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SEED DORMANCY IN RELATION TO WEED CONTROL

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Summary The possibility of controlling weed populations via manipulation of seed dormancy is discussed in the light of current views on the mechanisms involved in this process.

It is now well established that a principal cause of weed infestation lies in the capacity of such species to shed large numbers of seed, a high percentage of which may remain viable in the soil for very long periods. Although a proportion of such seeds will germinate each growing season and may thus be eradicated by conventional means, the magnitude of the problem - up to 348 million buried weed seeds per acre have been recorded (Roberts & Stokes, 1966) - is such that eradication is likely to be a process of very slow attrition, especially since an additional input of seed is likely to occur annually, even on the best-managed land. Clearly, therefore, it is worthwhile considering whether it is possible to design means whereby the pool of viable seed within the soil may be manipulated such that the potential for infestation be reduced.

From the point of view of dormancy we can place weeds into three broad groups.

(a) Those whose seeds are non-dormant when shed and which may germinate in the same season as the parent plant or whenever conditions become favourable.

(b) Those whose seeds have an after-ripening phase before germination can occur or those whose seeds are truly dormant and have a requirement for a period of exposure to some environmental stimulus, e.g. low temperature, before dormancy can be broken by favourable conditions.

(c) Weeds such as those under (a) or (b) which have either non-dormant or dormant seeds but whose seed becomes buried during cultivation. Seed in these circumstances very often 'acquires' a light requirement for germination, possibly in addition to some other form of dormancy (Wesson & Wareing 1967).

Looked at in this way there are three obvious strategies which might be followed as a means of control, viz:-

1. A means whereby the dormancy of most or all of the buried seed could be broken such that germination and emergence occurred over an appropriate and defined interval.
2. A means whereby the dormant phase of the weed seeds could be prolonged such that germination was delayed until, say, after a crop had become well established or had been harvested.
3. A means of reducing the viability of the seeds in the soil.

In any case it must be obvious that for there to be any future for such approaches we need a clear picture of the factors involved in the imposition and breaking of dormancy. Hence, this paper will attempt a brief appraisal of these factors and attempt to highlight those areas where further research might be fruitful.

The number of different types of seed dormancy is considerable and reflects the widely different strategies for survival adopted by plants. Of the important environmental factors, the effects of which upon seed dormancy have been widely studied, we have most information on the roles of light and temperature. Much work has also been expended on the role of factors intrinsic to the seed, such as the effects of seed coats, seeds with immature embryos and the phenomenon of after ripening. These 'intrinsic' factors may be, and often are, modified by environmental factors.

From the standpoint of this paper it is in general of more importance in the case of *climatic* environmental factors to understand how the particular stimulus is perceived and thus to mimick its effects. On the other hand, where the environmental stimulus is *chemical* this has a more direct bearing on the discussion here. There are several examples of this category, one of which has been indirectly referred to above, namely the mechanism whereby burial induces a light requirement in many seeds. This problem was the subject of studies by Wesson & Wareing (1967a, b). The effect of burial did not appear to be due to either oxygen limitation or high carbon dioxide concentration in the soil. Further work using sterilised soil indicated that the imposition of the light requirement may be due to a volatile substance formed as a product of the seed's metabolism. Neither the identity of this substance nor its mode of action have been elucidated but it is of interest in this connection that a number of treatments such as osmotic shock (Khan, 1960) and high temperature (Borthwick et al 1965) are able to induce a light requirement in previously insensitive seeds.

Another of the factors in the same group is carbon dioxide, a role for which in the imposition of dormancy has long been suggested. It is,however, rather less well known that the presence of carbon dioxide may be necessary for dormancy to be broken. This was originally established by Bassi et al (1975) and Keys et al (1975) in lettuce and we have demonstrated a similar effect with seeds of *Spergula arvensis*, a species which also requires light and ethylene for germination. The results of an experiment with this species is shown in Table 1.

Table 1. Effect of ethylene (200 ppm) and carbon dioxide (0.03%) upon germination of *Spergula arvensis* L. seed

Additions	Germination (%)	
	Light	Dark
$C_2H_4 + CO_2$	44.8	19.6
C_2H_4	34.6	14.3
CO_2	36.1	8.5
0	11.8	6.0
LSD	7.3	5.6

Either CO_2 or ethylene when supplied alone promote germination in the light although only ethylene is effective in the dark. The effects of the two substances are less than additive in the light suggesting that they act on the same basic process. It should be emphasized that this is CO_2 at atmospheric concentration and that no additional effect is observable if the CO_2 concentration is raised.

Nitrate ions, which are capable of breaking dormancy in seeds of a number of species may also be considered as an environmental factor. The mechanism of this effect is unknown. In Spergula as in many other seeds nitrate appears to act by reducing the length of the light exposure necessary for germination or even by eliminating it altogether (Table 2). This is of particular interest if the proposals of Hendricks and Taylorson (1974 see below) concerning the mode of action of nitrate is correct since this could imply that the same processes are involved in mediating light effects, and that the imposition of a light requirement referred to above is a consequence of the inhibition or reversal of such processes.

Table 2. Effect of potassium nitrate (20mM) and ethylene (100 ppm) upon germination of *Spergula arvensis* L. seed

Additions	Duration of light exposure (min)		
	0	10	60
	Germination (%)		
None	1	3	3
C_2H_4	3	12	24
KNO_3	5	26	32
C_2H_4 + KNO_3	18	73	80

Ethylene itself falls into the category of substances discussed here since this endogenous plant growth regulator is also present as a component of the soil atmosphere where it arises as a consequence of the activities of microorganisms (Dowdell et al. 1972) at concentrations capable of breaking dormancy in Spergula. We were able to show some years ago (Olatoye & Hall, 1972) that ethylene is capable of breaking dormancy, at least in part, in a wide range of common weed species including Spergula. A singular feature of this effect is that nearly all the seeds affected by ethylene are also light-requiring, indeed, some of the species involved appear only to be normally light-requiring in their ethylene-sensitive stage. Both the ethylene and light requirements appear to be lost some weeks or months after the seed is shed but the light requirement is restored if the seed is buried (Wesson & Wareing 1969b). The loss of the ethylene requirement is however more apparent than real, since during storage, the capacity of the seed to provide its own ethylene changes, as shown in Table 3. Thus, upon imbibition in the dark, 18 month old seed appears to produce ethylene at more than twenty times the rate of fresh seed. It is notable that this effect is inhibited by light and in seed of this age germination is somewhat light-inhibited. We had originally thought that the change in the capacity of the seed to release ethylene reflected a change in the capacity for ethylene biosynthesis. However, we have recently observed that a large number of seeds, including Spergula, have a mechanisms for 'compartmenting' ethylene and furthermore that the extent to which they are able to perform this function changes during seed maturation and ageing (Jerie et al 1978a, b). A change in the ability of the seed to 'compartment' ethylene could

Table 3. Ethylene production by and germination of seed of Spergula arvensis

Age of seed from harvest (months)	Ethylene production ($nl\ g^{-1}$ seed h^{-1})		Germination after 5 days (%)			
			$-C_2H_4$		$+C_2H_4$[a]	
	Dark	Light	Dark	Light	Dark	Light
1	0.42	0.33	4	7	18	52
6	2.5	3.5	36	48	83	95
18	9.6	5.0	84	60	85	92

a. Ethylene used at 100 ppm

well account for the observed effects with Spergula during after-ripening; indeed, if the same effect occurs with other growth substances - for which there is some evidence with gibberellins (Browning & Saunders 1977) - then the phenomenon might have considerable bearing on the mechanisms of after-ripening in general. It is of interest that certain substances which reduce the capacity of seeds to compartment ethylene are also instrumental in breaking dormancy (Acaster & Hall, unpublished). It is perhaps dangerous to carry the analogy too far but it is equally possible that the changes in other endogenous growth regulators which occur during, for example, stratification (Webb et al 1972) and which appear to be important in the dormancy breaking process, might be brought by similar mechanisms to those described above.

This brings us to the more general role of endogenous growth regulators in the control of dormancy. There is neither time nor space here to discuss this matter fully but it is now well established that many endogenous growth regulators can inhibit (e.g. abscisic acid) or promote (e.g. gibberellins, cytokinins) germination and furthermore there is much evidence that the effects of environmental stimuli on dormancy may well be mediated via changes in levels of these substances as in the case of stratification referred to above and with light (e.g. van Staden & Wareing 1972). The fact that different growth regulators are effective in different systems or in the same system at different times may not be as difficult to interpret as appears at first sight and does not necessarily mean that different basic processes are being affected. Thus, there is excellent evidence from work on cell expansion that although different growth regulators promote this process in different systems there may well be a single basic process involved. This is suggested by the work of Marre and his colleagues (see Marre 1977) who have shown that the fungal toxin fusicoccin which affects proton pump activity will substitute for either auxins, cytokinins or gibberellins in promoting elongation in appropriate systems. A similar situation appears to obtain with seeds to some extent in that fusicoccin will substitute for gibberellins in promoting the germination of lettuce seeds (Lado et al 1974). However, too close a parallel should not be drawn between the two developmental systems if for no other reason that there appear to be more resemblances between different elongating systems than there are between different seeds for example between those with perisperm and those with endosperm, those with different types of food reserve, those with different modes of germination e.g. hypogeal, epigeal and so on. Nevertheless, it is still possible and even likely that only a few key basic processes are important and it is towards these that it is appropriate to direct our attention.

In a series of papers Roberts and his co-workers have proposed a hypothesis which suggests that in dormant seeds, normal respiration competes with some dormancy breaking oxidative process and that, as a prerequisite for germination seeds need to operate a considerable proportion of their initial respiratory metabolism via the pentose phosphate (PP) pathway rather than via the Embden-Meyerhof-Parnas (EMP) pathway. This scheme was based on evidence that many inhibitors of terminal oxidation such as cyanide could break dormancy and further, that many dormancy-breaking treatments, whether environmental or chemical (including plant growth regulators) tended to cause a shift in the C_6/C_1 ratio indicating a switch to the PP pathway from the EMP pathway (Table 4).

Table 4. C_6/C_1 ratios of a) Procter barley seeds under various conditions and b) Spergula arvensis seeds in the presence and absence of ethylene ($100\ \mu l^{-1}$)

a)

	Treatment	C_6/C_1 ratio	Germination (%)
Dormant seed	KCN 10^{-3}M	0.16	26
	Untreated	0.19	10
	GA 10^{-3}M	0.11	100
	Untreated	0.24	10
	$NaNO_2$	0.20	32
	Untreated	0.22	10
Non-dormant seed	Untreated	0.14-0.11	96-100

b)

Treatment	C_6/C_1 ratio		Germination (%)	
	$+C_2H_4$	$-C_2H_4$	$+C_2H_4$	$-C_2H_4$
Non-preimbibed seed	1.06	0.66	33.2	12.0
Preimbibed seed	0.25	0.14	36.8	12.0

a) From Roberts (1969)

b) Jones & Hall (unpublished)

Hendricks & Taylorson (1974, 1975) suggest a variant to this hypothesis whereby hydrogen peroxide released during substrate oxidation is used to oxidise NADPH to $NADP^+$ via peroxidase action. The $NADP^+$ thus formed is used in the PP pathway. It is proposed that this end is achieved by the inhibition of catalase activity. These workers showed that a number of dormancy breaking agents such as thiourea, nitrite (and by implication nitrate from which it is derived via nitrate reductase) and hydroxylamine also strongly inhibit catalase.

Attractive though these hypotheses are, they do not appear to apply in all cases since it has been shown in Spergula that the breaking of dormancy is not associated with a switch to the PP pathway, indeed if anything the reverse is true. (Table 4). Nevertheless, the basic idea of a dormancy breaking oxidative process remains attractive, however, the oxidation is achieved, and this particular area will repay further study.

The very multitude of types of seed dormancy and the bewildering array of substances and treatments capable of breaking dormancy might seem to rule out the possibility of finding compounds capable of either imposing or breaking dormancy for use in weed control in situations involving a large number of species. On the other hand the fact that certain compounds are capable of breaking dormancy in a wide range of species as well as the evidence that only a few key processes may be involved in the initial stages gives cause for optimism that by further research on the problem it may be possible to devise treatments which will be successful, although it seems likely that a successful treatment will be a multicomponent system.

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References

Bassi, P.K., Tregunna, E.B. and Purohit, A.N. (1975) Carbon dioxide requirements for phytochrome action in photoperiodism and seed germination. Plant Physiol. 56 335-336.

Borthwick, H.A., Hendricks, S.B., Toole, W.H. and Toole, V.K. (1954) Action of light on lettuce seed germination. Bot. Gaz. 115 205-25.

Browning, G. and Saunders, P.F. (1977) Membrane localised gibberellins A_9 and A_4 in wheat chloroplasts. Nature 265 375-377.

Dowdell, R.J., Smith, K.A., Crees, R. and Restall, S.W.F. (1972) Field studies of ethylene in the soil atmosphere: Equipment and preliminary results. Soil Biol. Biochem. 4 325.

Hendricks, S.B. and Taylorson, R.B. (1974) Promotion of seed germination by nitrate, nitrite, hydroxylamine and ammonium salts. Plant Physiol. 54 304-309.

Hendricks, S.B. and Taylorson, R.B. (1975) Breaking of seed dormancy by catalase inhibition. Proc. Nat. Acad. Sci. (U.S.) 72 306-309.

Jerie, P.H., Shaari, A.R., Zeroni, M. and Hall, M.A. (1978a) The partition coefficient of $^{14}C_2H_4$ in plant tissue as a screening test for metabolism or compartmentation of ethylene. New Phytol. (in press).

Jerie, P.H., Shaari, A.R. and Hall, M.A. (1978b) The compartmentation of ethylene in developing cotyledons of Phaseolus vulgaris L. Planta (in press).

Kahn, A. (1960) An analysis of 'dark osmotic inhibition' of germination of lettuce seed. Plant Physiol. 35 1-7.

Keys, R.D., Smith, O.E., Kumamoto, J. and Lyons, J.L. (1975) Effect of gibberellic acid, kinetin and ethylene plus carbon dioxide on the thermodormancy of lettuce seed (Lactuca sativa L. cv Mesa 659) Plant Physiol. 56 826-

Lado, P., Rasi-Caldogno, F. and Colombo, R. (1974) Promoting effect of fusicoccin on seed germination. Physiol. Plant 31 149-152.

Marre, E. (1977) Physiological implications of the hormonal control of ion transport in plants. In: Plant Growth Regulation ed. P.E. Pilet. Springer-Verlag. Berlin Heidelberg pp. 54-66.

Olatoye, S.T. and Hall, M.A. (1972) Interaction of light and ethylene in dormant weed seeds. In: Seed Ecology, ed. W. Heydecker Butterworth Press.

Roberts, H.A. and Stokes, F.G. (1966) Studies on weeds of vegetable crops. VI. Seed populations of soil under commercial cropping. J. Appl. Ecol. 3 181-190.

Roberts, E.H. (1969) Seed dormancy and oxidation processes. In: Dormancy and Survival. Symp. Soc. Exptl. Biol. 23 161-192.

van Staden J. and Wareing, P.F. (1972) The effect of light on endogenous cytokinin levels of seeds of Rumex obtusifolius. Planta (Berl.) 104 126-133.

Webb, D.P., van Staden, J. and Wareing, P.F. (1973) Seed dormancy in Acer: changes in endogenous cytokinin, gibberellin and germination inhibitors during the breaking of dormancy in Acer saccharum Marsh. J. Exptl. Bot. 24 741-50.

Wesson, G. and Wareing, P.F. (1967) Light requirements of buried seeds. Nature, Lond. 213 600-601.

Wesson, G. and Wareing, P.F. (1969a) The role of light in the germination of naturally occurring populations of buried weed seeds. J. exptl. Bot. 63 402-413.

Wesson, G. and Wareing, P.F. (1969b) The induction of light sensitivity in weed seeds by burial. J. exptl. Bot. 63 414-425.

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NEW CROPS AND AGRICULTURAL SYSTEMS

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Summary The biological characteristics of plants which can be regarded as powerful indicators of crop potential in wild species are discussed and the important factors which have contributed to the establishment of soya beans, sugar beet and oilseed rape are enumerated. Factors that might determine the expansion of oilseed rape in Europe are reviewed and the possibility of further genetic improvement of rapeseed as an important source of protein for human food is considered. Possible developments in the cultivation and breeding of linseed, lupin and sunflower for use in Britain are outlined and their impact on agricultural systems examined.

INTRODUCTION

Crop identification has played a decisive role in the development of human cultures, and, as expected with so much at stake, early agriculturalists were expert in their initial choice: barley and wheat in what is now eastern Iraq, maize and *Phaseolus* beans in Central America, rice and soya in China and sugar cane in the Indonesian islands. Of the 200,000 or so known species of flowering plants, Heiser (1973) estimates that about 3000 have been exploited for food as distinct from being gathered from the wild, about 200 have been domesticated, butthe major food crops are represented by less than 20 species. This quantitative sketch of the origin of food plants from the diversity of the World flora, is given only to dispel overconfidence of easy reward from contemporary searches for new crops.

The low probability of identifying truly new crops is further highlighted by experience during the last three centuries when none of the six crops, potato, clover, turnip, swede, oilseed rape and sugar beet, that were introduced into Northern European agriculture during this period, was new. They were in cultivation long before their introduction into systems that developed as European agriculture emerged from feudalism. Even sugar beet, the nearest to satisfying claims of new-crop status, had existed as a fodder root long before Napoleon took the administrative action that ultimately raised its status as a sugar crop equal to sugar cane.

Indicators of crop potential

There are distinctive elements in the distribution pattern of wild species prior to domestication which are noteworthy indicators of crop potential. Of these, success as weeds is among the most significant and consistent. Carl Linnaeus, as distinguished a botanist as ever lived, recorded the turnip as a serious weed of barley in Sweden in the mid-eighteenth century and questioned why *Brassica*, a common crop in areas now comprising Belgium, had not established as an oil crop in his native country. Indeed, it took oilseed rape fully two centuries after Linnaeus, before isolation in two world wars secured its firm establishment in Sweden.

Weed status signifies adaptation to both soil and climate and, more significantly, demandssynchrony of development of crop and weed. Synchronous growth and maturation ensure that weed and crop ripen simultaneously thus eliminating the impediment of late ripening that is often decisive in new crops. Weed status is also an unmistakable indicator of satisfactory seed production, an obvious pre-requisite for acceptable grain yields.

It is also a feature of plants introduced into cultivation that successful species achieve fodder status long before genetic selection and processing technology refine their potential for human food; both rape and beet were grown for fodder before their exploitation for oil and sugar. The soyabean, now the foremost grain legume, gained access to the U.S.A. only by accepting the status of a minor forage for almost a century and grain production from soya exceeded the area for fodder in the U.S.A. as recently as 1941. Production for grain, when it finally took hold in 1921, was explosive and the rapid development of soya in the U.S. after a century of marking time, merits serious analysis in relation to problems of crop introduction.

The first U.S. advisory bulletin on soyabean in 1899 recognised only eight types, solely for forage, half having pigmented seeds and considered undesirable for food grain. When world genetic resources were systematically surveyed, over 1100 new introductions, mainly from the Far East, became listed during 1900-1925. A recent inventory of soyabean introductions into the U.S. contains over 10,000 entries (Caldwell et al. 1973), and this large gene pool has contributed materially to the adaptation of the crop throughout most of North America and, more recently, in Brazil.

These elements in the development of soyabean in the New World: a long period of cultivation for forage and the identification of adapted genotypes, emphasize that crop introduction cannot be viewed as a part-time effort relying on minimal resources.

Lessons from the establishment of sugar beet and oilseed rape in Europe

An equally sustained effort was required for the establishment of sugar beet in Europe. The discovery that the beet then commonly grown for fodder and in gardens in Central Europe, contained cane sugar, was made in 1747 by A.S. Margraaf. The Emperor Napoleon, anxious to explore alternative supplies, weighed in with powerful financial inventives which eventually established the crop sixty-four years later. Even with powerful national support, trade in beet sugar became a serious challenge to cane sugar only gradually and there were many set backs. When duty was imposed on beet sugar in France in 1836, the tenuous economic state of the industry was clearly exposed with many factories closing. However, in spite of difficulties, the industry progressed steadily, culminating in 1899, 152 years after Margraaf's initial discovery, in beet sugar accounting for 65 per cent of World trade in sugar - an all time high.

Although the sugar content of beet was increased threefold to 18 per cent by the end of the twentieth century, the establishment of sugar beet in every country in Europe owes much to Government support. This is nowhere more conspicuous than in Britain, where in spite of successful experiences in France and Germany, the serious blockage of supplies during

1914-1918, the stimulus of a powerful commission and a substantial subsidy were needed finally to establish the crop. Oilseed rape too owes a great deal to financial incentives and it is doubtful whether the crop would have increased at recent rates, even accepting its role as a break crop, without E.E.C. support. Thus, national food policies have increasingly affected the introduction of new crops and new candidates of today, if they are outside administratively supported pricing systems, probably have little chance of success.

Sugar beet fulfilled the traditional roles of a cleaning and a break crop while adding a cash crop for arable areas. Indeed, it might even be concluded that it has been too successful: its intensive cultivation has promoted sugar beet cyst eelworm and precluded the uncontrolled cultivation of the crop over large areas of the eastern counties. In spite of its success, sugar beet did not fundamentally influence agricultural systems as clover and turnips affected the fertility-sustaining rotations and weed control two centuries earlier. No such claim can either be made for oilseed rape: its inclusion as a break in the barley acreage to date has been minimal, and past experience suggests that too much should not be expected from new crops in respect of modifying cropping systems in fundamental ways.

Further expansion of oilseed rape

The factors which have affected the recent increase in oilseed rape in Europe parallel closely those recorded for sugar beet. Two world wars highlighted the overseas dependence of Europe for fats and protein concentrates, and the need for a non-cereal rotational break generated a demand for supplies of oilseeds from British farms. The acceptance of oilseed rape has been affected until quite recently by doubts surrounding the nutritional status of the oil on account of its high content of erucic acid which has been associated with adverse effects on growth and on heart muscle in a range of animals. In addition, the quality of the meal is affected by the presence of goiterogenic substances derived from glucosinolates, and of sinapine, a compound which can cause flavour taints in eggs. Following the almost complete elimination of erucic acid from the oil and, more recently, of glucosinolates from meal of spring varieties, the value and future prospect of the crop have now been very substantially improved.

Consideration of the facts that production of fats and oils in the E.E.C. is only 39 per cent of consumption, and that 95 per cent of requirement for protein concentrate is imported, prompts the question why oilseed rape has not increased more rapidly during recent years? One might have expected such heavy dependence on outside supplies for vegetable oil and protein to justify greater confidence in the crop, but continuing low yield, increasing cost of disease control, and competition from sunflower, especially in France, the principal producing country in the Community, appear to have inhibited expansion at least temporarily.

In the U.K. the 1977 rapeseed acreage amounted to only 2.5 per cent of total tillage (3.5 per cent of the barley acreage) in counties where the crop is most widely grown (Fletcher et al. 1975, Fletcher 1976). In view of the need for a cereal break and of price support, a more rapid increase in acreage might also have been expected in this country. Recent surveys (Fletcher 1975, 1976) indicate that the chief production problems are disease and bird damage, especially pigeon damage. The rotational incompatibility of rape and sugar beet due to eelworm susceptibility has already been mentioned. Two other soil-borne diseases, canker (Phoma lingam) and club root, which are mainly controlled by long periods of exclusion of Brassicas from the rotation are also causing concern. These factors could prove crucial in restricting the ceiling acreage, especially if sunflower, a source of high-value oil, becomes firmly established as a major crop within the E.E.C.

New crops for oil and protein - problems and potential

It is significant that the new (or 're-entrant') crops currently being considered, linseed, sunflower and lupin, are potential sources of both oil and protein. With few exceptions, the major grain protein crops of the world, soyabean, cotton, peanut, oil palm and the Brassica species, are also rich sources of vegetable oil. Of these, the Brassicas alone are adapted to Northern temperate zones and there are the disease indicators which question the wisdom of exclusive dependence on a single crop. Furthermore, the future of rapeseed would be more certain if the meal could be processed for human consumption in competition with soya. Rapeseed meal has an excellent amino acid composition, but for food processing, the chlorophyll in the cotyledons and the pigment in the testa are important disadvantages. Neither of these characters would be difficult to modify and genetical advances in both have been reported recently in Canada.

Expansion in the use of processed grain protein for human consumption has been one of the notable developments in food technology in recent years. Many are convinced that increasing proportions of dietary protein supplies will have to come from this source. It is unlikely that this country will be isolated from these influences and new crops have a special role to supply this growing market. The dominant position of soyabean as a major world source of protein, and of vegetable oil, can be appreciated from Table 1.

Table 1: World production (10^3 hectares) areas of major oil and protein crops (1960-1975)

(F.A.O. Annual Production Year Book)

	1961-65	1974	1975	1976	Per cent Soya
Sunflower	7,034	8,977	8,650	9,436	20
Safflower	665	1,073	1,291	1,061	2
Linseed	7,843	5,925	5,820	5,727	10
Lupin	1,318	750	721	(900)	2
Rape seed	6,861	9,281	10,208	8,997	20
Cotton seed	32,047	33,047	33,889	21,648	49
Soya	28,373	44,743	46,006	44,885	100

Of the crops that are now considered as having a potential role in Britain, only sunflower can be remotely described as new to British agriculture: linseed has had a long, if chequered history in Britain both for seed and fibre, and lupins have been grown on the sands of East Anglia, though not for grain. Of the three lupin species currently being examined, Lupinus albus (white lupin) has been grown in Mediterranean agriculture since pre-Roman times. Lupinus angustifolius (blue lupin) is more recent, and has only been fully domesticated during the last decade following the isolation of genes for non-shattering pods in Western Australia. Lupinus mutabilis (pearl lupin), a native of South America, has the highest oil and protein content but is less well adapted to British conditions.

The considerations relevant to assessing their values are set out against rapeseed, soyabean and field beans in Table 2.

Table 2: Oil and protein content in grain crops

	Per cent dry matter in seed		Seed size
	Oil	Protein	g.wt./1000 seed
Rapeseed	42-48	20	3-5
Soya bean	17-18	38	84-160
Sunflower	30-45	17	50-120
Linseed	35-45	24	4-7
Lupin (white)	8-14	35	182-250
Lupin (blue)	7-8	28	124-140
Lupin (pearl)	12-19	37	120-180
Field bean	1.5	24	270-380
Peas	1.5	23	150-280

All three species are excellent sources of protein offering substitutes for rape, or more significantly, for soyabean meal. The low protein in field bean and sunflower need emphasis, especially to evaluate their potential in competition with soya. Linseed and sunflower equal rapeseed in oil content, but Lupinus albus is substantially lower. If the latter is to have a major role as an alternative to soya, it is probably desirable, perhaps essential, to lift oil content to 18-20 per cent of dry weight of the seed.

Table 3: Fatty acid composition of sunflower, linseed, lupin and soyabean oil

	Saturated			Unsaturated			
	Palmitic	Stearic	Others	Oleic	Linoleic	Linolenic	Erucic
Soya bean	11.5	3.9	-	24.6	52.0	8.0	NIL
Sunflower	5.9	5.2	-	15.9	72.5	T	NIL
Linseed	6.9	6.4	-	14.6	15.5	56.6	NIL
Lupin (white)	7.9	1.8	4.2	53.6	18.0	8.7	1.2

In the comparisons in Table 3, sunflower is noteworthy because the oil is rich in linoleic acid. Linoleic acid, besides being unsaturated at two carbon atoms and of interest for improving the balance of unsaturated to saturated fatty acids in the diet, has special significance as an essential dietary nutrient. For these reasons, sunflower oil is regarded among the highest quality vegetable oils, but it is worth noting that the relative amounts of the 18-carbon fatty acids, oleic and linoleic, vary considerably according to the environment in which the crop is grown, and its quality characteristics are therefore not invariable between samples.

Although it is arguable whether the ratio of protein:oil in sunflower is ideal for large scale market requirements, confidence in sunflower seems to be increasing; in Europe impressive increases in production have recently occurred in Spain and France. The higher oil content (up to 45 per cent) of seed together with dwarf habit and rapid maturation of modern varieties, have substantially increased the prospects for the crop (Unilever Research Division 1974). Bird damage, however, continues to be a serious problem in sunflower; each inflorescence is virtually a table generating its own source of bird seed. In wet weather desiccation is also troublesome and the fleshy capitulum readily suffers from infection from rotting fungi, but the new dwarf varieties have made chemical control of pathogens more feasible.

Sunflower fits arable systems on most soils, and combines advantages for weed control of a row crop with the capacity to produce a dense canopy very quickly. Although the crop is less tolerant of cool temperatures common in spring and early summer in Britain than other crops, the more favourable areas of Southern England with higher than average accumulated temperatures to mid-May, and lower late summer rainfall, should qualify for development work based on the dwarf varieties that are now available, and a programme of plant breeding seems to be thoroughly justified.

By contrast with sunflower which yields a high value culinary oil, oil from linseed finds use in industry as a drying oil, but substitutes have severely diminished this role in recent years. Linseed also contains cyanoglucosides which liberate hydrogen cyanide when the seed is crushed. The enzyme systems responsible for the reaction can be inactivated by heating, and cakes and meals after oil extraction are harmless. The cyanoglucosides may also be eluted from seeds by steeping. Gene mutations which block the synthesis of both the glucoside and the enzyme are known in many plants and it is likely that a search would identify similar, useful, mutant alleles in linseed.

There is no question mark attached to the ecological adaptability of linseed in Britain and the vulnerability of the crop to weed competition is no longer a serious problem thanks to effective pre-emergence herbicides. If E.E.C. support is discounted however, it is difficult to anticipate a firm future for linseed as a major source of oil and protein. Following its partial eclipse as a source of drying and surfacing oil, it would require a substantial improvement in protein content, a fundamental re-formulation of fatty acid composition of the oil, and ideally, the elimination of cyanoglucosides from the seed, for the crop to set a serious challenge to sunflower, and rapeseed in Europe and on a world basis, to soyabean.

The lupin species have the particular attraction of being legumes. Blue lupin is a good prospect for grain protein and as a forage crop, but its potential for oil is negligible. Current varieties are already well adapted for forage, either as a mono-crop or in a mixture with cereals, and forage yields of up to 20 tonnes of dry matter per hectare have been recorded. Given a modest amount of development work, the species could quickly become important for mid-summer or autumn silage as well as for grain protein.

White lupin is the nearest new prospect to soyabean in respect of content and quality of oil and protein. The seed protein of this species has an amino acid profile similar to soyabean, and at approximately 35 per cent protein in the dry matter, the grain is an obvious source of concentrate both for human food and animal feed (Williams and McGibbon 1977). Furthermore, the fatty acid composition of the oil is not dissimilar to that of soya oil which has enjoyed such phenomenal success on a world scale.

Lupins are adapted to most soils in the United Kingdom, excepting the chalk and alkaline soils generally, where they cannot be grown. Both white and blue lupins are tolerant of low spring temperatures and show none of the symptoms of cold damage seen in maize and sunflower. The data presented in Table 4 emphasize the importance of early sowing for maximising seed yield and for reducing unwanted vegetative growth at harvest (Tayler and Sylvester-Bradley 1977).

Table 4: The influence of sowing date on yield in Lupin (var. Kievskij mutant)

Date of sowing	Height (cm)	Seed on branches (per cent)	Pods per plant	Seed weight (g/100 seed)	Seed yield (t/ha.)
Feb.15	55	61	13	310	2.3
Feb.24	53	55	11	330	2.7
March 2	54	46	11	322	2.6
March 16	63	52	11	306	3.0
March 29	58	43	12	281	2.6
April 14	61	25	9	227	1.9
May 10	83	27	12	202	1.2
May 24	40	5	0	212	0.1

Although desiccant can be used to assist drying the haulm, results so far do not justify great confidence in chemical desiccation. The best stands in trials at Reading have given 3.4 tonnes of seed per hectare from the variety Kievskij Mutant (white lupin) and if this performance could be established generally, the future of the crop would be most promising.

The major (probably the only) restriction affecting grain production from lupin in Britain is the very slow drying of the pod wall after the seed is fully developed and mature which delays harvest to an unacceptable extent. This character can be modified by selection as has been achieved in other grain legume species such as soya, Phaseolus and field beans. Given success with this character, there is no reason why lupins should not be capable of an impressive contribution to supplies of protein concentrate and of vegetable oil in Britain and in Europe.

Although development with new crops can now be expected to move at a somewhat faster rate than the historical pattern of new-crop introductions described in this survey, it is still necessary to caution against instant success, especially if the research and development effort remains organised at low priority.

References

Caldwell, B.E. et al. (1973) Soybeans: improvement, production and uses. American Society of Agronomy, Madison, U.S.A. pp.681.

Fletcher, S.M., J.L. Dench and R.L. Vaughan (1975) Oilseed Rape. Agricultural Enterprise Studies in England and Wales. Economic Report No.41, pp.35, Department of Agricultural Economics, University of Reading.

Fletcher, S.M. (1976) Oilseed Rape. Agricultural Enterprise Studies in England and Wales. Economic Report No.53, pp.33. Department of Agricultural Economics, University of Reading.

Heiser, C.B. (1973) Seed to Civilisation. pp.241. Freeman, San Fransisco.

Tayler, R.S. and R. Sylvester-Bradley (1977) The effect of sowing date on yield of white lupin (cv. Kievskij Mutant). In: Report of Wolfson Oilseed Group, Reading University, pp.29. Mimeo 1977.

Unilever Research Division (1974) Growing Sunflower. pp.31. Unilever Research Division, Zevenaar, Netherlands.

Williams, W. and R. McGibbon (1977) Fatty acid composition in accessions of Lupinus albus and Lupinus mutabilis. In: Report of Wolfson Oilseed Group, University of Reading, pp.29. Mimeo 1977.

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SOME ASPECTS OF THE REGISTRATION OF HERBICIDES

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Summary A diverse range of chemicals possess herbicidal properties and these are used in various ways. Therefore a flexible approach is required in studies designed for registration. This paper concentrates on those compounds applied close to the time of planting of the crop. For this use, the behaviour of the chemical in soil is of prime importance. Both laboratory and especially field studies may be required to show the dissipation of the chemical in soil and the absence of carry over of phytotoxic residues to future crops. Residue chemistry is normally less important for these herbicides than for other types of pesticide. Registration studies should be rationalised as harmonisation of requirements proceeds. Many studies should be accepted internationally but to assist the design of meaningful studies and to accomodate the properties of the chemical, guidelines should allow flexibility. Currently there is increased interest in analysis of commercial products. It is clearly important to look for highly toxic impurities but to analyse for every impurity to levels below 0.1% is impractical. Analysis of this type should also concentrate on differences between the same products produced by different manufacturers.

INTRODUCTION

This paper deals mainly with the requirements for the residue and evironmental chemistry involved in the registration of herbicides. Although there is currently widespread use of post emergence herbicides, such as the hormone weedkillers, most of the herbicides introduced recently and probably those under development are applied to the soil before or shortly after the emergence of the crop. When used in this way, most of the chemical goes directly into the soil and the crop is harvested only after a long interval. The edible portion of the crop may well never have been in direct contact with the chemical. This situation is very different from that involving fungicides, insecticides or crop desiccants where one or more sprays are applied at an advanced growth stage of the crop. In these situations, a smaller proportion of the chemical will reach the soil but residues on the harvested crop are much more likely. These differences require some areas of different emphasis in Registration Studies. This paper deals with problems involved in the registration of those herbicides which are likely to most commonly be introduced during the next few years.

SOIL STUDIES

The class of herbicides being considered in this paper is that applied directly to soil. In the soil, the chemical exerts its effect by a differential action on the weeds and crop. To achieve this, the chemical is required to have some persistence in the soil in order to achieve a full biological effect. Persistence must not however be so long as to carry over phytotoxic effects to subsequent crops. Clearly considerable effort must be used to study the behaviour of herbicides in soils both in the laboratory and in the field.

Laboratory studies with radiolabelled herbicides are needed to produce a detailed, but somewhat qualitative picture of the degradation in soil. It is important in these studies to identify major metabolites which are not transient. These can then be monitored in subsequent field studies. During the laboratory studies, to achieve a total radiochemical balance, it is important to trap any $^{14}CO_2$ produced by degradation of herbicide radiolabelled in a suitable position, normally an aromatic ring. The formation of $^{14}CO_2$ indicates mineralisation of the molecule and loss of the compound from the soil. Frequently in these labelled studies, a proportion of the radioactive tracer becomes bound to the soil. In the case of the chloroanilide herbicides, this can be a large percentage of the applied compound.

In recent years, data on the chemical nature of bound residues has been required although this requirement now is starting to be dropped. It is however much more important to assess the significance bound residues and I think that questions on the nature of bound residues should not be asked for registration. The significance of any bound residue is assessed as an integral part of ecological studies with soil and by studying the uptake of aged residues from soil into plants. In most cases, such bound residues are unlikely to be biologically available to plants.

Similarly leaching studies should be carried out to study the mobility of herbicides and their degradation products in soil. Leaching studies are ideally done on soils treated with radiolabelled pesticide and then incubated for a period. Perhaps the study should be started when 50% of the herbicide has degraded or after 6 weeks incubation, whichever is the longer. These studies, which assess the leaching of both parent compound and metabolites, approximate to the real situation. Studies measuring leaching of only parent compound are, I believe, inferior to those conducted on soil preincubated with radiolabelled product. General agreement to adopt only the latter studies would simplify registrations.

The above laboratory studies should be carried out, when applicable under reasonably standard conditions with local soils which can be collected freshly from the field. Ideally there should be a set of internationally agreed soil classes specifying composition (ie % organic matter and sand) and pH. The local soils chosen by a laboratory should comply with these standards.

Each laboratory should standardise its own procedure and vary only such factors as rate of application and method of application of the compound. The changes in procedure should depend on the actual use proposed for a product and should be designed to devise a meaningful study. The laboratory should also use local soils which cover a range of soil types but so far as possible should continue to use the chosen soils for a long period.

There is a danger of data being required on different soils from country to country. This already happens to some extent and if this trend were to proliferate it would create an impossible situation for the soil chemist.

It should be recognised that laboratory studies are unlikely to be quantitatively representative of what happens in the field. Their real purpose is to identify the metabolites which are formed and to establish which, if any, product leaches.

To require a wide range of conditions for laboratory degradation studies is unnecessary. Studies on 4 soil types incubated at 20-25°C at 40% moisture holding capacity and under flooded conditions would provide a sound body of information. At present to comply with various requirements one has to carry out studies involving about 25 combinations of soils/conditions. In many cases it is necessary to use samples of product labelled in different positions. This may double the work and can involve a prodigious effort if the studies are done carefully and accurately.

If the results of laboratory studies indicate that a herbicide is rapidly degraded, field studies are probably unnecessary. If the compound is more persistent, field dissipation studies should be carried out on three or four soil types under different climatic conditions. These studies should be of the "baseline" type where formulated product is applied to bare soil and the plots maintained crop-free during the trial. The plots should be sampled at intervals by an acceptable sampling procedure and, from the results of the analysis, residue dissipation curves constructed. With the increasing biological activity of pesticides, it may be important to use higher application rates than normal to obtain residue levels which can be measured by the residue method. From such studies, the movement down the soil profile can be followed and the loss of pesticides by degradation can be measured. If laboratory degradation studies show the likely presence of a major fairly stable metabolite this may also be monitored. A series of three or four such studies will indicate the behaviour of the herbicide under a range of soil types and climatic conditions. Such studies supported by laboratory data should be recognised as being generally acceptable. A requirement for such studies in individual countries is,I believe, unnecessary and a misuse of the available research effort.

The alternative study, which superficially has advantages, is the 'in-use' study where the treatment is applied as in practice ie growing crop. However studies of this type present accurate application and sampling difficulties and are not really practical.

When carried out how should the results of soil baseline studies be interpreted? If the time taken for loss of half of the original pesticide residue is less than 3 months, there is not likely to be a residue carry-over problem into crops planted the following year. If the half-life is 3-6 months, the possibility of carry over should be examined carefully. If the half-life of the residue is greater than 6 months, there is an obvious need for careful observational studies to look for the carry over of phytotoxicity to subsequent crops.

In the case of those herbicides which are normally applied close to the time of planting the crop, a subsequent crop will not be planted for at least 6 months and probably one year. If residues are not detected in the mature harvested crop, there will not be a carry over into subsequent crops and there should be no soil persistence problem. Such measurements could be made by residue analysis studies if little metabolism of the herbicide is found. However the measurements are best made in well designed radiolabelled experiments.

If significant residues are present in the mature crop, then I think a crop rotation study with both radiolabelled and 'cold' herbicide should be carried out to look for uptake into selected following crops. Clearly the crop rotation study with herbicides will, in most, cases need to be started about 6 months after treatment of the soil. If, after a Spring application of herbicide, a second crop will not be planted until the following Spring, then a one year interval can be allowed between treatment of the soil and planting of the subsequent crops. These crop rotation studies are time consuming. Where residues need to be identified in following crops, the study requires a highly skilled metabolism chemist. However I think it is only in rare cases, where one is dealing with a persistent herbicide, that such studies will be needed. In these rare cases I think the study should be undertaken.

The soil studies discussed above are clearly among the most important ones for herbicide registration. To have acceptable and reliable efficacy, herbicides should not leach readily and cases of herbicides leaching from soil into waterways will be rare. Clearly if leaching is found in the soil studies, some studies in aquatic systems may be necessary.

I have heard suggestions that interactions between herbicides and other pesticides in soil should be studied. This presents a frighteningly large task to look at the vast number of possible combinations. The limited data I have seen suggest that there is no effect or only very small effects on the rate of degradation in soil. These studies although interesting academically should not be included as a registration requirement at this time.

ECOLOGICAL STUDIES

This is largely outside the scope of this paper. Ecological studies should mainly concentrate on the effects on soil processes and organisms and this is being presented elsewhere at this meeting. Since most herbicides are applied directly on to the soil, it is very unlikely the effects on bees and birds will be important.

CROP RESIDUE STUDIES

Since most new herbicides are likely to be applied long before harvest, and probably before the edible portion of the crop is formed, it is unlikely that residues in food will be important. Insecticides and fungicides are often applied close to harvest and residue decay curves are needed to establish a safe harvest interval. In the case of herbicides, most of the crop residue analysis is likely to involve harvest samples. Some analysis of immature crop is however desirable to determine whether uptake of residues from the soil is significant and to provide data on the likely ingestion of residues by wildlife.

Since residues are likely to be small it is important to have a sensitive method to monitor the residue. However only in exceptional cases, where one is dealing with a very toxic chemical, should residues down to levels of 0.01mg/kg be measured. At this level, it is unlikely that residues have toxicological significance and to routinely measure residues to 0.01mg/kg is simply testing the ability of the analyst.

Levels of metabolites of a herbicide in crops are also likely to be low. This may present special problems for a metabolism chemist who may be required to identify the metabolites as one cannot do experiments at higher rates without damaging the crop.

Also any residue present in harvested crop will be derived from soil, treated several months previously with radiolabelled herbicide. Frequently such residues may be bound to the crop structure or be simply radioactivity incorporated into natural plant products. The importance of identifying such trace levels of metabolites is questionable.

With insecticides, the analyst frequently monitors crops for residues of parent and one or more metabolites. The norm for many herbicides should be to analyse for only the parent molecule since the very low levels of metabolites are unlikely to present a significant toxicological hazard.

HARMONISATION OF REQUIREMENTS

Steps are in hand to attempt to harmonise registration requirements internationally. Inevitably in trying to reach an acceptable international agreement, progress will be slow but as a chemist working in industry, I applaud these efforts. International agreement on broad areas of registration data requirements would enable the research effort to be used more effectively.

Registration guidelines should also be kept as general as possible. When test studies are defined precisely,they frequently negate the general usefulness of the study and do not allow the researcher to modify a study to take into account the properties of a compound. This is frequently important,as the way in which a study is designed,frequently affect the results. For instance one should chose between soil incorporation or surface application of a herbicide. Aquatic studies should take into account the presence of sediments and microbial activity. Hydrolysis studies in distilled water under a range of pH and temperatures have little relevance to environmental behaviour. Studies involving river water and sediments are far more meaningful.

Requirements should always be in terms of meaningful studies. Degradation of chemicals in soil is highly relevant. Microbial degradation in pure culture may be an interesting way of elucidating degradation pathways but, in terms of predicting environmental behaviour of chemicals, they can be very misleading. The need for and value of microbial degradation studies as part of registration guideline is questioned by many soil microbiologists.

ANALYSIS OF COMMERCIAL PRODUCT

An area of increasing concern in Registration requirements is the analysis of commercial product for traces of impurities and even prediction of, and analysis for, theoretical impurities. Interpreted literally this poses a potentially alarming prospect for industry.

In current toxicological and ecological studies, product with a composition as close as possible to a typical commercial sample is used. This allows impurities as well as the product to be evaluated in the test systems. It is logical that the close similarity of product used in tests and that sold commercially is established and analysis for impurities in the range 0.1 - 1.0% is normally feasible. However suggestions that analysis is carried out for impurities at levels of 0.01-0.1% presents a major technical problem and, at this level, perhaps only classes with severe toxicological hazard should be looked for eg dioxins, nitrosamines.

A much more acute problem probably lies in differences between products manufactured by different manufactures. When "me-too" registrations are considered, it should be established that the two products are identical. Clear differences between the products necessitate that the toxicology and environmental behavior of the "me-too" product should be established.

Finally I suggest that industry and Regulatory Agencies are not poles apart in their thinking - our joint aim is to produce safe pesticides as aids to agriculture. We are all consumers of food produced with the aid of pesticides and we all inhabit the same environment. Industry and regulatory bodies should work closely together to devise sound guidelines which are widely accepted.

NOTES

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A MERCHANT'S VIEW OF THE PRESENT POSITION, ITS STRENGTHS AND WEAKNESSES

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GENERAL INTRODUCTION

The chain of distribution in the United Kingdom is based mainly on a system of manufacturers distributing to main distributors who then distribute to the ultimate user, and to a minor degree to smaller merchants. The number of wholesale merchants who do not retail to ultimate users is very small indeed. There are one or two manufacturers who distribute direct to the ultimate user, or through wholely owned subsidiaries who perform similarly to the normal manufacturers' main distributor.

As far as specialisation is concerned, a considerable proportion of the crop protection market is held by specialist agrochemical merchants and/or contractors, a further large proportion by general agricultural merchants with specialist departments, and a lesser number, who up to now have merely looked upon agrochemicals as a "sundries" item along with Wellington Boots, Barbed Wire and Overalls.

This brief look at the distribution set up gives perhaps a better understanding of how it is that in the United Kingdom there is no doubt whatsoever that the farmer relies to a greater extent on his merchant or merchant/contractor in relation to what he finally decides to do to protect his crops than on any one else, and that includes both manufacturer and the advisory services, which does not mean that he does not listen politely to them when they discuss his problems with him.

With these underlying factors in mind, what is really the current educational chain operating so that a farmer actually gets sound advice - advice which is based on valid criteria in terms of cost effectiveness, coupled with safety and minimal environmental disturbance ?

The chain, up to now, has never been long enough to reach the category of distributor who regards crop protection chemicals as "sundry" items, but the advent of BASIS means that beyond where it reaches, distribution will shortly cease.

It seems to me that technical education is, in our U.K. circumstances, basically divided into four main parts :-

1. There is education relative to basic technical knowledge of crop, plants, weeds, pests and diseases, their cultivational and general crop husbandry requirements, and the inter-relationship between all the factors which influence the maximisation of crop yield potential, particularly in relation to agrochemicals.

2. There is education aimed at the commercial knowledge required

regarding detailed information and understanding of product performance, costs and application requirements in the field under normal farming conditions.

3. There is education relative to the administrative sections of crop protection distribution such as :-

   (a) Office administration, legislation and other legal aspects,
   (b) Delivery requirements relative to safety and other legal aspects,
   (c) Storage and handling requirements.

4. There is education relative to application techniques for crop protection products such as :-

   (a) Contractor operators,
   (b) Advisory work relative to operation of machinery.

To take the first of the parts into which I have divided the whole concept of education within the distributive industry: This can be further sub-divided into theoretical categories of level of technical expertise.

Several Colleges include crop protection subjects in their courses for higher National Certificates and higher National Diplomas.

Graduates in Agriculture, Horticulture, or the Agricultural services are mostly trained in scientific principles such as Biology and control of pathogens, weeds or pests, but comprehensive courses in crop protection per se are offered at such Universities as Aberdeen, Newcastle, Bath, Bradford, Reading, Wye and Nottingham.

The only comprehensive courses at post graduate level are those offered by Reading and Edinburgh Universities and Harper Adams Agricultural College.

Recently the crop protection distribution industry has realised the necessity for a higher level of technical training for the merchant distributor's staff who may not have attained any of the recognised qualifications so far mentioned, but who have in most instances finished their formal education at 'O' or 'A' level standards in relevant subjects such as Biology or Chemistry.

A course for new entries in the agrochemical distribution industry inaugurated by "Landmark", was designed and aimed at just such personnel.

The UKASTA two-year course, originated by BASAM, was aimed at those with relevant basic qualifications. This course is likely to be modified and condensed so as to be completed within one year, and negotiations are proceeding to extend the number of Colleges offering it. It is a course designed to give a broad basis of understanding of the pathogens, pests, and weeds of major crops and the crop protection tools at present available to deal with them at farm level within the concept of an integrated crop protection approach.

A variation of this course is offered for those with a minimum of five years experience in the advisory role but who have no formal qualifications and combines revision, vivas, written tests and an oral examination.

These education facilities have been examined by the Board of BASIS and have been formally recognised as acceptable within the terms of operation of the scheme.

Now let us look at the second of my somewhat arbitrary divisions of the educational field.

The United Kingdom distribution industry can be justly proud of the way in which the manufacturers of crop protection products have consistently up-dated their distributors relative to the development of new techniques and products on an annual basis. It is an on-going constant process which already forms an integral part of the on-the-job training of distributors' technical sales personnel, and includes not only commercial and technical briefing but revisionary training as well. The dissemination of this information to farm level, on the basis of the manufacturer operating with his distributor as a team, is looked upon as a perfectly natural progression of the educational process from manufacturer to ultimate user.

This education procedure is of paramount importance, but goes nevertheless, virtually unrewarded in so far as ever getting a recognised specific qualification is concerned.

Formal education under the sections dealing with administration, legislation and other legal aspects of the specific problems of the agrochemical distribution industry is hard to come by as far as the distributing merchant is concerned.

(a) The only real source of specific crop protection education for the administrator of a distribution set up emanates from the frequent and accurate translations of Government documents which are regularly sent by UKASTA to its members, or which appear under specific sections of more general courses designed for the technical salesman.

The recently developed UKASTA crop protection short conferences go some way towards augmenting the specific education of the crop protection product distributor operator.

Experience gained from the UKASTA courses which have been completed would indicate that there is a need for specific emphasis on aspects of the education of the administrator/advisor as opposed to the purely field advisor in the agrochemical distribution industry.

(b) There are few merchants who would know where to send an employee who needs to know exactly what the specific aspects of his job are as driver of a vehicle which is solely engaged in the delivery of agrochemicals, with which he should be thoroughly conversant.

(c) The Institute of Purchasing and Supply offers Certificates in stores supervision and stores management. These deal with the general principles involved but training in dealing with the specific problems of the agrochemical industry is entirely absent from the curriculum. Guidance is given as to storage under the BASIS scheme and certain manufacturers will assist in training storemen but there really is no formal education qualification obtainable especially for the storemen of a specialist agrochemical distributor. No doubt such recognised qualifications will be forthcoming when BASIS gets going.

(d) As far as spray machinery operators are concerned, there is a National Proficiency Certificate issued by the National Proficiency Test Council for Agriculture and Horticulture concerned with ground spraying, and a good course run by A.T.B. for field crop spray operators, and maintenance.

There seems to be a need for specialist courses in aerial application because the C.A.A. requirement does not appear to be sufficiently detailed to be really satisfactory from the agrochemical point of view.

Briefly the strengths and weaknesses of the educational chain seem to be as follows :-

Higher education at graduate level seems readily available but can, if care is not taken, be too theoretical and specific in nature to be of much use to the agrochemical adviser or distributor who is dealing with balances and practical applications of crop protection within the sphere of agriculture as a technology.

The general level of education of the specialist distributors' technical adviser is probably higher than he is given credit for, and the value of his practical experience is also probably under-rated. The courses and educational facilities now offered will give recognition where it is due, but at present suffer from being unable to provide sufficient places for the candidates who will require them, although the advent of a modified UKASTA long course to include places at a number of Colleges will go a long way towards alleviating the problem.

As far as administrative, delivery and stores staff are concerned, it seems to me that it is in this particular sphere that lack of education is most apparent and the facilities for providing it most in need of improvement.

I do not believe that too great an attempt at "standardising" courses within their relative spheres will do anything to improve the situation, but that a co-ordinating body such as BASIS should be able to verify the relevance of the syllabus of any course offered, offer suggestions as to the improvement where necessary of the syllabus, and be prepared, if such a syllabus is approved, to recognise whatever diploma or certificate is offered to successful course candidates as being valid in relation to the BASIS scheme.

Finally I do not believe that the present United Kingdom distribution system will survive commercially unless due recognition of the cost of implementing a worthwhile educational system is given and is reflected in the profit margins of the products marketed, coming as it does on top of considerably increased overheads relative to storage, handling, and delivery which will be incurred under the BASIS umbrella.

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INDUSTRY'S REQUIREMENTS AND ITS CONTRIBUTION IN TRAINING TERMS

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INITIAL TRAINING

The novice agro-chemical salesman is unlikely to possess knowledge, skill or have any trading relationships within his territory, and yet he will be asked to achieve a target of products and packs in a given time scale. His initial training programme would begin to prepare him for such a role and would be likely to include the following subjects:-

1. Job Responsibilities - these would leave him in no doubt as to his duties.
2. The Marketing Plan - to ensure that he calls on the right farms with the right product at the right time etc.
3. Technical Training - to equip him to understand the problem associated with weeds, diseases and pests or arable farming.
4. Product Training - to have a thorough understanding of the scope and limitations of the companies and competitive products.
5. Sales Training - to ensure that he can secure and conduct a sales interview in a business-like manner.

When we add to this training the combination of experience and much hard work calling on prospects, the 'novice' will begin to find that he is accepted by farmers who will give him time for a discussion and who in emergencies will reverse the role and contact him. Once this stage is reached he is likely to be of great value to his company and will begin to enjoy a rewarding place in the community he serves.

I will return to this salesman or commercial, but in the meantime I would like to draw your attention to the current situation regarding the training carried out by the various organisations who make up our industry.

TRAINING THROUGHOUT THE INDUSTRY

Current training practices are based on well founded principles of business efficiency, and it is not intended to portray a derogatory picture of training shortcomings.

1. There is a major, albeit hyporthetical training requirement based on the likely curriculum for the UKASTA Crop Protection Certificate. It is thorough and is intended to cover most problems associated with the growing of crops.
2. A limited level of training is carried out by a manufacturer who produces a

programme which is largely based on his limited range of products and is sufficient to accomplish the sale of those products.

3. Then there is a significant training area within a small/medium sized distributor whose business is conducted in a part of the UK with a range of products to meet local needs which again is sufficient to accomplish the sale of those products.

4. Finally, there is the comprehensive training opportunity from a national distributor whose product range will meet the needs of most farmers in the UK. Once again the yardstick is can he/she have enough knowledge to accomplish the sale of the range of products.

Clearly there is a vast difference in the training carried out by the companies who make up our industry. I have deliberately avoided specifics but would recognise that the balance of training carried out would also vary and one would expect to find the smaller distributor with little or no resources to have a bias towards product training since he is likely to be jumping on the bandwaggon of market leaders. On the other hand the manufacturer may take a wider view, perhaps because his attitude is more responsible, he has better resources, and he would therefore be developing staff to a higher plane.

STAFF CATEGORIES

Let me now draw your attention to the three separate job categories I have been asked to consider, to briefly describe their role and to examine the method of establishing effective training for that role:

The Adviser

His current role within my Company is to:-

provide technical support to the 'commercial' on farm
set up and monitor field trials
deal with complaints
liaise with Ministry bodies
advise the Company on markets/products
and work in support of a regional team of Crop Specialists.

The Commercial

His duties require him to achieve a sales target of products within a required time scale and with control of credit. Whilst the description is brief, his role is, of course, a vital one - and the company's future is more dependent on the effectiveness of this individual than anyone else.

The Storekeeper

Whose main function is to process orders - to keep stocks in readiness for those orders which call for knowledge of the marketing plan whilst being mindful of stock turnover, stock investment and the provision of speedy but economic delivery to farm.

Can we now consider the training of these staff who are likely to be present in most companies? The system I described is based on well-founded principles as practised by the majority of companies found in our industry.

Firstly, let us consider the role of the crop specialist 'or commercial'. He is seen by the farmer as someone who can be trusted and leaned on when problems occur. His acceptance of the role as counsellor is part of his job. The knowledge and skill which he portrays is there probably because he works for a company which realises that this kind of expertise will be recognised by the farmer and will create a relationship which if used correctly will have a symbiotic effect on both parties.

We, within the agrochemical industry cannot expect to employ a man or woman no matter how well qualified and expect them to contribute towards our sales objectives without considerable training which is accomplished both on and off the job and which should begin with a programme which is decided via the following documents.

1. Job description

The job description is a document which describes the purpose, scope or dimensions and duties of the commercial. Where possible certain tasks should be quantifiable (such as the target) so as to provide standards which can be assessed when appraising the incumbent at some future date.

2. Job specification

A detailed statement of the physical and mental activities associated with each task element. One area often omitted from the training of an individual is the section which deals with attitude - if neglected a man or woman may be employed and given training in the knowledge and skill areas and yet may still be of little value because of his/her attitude. As this is the key area the recruiter will need to be searching for raw material with the right attitude the remainder can be provided via training programmes.

3. Once a job specification is produced the commercial staff can then be measured against it to establish a learning gap which is then used to form the basis for training objectives and a programme.

Another useful document for the trainee is an instruction plan which asks the following questions. How, where, how long and by whom.

TRAINING OBJECTIVES

Since many of the training needs arrived at via this system are likely to be of a technical nature this document which is so often omitted from the procedure will serve to introduce methods of proving the value of the training undertaken and to establish methods of accomplishing objectives.

In practice what this means is that the person who is responsible for training decides on objectives and builds progress checks into the programme which will have the following effect:-

1. It will serve to check on the knowledge of individuals.

2. It will serve to check on the effectiveness of the training.

3. It will give the trainer an opportunity to take remedial action whilst the training is in progress.

In addition the document will create opportunities to set standards for subjects which may be considered to be unquantifiable.

Knowledge Easily quantifiable (either he knows or he doesn't).
Which can be checked via test papers etc.

Skill Less quantifiable - an evaluation within our industry is likely to be personal skills i.e. handling people etc.

Attitude Difficult to quantify but can be taught via exercises, and can be assessed via questionnaires.

THE TRAINING PROGRAMME

Is an interpretation of the training needs expressed in units of instruction. Having decided that the distributors' requirement in terms of knowledge required is much greater than that of the manufacturers, the managers must then decide whether to use this method to bridge the learning gap in total. Perhaps they must compromise and use the marketing calendar to decide on priorities, or perhaps consider such elements as gross profit to define requirements. If this method is used as a standard, we cansee that no matter what the role (Sales, Storekeeper, Adviser) the procedure remains the same, a well written job description being used as the basis for all training activities.

BASIS STANDARDS

How does the provision of standards by BASIS affect this package? Clearly it calls for planning at an early stage where the manager responsible for training ensures that the package contains those elements which are there as a pre-requisite for our staff and their future. The ultimate objective will be to complete the education of staff by reaching that standard which is set for the industry - not to work backwards from the product range on offer to the distributor or farmer (which appears to be the common approach by many in our industry). This philosophy of working backwards is short-sighted since the 'commercial' is only effective whilst the product inventory is static. He would also be inadequate if he were moved to an area where the arable enterprises were diverse which would in turn require a greater variety of chemicals to combat the associated problems.

MANUFACTURERS CONTRIBUTION

I am aware that by setting standards for member companies the result will be an increase in expenditure by those members whilst fulfilling their obligations. Training is expensive, since it takes people off the road where the majority would be meeting costs and perhaps showing a profit to the employer. The main costs are therefore based on the following:

(a) Salary of the delegate.

(b) The G.P. of lost sales.

(c) Accommodation/meals.

(d) Proportion of training staff salaries.

(e) Professional fees.

(f) Travelling.

The manufacturer will be better placed to cope with this since his margins are not subject to the peaks and troughs of the agricultural industry. They do not enter into the horse-trading which occurs at the farm gate nor are they subject to customers who stretch the word 'credit' to breaking point. We must do all in our power to ensure that these manufacturers are encouraged to participate formally in the training of staff in the direction of those standards set out by BASIS and that this be incorporated into programmes which are currently available to distributors, many of whom have no training facilities whatsoever.

CONTRIBUTIONS BY THE INDUSTRY

It must be the aim of every member to produce programmes which result in our staff being able to uncover real areas of needs and to meet those needs via the products in the inventory.

At the moment we have in our industry a section who because of lack of training and direction and because of a policy which looks for a profit via market leaders, results in many farmer interviews being conducted around a product i.e. product centred interview. Clearly this method of operation is unsatisfactory since the farmer could well be purchasing a product which is not suitable for his needs. In addition it inevitably results in the farmer making a purchase on a basis of price instead of meeting his needs, thus bringing the ethics of our industry into one of ill repute. The greatest contribution which we as an industry can make, is to ensure that our members accept that we will no longer be able to conduct our business in this manner, and that those who participate do so with knowledge of crop husbandry and its problems.

We are continually being told by agriculturalists that the role of the manufacturer and the distributor is changing and will continue to change through the next decade or so. A glimpse at the last decade will remind us as to the strides taken by our industry. During this period the crop chemical has been developed from a useful aid to an essential tool for most arable farmers and the machinery it is applied with has kept with this wider usage. We are already seeing new technology emerging such as tramlining and CDA. The industry must therefore recognise that standards will require revision and that development programmes be introduced to update staff no matter what their qualifications or experience. With this in mind it would be shortsighted of us to set up programmes to prepare staff for duties which are geared for today's market, and then to firm up on these policies by making them representatives for the industry as a whole via BASIS and UKASTA etc. "Necessity" is the mother of invention. The world is short of food, and we know that the production of food from livestock is a lengthy and costly process. This fact will ensure that the arable industry will remain under pressure to increase yields and shorten the maturing of plants. We have demonstrated an ability to make tremendous progress in the past and can look forward to a future where development will continue.

Clearly, training policies which are being sought and put together at this moment by organisations which represent our industry will need to be futuristic enough to have real value when used in ten years' time.