year. Apart from the role of a herbicide in suppressing competition, its performance on wild oat ought to be judged in terms of plant - 3 years later, this would compound its performance in suppressing plants, reducing seed formation and lessening dormancy. We have a long way to go to establish what our herbicides are really doing beyond the obvious counting of panicles in the current crop.

4. Are we adequately knowledgeable about A. fatua's performance when germinating in autumn cereals which are now being sown earlier than used to be the case. this situation we need to know more about the effect on wild oat of winter temperature in relation to stage of growth, and whether competition between weed and crop is occurring during the early winter; how successful are spring germinating wild oats in an autumn cereal in terms of seed production?

Fig 2

Wild oat control by barban



Factors affecting the selectivity of Barban for the control of Avena fatua in wheat and barley. R. K. Pfeiffer, C. Baker and H. M. Holmes 1960. Proc. 5th Br. Weed Control Conf. 297.

Table 4

Wild oat spikelet production in relation to date of emergence

Spring Barley. Sown 3 March 1960

Wild oat emergence:	No. Plants	Spikelets/plant	Total spikelets
before 1st April	42	22.6	950
1 - 7 April	126	8.5	1072
after 7th April	27	3.4	93

Winter Wheat. Sown Autumn 1960

Wild oat emergence:			
before 25 Jan.	30	41.0	1230
after 25 Jan.	169	2.3	397

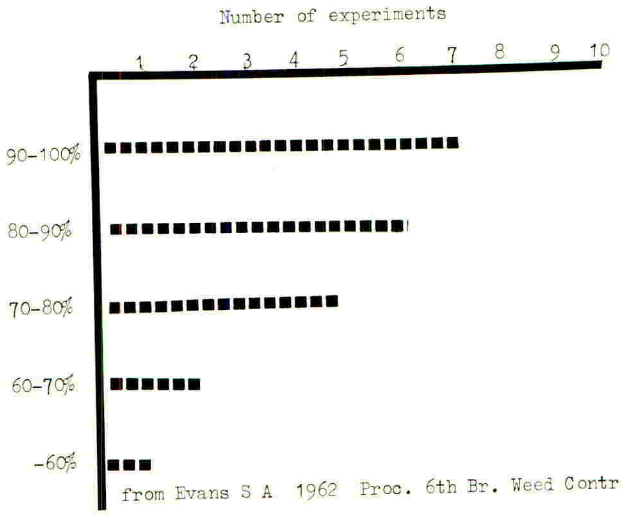
From: Pfeiffer R. K., Baker C and Holmes H. M. 1960. 5th Br. Weed Control Conf. 441.
Holmes H. M. and Pfeiffer R. K. 1962. Weed Res 2, 112.

5. May I sum up the whole herbicide situation by saying that up to now we have seen them as weapons for reducing panicle numbers and increasing crop yield and are only just beginning to consider them in relation to each other and to the rest of crop husbandry as components of systems for reducing seed formation. A study of published information about barban indicates that this herbicide has on many occasions achieved good cereal yield increases at rates well below 5 oz/ac which is the recommended dosage (Pfeiffer et al 1960). There is also evidence that the early emerging wild oats provide most competition and form most seed (Pfeiffer et al 1960, Holmes and Pfeiffer 1962). As an alternative to the present recommendation for spring barley and wheat could we not offer the farmer an approach that is both simple and cheap; "if wild oats emerge with the crop, apply barban at 3 oz/ac when the crop is at the 2 leaf stage". The literature reveals similar possibilities in respect of di-allate and tri-allate. Their performance on wild oat is intimately related to the fineness of the seedbed and the efficiency with which the chemical is incorporated in to the soil: providing these two requirements are achieved the response to increased dose between $\frac{3}{4}$ and $1\frac{1}{2}$ lb/ac in terms of wild oat control is relatively small (Holroyd 1962). If the two requirements are not achieved, increased dose of chemical does not wholly compensate. The literature also indicates that these chemicals control a proportion of the wild oats, and the proportion varies according to circumstances. An 80% reduction of a population of 10 wild oats/yd^2 results in many less surviving plants than a similar reduction of a population of 100 wild oats/yd^2. Are we right to recommend the same dose for light soils and light infestations as for heavy soils and heavy infestations? Could we not do quite well in some circumstances with 1 lb/ac instead of the recommended $1\frac{1}{2}$ lb/ac (Evans 1962). I am not suggesting that we should throw away our existing recommendations. But these approaches merit further research in the context of the farmer who requires cheap but not necessarily maximum performance from a herbicide.

Fig. 3

Control of wild oat

by 1 lb/ac di-allate in 21 experiments



from Evans S A 1962 Proc. 6th Br. Weed Control Conf 297

6. Our ignorance of the economic consequences of wild oat and of the finer justifications for expenditure on control have reduced farmers' willingness to accept herbicides and use them. There is a need for more quantitative information on the economic consequences of wild oat.

The major programme of research on wild oats at the Weed Research Organization, at Experimental Husbandry Farms and elsewhere contains many experiments designed to fill gaps in knowledge relating to the subjects I have just mentioned. Indeed this session and others at this Conference contain new and important information. Nevertheless the gaps are real and they are going to require major effort to fill them.

A systematic approach to control

Although we are ignorant of some aspects of wild oat we know enough to construct sensible systems for the variety of situations that farmers encounter. Where knowledge is inadequate, the systems should be flexible enough to be modified in the light of new knowledge. The first need is to classify the very diverse situations which call for radically different approaches.

The farm is free of the weed and the farmer wishes it to stay that way

Here is a clear cut situation in which the first essential is to prevent the ingress of seed on to the farm from outside. The farmer should create a 'hygiene barrier' round his land taking particular care over imported cereal seed, feed grain, straw, machinery etc. Everything that comes onto the farm should be viewed with suspicion. But however well a farmer strives for this perfection he is unlikely to achieve it wholly. So a further requirement is a regular and painstaking inspection of all arable crops and particularly cereal crops in July - with the intention of finding wild oats if they are there. If any are seen that field should be rogued systematically using hand removal or the chemical glove. The object is to stop the formation and shedding of wild oat seed on the farm which would, in a few years, turn an initial presence of a few plants into patches of dense infestation and thereby eventually contaminate the whole farm.

There are farmers who have operated such a policy over many years and with success. Our experience at Begbroke Hill has been less encouraging. All the cereal crops have been rogued during the past 5 years but the counts of wild oat plants have increased: in 1973 the farm will receive its first commercial application of a herbicide. However a research station on to which the weed is imported and planted should not be regarded as typical.

Table 5

Begbroke Hill Farm - Roguing of wild oat

Year	Acres	Plants	Time hours
1969	80	4,310	70
1970	77	9,145	90
1971	85	13,220	85
1972	72	34,905	114

The weed has entered the farm and is beginning to establish

The farmer has failed to have a hygiene policy and now faces the escallation of the present centres of infestation leading eventually to the contamination of the whole farm and a substantial expenditure on herbicides. The first important requirement is that the farmer should abandon his complacency in favour of an acute awareness of wild oat and the danger it poses. His attitude should not be one of helplessness but of energy and confidence because there is much that he can do. It is very much in his own interest that he act quickly.

The weed problem is at two levels. Most of the land may be either free of wild oats or contain so few that they are roguable. In respect of this land the farmer ought to institute the hygiene precautions described in the previous situation but with the added caution that materials and equipment moving round a farm can spread seeds. It is important to isolate the areas of low infestation from those of high. The areas of high contamination call for herbicide treatment since they are beyond roguing. If seedbed conditions permit, tri-allate may be the choice of herbicide because surviving wild oat plants have normal panicles and these may be removed as the roguing gang moves through the field. As it is impossible in the case of tri-allate to define the area of a wild oat infestation at the time of spraying, application to the correct area necessitates mapping or marking the previous July when the panicles are obvious.

Since herbicide treatment is incurred on a 'per acre' basis and is more expensive than hand-roguing which is paid by the hour, it is economically sensible to use a herbicide on the areas of high infestation however small and then rogue the whole acreage. During the years when the weed is establishing on a farm the areas of high infestation can amount to surprisingly few acres. Whatever else happens no more seed must shed on this farm.

Eradication on a contaminated farm

This is the most difficult situation in which to give practical suggestions. The requirements are clear, that no more wild oat seed shall be brought on to the farm, and that no more seed shall be produced on the farm. But the fulfilment of such a policy over the 7 or 8 years necessary to allow a run down of seed in the soil may be so costly as to deter all but the brave or those who can see a specific financial incentive such as cereal seed production.

The basic question is financial: whether to spend substantially from the start on herbicides plus hand roguing in the expectation that the expenditure can be limited to roguing only after 4 or 5 years, or to pursue a more modest policy at the start based on herbicides alone which gradually reduce the seed population over a longer period of years. The total expenditure will probably be the same in each approach.

Since none of the herbicides guarantee to prevent seed formation entirely, an eradication policy cannot be fulfilled without hand roguing, and wherever roguing is intended tri-allate should be the choice of herbicide. There is now one possible exception to this rule: in the case of autumn wheat which is treated with tri-allate (liquid or granule) it would be possible to apply benzoylprop-ethyl in the spring, the double application should virtually prevent seed formation but at a cost.

The main source of information about the repeated use of herbicides on wild oat in Britain is from experiments carried out by the Agricultural Development and Advisory Service (ADAS) at Boxworth (Selman 1970). These show the cosequence of using tri-allate to wear down or contain a population. There is however no published information involving measures used to the point of eradication. Our knowledge and therefore our ability to advise the farmer intent on eradication is severely limited.

The farmer who lives with wild oat

I suspect that this group contains the majority of farmers currently suffering from the weed. What does living with wild oat entail? First of all the annual growth of wild oat must be limited either in numbers or vigour to a level at which competition is negligible or at least minor so that the crop may develop its full potential yield. Thereafter mass formation of seed should be prevented. While routine precautions are desirable to prevent mass entry of wild oat seed, it is unnecessary to prevent all seed entry on to or around the farm because the soil may already contain millions of wild oat seeds per acre. There would appear little point in paying extra for cereal seed guaranteed free of wild oat; a good standard of merchant's cleaning should be adequate.

The important question for this type of farmer is what his herbicide policy should be. Broadly he can choose one of two approaches: either to spray the worst infestations as they occur or to treat a proportion of the cereal acreage each year in rotation. The first approach necessitates a post-emergence herbicide such as barban, benzoylprop-ethyl or chlorfenprop-methyl; while the second approach can embrace any of the herbicides. The farmer who lives with wild oats accepts a charge for for herbicides as an overhead on every acre of cereals in perpetuity, so he is bound to be very interested in chemical costs.

The current herbicide recommendations appear quite inadequate for the needs of this type of farmer. He should have a long term policy of ensuring that seed inflow remains lower than outflow. If we assume seed outflow to be fairly regular over a 5 year period, it is necessary to ensure that seed formation in any one year does not rise above the average permissible level; and this should be achieved at the lowest possible cost. Thus knowledge of seed formation in relation to herbicide cost is crucial. At present we do not know what can be regarded as a permissible level in particular circumstances and we don't know how cheaply the farmer can keep below it.

The need for a new R and D approach

Although the wild oat situation is serious, there is a great deal that we collectively as an R & D Service can and ought to do. To sum up:

1. Farmers have different needs of wild oat control. Let these be defined and classified so that each can get the help he wants rather than the present generalised recommendations.

2. It is necessary to take a long view based on the balance of seed inflow and outflow to and from the soil. To do this we should not judge the whole situation on the basis of the panicles to be seen in July.

3. Preventive hygiene is important in avoiding new infestations, it merits more attention than it's getting.

4. We have been too narrow in devising ways of using the herbicides available to us, we should adjust the recommendation to the situation.

5. Most cereal farmers have some form of alternate cropping and are prepared to vary their cultural practices; control systems should take account of what straw burning, cultivation and rotation can do to help.

These objectives will not be achieved by organizations and companies taking a parochial view; what is needed is a national collaborative effort. It is encouraging to see ADAS fostering such an undertaking in the advisory field in 1973.

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BLACKGRASS (*Alopecurus myosuroides* Huds.) AND ITS CONTROL

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Interest in blackgrass (*Alopecurus myosuroides* Huds.) has increased greatly in Europe and in Britain since the more spectacular broad-leaved weeds have been successfully controlled. About 30 papers on biology of blackgrass have been written since 1960, but our knowledge of the weed is still incomplete, and some statements in the literature are contradictory. However, some of the points to be considered in planning control-measures already emerge clearly, and are confirmed by independent investigations.

Although blackgrass and wild oats are both annual grasses and often occur together, they differ in some important biological characteristics so we cannot assume that control measures appropriate to one will also suppress the other, although sometimes this is so.

Appearance (Information additional to that usually found in Floras).

Autumn-germinated *Alopecurus* seedlings with adequate space to grow produce many tillers in a flat rosette, but spring-germinated seedlings may have fewer tillers and a more upright habit (Naylor 1972c). Different inbred populations may differ genetically in vigour and habit (Naylor 1972c) but frequently the progeny of differing populations will each display a range of variations, sometimes the opposite of the characteristics of the parents (Thurston 1970). Presumably this is because *Alopecurus* is normally cross-pollinated (Beddows 1931), and the genetical variation may ensure adaptability of the species to a wide range of agricultural situations, but it makes growth studies requiring uniform plants very difficult, and their results inapplicable to a variable field population.

The name blackgrass derives from the dark colour often shown by ripening ears and stems, contrasting with the cereal crop which is still green in early July. The colour is a cyanidine-glycoside formed when more carbohydrate is synthesized than can be assimilated, or when starch is being broken down during ripening. Sensitivity to colour formation may be partly hereditary but is mainly environmental (Willems 1971).

After the first-formed ears are ripe, side-branches may arise from above-ground nodes (Fruwith 1908) and branching may continue to the production of second and third order side-shoots (Menck 1968). These side-shoots frequently produce ears and in a lodged cereal crop they may emerge from the tangle of straw to produce ripe seeds, even if the first-formed ears lie on the ground and rot (Thurston unpublished).

Blackgrass seeds are similar in size to those of herbage grasses and can be spread in them, but they also occur in cereal seed stocks (Tonkin 1968).

Occurrence

Alopecurus myosuroides is found in Britain, Europe, the Mediterranean, Western Asia and India where it is said to be native, and has been introduced to Denmark, Sweden, Norway (in ballast at ports), North America from California to the Atlantic Coast, New Zealand and China. It is absent from Finland, the Faroes, Ireland, Greenland and S. Africa. The north-western limit in Europe may be determined by low summer temperatures. In Britain it is found mainly where the July mean temperature is over 15°C and annual rainfall below 1020 mm (Naylor 1972c). Within the area bounded by the rivers Trent, Severn and Exe, in which cereal-growing predominates, blackgrass occurs chiefly on heavy soils. It is seldom if ever found wild, and is mainly associated with man's activities i.e. in arable or waste land, in open or disturbed habitats (Naylor 1972c). The association of Alopecurus with heavy, poorly-drained soils and frequency of winter crops especially cereals is also noted in France (de Gournay 1963), Belgium (Stryckers and Delputte 1965, Willems 1971) and Germany (Fruwith 1908, Rademacher 1959, and Menck 1968). Both germination and plant growth are better in soils with a larger proportion of fine particles (Thurston 1966, 1967).

Germination

As with most annual weeds, periodicity of germination, causes and duration of seed dormancy, and the factors affecting them, are of paramount importance in successful control of blackgrass and have been much studied. It is generally agreed that seeds are dormant when they are shed and that there are two peaks of germination in the field, one in autumn and the other in spring (e.g. Rademacher 1959, de Gournay 1963, Thurston 1964, Stryckers and Delputte 1965, Willems 1971). The relative importance of these peaks can vary from year to year with changing weather conditions (Koch and Rademacher 1966), and autumn drought (Willems 1971, Thurston 1971) or an abnormally wet autumn (Thurston 1964) delaying germination until the following spring. Obviously this will affect control by any soil-applied herbicide, e.g. terbutryne, metoxuron, put on in autumn and not persisting until the spring peak of germination. A mixture of simazine and metoxuron may help to overcome this difficulty (Ayres et al 1972). Equally, a post-emergence herbicide applied in spring and only active against young seedlings, e.g. barban, will give inadequate control of autumn-germinated plants which have continued to grow throughout a relatively mild winter such as we experienced in England in 1971-72. This is less likely to happen in parts of Europe with a more severe winter, and may account for the failure in England of some herbicides successfully developed on the Continent.

The autumn and spring flushes of germination vary in time with the prevailing weather-conditions, and the periods within which they occur also vary slightly between countries, e.g. England, September to November (Wellington and Hitchings 1965) usually late October (Thurston 1964), France, September to December (de Gournay 1963), Belgium, mid-October to early November (Stryckers and Delputte 1965). Spring peaks are generally in March or April, although they may be in April or May in Belgium (Stryckers and Delputte 1965).

In Germany, the date of autumn cultivation affects germination-time, and the recommendation is cultivation in early October followed by sowing 4 to 7 weeks later i.e. in November (Rademacher 1959). This agrees well with control of black-grass obtained at Rothamsted by sowing winter wheat after Nov. 8th (Thurston 1964) and observations on germination following soil-disturbance in pots (Thurston 1966).

Laboratory studies show that there are two distinct types of dormancy involved - one innate and operating when the seeds are shed, the other induced in response to external conditions (Brenchley and Warington 1930, Lewis 1961, Thurston 1964, Wellington and Hitchings 1966).

Innate dormancy can disappear in about two or three months' dry storage after harvest, but conditions during ripening and during storage greatly affect the speed with which it is lost, and this probably accounts for contradictions in the literature. Wellington and Hitchings (1966) found that most seeds lost their dormancy in two months' dry storage, whereas Menck (1968) found that seeds retained their dormancy for $1\frac{1}{2}$ to 2 years when stored dry in the laboratory. He found that dormancy was broken by removing the husks, by stratification in damp soil or activated carbon at about 20°C, or in atmospheres of nitrogen or helium. Light also helped to overcome dormancy, and even a single flash of 1/1000 second allowed some seeds to germinate. Dormancy of dry seeds broke most quickly at 30°C but prolonged storage at this temperature and at -10°C was detrimental. De-husking helped to overcome sensitivity to temperature. Swedan (1970) showed that seeds ripened at 30°C lost their dormancy more quickly than those ripened at 20°C, and seeds ripened at 10°C were even slower to start to germinate. Germination was greater in his tests at 20°C than at 15°C or 10°C, especially after treatment with thiourea, but Barralis (1969) got optimum germination at 15°C. Fluctuating temperatures stimulated germination in an uncontrolled glasshouse and at 10/20°C or 20/30°C alternation in the laboratory (Warington 1936, Menck 1968, Willems 1971). Light made some dormant seeds germinate but scarcely affected speed of germination of non-dormant seeds (Menck 1968, Barralis 1969, Swedan 1970). Consequently, sensitivity to light was mainly in the first six months after shedding. Individual seeds differed in light-requirement (Wellington and Hitchings 1965), possibly because they were at different stages in losing their primary dormancy. Light-sensitivity must be important in determining germination or otherwise of seeds on the surface of the soil or buried at different depths. No-one seems to have examined the effect of giving light as a pre-treatment while imbibed seeds are held at an unsuitable temperature for germination, and subsequently transferring them to a suitable temperature and humidity but in the dark. Light pre-treatment of dry seeds is unlikely to be effective, as seeds stored in clear glass bottles in the laboratory still require light during germination testing.

Experiments on temperature in dry storage are not of direct relevance to field germination, as blackgrass soils are normally moist. Seeds germinated best in peat and worst in sand, when both were kept moist, and germination in loam was between the two (Swedan 1970). Dormancy disappeared more quickly when seeds were stored 10 cm deep in soil (i.e. in cool moist conditions) than in warm dry storage. The optimum moisture-content of eight soils for germination was between 30% and 60% saturation, with a higher optimum where the clay and silt fraction was greater (Menck 1968). Barralis (1965) obtained maximum germination in soils at about field capacity. The few seeds which retained their dormancy after two months' dry storage soon lost it in damp storage at 15-20°C but secondary dormancy was induced in damp soil at 0-5°C. This disappeared when the soil temperature rose to 15°C in summer (Wellington and Hitchings 1966). Periodicity of germination in the field may be influenced by soil temperature, but there is also some evidence for endogenous rhythms of germinability, even in seeds stored dry in the laboratory (Menck 1968).

Alopecurus can start to germinate at oxygen tensions as low as 0.5% to 1.5% and 70 to 80% of the seeds will germinate at 4 to 5% oxygen, although germination increases as the oxygen content rises from 10 to 15% at all three carbon dioxide concentrations tested (3, 5 and 8%) (Koch 1968b). Koch cannot decide which is the more important, CO_2 or O_2, as under a soil crust in the field oxygen content seldom falls below 15% and carbon dioxide content seldom exceeds 10%, and blackgrass germination within these limits is not greatly affected. Ability to germinate at low oxygen tensions must be a prerequisite for growth in wet soil, but immersion in water prevents germination (Lewis 1961, Thurston 1964).

Some of the experiments on soaking seeds in solutions of various chemicals are of more theoretical than practical interest at present. Blackgrass seeds are little affected by 1N H_2SO_4 for up to 24 h, 1N HCl is only slightly detrimental, and even 10N H_2SO_4 has comparatively little effect in the first 24 hours, though only a few survive 48 h and all are killed in 72 h (Swedan 1970). This acid-resistance suggests that seeds might survive being eaten by animals, provided that they were not chewed up, but Alopecurus does not figure in existing lists of viable seeds found in dung or bird-droppings. Pre-soaking seeds in urea or thiourea solutions stimulates germination of freshly-harvested seeds and is even more effective when they are six months old. There is a slight additional benefit from cutting the seed-coats in freshly-harvested seeds, and in urea-treated seeds at six months old, but germination of seeds at six months old, treated with thiourea, is already 90% so there is little scope for further improvement by cutting the coats. Pre-soaking in water without added chemicals is detrimental to subsequent germination, even in light, but cutting the seed-coat almost overcomes the disadvantage of 24 h pre-soaking (Swedan 1970). Evidently the seed-coat is the site of several dormancy-breaking processes. Removal of lemmas is far more effective than soaking in gibberellin (Koch 1968a, Swedan 1970) but the effects are sometimes additive.

With so many internal and external factors affecting dormancy the exact germination-period of blackgrass in any season is bound to be difficult to predict.

Viability persists long after innate dormancy has been broken. Seeds may remain viable for 11 years in soil and 13 years in dry storage, but viability starts to decline sooner in moist soil than in dry storage. After four years in moist soil only 87% germinated, compared with 97% after eight years and 91% after 12 years dry storage (Koch 1968c). Barralis (1970) maintained viability in dry storage for seven years, then it began to fall and was only 25% at nine years. In shallow moist clay soil in a glasshouse, cultivated at six-week intervals, only about 1% of seeds retain their viability into the third year from shedding (Thurston 1964). Depth of burying can affect survival, seeds at 9 in. retaining their vitality longer than those at 7 in. or 5 in. (Ling and Price 1930). Probably about 2/3 of the seedlings appearing in a field are from seeds less than one year old (Naylor 1972b) but the few seeds which survive longer may be the source of renewed infestation in later years.

Depth of sowing also affects percentage seedling-emergence, and this in turn depends on temperature. Emergence decreases with depth of burying, but 0.5% came up from seeds buried at 12 cm, more of them at 17°C than at temperatures above or below this (Barralis 1968). In the same French experiment, 33% emerged from unburied seeds, and 11% from seeds buried at 2.5 cm. Corresponding figures from an English experiment were 27% from unburied seeds, 18% from 2.5 cm and 0.3% from 10 cm (Thurston 1968). Thus in considering the depth to which soil-acting herbicides must be incorporated for effective control of blackgrass, we must remember the few seedlings which may emerge from considerable depths, as well as the 90% from the top inch of soil (Naylor 1970). In a soil-inversion experiment Naylor (1972b) claimed some seedling emergence from 17.5 cm.

Although the seedlings start with their seminal roots at the depth at which the seed was buried, the mesocotyl elongates and the adventitious roots (which soon take over from the seminal roots) are formed near the surface (Naylor 1972c) even in plants from deeply-buried seeds. This will affect uptake of herbicides applied to the soil surface.

The seedlings stop growing when the temperature falls below about 5°C (de Gournay 1963) but can withstand temperatures down to -8°C at the one to two leaf stage and -25°C when tillered (Barralis 1970), appearing frozen at the time and starting to grow again when the weather becomes warmer. Willems (1971) found seedlings killed by -10°C or under prolonged snow, but de Gournay (1963) claims that emerging seedlings are killed only at about -15°C. Ground temperatures in England seldom fall so low.

Growth and Development of plants, and seed-production

Plants from the earliest-germinated seeds in autumn may form well-tillered flat rosettes before the winter. Those emerging in November may not tiller until January, and plants from early spring germination, having avoided the worst of the winter weather may grow heavier than November plants (Thurston 1968, 1969a), but are taller with fewer tillers than October plants. Seasonal variations in weather affect both time of germination and subsequent growth, and after the abnormally dry and mild autumn of 1969 the largest plants at harvest in 1970 in winter wheat were from the December germination (Thurston 1971). Menck (1968) states that low temperatures are necessary to initiate the reproductive phase, but the plants grown in a cool glasshouse in England flower satisfactorily at any time of year, when the temperature is high enough for the culms to elongate, i.e. with the maximum temperature above 10°C and minimum above 5°C. Flowering is induced in spring and autumn but not in the long days and high temperatures of summer. After induction, flowering does not occur in late autumn and winter because low temperatures prevent stem elongation (Wellington and Hitchings 1966). Thus although blackgrass flowers from May to July in the field, it cannot truly be called a long-day plant. Flowering specimens have been seen in sugar-beet fields in November.

As the plants vary so much in size according to conditions, it is impossible to give a useful figure for the average number of seeds per plant. The range is from one ear with five to ten seeds to over 200 ears and probably 20,000 seeds (Stryckers and Delputte 1965, Thurston 1967, Menck 1968). The mean number of ears per plant decreased from 4 to 2.5 as the population per unit area increased from 30 to 500 plants/m^2 in an experiment in winter wheat (Guillemenet 1972).

Seldom more than 70% of the spikelets of Alopecurus contain viable seeds (Naylor 1972b, Thurston 1964). Seeds from spring-germinated plants are frequently of lower viability than from autumn-germinated ones in the same field, because of the high incidence of ergot (Claviceps purpurea), and on plots with high fertility the per cent viability may be increased by infection with the twist fungus (Dilophospora alopecuri) (Moore 1970).

Many seeds ripen and shed before winter wheat is ready for combine-harvesting. The later harvest-date compared with binder-harvesting is thought by Petzold(1959) to be responsible for some increase in infestation. He found that only 25% of the seeds were shed when wheat would have been ready for cutting with a binder, but by combining-date 68% had actually shed. However, this makes no allowance for further development in the stooks and subsequent shedding in the field during carting. In the Paris basin, 70% are shed before wheat is harvested (de Gournay 1963).

Dormancy persists longer in seeds ripened in damp conditions than in those from drier situations (Menck 1968, Barralis 1970, Willems 1971), and seeds ripened at lower temperatures retain their dormancy longer than those ripened at 30°C (Swedan 1970) - possibly the same phenomenon stated differently. This may be partly responsible for the association of blackgrass with cool wet conditions.

Competition with crops

Thus far we have considered the weed alone - but it seldom grows in isolation, and in weed control we are concerned with it in the context of crop-competition. Because of its periodicity of germination it is most often associated with winter-sown crops, and in England these are mainly cereals, although in the NAAS/Rothamsted survey one-third of the samples came from spring-sown crops. Fruwith (1908) in Germany found that Alopecurus made least growth in winter rye and most in winter wheat and spelt among cereals, but light stands of winter rape and winter beet allowed the weed to grow even bigger. The same was true more recently of cereals in France (de Gournay 1963), where Alopecurus plants formed 10 times as many seeds per plant in winter barley as in winter rye, with winter wheat intermediate, and in Belgium (Stryckers and Delputte 1965) where Alopecurus developed 3,625 seeds per plant in winter barley and only 363 in winter rye. Herbage seed grasses also differ greatly in competitive effect depending on their earliness of development, and density of stand. Planting in widely-spaced rows also allows blackgrass to become well-established before it meets competition from the crop (Budd and Shildrick 1968). Obviously the crop itself can be a valuable ally in control of blackgrass, but if it is not very competitive, the blackgrass flourishes unchecked. Gaps in the crop, due to faulty drillings (especially missed rows) or to attack by pests such as wheat bulb fly (Leptohylemyia coarctata), also provide opportunities for it to grow large (Thurston 1969b), which it usually takes.

Conversely, blackgrass can seriously decrease crop yield (Guillemenet 1972); losses of 50% are not unusual (Stryckers and Delputte 1965, Griffiths and Ummel 1970). The biggest per cent yield-increases occur where the yield of unweeded plots is least (North and Livinston 1970), e.g. the 50% increase recorded by Griffiths and Ummel (1970) was on 20 cwt/ac (10 cwt) but on an infested crop which yielded 41 cwt/ac the increase was only 15% (6 cwt). The return from expenditure on herbicide was thus greater on the poor crop than on the good one, but the poor crop was still not increased to a profitable one.

In an experiment Naylor (1972a) found that crop yield was unaffected by the presence of less than 10 blackgrass plants per yd^2, but as the density of blackgrass increased the crop yield fell; 30, 100 and 300 plants per yd^2 decreased the crop yield by 13, 32 and 37% respectively. The 5% loss in yield as the infestation increased by 200% (from 100 to 300 plants per yd^2) shows that at that density the blackgrass plants must have been competing with each other. Many French farmers plough up cereal crops infested with more than 300 Alopecurus plants per m^2 (de Gournay 1963).

Crop grasses competed more strongly with blackgrass plants than did additional blackgrass plants (Budd and Shildrick 1968). This can also be demonstrated for wheat (Thurston 1973 in press). In a pot experiment with 8 plants per pot of Alopecurus, or wheat alone, or 4 plants of each, the mean dry weight per plant of tops and seeds averaged over six fertilizer treatments was 4.2g for Alopecurus competing with Alopecurus, 3.8 g for Alopecurus competing with wheat, 8.5 for wheat competing with Alopecurus and 6.1 for wheat competing with wheat. But the environment in which the plants are growing will affect the balance of competition, if one species reacts more than the other to one or more of the factors concerned. Thus the use of fertilizers might be expected to affect the outcome of competition between crop and weed. In winter wheat on the famous Broadbalk field at Rothamsted, wheat appeared to respond to increasing amounts of nitrogen (as ammonium sulphate) more than did blackgrass, but the blackgrass seemed more responsive to a mixture of phosphate and potash than the wheat (Thurston 1969b).

In a series of pot-experiments (Thurston 1971, 1972, 1973) in Rothamsted clay-with-flints (pH 5.8, 0.190%N, 13.3 mgK/100g and 0.78gP/100g air-dry-soil) 232 ppm K as KCl was slightly harmful to Alopecurus. This low K-requirement may be one reason why blackgrass invades wheat on K-deficient soils (Thurston 1969b). The dry weight of young plants was almost doubled by giving 232 ppm P, and at that stage adding 174 ppm N (treatment N4) was detrimental, but as tillering progressed the response to N became positive. By September the effect of added P on dry weight had disappeared and added N increased dry weight fourfold. However the retardation of early growth due to P-deficiency was still visible, the no-P plants remaining green and continuing to grow after the +P plants had ripened.

Naylor (1972c) got increased growth with added N and K but not with P, although his plants were the same age as those of the first harvest of the Rothamsted pots. However his pot-size, fertilizers and concentrations were different and he used a loam/peat/sand compost of unspecified chemical analysis. His plants were grown at a minimum temperature of 15°C and with 16 h days of supplemented daylight i.e. warmer nights and longer days than Alopecurus seedlings would experience in the field (Naylor, personal communication) and attained up to 10 times the dry weight of the cooler-grown plants in the same 6 weeks. They were probably sufficiently advanced to show the N-response found in older plants at Rothamsted. Obviously, growing-conditions affect fertilizer-responses.

The 1972 Rothamsted pot-experiment compared the growth of 8 wheat plants or 4 wheat and 4 Alopecurus with 8 Alopecurus plants per pot in the same fertilizer-treatments. Wheat alone responded like blackgrass alone to levels of P and N. However, when the two were competing, wheat usually grew larger and blackgrass smaller than when grown alone. In April, shortage of P and toxicity of N partly obscured this result, but by September only P0 N4 showed the reverse, wheat alone weighing 7.0 g/plant and wheat with Alopecurus only 6.5 g, whereas Alopecurus with wheat weighed 7.0 g and alone only 5.0 g. This may have been connected with the larger % increase in wheat than in Alopecurus from added P at 174 ppm N when growing alone. The Broadbalk comparison of response of wheat and Alopecurus to N and PK unfortunately does not include a high N no PK treatment.

Pests and diseases

As already noted, blackgrass seed-set can be affected by two fungi, twist and ergot. The first is specific to blackgrass but strains of ergot attack cereals and other grasses; according to de Gournay (1963) infected blackgrass in France may be a reservoir for rye ergot. In England, the ergot found on blackgrass is suspected of being the same strain as that attacking wheat, because the wheat in which the infested blackgrass occurs is often also affected (Moore 1970). Cross-inoculation experiments to determine whether wheat and blackgrass ergot strains are capable of infecting each other's host plant should start soon. If they are, then infected blackgrass in spring beans grown as a break-crop may not only carry ergot across the break to the next wheat-crop but actually increase it faster than it would multiply in wheat. Ears with 13 or 14 ergots projecting from them have been found in spring beans recently introduced as one of the break-crops on part of Broadbalk (Thurston 1970) whereas infected winter wheat on that field seldom if ever has more than one ergot per ear, and very few ears are attacked. Other fungi reported on blackgrass and also affecting cultivated cereals are take-all (Ophiobolus, now called Gaeumannomyces graminus), choke (Epichloe typhina), Mastigosporium album and two rusts, Puccinia graminis and P. coronata (Naylor 1972c). Eyespot (Cercosporella herpotrichoides) has also been reported on blackgrass in Europe (Stryckers and Delputte 1965, Ponchet 1959 quoted in de Gournay 1963). In glasshouse experiments mildew (Erysiphe graminis) can be very troublesome on blackgrass.

Blackgrass is a host of two cereal aphids, Macrosiphon granarum and Aphis avenae, and also of the gall-midge Contarinia merceri. A most unusual instance of Alopecurus seeds sprouting in the ear was associated with the presence of gall-midge larvae. (Holroyd and Thurston, unpublished). Presumably the larvae had broken the innate dormancy of the seeds by biting through the seed-coats.

The ability to transmit and multiply crop pests and pathogens is an added reason for controlling blackgrass.

Some points to consider in planning control of blackgrass

Blackgrass favours moist soils, especially clays, but can grow on lighter soils with impeded drainage. Waterlogging restricts farmers to growing winter cereals which themselves favour blackgrass because it normally germinates mainly in autumn. Can drainage be improved?

Blackgrass infestation is worse where cereals are grown frequently, so could cereals be grown less frequently? If not, is it possible to grow more spring-sown crops, allowing destruction of autumn-germinated plants during pre-sowing cultivations? If so, is the blackgrass in them infested by ergot, which may attack subsequent cereal crops? If winter cereals must be grown, could sowing be delayed until early November so most of the autumn seedlings could be destroyed before drilling, without losing more yield from late sowing than from leaving all the blackgrass to compete with the crop?

Although most blackgrass seedlings germinate in their first year, a few survive longer, so one year's control is not enough to eliminate it. And although most seedlings arise from seeds in the top 1 in. of soil, a few may emerge from seeds buried 4 or 5 in. deep and seeds buried 9 in. deep remain viable longer than those nearer the surface, so if possible avoid burying seeds deeply.

The numbers of seedlings emerging in autumn and spring vary unpredictably according to the weather from one year to another. Plants which have been growing all winter may be too well-established to be controlled by spring treatment, and some autumn-applied herbicides lack sufficient residual activity to control spring seedlings, so look for a herbicide which will control both autumn- and spring-germinating blackgrass. The range of chemicals for blackgrass control has greatly increased recently but some are unsafe on some newer cereal varieties, so keep up-to-date and consider crop-tolerance, even if this means planting a resistant variety on a field which requires spraying.

Blackgrass can decrease cereal yields by 50%, especially in low-yielding crops, so it is probably economic to apply herbicide. If the infestation is severe and the herbicide efficient; yield might be increased by 6-10 cwt/ac.

Blackgrass seeds occur in many samples of cereal seeds and even more in herbage seeds, so make sure that blackgrass is not being sown, infesting clean fields or defeating control of existing infestations.

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THE SELECTIVITY OF POST-EMERGENCE HERBICIDES FOR AVENA FATUA CONTROL IN SPRING WHEAT AND BARLEY

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Summary Because of the increasing importance of *Avena fatua* in Ireland trials were undertaken to determine the effect of five herbicides on varieties of spring wheat and barley.

Wheat, cv. Atle and 8 varieties of barley proved tolerant of barban, chlorfenprop methyl and metoxuron applied at rates expected to control *A. fatua*. Barley cv. Emma, Herta, Hunter and Nessa and wheat cv. Atle and Quern proved susceptible to barban when used at double the recommended rate.

INTRODUCTION

Wild oats *Avena fatua* has become noticeably more abundant in Ireland in recent years. It is now of serious consequence in some important cereal growing counties. It is known that there are differences in varietal reaction to barban, (Pfeiffer, Baker and Holmes 1960). Most of the varieties grown in Ireland were bred at a time when *A. fatua* was uncommon and barban was not in use. It was necessary therefore to determine the reaction of these varieties to barban and other herbicides for the control of wild oats.

MATERIALS AND METHODS

Ten trials were laid down on spring sown barley or wheat during the period 1970-1972. All sites except number 7 were free of *A. fatua* and only four required treatment for infestations of broad-leaved weeds (Table 1).

Table 1

Details of trial sites

Site number	Crop	Variety	Date of sowing	Date of experimental treatment	Additional herbicides
1	Wheat	Quern	11 Mar. 1970	30 Apr.	None
2	Wheat	Atle	19 Mar. 1970	15 May	None
	Barley	various	25 Mar. 1970	8 May	None
3	Barley	Hunter	20 Mar. 1970	8 May	None
4	Barley	Hunter	20 Mar. 1970	11 May	None
5	Barley	Hunter	2 Apr. 1970	12 May	None
6	Barley	Hunter	28 Apr. 1970	13 May	dichlorprop, mecoprop
7	Barley	Emma	24 Mar. 1971	13 May	bromoxynil ioxynil
8	Barley	Banba	23 Mar. 1971	4 May	MCPA, dicamba & mecoprop
9	Barley	Deba Abed	7 Apr. 1971	24 May	None
10	Barley	various	20 Mar. 1972	2 May	dichlorprop

A randomised plot design was used with sprayed plots between 55 m^2 and 104 m^2 in area. A minimum area of 45 m^2 was harvested. Treatments were usually replicated four times but there were five replicates at site 9, three at sites 8 and 10 and only two replicates were harvested at site 5. Treatments were applied with an AZO propane knapsack sprayer with cone nozzles.

Barban was applied at 225 l/ha of spray solution, other herbicides in 340 l/ha. Volume rate was altered by adjusting walking speed. A spraying pressure of 3.0 kg/cm^2 with the appropriate Birchmeier Helico Sapphire-nozzles produced a fine spray. At site 2 in 1970 and site 10 in 1972 single areas of several varieties were sown side by side and a separate trial was carried out on each variety.

Plots were harvested with a farm combine and yields were converted to 14% moisture. Nitrogen content and 1,000 corn weight were measured and germination capacity was tested after a suitable interval.

The chemicals used and their formulations are listed below. All doses are expressed as kg/ha a.i.

Barban - Emulsifiable concentrate 12.5% w/v a.i.
Chlortoluron - Wettable powder 80% a.i.
Chlorfenprop methyl - Emulsifiable concentrate 53.5% w/v a.i.
Metoxuron - Wettable powder 80% a.i.

RESULTS

Effect on yield

The results of two experiments in which three herbicides were compared on a number of varieties of barley and wheat are given in Table 2.

Table 2

Effect of herbicides on yield of barley and wheat

Yield as a percentage of the appropriate untreated plots

	Chlorfenprop methyl	Metoxuron	Barban	Barban	Barban
Rate kg/ha	3.80	4.50	0.37	0.39	0.70
Site numbers	10	10	10	2	2
Banba	104	98	93	-	-
Kristina	108	104	102	-	-
Deba Abed	100	91	103	97	93
Emma	102	108	101	114	72*
Herta	108	103	100	96	86*
Hunter	90	95	95	87	72*
Julia	101	105	93	-	-
Nessa	93	97	94	92	56*
Sultan	-	-	-	117	119
Zephyr	-	-	-	93	94
Atle	-	-	-	92	78*
Quern	-	-	-	80*	56*

*Significantly different from the untreated control at P/0.05

Chlorfenprop methyl and metoxuron at rates normally used for the control of A. fatua had no adverse effect on the yield of eight varieties of barley.

Barban applied at the recommended rate or 10% higher did not reduce the yield of the varieties of barley tested. Barban at twice the recommended rate caused a significant reduction in the yield of Emma, Herta, Hunter and Nessa, but Deba Abed and Zephyr were unaffected.

Yield of wheat, cv. Quern was reduced by both rates of barban; they yield of Atle by the higher rate only.

Table 3

Effect of chlorfenprop methyl on yield of barley and wheat

Crop	Barley					Wheat
Cultivar	Hunter	Hunter	Hunter	Banba	Deba Abed	Quern
Site No.	4	5	6	8	9	1
Range of rates kg/ha	Yield as a percentage of the control					
2.5-3.0	-	97	93	92	97	-
3.8-4.7	105	105	97	100	102	103
5.3-5.8	105	-	-	-	97	116
Control kg/ha	4301	4477	3938	4414	5643	4577
S.E. Treatment mean	±4.1	±7.7	±4.1	±3.4	±2.0	±4.1
LSD P∠0.05	NS	NS	NS	NS	NS	12

Results of other trials with chlorfenprop methyl (Table 3) show that the yield of barley, cv. Hunter, Deba Abed and Banba was unaffected by the highest rates tested (these were 5.8, 5.3 and 3.8 kg/ha respectively). Banba barley on site number 8 was infested with *A. fatua*. Treatment reduced the number of wild oat panicles from $11/m^2$ on the unsprayed to $4/m^2$ on plots treated with 3.8 kg/ha. Yield of weed-free treated wheat, cv. Quern was significantly higher than the untreated control.

Metoxuron was applied to Hunter barley at 3.9 kg/ha and Emma at 5.2 kg/ha without a significant reduction in yield (Table 4). Chlortoluron at 1.5 and 2.9 kg/ha reduced yield of Emma but the difference from the untreated was not statistically significant (Table 4).

Table 4

Effect of metoxuron and chlortoluron on yield of barley

Cultivar		Hunter (site 3)	Hunter (site 6)	Emma (site 7)
Chemical	Rate kg/ha	Yield as percentage of the control		
Chlortoluron	1.5	92	-	-
	2.9	95	-	-
Metoxuron	3.0		94	
	3.9		96	
	4.8		-	99
	5.2		-	98
Control kg/ha		4590	3938	3941
S.E. Treatment mean		±4.3	±4.1	±2.6
LSD P∠ 0.05		NS	NS	NS

Effect on quality

Nitrogen content of barley grain was increased in those varieties where yield was seriously reduced by barban at 0.7 kg/ha. Metoxuron at 4.8 kg/ha raised the nitrogen content of Emma barley above the level on the untreated plots although yield was not affected.

There was no alteration in nitrogen content of grain treated with chlorfenprop methyl at 5.6 kg/ha or with the highest rates of chlortoluron.

Barban at 0.39% kg/ha reduced the 1,000 corn weight of the varieties Emma, Herta, Nessa, Sultan and Zephyr (Table 5). Grain weight of Hunter was not affected by any herbicide.

Table 5

Effect of barban on 1,000 corn weight of barley (at 0% moisture)

Variety	Barban kg/ha			S.E. Treatment mean	LSD $P < 0.05$
	0	0.39	0.7		
Deba Abed	41.5	40.3	41.1	±0.65	NS
Emma	40.9	38.4	38.1	±0.58	1.8
Herta	39.9	38.2	38.2	±0.46	1.5
Hunter	40.9	41.1	39.9	±0.74	NS
Nessa	38.4	37.2	38.0	±0.40	1.2
Sultan	40.7	38.8	38.1	±0.60	1.9
Zephyr	42.1	39.5	39.0	±0.71	2.2

Germination of the variety Hunter was reduced by chlortoluron at both rates, other herbicides did not affect the germination of any variety.

DISCUSSION

The effects of barban on the barley varieties Deba Abed, Hunter, Sultan and Zephyr are in agreement with published information Anon, (1972).

Barban at rates above those recommended caused a yield reduction in Emma, Herta, Hunter and Nessa barley and Atle and Quern wheat. This indicates a risk when barban is used in commercial practice.

Chlorfenprop methyl was used without effect on the yield of seven varieties of barley and of Quern wheat. Good control of *A. fatua* has been obtained at 3.8 kg/ha.

Metoxuron applied 43 days after sowing, appeared safe on the barley varieties Banba, Kristina, Emma, Herta and Julia. There is evidence from a trial not included in this report that application of 4.5 kg/ha 70 days after sowing caused severe yield reduction of barley varieties Deba Abed, Emma, Herta, Hunter, Nessa, Sultan and Zephyr and of Atle and Quern wheat. Thus further experiments are necessary to determine the effect of metoxuron on spring sown varieties.

Acknowledgements

The very competant technical assistance of Messrs. T. O'Donovan and P. Tiernan is gratefully acknowledged. Thanks are due to co-operating farmers and to firms which supplied experimental formulations.

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Proc. 11th Br. Weed Control Conf.(1972)

THE EFFECTS OF APRIL AND JULY APPLICATIONS OF GLYPHOSATE, PARAQUAT AND DALAPON ON OLD PERMANENT PASTURE

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Summary The response of a mixed sward to logarithmic doses of glyphosate, paraquat and dalapon applied in April and July was measured in terms of reductions in general green material and presence of individual sward constituents. The effect of all three herbicides developed more rapidly and were more severe in July than in April. Re-growth tended to be slow following glyphosate and dalapon especially in July, while in contrast the more rapid recovery with respect to paraquat was accentuated in July. All grass species were susceptible to the three chemical applications except *Festuca rubra* which was moderately checked by glyphosate only and *Holcus lanatus* which, in April, was only moderately susceptible. *Agrostis stolonifera* and *Lolium perenne* were moderately resistant to dalapon. On the whole glyphosate and paraquat were more effective in reducing the broadleaved content than was dalapon.

INTRODUCTION

Initial investigations had suggested that glyphosate was promising as a chemical for sward destruction. It was therefore required to evaluate this chemical in terms of the response of a mixed sward to seasonal applications in comparison with other herbicides used for sward destruction.

The object of the experiment was to compare the effects of logarithmic doses of glyphosate, paraquat and dalapon applied in April and July on a mixed sward.

The response of the sward to the treatments applied was measured in terms of the reduction in general green material and presence or absence of the main constituents of the sward following application.

METHOD AND MATERIALS

The experiment was located at Begbroke Hill, Oxon., O S Grid Ref S P 485132. The soil is a poorly drained silt clay loam. The annual rainfall averages 23 in. The pasture is an aged one, containing many grass and broadleaved species and has been grazed mainly by beef cattle.

A fully randomised block design of 3 replicates was used with plots 25.05 m x 4.5 m.

Treatments

Logarithmic doses of glyphosate starting at 3.0 kg a.i./ha, paraquat starting at 2.0 kg a.i./ha, and dalapon starting at 16.0 kg a.e./ha were applied on 12th April and 21st July 1972. On both occasions the chemical was applied in 300 l./ha aqueous spray solution containing 0.1% agral 90 surfactant. The solutions were sprayed at 2 kg/cm^2 pressure through Bray 'O' fan jets fitted to the 4.35 m boom on the Land Rover mounted Chesterford Logarithmic Sprayer.

The conditions at spraying

On 12th April — Sward topped 7 days before spraying. Herbage damp 7.5 cm high. Temperature 11.25°C. Relative humidity 95%. Cloud cover 100%.

Owing to a sprayer malfunction, the application of dalapon on replicate 3 was ruined. Assessment of 2 replicates only of this treatment were therefore made.

On 21st July — Sward grazed by beef cattle until 2 days before spraying. Herbage damp, 5-7.5 cm high. Temperature 17.5°C. Relative humidity 100%. Cloud cover 100%
On neither occasion did rain fall for at least 6 hours after spraying.

Assessments

Four points, 8.35 m apart, were marked along each 25.05 m long spray run. These points indicated the starting dose applied for each chemical and the three subsequent logarithmically reduced half-doses. At each of the four points an area measuring 3.5 m across the width of the spray run by 0.3 m along the length, was chosen for all assessments.

The visible effect of each of the chemicals was measured in terms of scores for the amount of green material present at each dose chosen for assessment compared with unsprayed vegetation. A mean of two independent scores was obtained for each dose per replicate (fig. 1).

An estimation of the species composition of the sward before spraying and the response of those species to application of the various chemical doses was obtained by means of a simple presence or absence assessment. Immediately prior to spraying, a total of fifty 10 cm^2 quadrats were thrown at random over the area to be sprayed and the frequency of each of the main species present within each quadrat was recorded. When visual assessment indicated the commencement of sward re-growth from a particular chemical application the frequency of the individual species was measured using the chosen areas on each spray run, ten 10 cm^2 quadrats were thrown at random over each area and the presence of any species growing therein was recorded (tables 1 and 2).

RESULTS

The development, severity and longevity of the effects of each chemical on general green material in April and July is indicated by the graphs (fig. 1). The response of the main sward constituents to each treatment is shown in table 1 regarding the April application and in table 2 which refers to treatments sprayed in July.

The effect on the sward in general

1. Development

The first visible signs of treatment in April were noted 2 days after spraying with paraquat, after 5 days with glyphosate and after 7 days with dalapon. Following the July application the effects of paraquat were noted 24 hours after spraying. Effects of high and medium doses of glyphosate were visible 3 days after spraying and low doses after 7 days. The dalapon treatment began to show 5 days after spraying.

Effects reached a maximum 3-4 weeks after paraquat application, 5-7 weeks after glyphosate application and 5-6 weeks after dalapon application, when applied in April. Maximum effects following the July applications were reached after 3 days by paraquat 3-5 weeks by glyphosate and 5-6 weeks by dalapon.

Rapid discolouration of green vegetation followed all applications of paraquat while a more gradual chlorosis was effected by dalapon. In April, the visual effect of the glyphosate treatment appeared as a red-coloured chlorosis on treated vegetation. As the effect matured, the herbage acquired the straw-colour similar to vegetation treated with paraquat and dalapon. Vegetation sprayed in July displayed an immediate straw coloured appearance.

2. Severity

An 85% sward kill of foliar parts was achieved by the high dose of paraquat when applied in April, reductions of 70% and 55% being caused by medium and low doses respectively. The high dose of glyphosate reduced green material by 90%, the medium dose providing 70% reduction and the low dose 35% reduction. The sward suffered a 65% kill of aerial parts from dalapon at the high rate, 55% from the medium rate and 15% from the lowest rate applied.

In July, almost total sward destruction was achieved by the high and medium doses of paraquat while the lowest dose effected an 80% top kill. The high dose of glyphosate provided 95% kill, the medium dose 85% and the low dose 50% kill. The highest rate of dalapon applied was only slightly more effective than the medium rate, providing 80% reduction, while the low rate offered a 35% kill of vegetation.

3. Longevity

The maximum effects on the sward caused by the high and medium doses of all treatments were sustained for 2 weeks following April applications. Recovery from medium doses of each chemical was complete after 15 weeks. The sward had almost fully recovered from the high dose of paraquat but 30% and 15% reductions in green material was recorded at this time following similar applications of glyphosate and dalapon respectively. Recovery of the sward from the effects of low chemical doses occurred almost immediately and was complete after 11 weeks with paraquat, and 13 weeks with both glyphosate and dalapon.

In July maximum effect was sustained for 3 days after high, medium and low doses of paraquat. Sward recovery was achieved 8 weeks after the low dose application and 12-14 weeks following the medium rate, whereas effects were still just visible 15 weeks after the high dose application. Maximum effects of high rates of glyphosate and dalapon were visible for 3 and 4 weeks respectively and reductions of 55% green material were recorded even after 15 weeks. Medium rates of both chemicals caused a maximum effect which lasted for 2 weeks, moderate reductions still remaining after 15 weeks. Effects of low doses were retained at a maximum for 1 week, the sward having almost fully recovered after 15 weeks.

The effect on the main individual species

1. Grass species

Festuca rubra was resistant to all treatments except the high dose of glyphosate applied in April to which the species was moderately susceptible.

Holcus lanatus was susceptible to all high chemical doses, in April and July, and also to high and medium doses in July. A moderate resistance to all other treatments was shown.

Agrostis stolonifera frequency was reduced in April and July by high and medium rates of paraquat and glyphosate. Moderate susceptibility was noted following all other applications, when dalapon was less effective except at the high rate applied in July.

Poa trivialis displayed susceptibility to all chemical applications except that of paraquat at medium and low rates sprayed in April.

Lolium perenne showed a moderate resistance to medium and low rates of paraquat and dalapon applied in July but was seriously checked by all other applications.

Alopecurous pratensis which was only present in any great profusion in April was affected by all rates of chemical applied at this time.

Bromus mollis and Poa pratensis, two species present later in the summer were also very susceptible to all treatments applied in July.

2. Broadleaved species

In general, all broadleaved species were effectively controlled by applications of glyphosate and paraquat in April and July. Dalapon was less effective especially on Ranunculus spp. in April and July and Rumex spp. in July

DISCUSSION

The results of the experiment under report show that the effects of each chemical application on the sward were quicker to develop and were more severe in July than in April. On both occasions the effects of paraquat were the first to appear and most rapid in reaching maturity, glyphosate and dalapon being similarly slower. Sward recovery commenced sooner with paraquat, especially in July. A greater longevity of effect was noted following treatment with glyphosate and dalapon, which was increased in July.

Glyphosate was generally more effective than paraquat or dalapon in the reduction of grass species but together with dalapon was less promising in the control of broadleaved species, especially in July.

Reasonable control of the sward constituents was achieved by all treatments, although there were notable exceptions. Only the high dose of glyphosate gave moderate control of F. rubra in April when reduction of H. lanatus was also only partially successful. A stolonifera and L. perenne showed resistance to dalapon applied in July.

The suitability of any herbicide for sward destruction is decided by its ability to control effectively, at an economical dose, all the constituents of a sward for such a period that will ensure the successful establishment of a new crop. In the spring and summer when vegetative growth is prolific, it is essential that any herbicidal treatment is quick to develop and maintain an effective kill of the unwanted sward without the risk of residual effects inhibiting crop germination. Rapid development of effect is not a pre-requisite for an autumn treatment prior to a spring re-seed, however, and the importance of harmful residues is not so acute.

On the evidence of this work paraquat which produced rapid effects, especially in July would appear to be most suited to use in the summer although the rapid re-growth following applications might be regarded as being a disadvantage in its use.

The fact that the effects of both glyphosate and dalapon were slow to develop, moderately sustained and only gradually lost would indicate that the use of both chemicals for sward destruction lies in the autumn.

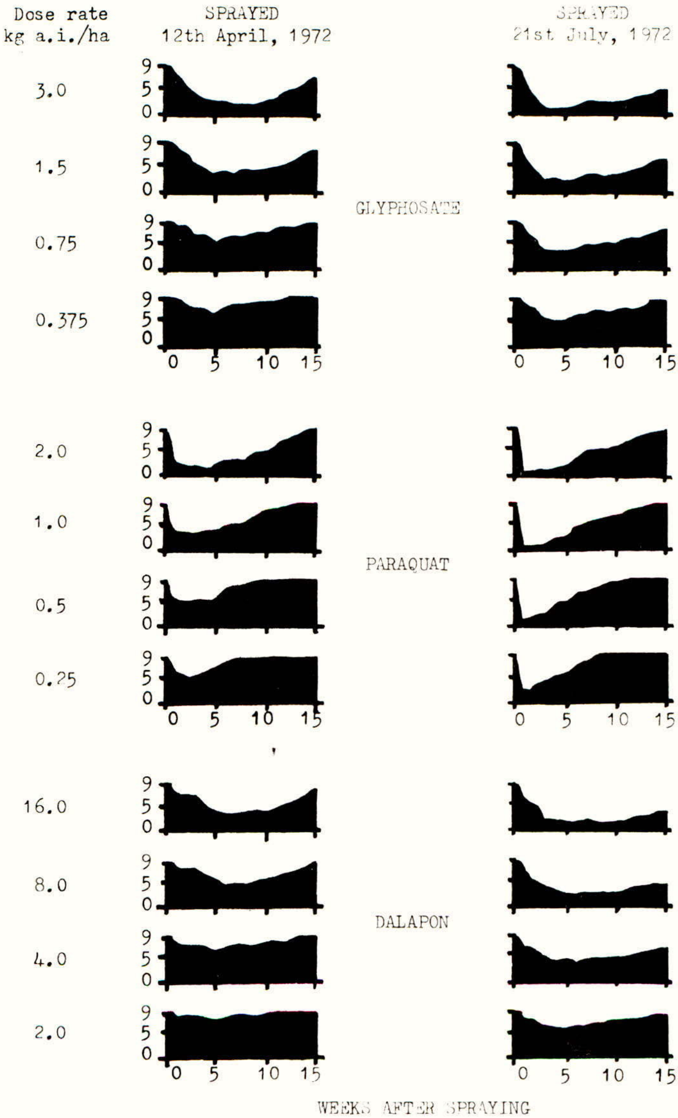
In terms of sward destruction glyphosate compared favourable with its two more traditionally used counterparts as, although total sward kill was not achieved, a satisfactory degree was reached by the highest dose, namely 3.0 kg a.i./ha. It is therefore desirable that the use of glyphosate as an autumn treatment should be seriously considered and more detailed evaluation of its effect at such a time be undertaken.

Adknowledgements

The author wishes to thank Messrs. C M Ellis and P Ayres for their assistance with the field work involved in this investigation, and also to Mr J G Elliott and Dr R J Haggar for helpful comment on the presentation of the results.

Fig. 1

Visual effects after spraying expressed as scores for the amount of green material present



Scored 0 = absence 9 = amount comparable with unsprayed area

TABLE 1

Presence of the main species in the sward before spraying on 12th April 1972, and at the commencement of re-growth from each chemical treatment. Means of 3 replicates.

Main species	Pre-spray presence per 4m²	Presence per metre² at each chemical dose														
		GLYPHOSATE assessed 50 days post-spray					PARAQUAT assessed 21 days post-spray					DALAPON* assessed 50 days post-spray				
		kg.a.i./ha				Total 4m²	kg.a.i./ha				Total 4m²	kg.a.i./ha				Total 4m²
		3.0	1.5	0.75	0.375		2.0	1.0	0.5	0.25		16.0	8.0	4.0	2.0	
Festuca rubra	40	6	8	10	9	33	9	10	10	10	39	9	10	10	9	38
Holcus lanatus	25	TR	3	5	8	16	2	5	7	8	22	2	3	3	6	14
Agrostis stolonifera	29	2	3	4	5	14	1	0	3	5	9	6	4	5	6	21
Poa trivialis	15	TR	0	0	1	1	1	2	4	5	12	1	1	0	1	3
Lolium perenne	13	0	TR	TR	0	TR	1	1	2	4	8	1	1	0	0	2
Alopecurus pratensis	13	1	2	1	2	6	0	1	3	4	8	1	2	5	2	10
TOTAL GRASS SPP.	135	9	16	20	25	70	14	19	29	36	98	20	21	23	24	88
Ranunculus spp.	23	0	0	3	2	5	0	0	0	0	0	3	6	3	4	16
Rumex spp.	5	0	0	1	1	2	0	1	1	1	3	1	1	1	3	6
Trifolium repens	4	1	0	1	3	5	3	1	0	1	5	0	1	1	0	2
Veronica spp.	4	1	TR	0	0	1	0	0	0	1	1	2	2	1	1	6
TOTAL BROADLEAVED SPP.	36	2	TR	5	6	13	3	2	1	3	9	6	10	6	8	30
TOTAL	171	11	16	25	31	83	17	21	30	39	107	26	31	29	32	118

* Means of 2 replicates only

TABLE 2

Presence of the main species in the sward before spraying on 21st July 1972 and at commencement of re-growth from each chemical treatment. Means of 3 replicates.

Main species	Pre-spray presence per $4m^2$	Presence per $metre^2$ at each chemical dose: GLYPHOSATE assessed 35 days post-spray kg.a.i./ha 3.0	1.5	0.75	0.375	Total $4m^2$	PARAQUAT assessed 14 days post-spray kg.a.i./ha 2.0	1.0	0.5	0.25	Total $4m^2$	DALAPON assessed 35 days post-spray kg.a.e./ha 16.0	8.0	4.0	2.0	Total $4m^2$
Festuca rubra	40	7	10	10	10	37	9	10	10	10	39	10	10	10	10	40
Holcus lanatus	32	TR	0	2	4	6	1	2	4	4	11	3	2	5	7	17
Agrostis stolonifera	26	1	1	4	6	12	1	2	2	4	9	1	3	6	7	17
Poa trivialis	14	0	0	1	1	2	1	1	2	1	5	TR	1	1	1	3
Lolium perenne	14	TR	TR	1	2	3	1	3	2	4	10	2	3	3	4	12
Bromus mollis	19	0	TR	1	3	4	0	1	2	2	5	1	2	2	4	9
Poa pratensis	18	0	1	1	1	3	TR	TR	1	0	1	1	2	2	2	7
TOTAL GRASS SPP.	163	8	12	20	27	67	13	19	23	25	80	18	23	29	35	105
Ranunculus spp.	1	2	1	2	1	6	TR	0	0	0	TR	1	2	2	2	7
Rumex spp.	8	1	1	1	2	5	1	TR	1	2	4	2	2	2	2	8
Trifolium repens	9	1	3	1	1	6	2	2	1	2	7	0	1	0	2	3
Veronica spp.	3	0	TR	TR	TR	TR	TR	0	0	TR	TR	1	1	1	1	4
TOTAL BROADLEAVED SPP.	21	4	5	4	4	17	3	2	2	4	11	4	6	5	7	22
TOTAL	184	12	17	24	31	84	16	21	25	29	91	22	29	34	42	127

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THE ROLE OF HERBICIDES IN MODERN FRUIT MANAGEMENT

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THE NEED FOR WEED CONTROL

Weed control is not just a case of making an orchard tidy. Weeds compete for light and nutrients. Some, like nettles and thistles, present a hazard to workers at harvest and at other times, interfering with management procedures. Weeds can encourage pests and diseases and in fact in the early days the chief reason for controlling grass and weeds round the base of the trees was because, as Sewell of East Malling showed, this weedy environment encouraged collar rot, *Phytophthora cactorum* (Sewell, 1956). Work in the USA showed that it also encouraged rodents.

EARLY DEVELOPMENT

Weed control as understood today arrived in the late 1950s; to understand how it was developed anyone interested should refer to the paper by Roach given to the British Weed Control Symposium "Herbicides in British Fruit Growing" (Roach, 1966).

The two chemicals which have probably made the greatest impact are paraquat and simazine. They played their part with the arrival of the spindle bush in Holland and palmettes in France and Italy, allowing the intensification of fruit growing into the rectangular spacings of modern hedgerow systems. Such systems depend on the maintenance of weed free strips down the rows. Machine weeding of these strips was not possible; weeding by hand was too costly and in any case in Britain there had been a rapid reduction in the manpower available to carry out work "brushing" weeds from around the trees.

The two herbicides simazine and paraquat opened up the whole concept of strip weed control, and without herbicides these modern hedgerow systems could not have developed. Herbicide usage is now a corner stone of current orchard management. History is a thing of the past; we can learn by past mistakes so that today we are even considering clean cultivation with total herbicide coverage.

THE PRESENT

I work for a farming group, comprising three companies with about 2500 acres of top fruit. Today's total labour force is 150 men plus 100 women. The women are largely pack house staff who assist outside for short periods. On one farm with 750 acres of fruit, the male labour force in 1960 was 107; today it is 59. If the labour of 1960 were available today the weekly wage bill would be approximately £2140; in fact it is about half. As a result of the adoption of herbicide control, mechanisation etc. the wage bill in 1972 is very similar to that of 1960 when there were nearly twice as many employed. This puts our farming operations in perspective for you. For large fruit growers herbicide management is very important. Weed control is geared to a good commercial control, not a scorched earth policy, but it must be sufficiently effective to give a suppression of weed growth until harvest, because weed problems at this time can slow up picking very considerably. Soils in our group range from the very deep brick earth's to fairly shallow clay with flint over chalk. We are involved with three main tree fruits, apples, pears and plums and some soft fruit; strawberries and black currants. This paper concentrates on weed control in top fruit only. The problems of weed control within any one type of fruit are not similar.

Economics predominate in management today. Formerly management was concerned with the art of growing each variety to perfection. Individual variety needs, spacing, spraying programme, harvesting, were organised to suit the variety. Now management is concerned with the art of the possible. Apples are traditionally grown in a grass sward. Our new attitude to mowing illustrates the emphasis now placed on economic aspects of management. Natural development on our farms has resulted in a number of planting systems. Many different spacings were used and one width of mower cut all these varying widths of alleyways by making one, two or three passes up the row. Considerable time is saved by making only one pass rather than having to go back to cut a part row. Twenty to thirty acres per tractor per day can be cut with complete passes but only half of this if you need to go back for an extra cut. So today we can only afford one pass. We have standardized on our farms to two widths of mower and about three spacings. It is now our policy to buy 6 ft and 9 ft grass cutters on skids so that the grass alleys are either 5 ft 6 ins or 8 ft 6 ins or multiples of this in width. Herbicides are then applied by vibrajets, "T" jets or in the case of granules by some broadcaster over the remainder of the area down the tree rows. In this way tractor plus sprayer can apply herbicides to cover 35-40 acres per day. Thus we tailor the width of sward to the mower by varying the width of the bare herbicide strip along the tree row. In this way herbicides allow us to rationalise other aspects of management like mowing that are more costly in terms of men and machines. We grow to obtain the maximum class one fruit per acre and adapt the machine to suit demands of growing. Standardization of planting distances, the use of certain rootstocks all aid the control of herbicide management policy. Hence we have standardized as follows:- pears on Quince A rootstock are planted at 12 ft x 6 ft; apples on MM 106, 18 ft x 12 ft or 15 ft x 10 ft or if on M IX then 14 ft x 8 ft (see Fig.1).

Modern growers regard herbicides just as much a part of fruit tree management as insecticide and fungicide spraying. Herbicides are now planned in the annual routine spray programme, not applied ad hoc when trouble becomes noticeable. Too often this latter policy resulted in too little too late, or the inability to use the correct material. Perhaps the point should be made early in this paper that weed control is no longer a real problem if the grower knows what he is doing and does not allow any weed, however simple, to gain control. Probably the greatest problem of any fruit farm today results from ignoring the species escaping perhaps from a hedgerow, which finding no competition in the weed free environment quickly spreads across the orchard. An excellent example is hogweed (Heracleum sphondylium).

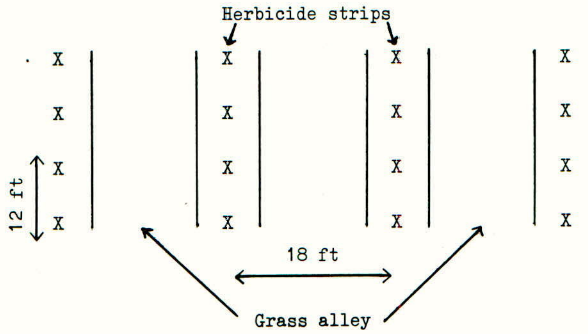
CURRENT HERBICIDE PRACTICE

New plantings

May I first say that all rates of herbicides are quoted in terms of active ingredient. The policy with new planting is to plant into herbicide sprayed land. If, for example, an orchard is to be removed, immediately before grubbing it in the

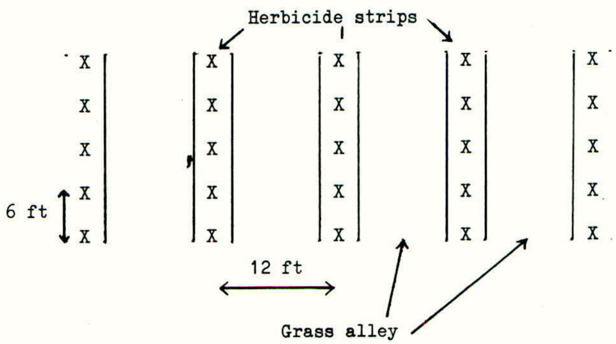
Fig. 1 Grass alley and bare row systems

Cox's Orange Pippin on MM 106 planted 18 ft x 12 ft



Grass alleys 11 ft reducing to 8½ ft

Pears on Quince 'A' planted 12 ft x 6 ft



Grass alleys 8½ ft possibly reducing to total herbicide autumn, aminotriazole (Weedazol T-L at 2-3 gallons (4-6 lb) per acre costing £5.94 - £8.91) is used to kill off all ground vegetation. Similarly, if in the spring there is a good weed cover, aminotriazole could be applied to kill it off. In both cases regular working of the soil should be made once the weeds are dying. In July the soil is ripped to 2 ft 6 ins with three tines pulled by a D8 Crawler tractor. The soil is then cultivated and 30 lb per acre of Westerwolth Ryegrass (14p per lb) is broadcast over the whole area. The land is then marked out in August and September and stakes put in position ready for the trees. About 14-21 days before planting a mixture of 2 pints ($\frac{1}{2}$ lb) paraquat per acre plus 5 lb of urea per acre is applied to a 3-4 ft wide strip down the rows and the trees planted into the stale sward. The following spring it would be normal practice to apply 1 lb a.i./acre of simazine (£1.32/acre) to the tree row area.

Established trees

Apples, pears and plums are treated similarly. We cannot afford variation. They often receive an autumn aminotriazole spray at 4-6 lb/acre down the tree rows. This material has been found especially reliable against invasion of the bare strips by perennial grasses, e.g. couch, *Agropyron repens*, docks, *Rumex* spp. and plantains, *Plantago* spp. Excellent results have been achieved by autumn applications and in my view not nearly enough use has been made of aminotriazole in the autumn by fruit growers.

The choice of material applied in the early spring depends largely on the weeds that were present the previous year. The aim is to time the spray to catch the majority of germinating seeds. However, it is difficult to get a correct timing if the season is early. The main chemicals used are simazine and diuron, and aminotriazole if this was not used in the autumn. The continual use of simazine has led in recent years to knot grass (*Polygonum aviculare*) becoming a serious weed. Diuron (4 lb/acre "Karmex" costing £4.40/acre) has given by far the most effective control. We do not find, as others have suggested, that increasing simazine to 3 lb a.i./acre results in a satisfactory control of *Polygonum aviculare*. In the field of pest, disease and weed control one problem often leads to another and it is interesting that three years' use of diuron has lead to a serious plantain problem, mainly *Plantago major*. This is another reason why we like autumn applications of aminotriazole; it controls plantains. It also emphasises the need to be aware of the weed spectrum controlled by any herbicide. The recent introduction of mixtures of aminotriazole with diuron and simazine have been welcomed. They have considerably reduced costs if only because of the convenience of application by reducing the time taken to weigh and mix. Furthermore some mixtures seem to do much better than their constituent parts individually. The synergistic effects of mixing herbicides or adding other materials calls for a great deal more attention from manufacturers. Results can be quite spectacular, faster and more reliable. New formulations are required to facilitate the preparation of new commercial mixtures.

In the course of the summer, various other materials such as CMPP, MCPA, 2,4-D and mixtures are used as spot treatments to control such weeds as cleavers, *Galium aparine*, thistles, *Carduus* and *Cirsium* spp. and bindweed, *Calystegia sepium* and *Convolvulus arvensis*. These weeds are not now a real problem in our plantations though they always need watching and in a season like 1972 they require more than one spot treatment per year.

SOME HERBICIDE INDUCED PROBLEM WEEDS AND SOIL CONDITIONS

Despite intelligent spray programmes, previously untroublesome plants flourish and develop as new weeds. One or two individuals are easily overlooked and in the weed free strip soon thrive in the absence of competition from others. All farms have difficult species and they change over the years in relation to the herbicides available. Knot grass, *Polygonum* spp. used to be our main problem but diuron takes care of it. Nowadays our three main weeds are hogweed, *Heracleum sphondylium*, mallows, *Lavatera arborea* and *Malva rotundifolia* and hypericum, *Hypericum pulchrum*. These three weeds are probably causing more concern than any others.

Hogweed (*Heracleum sphondylium*)

To emphasise the dangers and to encourage constant vigilance let me say that in the case of hogweed the invasion probably started by the odd seedling establishing in the weed free environment along a row of apples. Over a period of a very few years large patches have appeared. Control of germinating seedlings is effective with the use of aminotriazole but we have found that nothing else has proved of any use on a large scale. On established plants we have tried mixtures of aminotriazole and terbacil at 4 lb + 1 lb/acre, but regeneration occurs. This summer it has been our farm policy to remove all flowering heads as a routine measure and in some plantations plants were cut off and the stumps treated with casuron granules. This is very slow and not always effective. One part-time pensioner was employed for 3 weeks cutting and applying granules to the crowns. This demonstrates just how expensive the manual alternatives to herbicide control have become. Because recurring expenses at this level are unacceptable, we have screened various combinations of weed killers. We are now getting quite outstanding success with 2,4,5-T in diesel oil. We have found 2,4,5-T on its own does not give a complete cure, and diesel only kills if a quantity gets into the crown. It is the combination that is so effective: this is another case of synergism, and I commend manufacturers to consider other possibilities. Of course 2,4,5-T plus diesel oil is a dangerous combination. In the wrong hands it could result in root damage and severe distortion of the shoots, possibly for more than one season. However, the fact that we were prepared to use it does illustrate the degree of the sophistication that characterises the spray programme of large fruit growers. We are by no means unique. Good growers are prepared to accept tisks and take all the care in application that is implied with such materials, spraying accurately and intelligently only under the safest conditions because they know that the alternatives are prohibitively expensive hand labour or weed domination.

Table I gives some results from our trials with 2,4,5-T in diesel oil for the control of hogweed.

All chemicals were applied as a fine spray to completely cover the leaves. The plants were not cut down and in some instances stood about 15 inches from the ground when sprayed.

Table 1

Control of hogweed (Heracleum sphondylium)
2,4,5-T in diesel oil applied 1.8.72

Treatment	4.8.72	8.8.72	15.8.72	1.9.72
Control 1 gallon oil	No effect	Spotting	Some crown death	50% kill
1 gallon oil + 25,000 ppm 2,4,5-T	Wilting and browning	Centres rotted	95% kill	5% left very sick
1 gallon oil + 12,500 ppm 2,4,5-T	Wilting and browning	Wilting crown death	90% kill	95% kill
1 gallon oil + 6250 ppm 2,4,5-T	Some wilting	Plants wilted and leaf browning	Some re-growth 75% kill	95% kill

Mallows (Malva spp. and Lavatera spp.)

Mallows are a relatively new weed to us; now they are established they have become a real nuisance especially the woody species Lavatera. It is a perfect example of a plant which is not normally a nuisance being allowed to increase in the absence of competition from other plants which are controlled by the current herbicide regimes. When this situation arises it is usually because there is something unique or different in the life cycle of the plant. In this case it is the fact that the seeds do not germinate until late, even August. Thus the normal spring sprays do not control it. A Bath University student carried out trials this year and as Table 2 shows one gallon of diesel oil containing 12,500 ppm of 2,4,5-T has killed all plants. The grower must constantly be on his guard against the emergence of new species as weeds.

Table 2

Control of mallow (Malva rotundifolia and Lavatera arborea)
2,4,5-T in diesel oil applied 11.8.72

Treatment	15.8.72	1.9.72
1 gallon oil + 12500 ppm 2,4,5-T	Severe browning and dieback	Complete kill of all plants
1 gallon oil + 25000 ppm 2,4,5-T	Severe browning and dieback	Complete kill of all plants

Hypericum spp.

Hypericum is a woodland escape that has established despite our efforts with a number of chemicals including ammotriazole and paraquat. This year, excellent results have been obtained by Dr J. Davison of the Weed Research Organisation using MON 1139, a new post-emergence herbicide, produced by the Monsanto Chemical

Company. According to reports in Weed Abstracts the weed spectrum of this new herbicide appears to be very wide (Monsanto Europe S.A. 1971). These three examples illustrate how species can develop to become new weeds and how the grower must be constantly vigilant. There are, however, a wide range of weed killers currently available for the fruit grower to try. As with everything else in fruit growing, attention to detail pays handsome dividends. Due to the range of conditions in fruit growing there is an equally large range of potential weeds and since it is unlikely that the manufacturers will test all materials against all species, it is up to fruit growers to try new materials out when particular problems arise. Fruit growers should even be prepared to take calculated risks to control a weed immediately it appears and not allow it to become established so that it is then twice the problem and four times the risk to control.

As a result of maintaining weed-free conditions either in strips or more adventurously overall, some other problems are arising to remind us that herbicides are capable of altering the environment in ways other than killing weeds or changing the dominant flora. Due to maintaining a bare soil surface with paraquat and simazine, we are noting new problems with certain soils, namely surface acidity, nitrate levels and suckering.

Soil surface acidity

A year or two ago this problem arose particularly in young trees of Discovery and Cox's Orange Pippin which produced symptoms of bark measles, a disorder caused by high manganese levels. However, it was not until the receipt this year of ADAS soil sampling results that the full implications of the problem became clear. These samples were taken in the winter of 1970/1971 to give general information of the soils of the farm. (It is a general aim to have land at a pH of 5.9 - 6.0 at planting. A low pH often overcomes the need for treating the land against soil sickness - replant disease). Examination of the pH values of one of the farms, orchard by orchard has shown that the pH in the top 3 inches in the herbicide strip area has fallen at a greater rate than in the grass sward (Table 3).

Table 3

pH of orchard soils assessed July 1972

		Grass sward	Herbicide strip
Orchard A	(Pears)	5.3	4.8
Orchard B	(Apples)	6.1	5.0
Orchard C	(Apples)	5.2	4.4
Orchard D	(Apples)	4.9	4.3
	Mean	5.4	4.6

In modern planting where the tree is contained in a particular zone, quite clearly much of the feeding root lies beneath the herbicide strip in this extremely acid zone. Whether the acidity arises because of natural leaching, or the action of herbicides within the soil cannibalising the calcium I do not know. It has been known for some time that on mineral soils the acidity in the top inch increases after simazine has been applied. The acidity leads to mobility of manganese and thus to manganese toxicity. We have seen manganese toxicity symptoms in such apple varieties as Lord Lambourne and Discovery in their maiden years. Break-down of the tissue then follows and is an entry point for canker (Nectria galligena) or can lead to the complete down-grading of the nursery stock. This problem has arisen on some of our soils, notably the Thanet beds and the brick earths which have a natural tendency towards acidity. It may be more widespread in Kent and in other parts of the country. This problem could be slowly building up and might eventually jeopardise the whole new management methods of growing trees in herbicide-maintained weed-free strips. Elsewhere it poses a big question mark over complete herbicide culture, i.e. the overall application of herbicides to maintain a completely weed-free surface which we practice for pears and which has been advocated by some for apples and plums. In the pears we have noted very low pH readings in the zone from 0 - 3 inches. Further problems are whether soil samples should be taken from the grass or herbicide zones and whether differential rates of lime or fertilizers are called for along these herbicide strips. In modern plantations existing machinery used to spread lime is often unable to get down the alleyways. Fertilizer spreaders are not made to apply rates of 2 tons per acre!

Nitrate levels

It has been shown following some work by ADAS in West Sussex that there can be a marked build up of nitrate in the herbicide treated areas, in some instances to super luxury levels. Over many years this could lead to a reduction in fruit quality and storage capacity. This point illustrates the implications that herbicides have on current fertilizer programmes. At present, fertilizer rates are geared to the needs of trees and the traditional grass and are broadcast over all. No doubt the bare strips should receive a different rate, or combination of fertilizers than the grass alleyways, since the strips lack the effect that grass is known to have on recycling P and K (Wallace, 1953),(Montgomery and Wilkinson, 1962). This problem is under investigation by research workers and by ADAS.

Suckering

A different managerial problem has arisen from the introduction of herbicide control especially in pears and plums in that suckering has increased. Plums have always been a problem but with herbicides it has become much worse. Apples on M II rootstock have always been prome to sucker but more recently apples on M 26 and M IX have tended to sucker and also pears on Quince A. In the absence of a grass sward the tree roots come nearer to the surface and local erosion may expose part of the roots. When quince roots come near the surface, adventitious buds are formed and often grow into suckers. Since we no longer have labour available to go round cutting them off by hand, a chemical means of sucker control is needed. So far, promising work has been carried out by Dr Quinlan at East Malling Research Station, with NAA and long chain fatty acids on apples and plums. The commercial applications of Treehold (NAA ethyl ester) open up another method of dealing with suckers.

As stated previously, weed control is not just a case of making an orchard look tidy. If properly done and care is made in selection, the cost can be as low as £3/sprayed acre/annum using simazine. In established orchards, especially old ones at wide spacings, a choice still exists between chemical and other methods of weed control and it is a matter for management to decide. But with intensification to densities of 600 trees/acre and in the future even higher, weed control by herbicides will be obligatory. Even now planting distances have to take account of the subsequent ease of management. Formerly one chose the ideal distance for the variety, its rootstock and the environment and modified one's management to suit. This change exemplifies once again the importance that has now to be placed on the labour requirement of various methods of management. For convenience of mechanisation, the grass strip down the alley should be measured in terms of grass cutter widths, and as mentioned earlier we are trying to standardise on 6 and 9 ft. We also find that grass cutters running on skids which slide on the clean soil of tree-row strips allow a very high performance per tractor-day, i.e. 20 - 30 acres per day.

THE FUTURE

Formerly, weeds that were allowed to grow unchecked in the summer and throughout harvest became entrenched. Today, most can be controlled by post harvest or autumn sprays, so that passage down the rows in the late summer to spray them is unnecessary. Furthermore better insecticides and more persistent fungicides are reducing the necessity for weekly or fortnightly spraying down the alleys after July when the fruit starts to hang down. The alley closes as the fruit matures bringing down the branches. Hence in the future with further modifications of hedgerow planting and narrower alleyways, the aim of the progressive fruit grower will be to avoid mechanical passage down the rows after July. This aim is baulked at the moment by the need for tractor mowing one or more times per month. However, the continued development at Long Ashton Research Station by Messrs Stott and Morgan of the use of maleic hydrazide with or without 2,4-D to control orchard grasses could provide just the answer we need. Grass mowing may become unnecessary so the passage down the alleys could be avoided altogether from July to harvest. In our trials this year with maleic hydrazide with or without 2,4-D, the most promising results were from applications of the mixture, not necessarily because broad leaved weeds are then controlled but because when mixed these herbicides appear to achieve a much greater and more persistent control of the growth of grass. This is another case of synergism.

Future super-intensive systems of multi-rows, bed systems or the so called Long Ashton meadow orchard will depend on the availability of chemicals for means of effective weed control, possibly from overhead sprinklers. The future of weed control in fruit management will rely on a much greater awareness of what the present chemicals will achieve and the need for careful vigilance of the changing weed spectrum to prevent the hogweeds of this world gaining the upper hand. Finally a quote from a speaker at a conference organised by the Society of Chemical Industry reviewing the use of herbicides in relation to profitability - "Weed control in crops other than cereals is based on the insurance premium policy of using pre-emergence herbicides, so there is a potential market for more post-emergence products. The future of the herbicide market does not appear encouraging for the manufacturer unless there can be further rationalization of production, or users are prepared to pay substantially higher prices for materials only marginally better than those now available".

Speaking for fruit I say we do not want any new, marginally better materials. We are quite happy with the present range. What we want is better packaging or formulation to make far simpler application and better more informative labelling so that we know what the chemical will do. There is a market for post-emergence chemicals but they must completely eradicate weeds that survive the pre-emergence era. We need the development of mixtures that are complementary, or better still, synergistic.

There are no doubt many failings in this survey of the commercial use of herbicides in top fruit. The future is very challenging for the fruit grower. The task becomes more precise with every week. We need to have more precise control of what we can do because the future demand will be for a quality article produced in stable, not fluctuating quantities, to well defined specifications of size, appearance and flavour. We welcome new developments as a challenge to better production.

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THE EFFECT OF ENTRY INTO EEC ON AGRICULTURAL CROPPING SYSTEMS AND PRODUCTS

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Summary The entry of Britain into the EEC and adoption of the Common Agricultural Policy in its present form will change quite radically the relative profitability of the main crop and livestock products produced on British farms. In particular, a substantial boost to the profitability of cereal production is in prospect, given the markedly higher grain prices in EEC. Some commentators have argued that this will lead to a significant change in cropping patterns with the acreage of cereals expanding at the expense of grassland, forage and cash root crops. Recent work at Newcastle, however, suggests that the scope for expansion of UK grain production is rather limited and that relative stability in cropping systems is to be expected.

INTRODUCTION

The main objective of this paper is to consider the effect of adopting the Common Agricultural Policy (CAP) of the European Economic Community (EEC) on the pattern of cropping in Britain and in particular to assess the impact of changes in relative profitability on systems of crop production. In so doing, it focusses attention on so-called "agricultural" crops - cereals, potatoes, sugar beet, field beans, forage - since "horticultural" crops are considered in another paper.

The paper begins with a brief review of the arrangements which exist under the CAP for the main agricultural crops produced on British farms. It then goes on to assess likely changes in the gross profitability of these crops as a prelude to discussing the possible effect of changes in relative profitability on cropping systems. In this latter context, emphasis is placed on empirical results of a study currently in progress in the Agricultural Adjustment Unit; reference is also made to the results of other recent studies.

AGRICULTURAL CROPS AND THE CAP

Most, but not all, agricultural crop products are covered by price and market regulations under the CAP. (There is, for example, no CAP for potatoes and beans). All, however, are subject to community preference, that is to say the liberalization of trade between member states and the erection of common barriers against imports from non-member countries. The main instruments of EEC policy for agricultural crops are summarised in Table 1.(1)

Table 1

EEC Policy Instruments for Major Agricultural Crops

	Wheat	Barley	Oats	Maize	Field Beans	Sugar	Potatoes	Rape
Target price	*	*		*		*		*
Threshold price and variable levy	*	*	*	*		*		
Export restitution	*	*	*	*		*		*
Intervention price	*	*		*		*		*
Tariff					*		*	*
Production quota							*	
Minimum prices							*	

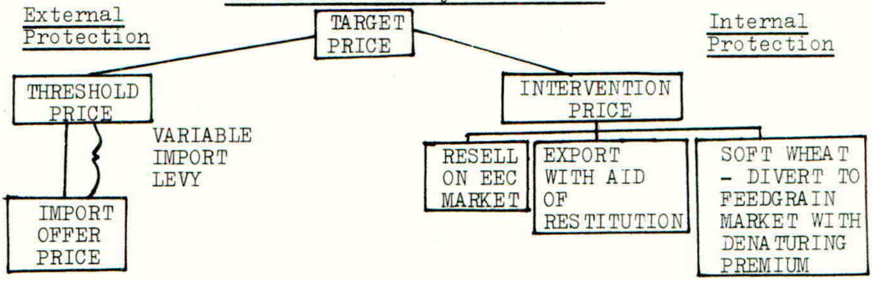
A brief explanation of these terms is appropriate here.

Target prices are the prices, usually at the wholesale level, for which the EEC is aiming through the operation of its various commodity arrangements. It is a price objective rather than a guaranteed price and is supported by import levies, export restitutions and intervention buying. Threshold prices are the lowest prices at which imports from non-member countries can cross EEC frontiers. When the lowest import offer price is less than the threshold price a variable levy, amounting to the difference between the two is charged. Intervention prices are the prices at which EEC authorities undertake to support the market for the commodity in question. Export restitutions are subsidies which allow EEC producers to export at world prices; they are the equivalent of the import levy on the export side.

The inter-relationship of these measures for cereals - the characteristic EEC marketing arrangement - is illustrated in Figure 1.

Figure 1

EEC Market Policy for Cereals



The arrangements for sugar and rape seed are similar, with the exception that sugar production in the EEC is regulated by a system of country, factory and individual farm quotas coupled with minimum ex-farm prices for sugar beet.

CHANGES IN RELATIVE PROFITABILITY

After entry into EEC and adoption of the price levels ruling under CAP, marked changes will occur in both the absolute and relative profitability of agricultural crops. These changes are considered in this section. At the same time, changes in gross margins from land-using livestock must also be taken into account as these also will affect the cropping policy on farms through their demands for forage.

As is well-known, farm prices in EEC are, on average, substantially higher than in the UK (see Table 2).

Table 2

UK and EEC Official Prices for Selected Products, 1972/73

Product	Unit	UK Guaranteed Price	EEC Target Price	EEC Intervention Price
Soft wheat	£ per ton	34.40	47.41	43.65
Barley	"	31.20	43.44	39.88
Oats	"	28.80	-	-
Maize	"	-	42.40	-
Sugar beet	"	8.00	8.80 (a)	-
Potatoes	"	16.55	-	-
Rape seed	"	-	86.9	84.4
Milk	p. per gallon	20.6 (b)	23.0	-
Beef	£ per cwt	13.2	16.51 (c)	-
Sheep	p. per lb. dcw	24.3	-	-

(a) Minimum producer price within quota, including allowance for delivery to factory and free return of wet beet pulp.

(b) Pool price.

(c) Guide price.

Source : Annual Review & Determination of Guarantees 1972, Cmnd. 4928; J. van Lierde. Recent EEC Decisions on Price and Structural Policy. Paper given to AAU Conference. July 1972.

Prices of cereals will rise markedly during the transition period to 1978 as UK prices are aligned to ruling EEC levels. Gross returns to producers of rapeseed will also rise substantially from the 1972 level of around £50 per ton. There will be a smaller increase in ex-farm prices for sugar beet. Little change in maincrop potato prices is expected, assuming continuation of the UK Government's power to decide its policy for potatoes, until such time as a common market organisation for potatoes is introduced, and the natural protection afforded by transport c sts against imports from EEC. Finally, whilst higher feed grain prices and removal of the EEC tariff against UK exports could lead to an increase in demand, and hence higher prices, for field beans, any price increase would be moderated by competition from alternative sources of protein such as oilseeds which have duty free access to EEC markets.

These increases in product prices will be offset, at least in part, by higher variable costs. In particular, the restrictive nature of EEC arrangements governing seed production will probably lead to higher costs of production and hence to higher prices for seed. At the same time, removal of the fertilizer subsidy and general inflation will lead to increased prices for fertilizers, although such increases will be moderated by the effects of excess capacity in the European fertilizer industry and the removal of protection vis-a-vis UK imports from EEC.

But with further improvements in technical performance, as new technology becomes available and as management standards on farms rise, the impact of higher variable costs will be insufficient to wipe out the benefit of higher product prices. Thus gross margins will increase. Forecasts of gross margins per acre made by the AAU for the end of the transition period (1978/79) are given in Table 3; figures for a base year (1969/70) are also shown for comparison.

Table 3

Gross Margins per Unit for Selected Enterprises, 1969/70 with Forecasts for 1978/79

Enterprise	Unit	1969/70	1978/79	1978/79 as % of 1969/70
		£	£	
Spring Barley	Acre	25.9	50.6	195
Spring wheat	"	28.9	53.3	184
Winter wheat	"	35.0	63.5	181
Sugar beet	"	64.9	87.7	135
Maincrop potatoes	"	99.4	123.3	124
Dairy cows :				
(a) Winter milk	Cow	116.3	175.3	151
(b) Summer milk	"	107.9	165.4	153
Beef :				
Suckler herd, autumn calving	Cow	60	91	152
12-month cereal beef	Head	15	4	27
18-month grass/cereal beef	Head	32	58	181
Sheep :				
Fat lamb production	Ewe	10.3	13.2	128

EFFECT ON CROPPING SYSTEMS

Perhaps the most interesting question posed by the figure in Table 3 is how far the substantial improvement in the profitability of cereal production will lead to an expansion in the acreage of cereals grown in the UK. Many commentators have argued that higher grain prices in EEC will give a substantial boost to the UK cereal acreage and this conclusion is supported by the results of recent studies undertaken to examine the impact of EEC entry on British agriculture.

One such study, involving the present author, was undertaken by the Department of Agricultural Economics at Michigan State University for the United States Department of Agriculture.(2) A major conclusion of the MSU study was that the UK cereals acreage would expand by more than 45 per cent between 1969 and 1980, assuming EEC entry (Table 4).

Table 4

UK Crop Acres 1969, with Projections for 1980, Assuming EEC Entry ('000 acres).

	1969	1980
Cereals	9,307	13,652
Crops other than grain and forage	2,349	2,240
Forage crops	551	-
Grassland	18,216	14,037
Rough grazing	17,431	16,344
Total crops and grass, incl. rough grazing	47,854	46,273

Source : Derived from J.N. Ferris et al. The impact on US Agricultural Trade of the Accession of the UK, Ireland, Denmark and Norway to the EEC. Research Report No. 11, Institute of International Agriculture, Michigan State University, 1971.

Only a modest increase of 430 thousand acres was projected for wheat, the bulk of the expansion occuring in the feed-grain sector. To accommodate the larger cereal acreage, contractions in the area of other cash crops, forage crops and particularly grass were projected.

The results of the MSU study probably represent the upper bound of the adjustment that could take place in UK cropping patterns following EEC entry. Other, more recent, studies point to a smaller expansion in the cereal acreage. For example, McFarcuhar and Evans have predicted an increase in the wheat and barley acreage of 5.9 and 4.5 per cent respectively between 1969 and 1975.(3) In a more recent paper, McFarquhar and Hannah have estimated that home supplies of wheat and barley will increase by 26 and 31 per cent respectively over the period 1969 to 1978.(4) More particularly, work currently in progress in the Agricultural Adjustment Unit points to a considerable degree of stability in UK cropping systems over the rest of the 1970s, notwithstanding the substantial changes in relative profitability of different crops that will be occuring.

The AAU work is based on linear programming studies of a set of model farms which represent the main types and sizes of farm found in the UK. A particular advantage of this approach is that programming models take account of the fact that most farms produce many products using many resources and hence are well suited to examining the total impact of changes in relative prices on farm systems. In addition, the method is not so susceptible to the problems which can arise when the policies to be evaluated involve the extrapolation of explanatory variables beyond the range of past experience; this is particularly relevant so far as studying the transition to the CAP is concerned given that it involves substantial changes in absolute and relative prices. Over 40 models have been specified for England and Wales - separate models are being developed for Scotland and Northern Ireland - and results for eight typical farming situations are presented in Table 5.

Table 5

Optimal Cropping Patterns on Eight Representative Farms, 1970 and 1978 (Acres)

Type of Farming	Cereals 1970	Cereals 1978	Cash Roots 1970	Cash Roots 1978	Forage 1970	Forage 1978	Grass 1970	Grass 1978	Total
Predominantly Dairy	12	12	5	5	10	12	55	53	82
Mainly Dairy	178	210	5	7	23	30	166	125	372
Cattle and Sheep	81	81	10	16	-	-	387	381	478
Mainly Cattle	66	65	20	11	1	-	267	278	354
Mainly Sheep	40	41	-	-	1	-	147	147	188
Mixed	15	15	12	11	3	4	48	48	78
Pigs and Poultry	63	63	5	8	5	5	39	36	112
Cereals Cropping	260	266	11	6	-	-	57	56	328

Source : B.H. Davey. Supplies, Incomes and Structural Change in UK Agriculture. Paper No. 6 AAU Conference on Agriculture : Britain and the EEC, July, 1972.

With one exception, only marginal adjustments in cropping patterns were predicted for these farms by 1978. The exception is the mainly dairy farm where the cereals acreage is expected to increase by 32 acres, with smaller increases in the acreage of cash roots (potatoes and sugar beet) and forage, all made possible by a contraction in the area under grass. Of particular interest is the stability in the cereal acreage on the other farms, for which two reasons can be advanced.

First, there is the question of rotational constraints which limit the area of cereals which can be grown on any one farm in the interests of good husbandry. This is particularly important in the major arable areas of the country where the upper limit on cereal acreage has already been reached and in some cases, perhaps, even exceeded. As has been pointed out elsewhere, "The intensive cereal-growing countries of eastern England and Scotland have been running into problems of continuous cropping and they are short of additional land suitable for cereals production".(5) It is in these areas, of course, that the bulk of the cropping farms in the country are located.

Second, whilst it is true that there is scope for an increase in the cereal acreage in other parts of the country, farms in these areas tend to have a comparative advantage in the production of grazing livestock. As is shown in Table 3, the profitability of milk, beef and sheep production will also improve under EEC conditions. The programming results for livestock farm models suggest that in general few resources on these farms will be diverted into grain production. In addition, there is another factor to be taken into account. This is that as a consequence of changes in relative profitability, a change in systems of cattle husbandry is likely to follow EEC entry. With substantially higher feedgrain prices, farmers are likely to rely increasingly heavily on systems of cattle feeding which place more emphasis on grazing, conserved grass and forage crops. For example, the intensive systems of beef production based on an almost all-cereal diet could virtually disappear, with a concomitant expansion of grass/cereal beef systems.(6) Greater relative use of grass and forage crops in livestock production is a further factor limited the scope for expanding the cereals acreage.

One may conclude, therefore, that entry into EEC is unlikely to lead to any marked expansion in cereal acreages. In Table 6, cropping patterns on the representative farm models have been raised to provide estimates of crop acreages for England and Wales as a whole.

Table 6

Estimated Acreages of Agricultural Crops in England and Wales, 1970 and 1978 (million acres)

	1970 Actual	1970 Optimal	1978 Optimal
Cereals	7.86	8.30	8.99
Cash roots	0.96	0.77	0.79
Forage crops	0.56	0.83	1.04
Grassland	13.42	13.10	12.19
Total	22.80	23.00	23.01

This suggests that the acreage of cereals could increase by just over half a million acres between 1970 and 1978. To accommodate this expansion, and a smaller increase in the area of forage crops, the area under grass would contract by nearly one million acres. Implicit in this last adjustment, given further increases in livestock populations and a shift to grass-based production systems, is a marked improvement in the standard and intensity of grassland management.

The figures in Table 6 suggest that the total acreage of cash roots will remain fairly stable. But within the total, changes could take place in the relative importance of sugar beet and potatoes. So far as sugar beet is concerned, institutional factors will play a major role in determining the acreage of beet grown in the UK. In particular, a great deal will depend on how far the government is successful in obtaining an increased national quota when the Commonwealth Sugar Agreement comes up for re-negotiation in 1974. The Australian quota under the CSA is for 335,000 tons of raw sugar. After 1974, this will be re-allocated between EEC member countries, including the UK, and, hopefully, the developing Commonwealth countries which are party to the CSA. The government expects that within an enlarged EEC there will be room for an expansion of UK sugar beet production. (In the view of the present author there are strong economic, social and political arguments against any increase in UK sugar production, but that is another story). If the government could negotiate an increase of 100,000 tons in the UK's national sugar quota, for example, this would be equivalent, at an average yield of 2 tons of white sugar per acre, to an additional 50,000 acres of sugar beet on British farms.

On the other hand, there could be some contraction in the acreage of potatoes. With increasing affluence, consumption of potatoes by the British population is likely to decline through the 1970s.

According to one recent study, per capita consumption of potatoes in the UK will fall by 9 per cent between 1970 and 1978.(7) The implication of this is that the UK potato market could be supplied from a smaller acreage, particularly if the current trend to higher average yields continues.

Finally, "new" crops could fulfil an increasingly important role in UK cropping systems. For example, cereal farmers are continually searching for profitable crops to provide a break from white straw crops. Two crops which come into this category are maize for grain and oilseed rape. The greater profitability of these crops under EEC conditions could make them increasingly attractive. As noted earlier, EEC prices for maize and rape are well above current UK levels. A shift in relative gross margins in favour of these crops could stimulate an increase in acreage at the expense of other, more traditional break crops such as beans, although climatic factors will, of course, limit the production of maize for grain to certain areas.

CONCLUSIONS

To sum up, agricultural cropping systems in the UK appear to be very robust. The results of the AAU's programming work indicates that only marginal changes are likely at the farm level following entry into EEC, notwithstanding the considerable changes in relative profitability that will occur. In the aggregate, there could be a modest increase in the national cereal acreage and in the area of crops. This would be facilitated by a contraction in the acreage of grass with a concomitant intensification of grassland management and higher stocking rates. Within a relatively stable cash roots acreage, the acreage of sugar beet could expand and that of potatoes contract. Oilseed rape and maize for grain could feature in cropping systems more frequently as profitable breaks from cereals.

In the longer term, changes in the CAP itself will have an influence on cropping systems in the UK. With surpluses of cereals a real possibility by 1980, some modification of price differentials between cereals and livestock is probable. With relative grain prices lowered in an attempt to reduce potential surpluses, there will be a tendency for resources to be diverted from cereals into livestock production, with consequential changes to cropping systems. In addition, once self-sufficiency is attained within the enlarged community - and this is likely to apply to nearly all commodities except beef - we are likely to see the introduction of supply management schemes to constrain domestic supply to demand. The farmer's freedom to crop his land as he wishes could be directly restrained by land retirement schemes on the American pattern, or by the extension of quotas on production or marketable quantities to products other than potatoes and sugar beet. Indirectly, farm cropping policies could be influenced by schemes to limit the volume of output eligible for price support or which set threshold levels of production for EEC member countries. All in all, institutional factors could play a more important role in determining cropping systems than they do at the present time.

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THE EFFECTS OF UK ACCESSION TO THE EEC ON THE STRUCTURE AND CROPPING SYSTEMS OF BRITISH HORTICULTURE

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Forecasts about the effects of UK accession to the EEC on UK horticulture fall thick and fast. If a consistent pattern can be detected it is that the eventual elimination of tariffs/quotas, will make the UK market relatively more attractive to EEC producers and marketing organizations, thus attracting increased supplies to the UK with a downward pressure on prices.

These assumptions will be valid

(a) Where a commodity is already being produced in excess of EEC market requirements eg apples and pears.

(b) Where producers and/or marketing organizations are under pressure in EEC markets from supplies from third countries eg tomatoes on the German market where supplies from Rumania and Bulgaria are competing very strongly. The same seems true for processed vegetables and fruit on the same market because of pressure from low priced supplies produced from Hungary and other Eastern European countries. Such pressures coupled with the elimination of UK tariffs will make British markets more attractive to the Dutch, for example.

(c) Where the removal of UK tariffs will at certain times of year cause prices on UK markets to appear decidedly attractive. For example producers of early crops of strawberries, potatoes, carrots etc in France and Italy will compete strongly with home growers at those times of the year. On the other hand late British grown berry fruits eg strawberries, gooseberries, raspberries etc may find the markets of Western and Central Europe attractive.

In the case of the third example quoted the switching of relatively small resources of land and labour to early crops could bring appreciable financial rewards. But for the most part substantial additional supplies for marketing in the UK could be produced in the Six only by the diversion of substantial resources, especially labour and land from other agricultural or horticultural activities. Changes of this order would imply changes in whole cropping programmes and rotations and prices obtained on the UK market would need to justify such changes and be sufficient to cover high transport costs. Again the deliberate expansion of horticultural crops for export purposes, whether into or out of the UK, is likely to be strongly influenced by competing levels of profitability in agriculture for cereals, fodder crops etc. Whether UK horticulture is profitable is, at one remove, very much dependant on the level of profitability prevailing in agriculture.

In the short term, therefore, it would seem safe to assume that with the exception of the special commodities mentioned above or quoted later in this paper, UK accession to EEC will not result in many radical changes in cropped acreages.

Projections based on recent crop production statistics - UK and EEC

It might be expected that a study of recent trends in cropped acreages (hectarages), outputs etc as collated by the agricultural authorities in the countries of the Nine would be helpful in formulating projections. In the horticultural case, however, data from some of the EEC countries is either not comparable with that from the UK or is simply unavailable. If a Common Horticultural Policy (CHP) is to be evolved a pre-requisite would appear to be a common policy for the collection of agricultural and horticultural crop production statistics for planning purposes. Because of the paucity of data the provision of comparative tables has not therefore been attempted.

Comparative suitability of the United Kingdom as a base for horticultural production and Marketing

Before proceeding to an examination of such evidence & data etc as are available it may be helpful to examine the geographical, climatological and economic pros and cons of operating a horticultural production and marketing business in suitably chosen locations in the UK relative to that of the Nine. In this connection it is worthy of note that EEC citizens continue to migrate to the UK to engage in horticulture. That suggests that there are some locational advantages in this country. The principal ones are:-

Marketing.

If the EEC of the Nine be regarded as one trading community it becomes apparent that the UK and Ireland represent a North Western projection which is, geographically, "out on a limb" with relatively long lines of communication. This incurs high transport costs both from and to the other countries. The home industry has, however, a market of fifty five million people immediately adjacent to the points of production. It is in fact located in the midst of a large home market. This advantage must be exploited to the full by, for example, utilising local outlets, organising pick-it-yourself schemes and generally keeping the marketing chain from field to shop as short as practicable. In some instances this will require changes in production systems and techniques.

Climate.

The climate of much of the UK and Ireland differs significantly from most of Southern and Central Europe in that the summers are cooler, the winters milder and rainfall more evenly spread. This infers a climate generally favourable to vegetative growth. This is advantageous for the production of most kinds of vegetables, especially winter brassicae, soft and bush fruits, hardy nursery stock and flower bulbs such as narcissus. It also offers advantages to crops grown under glass or plastic protection. For most kinds of tree fruits it is, however, unfavourable to crop yield and commercial success in this sector will increasingly depend upon exploiting nearby markets and of the use of varieties of high quality some of which are favoured by a relatively cool summer climate. eg apple Cox's Orange Pippin.

The rainfall factor infers higher costs for weed control and a promising market for herbicide manufacturers. It is worth noting at this juncture that horticulture is a conglomerate industry. A wide variety of crops of relatively small individual acreage some of which have specialised requirements for weed and pest control chemicals. From the standpoint of the economical production and marketing of such chemicals an enlarged Community should offer advantages.

Labour costs.

We are frequently reminded that wages and standards of living have risen and are still rising faster in the EEC than in the UK. Labour represents some thirty to fifty per cent of production costs in horticulture and on this score the UK would also appear to offer advantages for economic production.

The UK, therefore, appears to offer a number of substantial advantages to horticulturists producing for the British market. Starting from a sound base of this kind it will be an additional advantage if farmers and growers can continuously advance and develop production systems and techniques which will enable them to "engineer" their products to meet the changing requirements of the market in regard to size, quality of product and continuity of supply. The rapidly rising price of agricultural land also lends fresh emphasis for the need to concentrate on high value crops and the maximisation of yield whatever the cropping programme may be. This will only be achieved by the skilful control of weeds and pests of all kinds.

Future prospects for individual commodities

To return to the consideration of such data as are available on recent crop production trends in the UK and the EEC; some tentative conclusions would be:-

Vegetables.

Accepting that the UK climate is favourable to many kinds of vegetables, and that the weight/value ratio often makes long distance transport to market uneconomic, certain commodities merit special comment.

i. Brassicae.

With the exception of winter cauliflower of the Roscoff varieties, as grown in South West England and South West Wales and of the early spring crops of cauliflower grown in Lincolnshire, Thanet etc, which may expect to meet keen competition at such seasons from French and Italian sources, the prospects for all crops in this commodity group look good.

Brussels sprouts yield exceptionally well in Eastern and Southern England but are frost sensitive in countries such as Germany where winters can be keen. In areas with mild damp autumn/winter climates, however, leaf Ring Spot becomes a problem. These factors probably explain why the UK sprout output at approximately one hundred and ninety thousand metric tons appreciably exceeds the combined output of the Six. The Netherlands and France are the only other countries with appreciable acreages. Over the last five years the UK acreage has expanded by some twenty five per cent and can be expected to fluctuate around the fifty thousand - fifty five thousand acre mark although if exports are proven to be feasible there may be further expansion. There is considerable scope for cost savings and for better quality (especially in regard to the winter browning problem sometimes met with in sprout buttons) by the use of single harvest production systems.

Export prospects for fresh or frozen sprouts to Northern and Central Europe, including Germany, appear good. At present only some ten per cent of the UK sprout crop is processed.

ii. Root Vegetables.

Of this group carrots are the most important in both the UK and in the Six. The acreage in the UK has expanded over the last five years from about thirty thousand to forty thousand acres. About twenty five per cent of the resulting output is processed. The future for main crop carrots seems reasonably stable. More early carrots are likely to be imported from France and the German position may mirror the future picture in the UK as the German acreage of early carrots has decreased while late crops have increased. In France carrot output has been moving substantially upwards for all types of carrot.

iii. Bulb Onions.

The soils and climate of Southern and Eastern England are very favourable to high yields of this crop but the unreliable climate at harvest together with highly unsatisfactory harvesting and drying techniques has made difficult the consistent production of a good quality crop. New production, harvesting and storage techniques have markedly improved results in recent years so that the acreage has risen from near five thousand in 1966/67 to about thirteen thousand acres in 1971/72. Imports still total eight million pounds annually and while the Netherlands crop will become more competitive by UK entry Polish, Spanish and Egyptian onions will have to contend with a thirteen/seventeen per cent CET whereas the current UK tariff is only ten per cent. UK production may be expected to continue to rise steadily.

iv. Peas and Beans.

The overall acreage of green peas (for processing and fresh market) has expanded steadily from about one hundred and seven thousand acres in 1964/65 to one hundred and thirty seven thousand acres in 1970/71. The present UK tariff of ten per cent will be replaced by ten - seventeen per cent CET and as the processing of peas is not a major activity in the EEC little additional pressure is to be expected from that source. On the other hand Rumania, Hungary etc are intensifying their efforts in this field and British attempts to enter the European market are likely to encounter increasing competition.

v. Field grown lettuce.

Since 1965 UK production has expanded by about one third. This reflects an increasing consumption of green salads in this country. Demand seems likely to continue to increase.

Potato Root Eelworm

Perhaps the most worrying aspect of UK accession for British horticulturists and farmers concerns the final outcome of Directive 69/465/EEC of the Council of the European Communities. In brief this Directive could restrict the ability of many home growers to grow for sale a large number of crops if the land in their occupation happens to be infested with potato root eelworm cysts (these cysts are the dormant encapsulated eggs of the eelworm). The cysts of this eelworm are present on many otherwise fertile soils which, over the years, have been used at one time or another for potato growing. To free such fields from the eelworm cysts will in the present state of knowledge require many years of avoidance of potato crops before the cysts become non-viable, ten years or more. Meanwhile, such soils could not be used for the growing of many crops for sale unless expensive precautions are taken prior to sale. Thus Article 4 states "Member States shall prescribe that on contaminated plots (ie those contaminated with potato root eelworm) (a) no potatoes may be cultivated and (b) no plant intended for transplanting may be cultivated, planted or stored." This latter requirement would affect the production and sale of such items as strawberry runners, bulb flowers, hardy nursery stock.

Article 5 proceeds to state "Member States shall prescribe that potato plants which are contaminated or suspected of being contaminated must be treated in such a way that they shall no longer be contaminated if they are distributed as potato plants." This rule would presumably apply to other crops grown for sale in potato root eelworm infested land.

Fortunately each EEC country still has its own rules on plant health matters and directives of the Council of the European Communities have yet to be harmonized.

Clearly, sufficiently cheap but effective control measures for potato root eelworm are urgently needed.

Fruit.

vii. Tree fruits.

The acreage of tree fruits has risen dramatically in recent years in both EEC and East European countries and EEC production alone is now twelve times greater than that of the UK. Excessive European plantings are rendering the world market unstable.

Acreages in the UK have been slowly falling but it is mainly older and less productive orchards which have been grubbed, and these have been partly offset by new plantings of intensive orchards. The output of dessert apples has been fairly stable if allowance is made for unfavourable seasons. The main decline has been in production from cooking varieties.

It would seem logical to expect a further contraction in acreage with more emphasis on dwarf tree orcharding systems, accompanied by clean cultivations, which will facilitate harvesting by semi mechanical methods or in some circumstances by "pick your own" techniques.

viii. Berry fruits.

The UK climate is favourable to all soft fruits and the prospects seem good on three counts.

(a) The scope for the further development of pick your own marketing systems which will place the home grower vis-a-vis overseas competitors in a strong position and

(b) Exports for late crops to Southern and Mid European countries.

(c) The scope for the development of mechanical harvesting systems for some crops intended for processing eg blackcurrants is promising.

Hardy Nursery Stock and Flower Bulbs

The UK climate is uniquely favourable to this group of crops. The UK nusery stock industry has been steadily expanding and the acreage is currently about 16,000 having expanded from 14,000 over the last five years. The area devoted to bulb flowers, especially narcissus, has also been expanding steadily and exports to Scandinavia, Germany and Switzerland are already developing. The UK area of narcissus now exceeds fifty per cent of the world total.

Summary

Exact forecasts for the future of horticultural cropping are difficult for reasons indicated and no reference has been made to crops grown under glass or plastic protection as these are not of great interest in the context of herbicides.

For some vegetables, berry fruits, hardy nursery stock and flower bulbs some expansion of UK acreage may occur; tree fruits, early strawberries and certain kinds of early vegetables will suffer from increased competition causing acreages to decline.

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REGULATORY SCHEMES OF CURRENT MEMBERS OF E.E.C.

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INTRODUCTION

Throughout the world, chemical pesticides are playing an ever increasing role in the production of crops for foodstuffs and fodder on a competitive and profitable basis. In the Member Countries of the E.E.C., herbicides head the list of agro-chemicals serving to ensure the farmer and gardener bigger and better yields. At the same time they reduce the manual labour necessary, thus helping solve the problem of labour shortage and simplifying cultivation and harvest. For these reasons the consumption of herbicides in the E.E.C. Countries has risen higher than that of fungicides and insecticides.

The increased use of pesticides, so vital to the farmer and gardener, has caused a storm of criticism from those concerned about its possible effects on man, animals and the environment. This modern outlook on chemical pesticides has put new emphasis on certain facets of the legislation governing their use.

CURRENT REQUIREMENTS WITHIN THE E.E.C.

For many years there have been regulations on the introduction, storage, marketing and use of pesticides. In the E.E.C. Countries, these regulations have now been amended or drawn up anew to make the introduction, storage and marketing of these products dependent on the granting of clearance (appendix 1).

Clearance can be allowed only after the proper authorities have satisfied themselves that the information submitted by the proposer proves there are no foreseeable risks involved for man, animals or the environment. Obviously it is a prerequisite that the authorities are satisfied on the biological action of the compound.

The requirements of registration authorities throughout the world vary tremendously, but in all E.E.C. Countries the emphasis is placed on safety. The work involved in ensuring maximum safety is the responsibility of the pesticide industry and costs a great deal of time and money. If at least the safety requirements were uniform throughout the E.E.C., it would be a step towards greater harmony. The Council of Europe has already published "Agricultural Pesticides", which can be used as a guideline for the safety of a proposed pesticide.

In the E.E.C. Countries the data that must be presented when applying for clearance may be classified under the following headings:

1. Information on the chemical and physical properties of the product and its active ingredient.

2. Information on the effect on the health of man and animals.

3. Information on the behaviour of the active ingredient on or in the plant or plant products, in particular on residues and degradation of the active ingredient.

4. Information on the behaviour in soil and water, in particular on the residues and degradation of the active ingredient.

5. Information on the methods used for analysis of the active ingredients in the pesticide and for estimation of the active ingredient residues, including degradation and reaction products.

6. Trial reports proving its efficacy as a pesticide.

The current public interest in the problem of environmental protection will no doubt bring pressure to bear to increase still further the range of tests required. Therefore the most expedient plan for the pesticide industry to follow is to adhere to the most comprehensive list of requirements at any given time.

TIME SCHEDULE FOR DEVELOPMENT AND REGISTRATION

The good relations existing between the scientists of the registration authorities and their counterparts in industry often enable them to discuss the trials programme before work is begun on long and difficult tests such as a 2-year feeding trial, 3-generation study or specialised subjects such as metabolite studies. The authorities also realise it is impossible to present the results of long-term studies at the time of application, and they are very accomodating on this point. The following account of the work involved in developing a herbicide for cereals serves to show how important this kind of attitude is to the pesticide industry:

If a new compound has shown herbicidal activity in screening tests, it must then be subjected to open-air trials in small plots to discover whether it is effective under these conditions. The time required for these outdoor trials can be estimated at two years. Further tests to determine the optimum formulation and the acute toxicity of both the active ingredient and the formulation can be run concurrently and will continue into the third year.

During the third year the compound is also tested in different soils and under various climatic conditions to establish the optimum rates and times of application for each type of cereal under these conditions. The initial work on residue analysis also falls into this period.

In the fourth year, work continues on the outdoor trials and completion of the data on the biological properties of the herbicide, some of which is carried out in official testing centres.

The behaviour of the residues within the plant is examined in more detail, and tests are begun on residues in soil and water.

In the toxicology sector, acute studies are carried out with the formulation with particular regard to the safety of the user, and the active ingredient is tested in sub-acute trials on rats and dogs.

In the fifth year, the long-term feeding trials, specialised toxicology and metabolite studies can be started, and by this time it should be possible to begin negotiations for the clearance of the compound, which is by now familiar to the authorities, at least as far as its biological action is concerned.

2-year feeding trials and a 3-generation study plus the evaluation and writing-up cover a period of three years. Thus the development of a new herbicide takes a full seven years from start to finish. (Cf. appendix 2)

In the light of this knowledge, it is not difficult to appreciate why clearance systems allowing a gradual accumulation of data find favour with the pesticide industry. In fact this is how the registration formalities work in the U.K., with the notable difference that they are not governed by hide-bound regulations.

REGISTRATION SCHEMES OF INDIVIDUAL COUNTRIES

Continuing with the example of our hypothetical herbicide for cereals, the clearance procedure is explained for each Member Country:

When applying for clearance in the Federal Republic of Germany, a form must be filled in that encompasses at present 70 detailed questions. The completed form is submitted to the Federal Institute of Biology for Agriculture and Forestry (BBA), Department of Pesticide Application and Equipment (appendix 3).

The toxicological data required with the application are as follows:

1. Results of acute oral and parenteral toxicity studies with the technical active ingredient on two animal species.

2. Results of acute oral, percutaneous, dermal and inhalation toxicities with the compound on two animal species.

3. Results of 90-day feeding trials with the technical active ingredient on rats and dogs.

Residue analyses must be carried out according to the methods set out in "Guidelines on residue data requirements" published by the BBA, and the results must be presented on the form supplied for that purpose. If the compound is to be applied to crops - as in the case of our herbicide - at least three degradation curves are to be plotted for each crop, the results having been obtained from areas with different soils and climates. The residue level must be given for the day of application, at harvest and at least once before and after the proposed waiting period. The results must include the level of compound in the plant material tested and the level of the toxicologically important metabolites, if it is possible to estimate the latter.

An important point to be considered in the behaviour of the compound and its degradation products in the soil is the question of the risk of compound uptake by later crops. As yet, no completely satisfactory method had been developed for determining the behaviour of the active ingredient in water.

When evaluating the biological effect of the product, the BBA will accept only these results that have been obtained from trials carried out according to the terms set out in the pamphlet "Guidelines on the official testing of pesticides". This includes, for instance, the stipulation that herbicides for use in cereals shall be tested on plots of at least 25 square metres and with three replications. The time of application, water application rate, plot length and width, equipment to be used and the time of evaluation are laid down according to the "Guidelines for testing herbicides" prepared by the Committee on Methods of the European Weed Research Council. Part of the trials should be carried out by the German Plant Protection Service.

The data on toxicology are evaluated by the Federal Health Office (BGA), and the BBA is responsible for checking the trial reports, the chemical and physical properties and the composition of a sample. The biological tests also come under its jurisdiction, and these are carried out in the trials centres of the Plant Protection Service over a period of two years. The final decision on clearance is made by an expert panel following completion of the biological tests and checking of the data submitted by the proposer. The panel convenes once a year, usually in November. Since it takes some time to obtain the official clearance permit (often until March), a herbicide that must be applied in the spring cannot be used widely in the first year. In fact, it usually comes into use after the various production processes, packaging and advertising have been organised, which is the beginning of the seventh year after commencing the development work, i.e. after application for a patent (appendix 4). At the same time that clearance is granted, the BBA issues instructions on the inclusion of any restrictions necessary in the directions for use and in the labelling of the packaging etc.

In France, the Ministry of Agriculture grants clearance of a pesticide (appendix 5). The data required on its biology and toxicology must be submitted in the form of separate reports to the Ministry of Agriculture, Plant Protection Service. Copies of both reports are distributed to the following bodies:

1. Toxicology Commission for Agro-chemicals

The Commission is made up of members from many different disciplines presided over by a toxicologist. In addition to the toxicologists, there are representatives from agriculture, the pesticide industry, the Quality Control Board, the National Institute of Agricultural Research (INRA), the Ministry of the Environment and the Veterinary and Plant Protection Services of the Ministry of Agriculture.

If there are no risks attached to the use of a new compound, the Commission imposes no limits on its application. It is however authorised to enforce certain regulations, e.g. restrictions on its range of use, concentrations to be applied and waiting periods. The Commission also places compounds in poison categories, in the case of pesticides, category A (toxic products) or C (dangerous products).

2. Committee for the Control of Agricultural Pesticides

The Committee is composed exclusively of representatives from the relevant departments within the Ministries of Agriculture and Industry, plus certain members of the Toxicology Commission.

The Committee studies the biology report, taking into consideration the decision of the Toxicology Commission. If they are satisfied on the biological action, and if there are no discrepancies between the results of the 2-year trials carried out by the industry and those of the INRA, a provisional commercial clearance is given. Full clearance is not granted until after completion of the trials by the Plant Protection Service, which are similar to those carried out by the equivalent authority in Germany.

3. Agricultural Pesticides Commission

The Commission is composed of representatives from the administration of the Ministries of Agriculture and Industry, the pesticide industry and agriculture. They are responsible for setting the standards for testing the biological action of the pesticides. According to whether the compound in question meets the requirements, they make recommendations to the Committee for the granting or suspension of the provisional commercial clearance or the full clearance, as the case may be.

The Commission meets once or twice a year.

When the proposer is satisfied that he has collected sufficient data on the biology and toxicology of the herbicide, he can apply for clearance. This is usually at the end of the fourth year, and the three official bodies study the reports during the fifth year. Since they meet frequently, it is often possible to obtain provisional commercial clearance within that same year, so that the herbicide can be brought onto the market in time for use in the following spring.

It is preferable to be able to present results other than those obtained within the company, and to this end it is recommended that part of the trials programme be carried out in the National Institute of Agricultural Research (INRA) or in other institutes specialising in various crops (e.g. Cereal Institute). If division of work among state institutes involves testing over a wide area, application for a trials permit must be made to the Ministry of Agriculture, giving details of the toxicity of the product and its active ingredient and the safety precautions to be observed.

In the Netherlands, the application for clearance for a pesticide must be submitted to the interministerial Phytopharmaceutical Commission (appendix 6). For herbicides, the deadline for submission depends on the planting time of the crop and the application time of the product. The Plant Protection Service carries out field trials to study the claims made by industry. Depending on the nature of the product, the crop in which it is to be applied and the information becoming available from other sources, this study may take one or more years.

The information required on the pesticide and its active ingredient does not differ greatly from that laid down in the Council of Europe's booklet "Agricultural Pesticides". The Public Health Institute undertakes the toxicological investigations and the residue analysis.

The biological trials carried out by the Plant Protection Service are very extensive, and exact details are laid down regarding the size of plots, number of replications, spraying and harvesting equipment and the evaluation itself.

When the toxicological data and the results of the technical biological trials (frequently supplemented by greenhouse studies) have been satisfactorily completed, clearance is granted by the Minister of Agriculture and Fisheries in agreement with the Minister of Social Affairs.

The proposer is under no obligation to submit all the necessary data on toxicology at the time of application for clearance but is allowed the two-year biological testing period to assemble all the facts. As in Western Germany, the herbicide is likely to be cleared towards the end of the fifth year.

When the Benelux Pesticide Act has been passed, it will standardise the registration formalities in three of the E.E.C. Countries. It is hoped that this will encourage other Members to harmonise too and thus bring about uniform conditions throughout the Area.

In Belgium, clearance proposals must be submitted to the Ministry of Agriculture. The "Toxicology Dossier" gives details on the information necessary on toxicology, residues and environmental protection and the manner in which it is to be obtained. The requirements are much the same as those throughout the remainder of the E.E.C. The data submitted are studied by the Phytopharmaceutical Committee, whose members are drawn from the Ministries of Agriculture, Health and Employment. The Phytopharmaceutical Station is responsible for the biological trials on herbicides, which entail 2-year studies with six replications on plots of 100 square metres. A company's own trial results will also be taken into consideration. Clearance is sanctioned by the Ministry of Agriculture.

Up to 1970, all pesticides that had been cleared in Holland and Belgium were given clearance in Luxembourg. Since that date, application for clearance must be made to the Headquarters of the Agricultural Advisory Service. Practically the same data on toxicology is demanded as in Belgium and Holland, and the Belgian and Dutch trial reports are submitted for evaluation of the biological action. Clearance is granted when the product has been approved in the neighbouring countries.

In Italy, application for clearance of a pesticide is made to the Ministry of Health. There is no special form for this purpose. Trial reports must be submitted that prove the efficacy of the product when used under conditions encountered in Italy, and details must be given of the toxicology of the product and its active ingredients. Reports on the company's own trials carried out over one or more years are acceptable as proof of the biological action, but the data on toxicology, residue analysis and the effect on the environment must be obtained by testing strictly according to governmental criteria. These regulations cover every conceivable question on the safety of the proposed product.

The only techniques that are checked are the analytical methods, which are run through again in the Ministry of Health Laboratories. The reports on all other methods and results are studied by the officials of the Ministry, who then request further information, if necessary, and finally pass on all the relevant data and documentary proof to the Clearance Commission, which is composed of members of the Ministries of Health and Agriculture and experts from various institutes. They study the data submitted and can ask the proposer to undertake further tests or to have the biological trials repeated in institutes of their choice before they pass judgement on the product to the Ministry of Health, which is the body responsible for granting clearance. A report on the newly registered pesticide then appears in the "Official Bulletin".

On granting clearance of a pesticide, the authorities responsible also place the product in a poison category, establish the maximum tolerable levels and decide on the duration of the clearance.

Unfortunately, the E.E.C. Countries have so far been unable to reach agreement on the classification of poisons and the symbols used for them (e.g. skull and crossbones). It remains to be seen whether they will follow the suggestions of the Council of Europe on the "Classification of Dangerous Formulations". This E.E.C. directive was drawn up in co-operation with the chemical industry and its representative body, the GIFAP.

When fixing the maximum tolerable levels, the various national authorities are often guided by the residue analysis in their own country and settle on low values that cannot be complied with in other countries where techniques are different or heavier spraying is essential. In order to obviate difficulties with the import or export of foodstuffs, it will be necessary to establish certain standards, such as the drawing up of E.E.C. tolerance levels for instance. The Codex Committee on Pesticide Residues could be used as a basis for this.

A clearance permit normally expires after ten years in the Netherlands and Western Germany. It can however be withdrawn after a shorter period if any of the conditions supporting registration becomes invalid.

SUMMARY

In the Member Countries of the E.E.C., there are laws governing the tests required for the clearance of pesticides. On a multinational basis, however, agreement is reached on certain points about the safety of proposed pesticides without recourse to legislation. Testing of the biological action also has in principle the same aims throughout the Area, but in practice there are certain differences, some of them being the result of procedures that have become traditional in a country. The Benelux Countries are currently formulating a common pesticide act that will be the first step towards standardising registration formalities.

The clearance of completely new compounds takes roughly the same length of time in all Member Countries (shortest period 5 years), but the introduction into one country of a pesticide that has already been cleared in another depends to a large extent on the requirements of the second country with regard to the biological action under local conditions. It should be possible to accelerate clearance in another country by establishing standards that would be acceptable in all Member Countries. Criteria on the degradation in plants could also be standardised in the same way.

A measure of harmonisation has been achieved with the classification of pesticides in poison categories, and the E.E.C.'s "First directive of the Council on the setting of maximum amounts of pesticide residues on and in fruit and vegetables" and a similiar one on raw cereals can be regarded as a step towards putting the matter into supranational perspective.

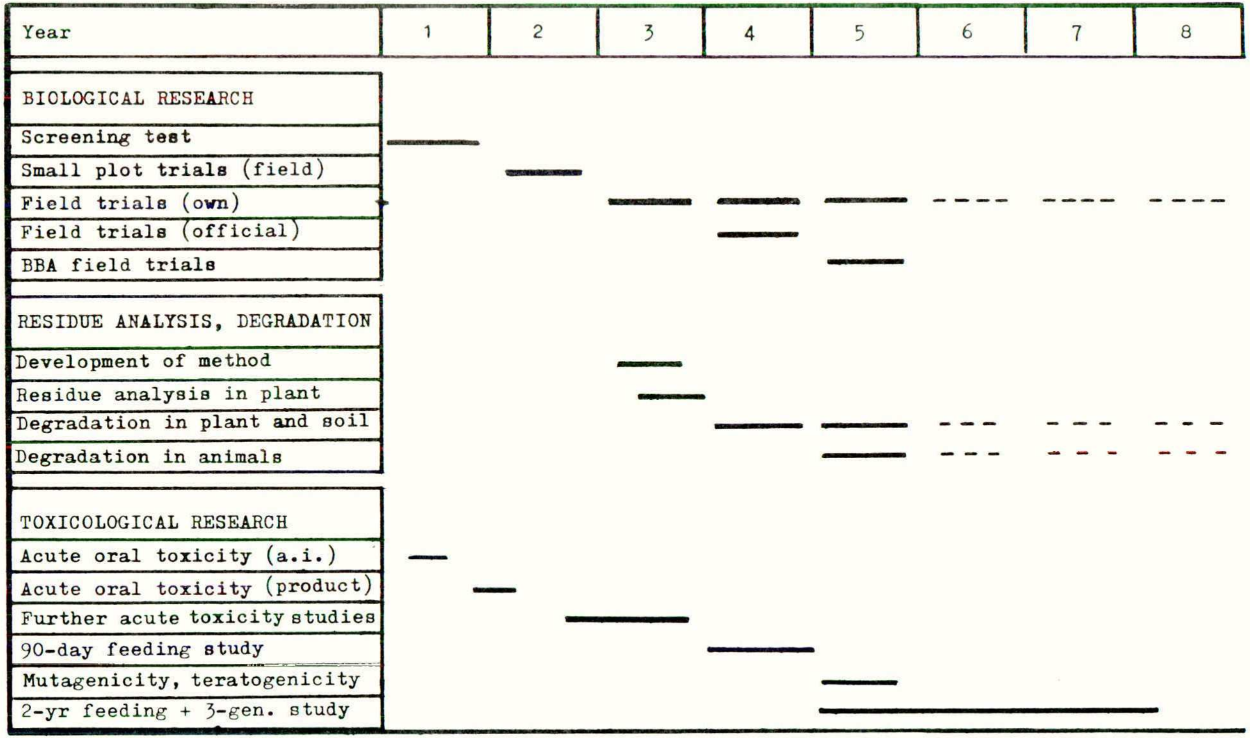
Appendix 1

Laws governing the clearance of pesticides in the E.E.C.

Belgium:	11. VII. 1959. - Arrêté royal modifiant l'arrête royal du 31 mai 1958, portant réglementation de la conservation, du commerce et de l'utilisation des pesticides et des produits phytopharmaceutiques.
Netherlands:	"Bestrijdingsmiddelenwet van 12. VII. 1962" und nachfolgende Verordnungen vom 25. VII. 1964 und 4. VIII. 1964
Luxembourg:	Reglement grand-ducal du 29. V. 1970 concernant le contrôle des pesticides à usage agricole et des produits phytopharmaceutiques
France:	"Loi du 2 novembre 1943 relative à l'organisation du contrôle des produits antiparasitaires à usage agricole" modifiée et validée par ordonnance le 13 avril 1945, modifiée par loi du 30 juillet 1963
Federal Republic of Germany:	Pflanzenschutzgesetz vom 10. V. 1968 und Verordnung über die Prüfung und Zulassung von Pflanzenschutzmitteln vom 4. III. 1969
Italy:	Regolamento concernente la disiplina della produzione, del commercio e della vendita dei fitofarmaci e dei presidi delle derrate alimentari immagazzinate. - 3. VIII. 1968

Appendix 2

Simplified representation of work entailed in the development of a cereal herbicide in the Federal Republic of Germany



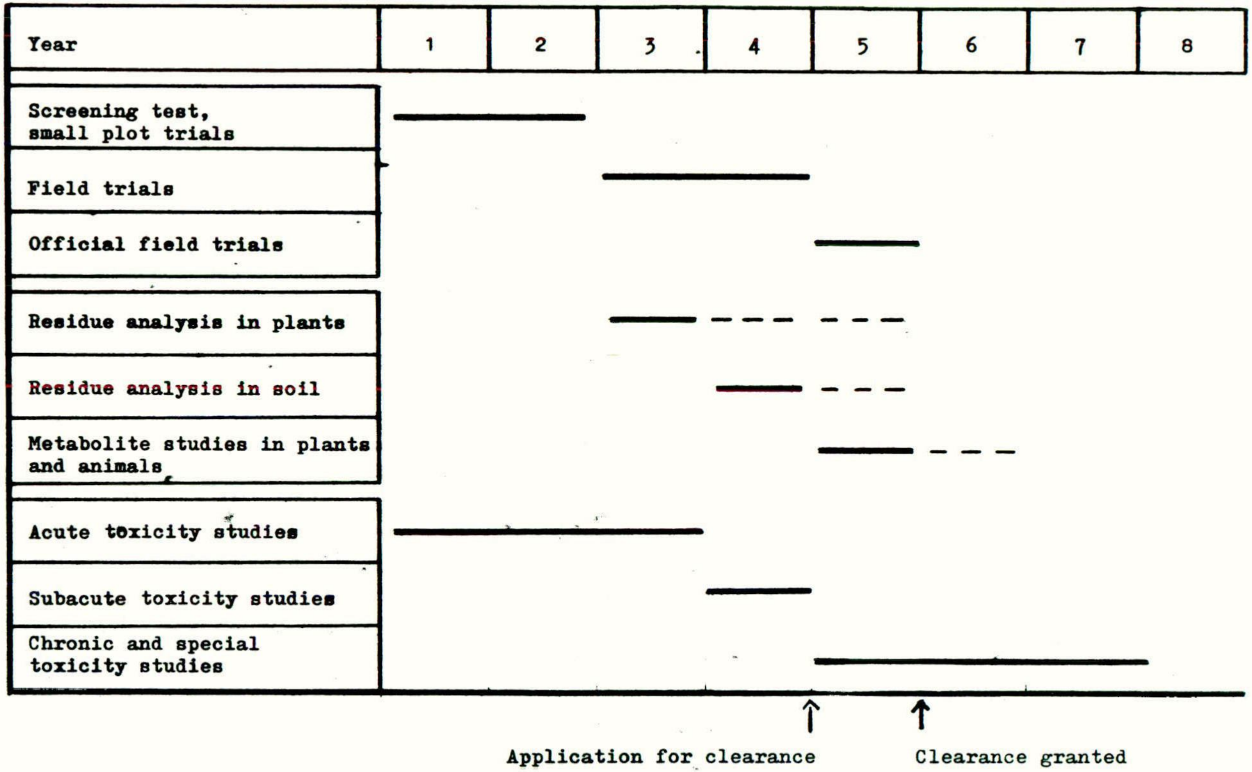
Appendix 3

Authorities dealing with applications for clearance of pesticides

Belgium:	Comité d'Agréation des Produits Phytopharmaceutiques Inspection des Matières Premières, Ministère de l'Agriculture (Bruxelles)
Netherlands:	"Commissie voor Fytopharmacie" c/o Plant Protection Service. (Wageningen)
Luxembourg:	Administration des Services Techniques de l'Agriculture Service de la Protection des Végétaux (Luxembourg)
Federal Republic of Germany:	Biologische Bundesanstalt für Land- und Forstwirtschaft, Abteilung für Pflanzenschutzmittel und -geräteprüfung (Braunschweig)
France:	Service de la Protection des Végétaux au Ministère de l'Agriculture Homologation des Produits Antiparasitaires (Paris)
Italy:	Ministero della Sanità Direzione Generale per l'Igiene degli Alimenti e la Nutrizione (Rome)

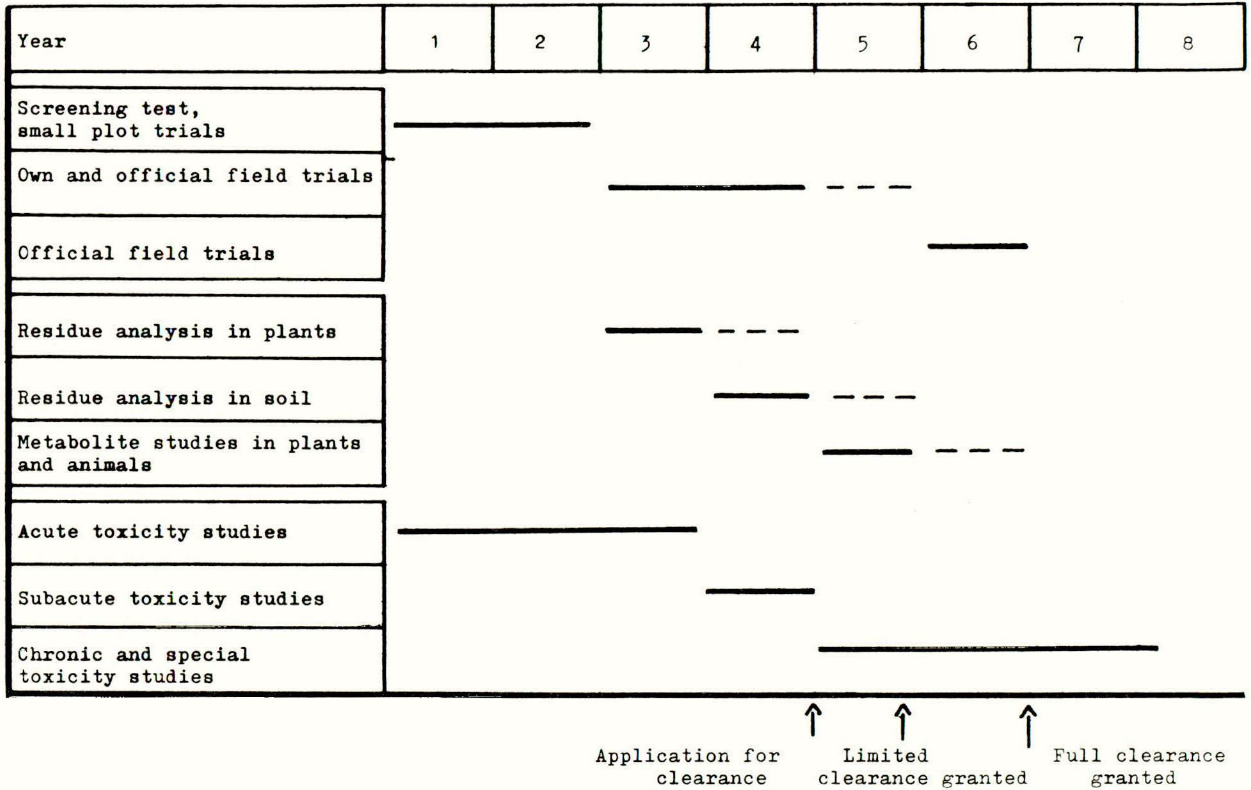
Appendix 4

Registration of a herbicide in the Federal Republic of Germany



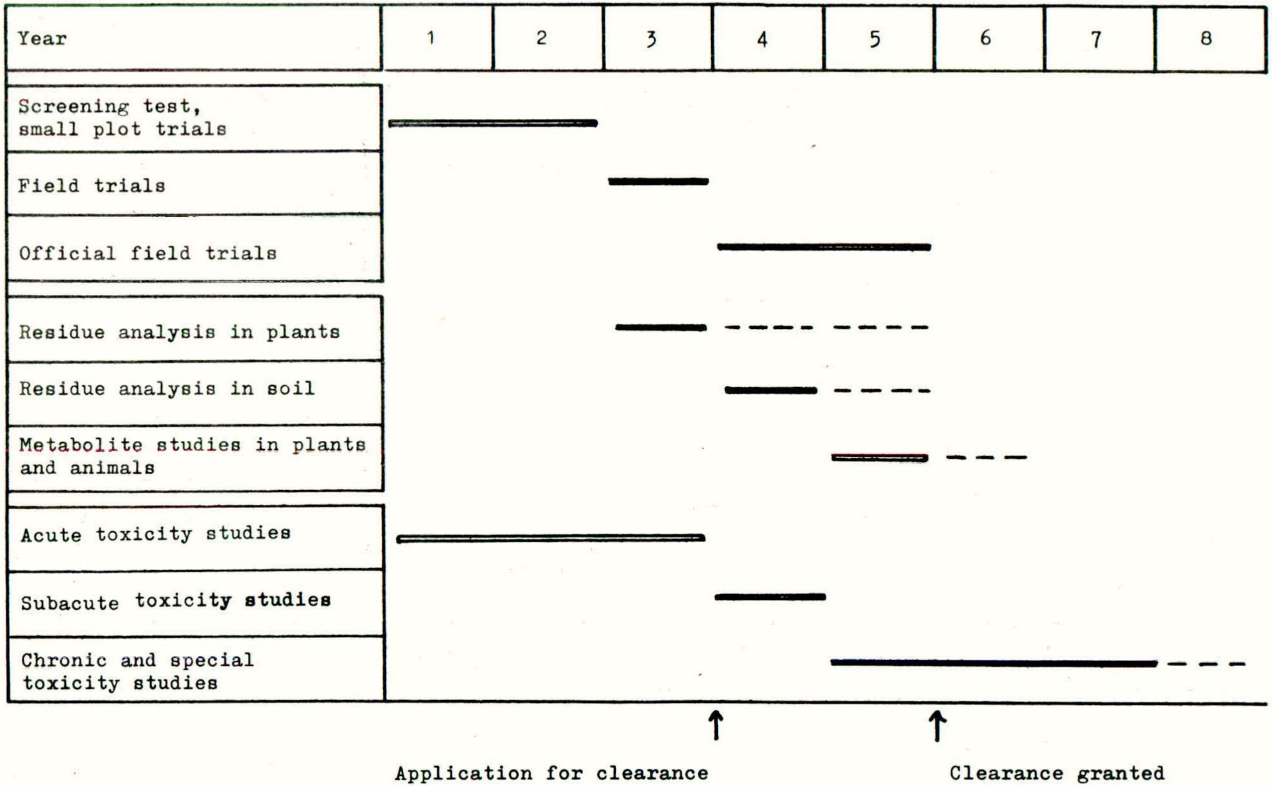
Appendix 5

Registration of a herbicide in France



Appendix 6

Registration of a herbicide in the Netherlands



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REGULATORY SCHEMES OF APPLICANT COUNTRIES TO EEC

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Pesticides, in particular herbicides, are an integral part of agriculture, horticulture, forestry and even amenity management. To all those involved in handling or applying such pesticides there has arisen an ever growing awareness that these materials need to be used with care and also that there is a need to regulate their use if society is to benefit from them. The main object of pesticide regulation is therefore to protect society in general. To do this it must protect the user against toxic hazards, to prevent environmental pollution and to give the consumer food that is free from residue or taint. In addition a good regulatory scheme can do much to promote good husbandry and to encourage the use of chemicals in areas where they will do most good. A further benefit from an enlightened scheme is that it can help to stabilise the manufacturing industry and prevent mistakes occurring by aiding the flow of information between different manufacturers.

The form individual regulatory schemes have taken is largely a reflection of the pesticide industry in each country. The most important factor in the evolution of a regulatory scheme being the presence or absence of companies synthesising new compounds and or manufacturing existing pesticides. The result of differing national attitudes, different agricultural industries and different pesticide industries is that in Western Europe we are now faced with widely divergent regulatory schemes. Any one involved in the international registration of pesticides knows how confusing and contradictory this situation is. Having allowed these schemes to emerge unaided we must now consider how we can harmonise our different interests so that at least within the enlarged common market our schemes are directed to a common need. The first aim of harmonisation must be to eliminate the duplication of very similar research required to satisfy the whims of individual schemes. Our next must be to establish exactly what our schemes have in common. From such beginnings it should be possible to produce acceptable technical methods for all schemes and to set standards that would be acceptable throughout the enlarged common market.

The regulatory schemes of those countries applying to join the EEC are no exception to the conditions described above. In Denmark, the Irish Republic and the United Kingdom different conditions have produced schemes that are somewhat divergent but suited to the climate in which they operate. It is worth noting at this point that these different systems were themselves arrived at as a result of internal efforts at harmonisation. Nowhere is this more true than in the United Kingdom. Collaboration between the Government, research bodies and the pesticide industry led to the formation of an approval scheme as early as 1942 under Dr. J.T. Martin. This scheme laid the foundation upon which the present voluntary schemes operate today.

It is unfortunate that a similar situation has not occurred more frequently in other countries. Too often the formation of schemes has been the result of the emergence of a pesticide law designed to placate adverse public opinion or as a result of a crisis arising from the use of certain pesticides. One clear benefit of a scheme that has evolved on a voluntary basis is that faced with a crisis the machinery of regulation can be quickly modified to meet such a crisis.

Collaborative action of both the industry and government in this situation does much to quieten the mind of the troubled public. Recourse to law often reflects that there is a lack of common ground between officials, research workers and industry. In such a climate it is not surprising that pesticides in general tend to be treated as guilty until proved innocent.

In the applicant countries the degree of intervention of the state in the regulation of pesticides varies widely. On the whole there is considerably less intervention than in the existing countries of the EEC. There is least intervention in the Irish Republic where there is no specific regulatory authority. In Denmark the role that the State plays in the regulation of pesticides is quite large. There is a statutory requirement for all pesticides to be registered with the Poisons Board before they can be sold to the public. Having obtained clearance through the Poisons Board further approval in terms of the efficacy of the product is voluntary. The position in the United Kingdom is intermediate between these two countries. There is a voluntary agreement between industry and government that no product is made available to the grower unless it has been cleared by the Pesticides Safety Precautions Scheme. Further approval on the grounds of efficacy is also voluntary but without the same moral committment that exists with respect to safety. Although there is no registration authority in the Irish Republic a manufacturer must comply with the requirements of the law concerning toxic compounds used in agriculture.

In all three countries the onus for providing data for clearance falls on the manufacturer. This covers information on such topics as toxicology of the chemical, methods of analysis, residues, safety to the environment, fate of metabolites etc., the requirements of each scheme differ. In the United Kingdom none of this data is checked in a laboratory although the methods supplied in submission can be later used if special needs arise. Some work on residues and environmental safety is carried out in the Irish Republic by the state research institutes. In Denmark the method of analysis is checked by the Chemical Control Institute. This body also carries out checks on the formulation. Further checks on a product are carried out during its life to ensure that it maintains the original specification.

It is of note that there is a clear difference between the schemes of the applicant countries and the current members of the EEC with respect to the approach to clearance. In the EEC countries there is a single registration covering both clearance and approval. In the applicant countries however the processes of clearance and approval are quite distinct. This latter appears to have the advantage of close surveillance on the critical aspects of safety whilst allowing considerable freedom in the commercial development of the product. It also has the advantage of keeping the costs of registration to a minimum. It is worth pointing out that this is of paramount importance with respect to the minor uses of pesticides of all kinds. We can already see in America the restricting effects of over-zealous authority in the loss of recommendations to the grower on purely cost grounds. It is unfortunate that statutory controls of pesticides tend to restrict development to those areas which are able to make a satisfactory financial return for the manufacturer over the costs of complying with the requirements of that law. The greater the complexity of the regulatory process the fewer are the number of recommendations available to the grower.

The efficacy of pesticides is voluntary in all the applicant countries. In the Irish Republic a certain amount of evaluation is carried out by the state research institutes. The results are embodied in the advice given to the user. There is no published list of approved products and no provision for examining products or uses not covered in the programmes of the research institutes.

In the United Kingdom the approval scheme is a voluntary one in which the onus for producing data is put on the manufacturer. Great store is set by the scheme on inspecting the trials carried out by the manufacturer in the field. The government research stations and the advisory service have no mandate to carry out work in support of the approval scheme but they do provide a large amount of unbiased data against which a manufacturer's claims can be judged. Once approval is granted it is renewed annually at the request of the manufacturer unless there are objections to the continuation of the approval from the scheme.

The position in Denmark is quite different in that there is a voluntary approval scheme but that approval is granted on the basis of results obtained from trials carried out by the Danish State Experimental Service. Once approval is granted it is renewed annually as in the United Kingdom. In some schemes, for example in Finland, the approval is limited to a period of 5 years after which it is reviewed. This I would consider a prudent rule. Although both the Danish and British schemes reserve the right to review any recommendation in practice it is seldom done and one is faced with both outmoded recommendations and different labels for similar chemicals. To make the review of each active ingredient every five to ten years a condition of approval would formalise the review procedure and enable label recommendations to be constantly brought into line with current practice.

The methods of product evaluation is not formally defined in any of the applicant countries although there are clearly preferred methods, especially in the Danish scheme. In all countries however the manufacturer is either consulted or has the right to discuss the methods by which his product will be tested. This is a most commendable feature of these schemes. It ensures that evaluation is fairly carried out and that it is based on the principles of scientific experimental technique. We have within the existing EEC the example of the adoption of statutory trial procedures. I think that the adoption of the German Biologisches Bundesanstalt of the 1-9 logarithmic assessment method a set-back to weed control and a backward step in scientific procedure. Perhaps it is at this level most will be gained by harmonisation.

In comparing the merits of testing by a state run system to that carried out entirely by industry one becomes aware of the different approach of the two sides. A state testing institute can become isolated from practice and may find it difficult to maintain expertise in areas of crop protection in which new products do not frequently appear. One can on the other hand be critical of a system based entirely on industry for its information. The ideal lies I think somewhere in between. It would I feel certainly be an asset if the scheme could have funds to support the evaluation of minor uses on a contract basis. This would enable the occasional products to be evaluated in institutes where there is greatest expertise.

The individual regulatory schemes of the applicant countries are summarised at the end of this paper. They are quite different from each other and will shortly be full members of the community. Against this background, although different from each other. they present a contrast to the schemes of the existing EEC members. In this situation it would appear that being the applicant any efforts to harmonise regulatory schemes would entail the compliance of these three countries with the existing six. How valuable this would be is not easy to ascertain. What is clear however is that this is a good opportunity to objectively assess the value of the voluntary principle in pesticide registration. Its great asset is the speed in getting new products to the grower. It also allows great flexibility in operation and keeps the practical use of the product to the fore.

There is no reason why these features cannot be taken into account in a pesticide law. It is unfortunate that very often legal processes are administrative tools.

Quite apart from the difficulty of recognising the role of the technologist, once formulated laws cannot quickly take account of changes in practice and tend to become political directives instead of desirable public safeguards.

Summaries of the Regulatory schemes in Denmark, the Irish Republic and the United Kingdom.

Denmark

(Fig. 1 and 2)

Before a product can be marketed in Denmark it must be registered with The Poisons Board of the Ministry of Pollution and Environment. The active ingredient is classified according to its poisonous nature as follows:

Class X - very highly poisonous pesticides (eg chloropicrin, methyl bromide)
Class A - highly poisonous preparations
Class B - poisonous preparations
Class C - non or least poisonous pesticides (eg phenoxyacids, linuron, diuron etc)

The Poisons Board clears specified formulations, for certain uses, which are controlled by law.

The Chemical Control Institute checks the method of analysis of a manufacturer and during the life of a product carries out sampling of commercially available products to see that they comply with the registered use and the contents declared on the label.

The approval of a product is voluntary. If a manufacturer or distributor wishes to seek approval he applies to the Danish State Experimental Service who will test the product on a fee paying basis. Regulations state the conditions under which a chemical is tested and the minimum requirement for approval.

The Irish Republic

(Fig. 3)

In the Irish Republic one is faced with quite the reverse situation to that in Denmark.

The Safety requirements of the public are controlled by the Ministry of Health under the Poisons Act. There are no specific regulations for the agricultural clearance of pesticides as a whole and no approval organisation. Research on pesticide use is carried out by the state research institutes and the results are embodied in the advice given to growers.

The United Kingdom

(Fig. 4 and 5)

The situation in Britain is that certain pesticides are listed as poisons and statutory regulations cover their handling, use, packaging and labelling. All other pesticides are dealt with on a voluntary basis.

The registration authority in the United Kingdom comprises the Pesticides Safety Precautions Scheme and the Agricultural Chemicals Approval Scheme of the Agricultural Departments. The former scheme involves the notification and clearance for use of specified formulations of a chemical. This process is mainly concerned with toxicology, environmental safety aspects, crop residues and harvest intervals. Trials and limited clearance are granted in order that the evaluation of the compound can be carried out. Provisional Commercial clearance is granted when all major requirements are satisfied but further information is required on minor points. Full commercial clearance is eventually granted when all the needs of the Safety Scheme have been satisfied.

After clearance under PSPS a product can be submitted for approval under the voluntary Agricultural Chemicals Approval Scheme. For this purpose the Agricultural Chemicals Approval Organisation is empowered by Ministers of the Agricultural Departments to grant approval on their behalf to proprietary brands of agricultural chemicals for which there is adequate evidence of efficiency. This evidence will be obtained from laboratory and/or field trials, supported where appropriate, by data gained from the practical use of the product under consideration. Wherever possible the manufacturers trials are assessed together with the independent work from the State research institutes and advisory services, although this is not a condition of approval.

No fees are charged for notifications under the PSPS but for each application under the ACAS fees are charged according to a prescribed scale. A certificate of approval is granted for each product approved under the Scheme; and the container of each approved product bears an identification mark, known as the Approval Mark, (a crowned A) and the registered number.

Fig. 1

The Danish Regulatory Scheme

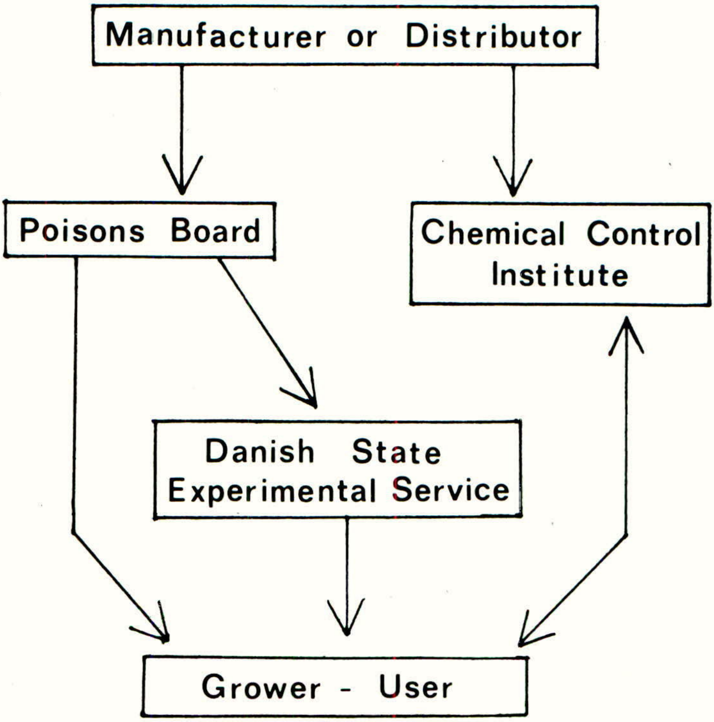

Fig. 2 Representation of the Programme for the Registration and Approval of a Herbicide in Denmark

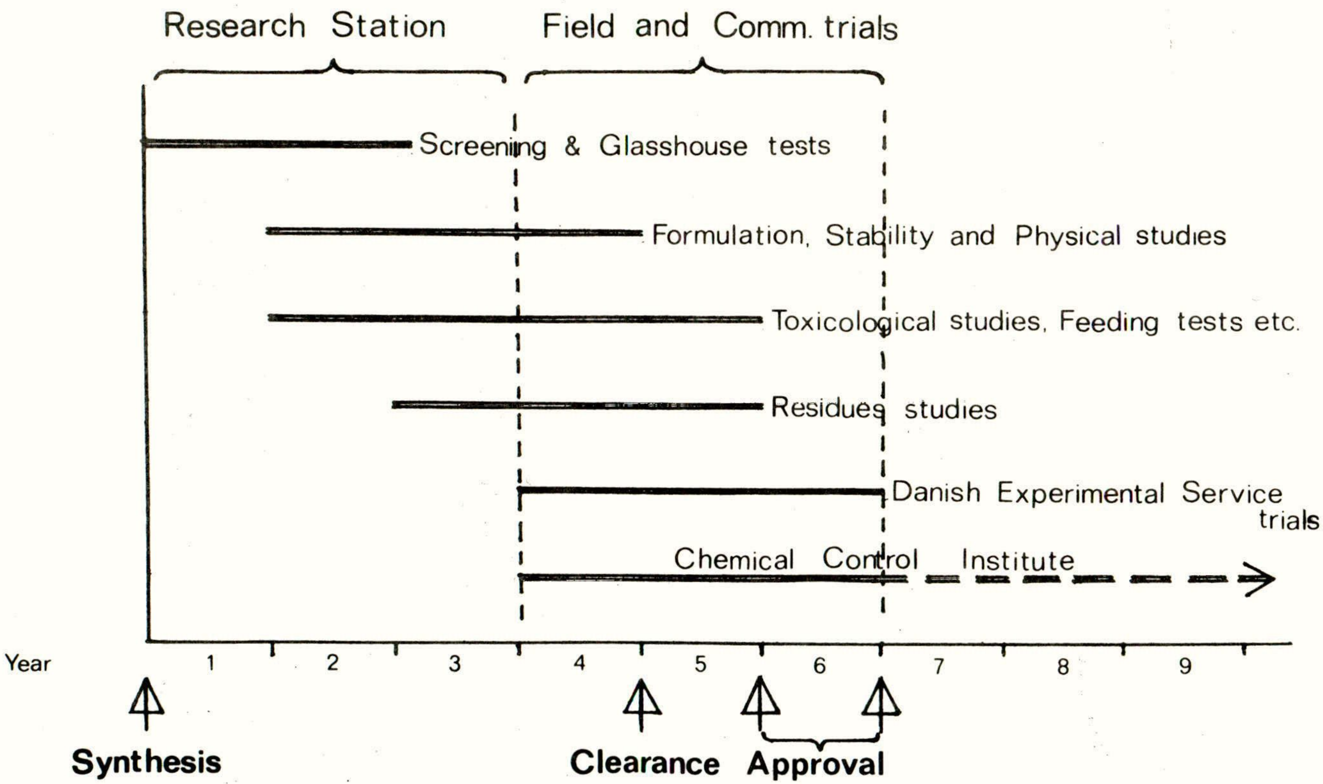

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Fig. 3

The Regulatory System in the Irish Republic

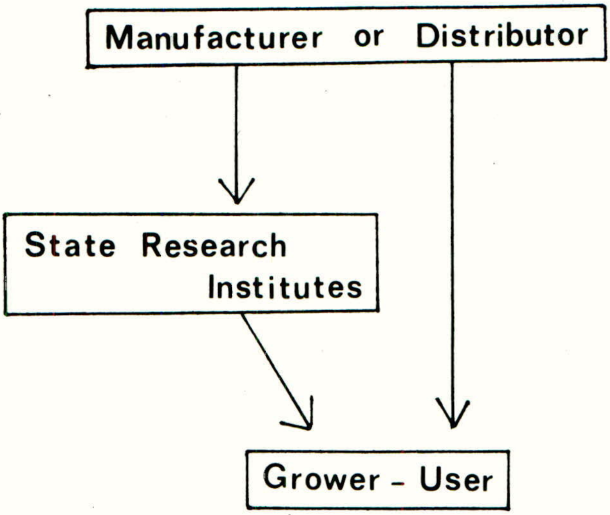


Fig. 4

The Regulatory Schemes in the United Kingdom

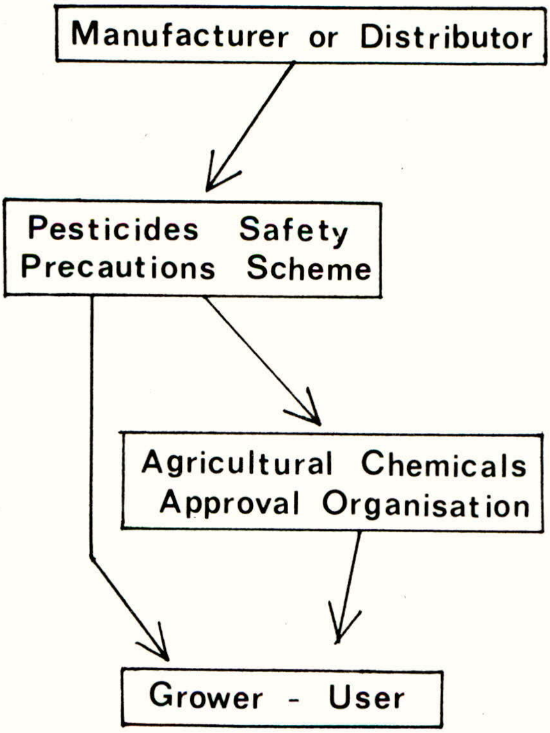
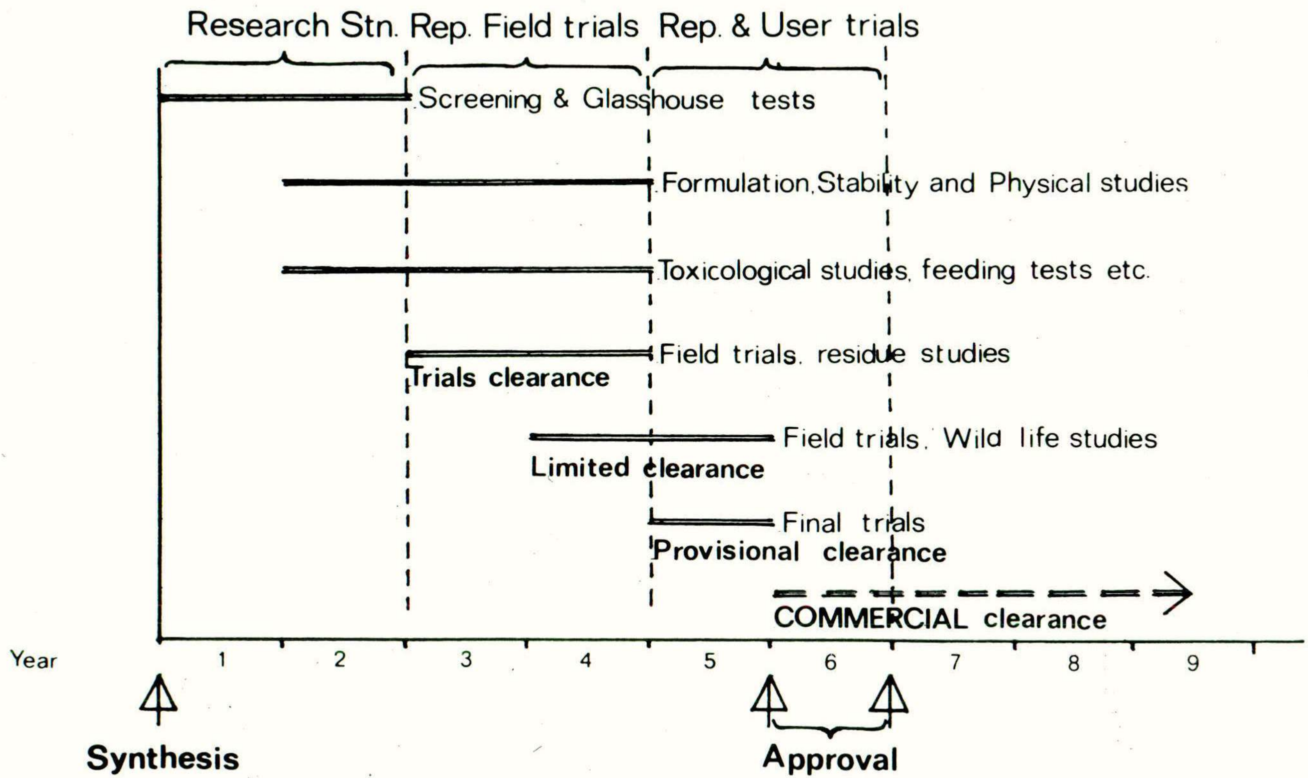


Fig. 5 Representation of the Programme for the Notification, Clearance and Approval of a Herbicide in the United Kingdom



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CONSEQUENCES OF BRITAIN'S ENTRY INTO EEC

CONTRIBUTION OF THE COUNCIL OF EUROPE

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Summary For some years now the Council of Europe has provided a valuable international forum for open discussion by official scientists of problems surrounding the manufacture, safety clearance and use of pesticides. Occasionally projects initiated by the Council of Europe have been handed over to other organisations with wider international remit. Recommendations and other publications arising from those projects which have been fully discussed within the Council of Europe have frequently been utilised by the European Economic Community as a starting point for community regulations or directives. The Council of Europe attempts to liaise with all groups and organisations interested in matters on its programme of work which is aimed at greater European unity.

GENERAL INFORMATION

The Council of Europe was founded by ten nations on 5 May 1949 as Europe's first political institution with the first international parliamentary forum in history. It's aim is to achieve a greater unity between its Members to safeguard their European heritage and to facilitate their economic and social progress.

The aim of the Council is pursued through discussion and common action in economic, social, cultural, educational, scientific, legal and administrative matters and in the maintenance and further realization of human rights and fundamental freedoms.

The following 17 countries are members : Austria, Belgium, Cyprus, Denmark, France, the Federal Republic of Germany, Iceland, Ireland, Italy, Luxemburg, Malta, Netherlands, Norway, Sweden, Switzerland, Turkey and the United Kingdom. Each member state contributes to the Council's budget in accordance with the size of its population.

The organs of the Council are the Committee of Ministers, consisting of the Foreign Ministers of member countries; the Consultative Assembly of 140 members, elected or chosen by the national parliaments of member countries in proportion to the relative strength of political parties and the joint Committee of Ministers and Members of the Assembly.

The Committee of Ministers is the executive organ of the Council. Its conclusion may take the form of international conventions or of recommendations to Governments. On major matters the Committee votes by unanimity. Nevertheless, abstention is permitted and decisions of the Ministers may then take the form of partial agreements. The Ministers may meet at the level of Deputies empowered to take all decisions which they do not wish to reserve for Ministers of Foreign

Affairs. Since 1952, member governments have accredited permanent representatives to the Council in Strasbourg and these Representatives combine their task with that of the Ministers' Deputies.

The Committee holds organized political consultation in the light of recommendations received from the Assembly. The Consultative Assembly may debate all matters with the exception of defence. Its findings may take the form of recommendations addressed to the Committee of Ministers. Ministers, including Ministers other than those for Foreign Affairs, may address the Assembly and take part in its debates.

The Assembly also debates reports received annually from the OECD, other European organisations, and the specialized agencies of the United Nations. It holds an annual joint meeting with the members of the European Parliament of the 'Six'. The Joint Committee permits the Ministers and the Assembly to discuss matters of mutual interest and endeavours to achieve harmony where doubt exists. It acts by consultation and not by vote.

Among the principal achievements of the Council of Europe are the European Convention on Human Rights, 1950; the European Cultural Convention, 1953; and the European Social Charter, 1960. Other conventions cover social insurance, equivalence of European diplomas for university entrances, equivalence of University degrees, public health, patents, travel without passports, hotel-keepers' liability, extradition, etc. Over 50 conventions and agreements have been concluded.

In May 1966, the Committee of Ministers unanimously approved a new programme of work for the Council of Europe. This programme represents an attempt to relate the inter-governmental work of the Council more closely to the Organization's statutory aim - greater European unity. It takes the form of a list of about 250 precise projects. It thus provides a guide to the Council's inter-governmental work for national administrations, international organizations and other interested circles. The Secretary-General submits a revised version to Ministers each year.

PARTIAL AGREEMENTS IN SOCIAL AND PUBLIC HEALTH FIELDS

As stated above, where a lesser number of states wish to engage in some action in which not all their European partners desire to join they can conclude a 'partial agreement' which is binding on themselves alone. It was on this basis that the Partial Agreement in the social and public health field was concluded under Resolution (59) 23 adopted on 16 November 1969 by the Council of Europe Ministers Deputies.

The Partial Agreement in the social and public health field deals with the earlier activities of Western European Union now being carried out within the framework of the Council of Europe by Governments of the following member States : Belgium, France, the Federal Republic of Germany, Italy, Luxembourg, the Netherlands and the United Kingdom of Great Britain and Northern Ireland. Since then, Governments of other member States of the Council of Europe have joined in certain of these activities: namely, Switzerland, Denmark and Ireland for public health questions; and Austria for social and rehabilitation questions.

The Partial Agreement in the social and public health field acts through the following bodies :

1. Social Committee (PA)

1(a) Subcommittee on Industrial Safety and Health (Engineering Questions)
1(b) Subcommittee on Industrial Safety and Health (Chemical Questions)
1(c) Working Party on Vocational Information and Guidance for Young People

2. Public Health Committee (PA)

2(a) European Pharmacopoeia Commission and 19 Groups and Sub-Groups of Experts
2(b) Subcommittee on Pharmaceutical Questions
2(c) Subcommittee on Poisonous Substances in Agriculture
2(d) Subcommittee on the Health Control of Foodstuffs
2(e) Working Party on Cancer Statistics
2(f) Group of Experts on questions arising from the implementation of the Administrative Arrangements for the Health Control of Sea, Air and Land Traffic
2(g) Group of Experts on the Definition of Congenital Malformations
2(h) Working Party to Study Hereditary Metabolic Diseases

3. Joint Committee on the Rehabilitation and Resettlement of the Disabled (PA).

A very close link exists between the Subcommittee on Poisonous Substances in Agriculture - and the Subcommittee on Industrial Safety and Health (Chemical Questions).

SUBCOMMITTEE ON POISONOUS SUBSTANCES IN AGRICULTURE

This Subcommittee was originally a Working Party, set up in 1956 by the Subcommittee on the Health Control of Foodstuffs of the Western European Union, to study the risks to human health arising from the use of pesticides in agriculture and food storage, and to make recommendations. In 1960 these activities were transferred to the Council of Europe under the "Partial Agreement" arrangement and the countries at present participating are Belgium, Denmark (sent an observer to meetings since 1961, but became a full member in 1964), Federal German Republic, France, Ireland, Italy, Luxembourg, Netherlands, United Kingdom and Switzerland. In view of the growing importance of the studies entrusted to it, the Working Party was converted, in April 1965, into a Subcommittee. In 1962 the Working Party published a progress report of its work entitled "Agricultural Pesticides". Up to the time of publication of the report, the Working Party's studies covered :

(a) the collection of information concerning the practices followed in member countries on :- (i) the safe use of pesticides. (ii) the methods of residues analysis.

(b) the preparation of :- (i) summary data sheets on selected pesticides. (ii) guidance documents for manufacturers on information required on pesticide residues and toxicity. This report included specimens of summary data sheets and the 2 guidance documents mentioned above.

Since then the Subcommittee has considered other aspects of the safe use of pesticides. The study of residues in cereals has resulted in the Subcommittee making specific recommendations. The recommendations AP(64)I (which are currently being revised) have been submitted to governments for consideration of adoption into their national practices. Similar studies on other commodities (eg edible nuts and oil seeds) have also been made.

Studies on toxicity assessment of selected pesticides have resulted in the Subcommittee arriving at maximum daily acceptable intake figures for a number of pesticides, but these figures have not been made public. As these studies were later taken up by the Joint Meeting of the FAO Working Party of Experts on Pesticide Residues and the WHO Expert Committee on Pesticide Residues the Subcommittee has directed its studies to other aspects of pesticide residues.

It has also made a study of the principles and procedures for the toxicity classification of pesticides and this has resulted in the publication of Resolution AP(71)4 "On The Classification of Formulated Pesticide Products" which member countries could consider adopting into their own national practices.

In 1968 the Public Health Committee interpreted the Subcommittee's terms of reference to include the examination of the following items and these subjects are currently on the Subcommittee's agenda.

1. The use of pesticides in livestock premises.

2. Pesticide residues in feedingstuffs intended for cattle, in so far as these chemical substances might then be transmitted to animal products intended for human consumption.

3. Pesticides used both in agriculture and non-agricultural situations.

The second edition of the booklet 'Agricultural Pesticides' published in 1969 concentrated on "the guidance to industry" aspects and omitted reference to data sheets which were then being published in the reports of the Joint Meetings of the FAO Working Party of Experts on Pesticide Residues and the WHO Expert Committee on Pesticide Residues. The Subcommittee also felt that the residue analysis aspect was being dealt with adequately by other international organizations such as the FAO Working Party on Pesticide Residues and the European Economic Community, who were recommending methods at an international level.

In concentrating on the guidance to manufacturers, the Subcommittee regarded labelling as the best means of informing users how to use pesticides safely and further agreed to include in the 1969 edition a chapter on "guidance for the safety labelling of formulated pesticides". This guidance was the result of a study carried out since 1962 in collaboration with the Subcommittee on Industrial Safety and Health (Chemical Questions).

The Subcommittee feels that the revised edition gives pesticide manufacturers useful guidance in preparing data for presentation to the authorities in support of applications for the safety clearance of new products. A further revision is being carried out at present, mainly to reflect current official thinking on safety criteria but also to introduce a section on the toxicity classification of pesticides which covers the recommendations in Resolution AP(71)4. This classification has been adopted by WHO as part of its recommendations on classification to the United Nations Committee of Experts on the Transport of Dangerous Goods and it will be used as a basis for discussion for further Regulations in the United Kingdom under the Farm and Garden Chemicals Act 1967.

SUBCOMMITTEE ON INDUSTRIAL SAFETY AND HEALTH (CHEMICAL QUESTIONS)

The early studies of this Subcommittee, originally an organ of the Brussels Treaty Organization, were carried out in the light of initial work by the International Labour Organization. In 1950, the Chemical Industry's Committee of the ILO had adopted a resolution on the classification, labelling and international safety symbols for dangerous, harmful and toxic chemical substances.

In 1955, the Social Committee of the Brussels Treaty Organization published, in English and French, a list of toxic and dangerous chemical substances and proposals concerning their labelling, using the symbols proposed by the ILO Chemical Industry's Committee, including a skull and crossbones and a St Andrew's Cross for toxic and harmful substances. A subsequent edition was published in 1958 under the auspices of the Western European Union, successor to the Brussels Treaty Organisation. It was in five languages and included new danger symbols for explosive, radio active and irritating substances and distinguished between flammable and oxidising substances. In 1960 when the social and public health activities of the Western European Union were transferred to the Council of Europe, the Subcommittee pursued its work under the "Partial Agreement" arrangement. The list of substances was then published in 1962 as the first edition of what is now generally known as the "Yellow Book" and this dealt with the danger symbols applicable to some 500 substances. The third edition of the "Yellow Book", published in 1971, covers over 600 substances, the majority of them pesticides. Work is in hand at present on the 4th edition which will contain some 300 new substances, revised and shortened risk phrases and security clauses and additional information of the physical, chemical and biological properties of the substances. The text of the "Yellow Book" has been adopted by the European Economic Community and forms the basis of the EEC directive on the 'Classification, Labelling and Packaging of Dangerous Substances'.

The main comments on the earlier editions of the "Yellow Book" concern the divergencies between it and international regulations on the transport of dangerous materials. During the past year consultation on harmonization of danger symbols in labelling has been wide and intense and there is at present a certain amount of optimism that agreement will be reached on the fundamental principles of classification and labelling of dangerous goods. The Subcommittee has been considering a further exercise on allocating danger symbols to formulations as well as the pure and technical materials currently covered in the "Yellow Book". As far as pesticides are concerned there will be close co-operation between this Subcommittee and the Subcommittee on Poisonous Substances in Agriculture in all future studies on this subject.

EUROPEAN COMMITTEE FOR THE CONSERVATION OF NATURE AND NATURAL RESOURCES

This Committee was created in 1962 under the title Committee of Experts for the Conservation of Nature and Landscape on a recommendation of the Consultative Assembly and reports direct to the Committee of Ministers. It has appointed several Working Parties and ad hoc study Groups, one of which, the ad hoc Group on Pesticides was set up in 1966. Its terms of reference were : to assess the dangers to wildlife arising from the widespread use of pesticides and to consider the means of eradicating or substantially reducing these dangers, taking account of the relevant work of other agencies, in particular :

1. to specify the scientific and technical bases upon which adequate control from the wildlife point of view can be achieved over the testing, marketing and use of pesticides.

2. to draw up a list of pesticides whose toxicity, selectivity and/or persistence is such that special measures of control are necessary to safeguard wildlife.

3. to report accordingly to the parent committee including the essential measures for any European Code of Practice.

The principal achievement of this Study Group is the Council of Europe Resolution (70) 24 "On the regulating, the manufacture, marketing and use of pesticides with a view to the protection of the environment". The appendix to this Resolution lists some general principles which it was felt should ensure that pesticides cleared by any national government would fully take into account the possible effects on the environment and make adequate provision in legislation or by other arrangements for the protection of the environment.

One of the articles recommends governments of member states (17 countries) to support the booklet produced by the Partial Agreement Committee, thus opening the door for a wide acceptance of the guidance on registration requirements.

COLLABORATION WITH INDUSTRY

The Council of Europe is an intergovernmental body supported by Government funds. Delegations to Council of Europe meetings, therefore, are official representatives of the countries concerned. In the past it was not possible to formally consult the Pesticide Industry on matters discussed at Council of Europe committees, although some national delegates would obviously be aware of the views held by their national manufacturers associations. Recently, however, the association of European manufacturers of pesticides, GEFAP has been asked for its views on various aspects of the work of the Subcommittee on Poisonous Substances in Agriculture and these have been taken into account in subsequent Committee discussions. GEFAP representatives have in fact attended meetings of the Working Party on the revision of the booklet 'Agricultural Pesticides'. Liaison between officials and Industry can be at two levels. Firstly, at a national level between the national official representatives and the national associations and secondly at an international level between Council of Europe and GEFAP. Precedent has now been set for consultation at both levels and it is hoped that the exchange of views will be mutually valuable.

REFERENCES TO COUNCIL OF EUROPE PUBLICATIONS

1969	Agricultural Pesticides 2nd Edition
1971	Dangerous chemical substances and proposals concerning their labelling 3rd Edition
Resolution AP (64) 1	On the importation of cereals treated with pesticides
Resolution (70) 24	On regulating the manufacture, marketing and use of pesticides with a view to the protection of the environment
Resolution AP (71) 4	On the classification of formulated pesticide products

CONTRIBUTION OF EUROPEAN WEED RESEARCH COUNCIL AND EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION TO THE HARMONIZATION OF THE CONTROL AND REGULATION OF HERBICIDES

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INTRODUCTION

At the 7th British Weed Control Conference in 1964, Prof. W.R. Furtick contributed at the banquet the story of a beauty queen. She was invited to demonstrate her intelligence by answering a supposedly very difficult question put to her by an international jury. I shall not repeat the entire story, but the situation she was suddenly supposed to be in was described as a South Pacific island, populated by thousands of marooned marines not having enjoyed the presence of pretty female company for many months. The beauty queen was invited to describe to the jury her reaction to that probably unfamiliar situation. But her much looked forward to statement was quite unexpected: Yes, she understood the situation very well, but would the jury please state the problem more clearly ?

I was reminded of this story when asked to contribute to this session on the consequences of Britains entry into EEC. The situation is quite clear to most of us but is there really a problem ? Or is there first of all and above all a new situation, a challenge that in the sense of our discussion does not require a problem analysis, but an analysis of new horizons, new vision possible ? Realism will force us, of course, to accept both viewpoints, although personally I am tempted to place more emphasis on the challenging aspects of the situation. I hope this attitude will become clear to you from this contribution.

CHARACTERIZATION OF THE TWO ORGANIZATIONS

In order to appreciate the nature and the extent of the contribution the European and Mediterranean Plant Protection Organization (EPPO) and the European Weed Research Council (EWRC) can give to harmonization of control and regulation of herbicides it seems appropriate to present some information on their structure and organization.

EPPO is an intergovernmental organization specialized in plant protection. It is basically not a research organization, although highly qualified officials represent their countries on EPPO, and participate in the activities. The objectives of EPPO are of two kinds: phytosanitary and phytopharmaceutical. Since its establishment the phytosanitary task has been the primary one: to advise and to assist member governments with respect to the introduction and spread of plant diseases and pests, to co-ordinate campaigns, exchange information on national phytosanitary legislation and establish a documentation service.

The phytopharmaceutical objectives have become emphasized more recently. This is due to requests from member countries for guidelines on important phytopharmaceutical issues in order to promote a common approach in these matters. Also the possibility of conflict between phytosanitary and phytopharmaceutical regulations has stimulated EPPO to consider activities in the phytopharmaceutical field. A Working Party on Pesticides for Plant Protection has now been formed, this Working Party will be discussed in more detail later in this contribution.

The "Convention for the establishment of the European Plant Protection Organization" was signed in 1951 by the representatives of 15 countries. Now 32 countries are members of the Organization which has also added "Mediterranean" to its title.

Unlike EPPO, EWRC is not an official governmental organization. It has a professional scientific status. The objectives of EWRC are to promote the exchange between the European countries of information on weeds and on their control, to promote weed research and the development of practical and acceptable weed control methods. The structure of EWRC is still evolving. The basic function is to act as a contact body. The weed scientists in each country, preferably organized in a committee, society, working group or similar organization delegate one member to the Council whose job is to liaise with the other members and to arrange national co-operation in co-ordinated European activities.

EWRC originally started as the International Working Group for Weed Research in 1959 and was officially established in 1961. 28 countries are now represented on EWRC.

COMMON CHARACTERISTICS OF EPPO AND EWRC

After this admittedly sketchy presentation of the main characteristics of the two Organizations we can summarize what EPPO and EWRC have in common.

The first interesting common element is that "Europe" in the names of EPPO and EWRC is a much less restricted term than "Europe" of the EEC. Our Europe is the geographical concept, even slightly enlarged with neighbouring Mediterranean countries. We consider this a fortunate situation. Any activity, common action, guidelines or recommendations are therefore automatically considered at many national levels.

The second item of common interest to EPPO and to EWRC is of course herbicides, in EPPO as part of the general phytosanitary objectives, in EWRC as one very important aspect of weed science and practical weed control technology.

REASONS FOR INTEREST IN THE CONTROL AND REGULATION OF HERBICIDES

Before discussing where and how EPPO and EWRC began to associate it is desirable to look into the interests of the two Organizations in the control and regulation of herbicides.

Most of the Plant Protection Services and Phytopathological Institutes co-operating in EPPO are nationally charged with the technical evaluation of herbicides for approval purposes. In practice this means the approval of claims made by industry. Generally the point at issue is not the chemical or its formulations but the specific uses of the proprietary product as indicated by clear label instructions. In many countries the safety aspects of application are the responsibility of other government authorities. In a few countries considerations with respect to herbicides approval have not been delegated to the authorities representing their countries on EPPO. This situation could be changed, however, if it were desired.

As far as approval of efficacy is concerned, EPPO hopes to work out guidelines for its member countries in order to promote common approaches. This is an important function of EPPO.

EWRC, being a non-governmental professional scientific organization does not and will never have any regulatory status or objectives. In this connection its only aim is to promote the professional competence of weed research workers engaged in field approval studies whether these have a regulatory basis or not. EWRC has an interest in the scientific soundness of the criteria used in regulatory activities and therefore in the exchange and discussion of information on research methods applied in this work. The official presentation of criteria as regulatory guidelines is not therefore the responsibility of EWRC. In the present situation it is clear that the preparation and distribution of such guidelines can best be handled through an international governmental organization in which the official national authorities are co-operating, such as EPPO.

EPPO WORKING PARTY ON PESTICIDES FOR PLANT PROTECTION

This Working Party was formed in 1971 in order to allow EPPO to give recommendations to its member countries on common approaches with respect to minimum requirements for pesticide approval. Further to achieve active collaboration between member countries in order to promote the development and use of a comparable and acceptable approach in the biological evaluation of agricultural pesticides for registration and approval. Exchange of information on existing regulations and the reporting of special problems encountered in plant protection arising from the use of pesticides are other objectives of the group.

The Working Party has set up 4 expert panels for the various groups of pesticides: insecticides etc., fungicides, rodenticides and herbicides. For herbicides the existing Committee on Evaluation of Herbicides of EWRC, demonstrated a very healthy activity when the work of the EPPO Working Party started. Under the chairmanship of Prof. J. Stryckers the officials charged in the various countries with the approval of herbicides and other official research workers interested in the development of new herbicides exchanged information on these matters. This EWRC Committee now functions as the EWRC-EPPO Commitee on the Biological Evaluation of Herbicides, a joint committee reporting to EPPO and to EWRC. The other panels are for the Biological Evaluation of Insecticides, Acaricides, Nematicides (co-ordinator Dr. W. Herfs of Federal Germany), the Biological Evaluation of Rodenticides (co-ordinator Dr. A. Myllimäki, Finland) and for the Biological Evaluation of Fungicides (co-ordinator Mr. H. Bouron of France).

At the last meeting of the Working Party the following conclusions and recommendations resulted from the discussions: the Panels were urged to give first priority to the establishment of standardized testing methods (guidelines for experiments) and to establish through their members contacts with the national associations of pesticide manufacturers and other interested national organizations for the exchange of views on evaluation methods to be submitted to the respective panels. It was agreed that before methods submitted by the Panels were approved by the Working Party it would discuss them with the International Association of Pesticide Manufacturers (GIFAP).

The Panels were also urged to consider possibilities of establishing common rules or simplified procedures for assessing the acceptability on the basis of comparable biological evaluation of products already officially tested in other countries. The Working Party recommended that EPPO should develop a documentation and information system similar to that which is in operation for the phytosanitary regulations of its member countries.

The EWRC-EPPO Committee on the Biological Evaluation of Herbicides, adapting itself to the new structural situation in relation to the EPPO Working Party, met earlier this year and agreed to form an ad-hoc working group on field methods for the approval of herbicides. This ad-hoc group will consider the many comments received from the various European countries on the "Guide-lines for testing herbicides" and "The Scoring Scheme 1-9" prepared by the former EWRC Committee on Methods, under its chairman Dr. H. Johannes. Another ad-hoc working group will start to look into laboratory techniques that can be recommended in approval studies.

REPRESENTATION OF THE UNITED KINGDOM IN EPPO AND EWRC

The United Kingdom is represented on EPPO by Dr. M. Cohen, the Director of the Plant Pathology Laboratory at Harpenden.

The representation of the U.K. on EWRC is through the British Crop Protection Council. We are very fortunate that in this way the interests and research of both Government and Industry are linked to the activities of EWRC. Mr. J.D. Fryer, the Director of the Weed Research Organization at Oxford and vice-President of EWRC, is the U.K. representative on EWRC.

On the Joint EWRC-EPPO Committee on the Biological Evaluation of Herbicides Mr. R.J. Makepeace of the Agricultural Chemicals Approval Organisation represents the U.K.

THE NEW SITUATION, A CHALLENGE

From what has already been said it will be clear that as far as herbicides and field approval are concerned the entry of Britain into EEC has been anticipated by the EPPO/EWRC association and the links with the British organizations and institutes are well established.

Within EEC I think there is progress towards greater uniformity in pesticides regulation. This is at a rather more advanced stage within Benelux and is likely to continue. The EPPO/EWRC co-operation should make a contribution to such progress.

The entry of Britain into EEC and its active participation in discussion and decision making is likely to stimulate the co-operative work of EPPO and EWRC with, it is hoped, mutually beneficial results.

It is for all of us engaged in the herbicides field to do all we can to speed this progress.

THE NEED FOR IMPROVED WEED CONTROL ON PEASANT FARMS - AN ECONOMIST'S VIEW

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Summary While the economist looks for substantial increases in land productivity by more intensive practices, the peasant is concerned with returns per unit of human energy expended and the extensive cultural practices which this implies. New weed control methods do not begin to make much impact in small-scale tropical farming therefore until there is an absolute shortage of human labour. Nevertheless, the demand for suitable herbicides as economic alternatives to hand labour is apparent from their selective use, not only in such situations as the wet paddy production areas of Thailand, but also in areas typical of the corn growing highlands of southern Mexico where peasants work with hoes and the techniques of slash and burn agriculture; the cost of spraying with herbicides is seen to be close to the cost of hoe weeding on recently cut fields. In the light of evidence that non-labour inputs of agro-chemicals are more readily applied by peasant producers who have access to considerable income from non-farm sources, the economist may be right in arguing that the use of herbicides is constrained by inadequate credit. Much of the cause of the low levels of tolerance of risk among peasant producers is, however, in the paucity of technical improvements available to them which can ensure substantially higher output from agriculture. So long as the use of herbicides for weed control remains costly and complicated, the peasant has no real option open to him. Failure to recognise the research needs in bridging this gap leads to the conclusion that the use of herbicides in tropical agriculture should not be regarded as a routine measure to replace labour, but as a supplement to human labour. Meanwhile, the current trend towards expansion of agricultural colonizations requires that weed-killers are available which are economic alternatives to hand labour; this is because recruitment is directed principally at the younger men in the economically active age group who have not an abundance of manual labour available to meet the crucial demands of time and intensity of weeding operations - especially in programmes for multi-cropping which are invariably associated with water resource development.

INTRODUCTION

What has to be recognised in any study of weed control on peasant farms is that benefits differ according as to whose point of view is being expressed. The economist is concerned with profitability; the peasant is concerned with returns per unit of human energy expended and, in his world, yields per unit of area are by no means all important.

The peasant makes his value judgements on the basis of his experience of traditional practice in which high intensity of production rarely leads to low labour costs - that is to say, high rewards per hour of labour input. Nevertheless, labour in the busiest period soon after the rains begin, and during the first weeding particularly, has opportunities of being much more productive than labour at other seasons. Furthermore, family labour is almost the only input at near-subsistence levels of production.

Table 1

Non-labour inputs as a percentage of total output

	Date of records	Cost of non-labour[a] inputs as a percentage of the value of output
Hand-hoe and cutlass[b]		
Ghana (Battor)	1964-65	3.6
Ox-plough cultivation[c]		
Philippines (Mindanao):		
Upland farming	1970-71	0.87
Lowland farming	1970-71	1.21

[a] Labour includes both human and animal labour
[b] Rowena M. Lawson (1972), p.41
[c] Margaret Haswell, unpublished data

Lawson observes that the figure for Battor is considerably higher than that of most other West African countries; however, records kept of all other inputs showed that these were mainly accounted for by the cost of implements, seeds, and planting material, and that they were not for agrochemicals. Lawson collected data first in 1954, and again over the period 1964-67.

What emerges as of special significance is that 10-14 year old children contributed some 5 to 7 per cent of aggregate agricultural production in 1954; the introduction of compulsory education in 1960 therefore, required an increase of at least 7 per cent in the labour productivity of adult farmers to compensate for the loss of child labour. Apparently only about 6 per cent has been achieved, and this not through any improvement in techniques, but by a slightly higher labour input indicating surplus capacity among adults in farm family households.

The role played by child labour on peasant farms is borne out by a survey of labour requirements in Gambia village (Haswell, 1953) in which children supplied some 10 per cent of weeding hours, and 7 per cent of total hours in the hand-hoe production of all crops grown.

THE PRIORITIES: PEASANT v. ECONOMIST

The composition of the family labour force directly influences the behaviour of peasant farmers at all levels of agricultural production activity in early stages of economic development. But it is the prospect for substantial increases in land productivity by applications of industrial inputs which preoccupies the economist.

Nakamura, in a study of the movement of herbicides in Japan, draws attention to the labour required for weeding in the production of paddy rice - which, together with wheat, forms the staple diet of some 80 per cent of the world's population. Around 1949, he states, before the use of herbicides had become popular, 506 of the average number of man hours employed in the cultivation of one hectare of paddy were used for weeding. By the latter half of the sixties, the adoption of new techniques had reduced weeding time from 506 to only 164 hours, and total time to 747 hours - an overall decrease of 67.6 per cent though the proportion of time devoted to weed control remained virtually unchanged at a little below one-quarter of total human labour requirement. In fact, this reduction was by no means simply a function of the use of herbicides. Other inputs have been crucial in the control of weeds - notably the use of a manually-operated rotary weeder with teeth and tines as a mechanical aid to the removal of weeds by hand. Nevertheless, about 80 per cent of all farming families are now using herbicides on irrigated paddy according to Nakamura, although no evidence is presented of any yield increase resulting from the use of herbicides in paddy fields. But Japan has already shown the highest world consumption of fertilizing elements ($N + P_2O_5 + K_2O$) per hectare of arable land; and Chemical Week (March 15, 1972) recorded that her pesticide output 'has levelled off in the last few years reflecting weakness in the home market ... Japan's herbicide output, however, rose 23.5 per cent in 1970 and is expected to continue increasing rapidly, spurred by a shortage of agricultural labour'.

Her relatively close neighbour, Thailand, however, lags well behind in the efficient use of herbicides as supplements to human labour. A survey carried out in the Chao Phya delta area of the Central Plain from May 1968 to May 1969 by NEDECO for the Royal Irrigation Department, showed that peasant farmers are well aware of the problem of weeds, and that they do not practise hand-weeding 'because it requires too much labour'. Their first method in the paddy fields is to try to suppress weeds by means of the water table; but as the water supply is not fully controlled, this method is not fully effective. Therefore herbicides are used; but these also are not fully effective, for spraying is delayed because of the peak labour requirements for field preparation and transplanting. Furthermore, the farmer tries to economise on the use of herbicides by spraying only on those spots where excessive weed growth occurs. The result is a relatively large number of low-yielding fields, the most affected of which are those which suffer most from water shortage, 'often occurring in the period just after transplanting. Under such conditions weeds will grow abundantly and are difficult to control. The only way,' the investigators conclude, 'is to weed by hand which is, however, not done by the farmer.'

Although it is generally considered that the use of herbicides is more likely to be an economic proposition in wetter regions, many cultivators are using herbicides even among extremely low-yielding hill paddy farms. In the afforested Fourth Division of Sarawak, an area accessible only by river craft, traditional practices persist even under conditions where the composition of the family labour force has been affected by out-migration. The forest continues to be cleared by axe and fire and planted to hill paddy for one or two years. Invariably, however, an unmanageable size of plot is cleared, and the cultivator finds he simply cannot keep up with the heavy weeding operation which follows without access to an abundance of hired labour. There is recent evidence of purchases of herbicides by numerous cultivators - one or two bottles which when diluted the cultivator applies by walking over the area selectively treating patches while the hand weeding of untreated areas proceeds alongside; but herbicide dosages are in fact too low to take much of the drudgery out of the task. Higher dosages would require a higher cash outlay, however, and cultivators try to avoid participation in credit markets to gain access to industrial inputs.

In a study of economic change among Maya Indians in the highlands of Chiapas in Southern Mexico, who work with hoes and the techniques of slash and burn agriculture to produce the major part of their families' food, Frank Cancian (1972) writes that 'for most farmers, weeding is the biggest job of the agricultural cycle. And it is the step that limits the amount a man can seed, since the first weeding must be completed early in the season, before weed competition hurts the corn.' He observes that some farmers have recently begun to use chemical weed killers which are effective for broadleaf plants; but, because of their limited knowledge, many of them 'lost their crops while waiting for the weed killer to work on old fields where grasses were the principal competition for the corn'. He found one hand-sprayer owner, however, who contracts to do the work of spraying at a cost which, as shown in Table 2, is 'much lower than the cost of weeding with a hoe on most fields; but it is close to the cost of hoe weeding on the recently cut fields where weed killers are most effective'.

Table 2

Comparative cost of weeding with a hoe[a] and spraying with chemicals in forest clearings

1965

		Man-days per hectare	Mexican pesos $ per hectare
Spraying with weed killer under contract (including all costs)		3	88.2
Hired labour cost of removal of weeds by hand hoe			
(i) Old fields:			
1st weeding	17		
2nd weeding	12	29	208.2
(ii) Recently cut fields:		9	64.6

[a]Calculated from data recorded by Frank Cancian (1972)

Ruthenberg (1971) attempts an analysis of labour input in typical African savannas which indicate important differences between shifting and semi-permanent systems. The emphasis changes from chemicals to reliance on animal power and traction power when a fallow vegetation of grass dominates and fields have been de-stumped. But, as he points out with respect to cotton in Sukumaland, the labour economy of ox-plough over hand-hoe methods in cultivation may be cancelled out by the greater work required for weeding; the cause of the heavier work load he states to have been failure to combine the ox-drawn weeder with ox-ploughing. The great reduction of labour input in groundnut cultivation in Senegal stems from this combination.

As is well known, within irrigation farming labour input tends to rise with increasing availability and reliability of water; but it is the disproportionate rise in labour input as multiple cropping increases that precipitates the need to make use of chemical herbicides. Dalrymple (1971) refers to the time factor in weeding which is greater than for any other operation in multiple cropping; but chemical control he sees as costly and complicated. Importantly, however, a feature of irrigation farming and the concentration of production in a small area which is worked with a high cropping intensity, is that households invariably have some additional non-farm income; and there appears to be some correlation between non-farm income and preparedness to take on the risk of borrowing additional working capital for industrial inputs associated with intensive cultivation.

Table 3

Labour inputs for selected crops

	Crop	Date of records	Weeding hours	Total hours	Weeding hours per cent of total hours
			per hectare		
'Dry' farming					
Hand-hoe:					
Senegal	Groundnut	1966	376	755	49.8
Tanzania	Maize-sorghum	1963	250	940	26.6
Tanzania	Cotton	1963	430	1490	28.8
Ox-plough:					
Senegal	Groundnut	1965	110	456	24.1
Tanzania	Cotton	1963	700	1520	46.0
'Wet' farming					
India	Paddy rice	1954	148	1398	10.6
Two-wheel tractor:					
Japan	Paddy rice	1954	432	1790	24.1
		1960	420	1663	25.2

Source: Hans Ruthenberg (1971) pp.71, 156.

The economist may argue that the use of herbicides is constrained not only by inadequate credit, but also by high rates of interest charged on loans which are obtained from non-institutional sources; but not even the offer of herbicides at subsidized rates will be a sufficient inducement to promote their effective use as an alternative to hand labour so long as there is an abundant supply of farm family workers with nowhere else to go.

The non-labour inputs of agrochemicals in the upland 'dry' farming rice and corn growing areas of Mindanao (Table 1) were in fact purchased only by those farmers with a considerable income from non-farm sources who did not seek production loans; but they were specifically for insecticides, whereas in the lowland farming area the availability of water for irrigation prompted some use of herbicides also - since relatively good road networks and accessibility to a sizeable urban centre had deprived farmers of some family members in the work force who had either gone away to school, or were in urban employment. In these circumstances, as wages began to rise in response to seasonal peaks of labour demand, farmers began to 'experiment' with herbicides as an economic substitute for hand labour.

THE APPROACH: ECONOMIST v. PEASANT

Armstrong et al. (1969) try to relate the cost and return factors associated with various methods of weed control in maize. The effects of cost, yield, timeliness, and alternative uses of labour were compared for each method from examination of twenty-one documented agronomic experiments. Considering costs and yields only, their results indicated that mechanical methods had a slight advantage over chemical control methods. Penalizing mechanical methods because of delay or timeliness characteristics, however, gave chemical methods a distinct advantage.

But, as Heyer (1972) points out in an analysis of peasant farm production in Masii, a semi-arid area of Kenya, the farmer has to make his production decisions long before harvesting takes place. Constraints were arable land, and labour at different times of the year; and Heyer concludes that 'time of planting, time and intensity of weeding, and September harvesting, are crucial, and any improvements in labour efficiency at these times of the year is likely to raise substantially labour's annual productivity'. The critical issue, however, is her finding that 'at present levels of technology, even maximising returns for "worst year" conditions, the majority of Masii farmers cannot meet their food requirements in "worst years" which occur roughly one year in five ... It would require substantial improvements in technology for Masii to be able to feed its growing population in famine years, whatever the farmers' strategies. In practice, Masii people survive on famine relief and remittances from absentee wage-earners in the town.'

Steele (1965), drawing upon evidence of the cost of non-chemical weeding methods in East African crops, concludes that it is obvious that small scale growers with a limited cash turn-over could not afford to substitute herbicides for hand-weeding methods, 'even though there might be long-term benefits by way of increased yields or reduction of the weed flora'.

But Kasasian (1971), who sees a different role for herbicides in tropical agriculture from that of temperate agriculture, maintains that the use of herbicides in tropical agriculture should not be regarded as routine measures to replace labour, but rather as supplements to human labour to increase its effectiveness.

Is Kasasian perhaps unduly influenced by concepts of surplus labour in under-developed agricultural economies when he demands no more of herbicides than that they should supplement human labour? It is true that in the low-income countries of the tropics with their overwhelmingly large agricultural sectors combined with the slow growth rate of the urban labour market, more labour will have to be absorbed in agriculture in the decades immediately ahead because of the rapid population and labour force growth currently being experienced.

The problem of raising productivity and incomes for small-scale farmers is not, however, one of labour surplus, but one of labour constraint, because timeliness of operation is absolutely over-riding in all cultural systems of peasant production in which labour is the main input; but what is in danger of being overlooked is the rapidly increasing importance in a number of countries of agricultural colonization.

Of special significance is that resettlement programmes are directed principally at the younger men in the economically active age groups; and that investment usually includes provision of irrigation facilities. The high cropping intensity which this requires for full utilization of the productive potential, is doomed to failure wherever young settlers are expected to rely upon an abundance of family labour (which they do not have) unless they can effectively substitute herbicides for labour.

There is immediate scope for encouraging continuing research and widespread use of herbicides in all areas in which agricultural colonizations are being established or greatly expanded as part of government policy, because the institutional framework already exists through which research agencies and manufacturers can operate. In this context, there is no reason to suppose that the use of weedkillers will not follow a similar pattern to that found in temperate agriculture as soon as suitable herbicides are available which are economic alternatives to hand labour.

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