PRESIDENT'S OPENING REMARKS

An elderly General Practitioner recently complained to me about his increasing difficulty in keeping pace with progress in human medicine. As an elderly General Practitioner in agriculture, I am well placed to appreciate his problem.

My memories stretch back, over a period of sixty years, to the time when farmers still relied exclusively on their traditional weapons against weeds: the plough, the harrow, the grubber and the hand hoe, with occasional resort to hand fork or the Scottish version of the bill-hook which was known as the whankie. Then there was the carefully-planned and strictly-observed cropping - sequence of corn, row-crop and ley; and there was the weed-smothering power of the dense and vigorous crop. There were many clean farms in those days and, amidst the rather bewildering choice of new weapons, we should not consign to the scrapheap all of the old ones. But we must not forget that clean fields of the old days were kept clean at immense cost in terms of man-hours - and women and child-hours as well.

I remember the early and rather halting steps of progress - the use of copper and iron sulphates; I remember the work of an Edinburgh colleague, back in the twenties, who explored the possibilities of powdered kainit. Later, two of my Oxford colleagues did some of the early work on sulphuric acid. But since the introduction of the first of the cresol derivatives and the first of the "hormone" killers, events have moved so fast that one's memory is unequal to the task of recounting their succession. Not only have herbicides reduced the labour of weed control; they have given us a degree of control that our grandfathers, with all the labour resources which were at their command, would have envied.

It would be a difficult exercise to assess the relative roles of various groups of scientific workers in the raising of crop yields. The recent rise, of course, has been spectacular. Speaking in terms of wheat, it took some three centuries to lift our own yield from four sacks to six. It took just about a century to bring on from six to eight; and it has taken little more than a decade for us to climb from eight to ten. The major contributors to this rapid progress have been the plant breeders, the plant nutritionists, the engineers and the workers in plant protection. I cannot profess to be able to say just how the laurels should be distributed.

We have an almost overwhelming amount of new work to survey at this conference, and I shall not stand any longer between you and our first speaker. I have pleasure in calling upon Sir John Russell. It would be absurd to introduce him to any agricultural audience. May I, however, say how thrilled we are to have him to begin our proceedings, and how grateful this and future generations will be that he has found time to write his autobiography.

ARE WEEDKILLERS BEING DEVELOPED AND USED
TO ENSURE EFFICIENT FOOD PRODUCTION

Chairman: The President

WEED CONTROL: A RECORD OF STRIKING PROGRESS

Sir John Russell, F.R.S.

The beginnings

I feel very honoured in being asked to give the opening address at this Conference and I propose to make a broad survey of the progress already achieved in this country in weed control. The subject is an old one: the first tillers of our soil, the Neolithic peoples who landed here some 4,000 years ago bringing their seeds with them, brought also accompanying weeds to which our native flora contributed. Primitive implements could do little against them. But they had their uses: after the harvest the weedy stubbles provided grazing for livestock, and, if we may judge from peasant countries today, many of the weeds while still green and succulent would be pulled up by the women to feed the small animals about the dwellings. Apparently weeds were not deemed important; my classical friends tell me that neither in Greek nor Latin is there a word for "weed", and while the name came to us from our Saxon forefathers no one knows where they got it from.

Effective control of weeds began only in the early 18th Century when Jethro Tull conceived the idea of growing crops in rows and cultivating between them. He was not thinking primarily of weeds, but supposed that plants fed on finely divided soil. But he achieved much more than he knew; his book, The new horse-houghing husbandry published in 1731, went through several editions: it is one of the most fruitful in the whole range of agricultural literature for it ushered in the great revolution that began with rotations and ended with cleaner crops and a close linkage of arable and live stock husbandry. It is written in the spiciest fashion to which Cobbett in the 1822 edition added many characteristic footnotes; both were masters of abusive epithets and, there being no law of libel, could deal faithfully with their numerous critics. The book was so stimulating that, as Cobbett tells us, it was "plundered by English writers not a few, and by Scotch in whole banditti's". Inventors got busy on the horse hoe and drill and in due course our marvellous range of cultivating and scarifying implements has appeared. On the old four course rotation land could be kept very clean.

The cereal crop was the great harbourer of weeds and not more than two at the outside could be safely taken in succession. The continuous wheat on Broadbalk, Rothamsted, began in 1843: from 1852 onwards wild oats had spread so much that teams of men and boys were engaged in pulling them out as soon as they could be distinguished from the wheat. Gradually in the 1870's and 1880's Alopecurus came in and proved even more difficult because pulling was so tedious. Edwin Grey, then a boy but later Field Superintendent, records the comments of one of the men: "We can't see nothing else, only this blinking grass. We see it on our plates when we get home to tea and supper, and on Sundays it's in our eyes all day, and then on Monday morning here we are again". In despair Lawes and Gilbert put village girls on to the job and thought they had done well but the young hussies cheated and the weeds still defeated them as later they defeated Hall and myself. Our slow horse implements could do little cleaning in the brief interval between harvest and sowing the next crop.

Farmers learned the lesson: by growing only one or at most two corn crops, a winter and a spring, in succession, and using a proper rotation and hand weeding where necessary, the best of them were able to keep their arable land remarkably clean. In those golden years between 1855 and 1880 British farming was famous throughout the world and agriculturists came from far and near to see it and admire. The scientists were jubilant; control seemed complete: there was nothing more to be learned about weeds. "There is perhaps no object the nature of which is so well understood", wrote John Buckman, the distinguished Professor of Botany at the Royal Agricultural College, Cirencester in 1855. Indeed he saw some educational value in weeds; he emphasised the farmer's need for knowledge of their "nature and habit" which botanists could give and which he urged farmers to acquire.

But those golden days ended: long years of depression set in from 1880 to 1900 and all that Lawes could advise farmers was that they should never spend a shilling more on the land than they could possibly help. Some valiantly struggled to keep down the worst weeds in their grass lands: I remember seeing a sad-eyed labourer at it. "I been over fifty years stubbin' these blasted docks and thistles in this 'ere pasture" he said "and they still keep on comin'". The war against weeds seemed lost.

Coming of the chemist and motor engineer

By 1901, although it was not realised at the time, two new agencies had been discovered which were destined to change the situation drastically: the internal combustion engine which led to the tractor and rapid cultivation; and a chemical method of controlling weeds. They were both in embryo and agriculturists knew little about them. The story of the chemical treatment is one of the romances of science. It began about 1885 with the efforts of a vine grower in Bordeaux to protect his grapes against the depredations of the village boys: having a little chemistry he knew that the addition of lime water to copper sulphate produced a nasty looking greenish mess, and he hoped that if sprayed on the grapes it would protect them effectively. It did, and to his surprise it did more: it protected against the mildew which was then causing great losses, also it did not damage the vines. On one occasion when somebody had upset some of it on the ground where plants were growing an observant person noticed that some charlock among these plants was killed. The observation was followed up and in 1896 Bonnet announced that a weak solution of copper sulphate sprayed on to a weedy corn crop destroyed the charlock without serious damage to the corn. Two years later the method was demonstrated by Strawson near Chelmsford; it was promptly taken up by the Agricultural Institutes of those days, and numerous chemicals were tested, especially in the United States. Copper sulphate remained the best; sulphuric acid had good points but was difficult and dangerous in use.

In the early 1900's a new substance came in. Sir William Crookes had rather frightened the world in 1896 by declaring that world starvation would soon be upon us unless methods could be devised for making nitrogenous fertilizers from the air. This was done and among them was calcium cyanamide, the least effective of the group but the easiest to make as it required the least power. It proved a useful weedkiller, selective in that it stuck to broad leaved plants and killed them but could not so firmly stick to the smooth upright stalks of the cereal. It had the advantage of yielding ammonia in the soil which rapidly nitrified and became a good fertilizer, but it was disagreeable to handle and the men did not like it.

When the first world war ended considerable quantities of sodium chlorate and perchlorate were liberated and found some use as weedkillers; sodium arsenite also was available. The position in 1919 was that the world of inorganic or mineral substances had been pretty well explored for effective herbicides, but only about half a dozen had emerged as really useful. Copper sulphate was by far the best and most convenient; its disadvantage was the large amount of water required: 50 gallons per acre of a 3 per cent solution, which meant 4½ tons of water for a 20 acre field of barley - a considerable quantity in those days when all water had to be pumped and in a dry season wells might run dry. With this limited range of substances little progress either scientific or technical could be made.

Advancing technology of organic chemistry

The next great advance came in the middle 1920's when the chemical industry of Great Britain was completely reorganised. Prior to the first war the principle underlying our political thinking was that each country should make the things it could do best and then exchange surpluses with other countries. The system produced the maximum of goods of maximum quality at lowest price: with sadness we remember what a lot we could get for a shilling in those days, and how far we had to walk to save a penny. But the disadvantages of the system became evident during the war: for example, our dye stuffs, pharmaceutical and other fine chemicals had all come from Germany and we had been making only the so-called heavy chemicals: the alkalis, the commoner acids and a few very simple salts. All this had to be changed, and thanks to the energy of Alfred Mond, Clavering Fison, Jessie Boots and a few others we developed a highly efficient chemical technology capable of producing the most complex compounds, organic and inorganic, in any desired state of purity.

This new manufacturing system required as an indispensable partner a highly organised and very efficient research service equipped with men and appliances at least as good as could be found in any University. Imperial Chemical Industries was established in 1926: in the following year it set up the agricultural experiment station at Jealott's Hill, at first chiefly for fertilizer investigations, but within a few years weed control research commenced there. Being linked with Imperial Chemical Industries' extensive factory and research organisation the staff have access to an indefinitely large number of substances, organic and inorganic, and enviable facilities for studying them. Since 1937 an associated company, Plant Protection Limited, has done much work at Fernhurst.

There have been other great developments. Pest Control Limited was founded under the guidance of Sir Guy Marshall and W. E. Ripper, primarily for the purpose of doing the actual controlling by contract: later reorganisation was undertaken by Messrs. Fisons: the work has had the valuable result of familiarising farmers with the use of the new agents and stimulating research into the best means of applying them. Fisons Pest Control Research Station at Chesterford Park was opened last month by Sir William Slater.

Boots Pure Drug Company also entered the field: their experience in the manufacture of pharmaceuticals enables them to make a wide range of specialised control agents which are likely to be more and more needed.

Another firm well known for high quality chemicals, May and Baker Limited, is now making herbicides - and incidentally taking an important part in this Conference - while Shell Limited not only make control agents but have set up an experiment station at Woodstock near Sittingbourne. Mention should also be made of Monsanto Limited.

All these organisations are able to manufacture complex organic compounds on the large scale, and investigators can be assured that if they discover an effective herbicide, however complex, it will in due course be available for agricultural use.

The supreme advantage of the organic compounds is that an extensive series can be made, all of the same general pattern but varying in the groups of which they are built up; and as their properties depend on their constitution it becomes possible to modify the properties in various directions, when the details of the dependence have been discovered. If a substance otherwise desirable has some undesirable quality, a search among the variants may always reveal one that is free from it or has the desirable quality to a higher degree. Two methods of investigation are adopted. Large numbers of chemicals can be tested on many weeds and screened, or the effects of selected substances on selected plants can be studied in great detail to find out their mode of action and any relationships that may subsist between chemical constitution and specific physiological effects. The hope would be to arrive at rules and hypotheses on the basis of which chemical patterns could be designed to serve particular purposes.

Both methods are necessary. The screening method requires ready access to a vast number of substances and correspondingly wide range of appliances; it is beyond the capacity of a State or University research organisation and is best undertaken by large scale manufacturers who have the necessary research organisation and all requisite equipment. It is tedious: Warren Shaw in the very stimulating paper he presented to this Conference in 1954 described it as "time consuming, inefficient, frustrating, and costly". In 1952 it was estimated that out of every 2,000 substances tested in the United States only one could find use in agriculture, and some half million dollars had to be expended on it before it could be marketed. But the method works. It is used at Jealott's Hill by W. G. Templeman and his colleagues who can obtain many of the organic compounds that human ingenuity can devise. And it gives a great body of well attested facts out of which connections may be traced between chemical constitution and herbicidal effect if the organisation allows the investigator time to think about his results - and to "brood over them", as Liebig insisted was an essential condition for scientific progress.

The compounds first picked out were poisons, mostly benzene ring compounds. Benzene itself is not very toxic but it becomes so when certain other groups are added. The most popular are the hydroxy-, nitro-, and chloro-groups; DNC dinoseb, and pentachlorphenol have proved very useful: properly used they are selective: DNC associated with Pest Control Ltd. can be used to kill cleavers in cereals which some of the other herbicides cannot touch. This enlisting of organic chemistry enormously enlarged the range of possible herbicides: nevertheless had it stopped at direct poisons its effects, however remarkable, would not have introduced any fundamental new principles into the subject.

A revolution in herbicide treatment: the hormone pattern

When growth promoting substances were first discovered in plants, agricultural chemists naturally tested them to see if they would stimulate growth when applied to the plant. They did not: indeed in water culture experiments at Rothamsted and elsewhere they often proved harmful. The extent of the injury varied with different species, however, and quite independently, and by totally different approaches, it was found both at Jealott's Hill and at Rothamsted that wheat suffered less than some dicotyledons, suggesting that these auxins could be used to destroy weeds in grain crops. As they were rapidly decomposed in the soil they had to be protected by the introduction of chlorine atoms into the molecule to make them more resistant to bacterial action. The work was done during the war and publication was forbidden by the Government: nothing was announced until 1945. It then appeared that the discovery had been made at Jealott's Hill in 1940 and at Rothamsted in 1942.(1) Rothamsted did not proceed with field trials and subsequent investigations were made at Jealott's Hill and by G. E. Blackman, first at the Imperial College and later with an Agricultural Research Council Unit at Oxford. Another unit for laboratory studies was set up later at Wye College under R. L. Wain.

The fact that substances of hormone type were so effective greatly extended the list of possible herbicides. Two came into wide use because of their ease of manufacture and of application on the farm: MCPA and 2,4-D. Their great advantages over the direct poisons appealed very much to farmers especially the facts that they are non-poisonous, do not stain the workers' clothes, and are so highly effective that only small quantities per acre are needed which can be applied in low volume sprays requiring but little water. They soon became very popular in Canada as they not only increased yields but enabled the prairie farmers to modify their cultivations so as to reduce the hazard of soil erosion. Here in Great Britain they proved so effective in grain crops that many dicotyledonous weeds came well under control. In recent years I have travelled widely over the chalk country and light eastern county soils looking for the fields of charlock I used to see but finding far fewer; often seeing instead a board announcing: "Sprayed with XYZ" or whatever it might be. This efficient control has been an important factor in the dramatic rise in yield of cereals in this country in recent years.

But the weed grasses still escape: hand pulling is still necessary on Broadbalk when black grass comes abundantly, indeed Dr. Woodford confided in me that if anyone wanted a pure stand of wild oats or black grass it would be easier to eliminate any stray wheat or barley than in the converse requirement. Root crops are not so easily freed from weeds as cereals: indeed Sir James Scott Watson pointed out at the last Conference that while in the old days cereals used to be regarded as fouling crops and roots as cleaning crops the rôles look like being reversed. The difficulty is that the leaves of root crops are very sensitive to herbicides, and pre-emergence treatment has proved difficult so that it is not as yet widely practiced; so much depends on the timing and on the weather. J. R. Moffatt reports that trichloroacetic acid has satisfactorily dealt with couch grass on the Rothamsted mangold field, and

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(1) The Jealott's Hill work is recorded by W. A. Sexton, R. E. Slade and W. G. Templeman and that of Rothamsted by R. S. Nutman, H. G. Thornton and J. H. Quastel in Nature of April 28th, 1945. The full account appears in the Annals of Applied Biology, 1955, 42, 162-173, which also records the American contributions.

did no damage to either mangolds or sugar beet sown two weeks after its application. Many vegetables are as sensitive as the leaves of the root crops, but steady progress is being made in controlling weeds in them. Successful treatment would be particularly valuable to growers of peas, one of worst harbourers of weeds.

A large number of other substances prepared by the ingenuity of organic chemists have been tested for herbicidal properties but are not yet classified. Among them are the nitrogen compounds: amides, imides, substituted ureas, carbamates, and rings like triazole containing several nitrogen atoms. Some of these are effective against grasses and other monocotyledons, being readily translocated in them. Some, including triazole derivatives, inhibit chlorophyll production in a number of species. The amine of maleic hydrazide, one of the most unlikely compounds ever to get outside a laboratory, acts adversely on grasses, and experiments at the St. Ives Station, Bingley, have shown that it could be used to stunt their growth on roadside verges, though it would not be admissible on a putting green.

How do herbicides act?

A considerable amount of work is being done to discover how these various herbicides act. Systematic investigations have been going on at Oxford since 1946 by G. E. Blackman and a team of Agricultural Research Council workers. All aspects of the action of herbicides are studied: their retention, their absorption whether by leaf or root, their translocation within the plant and the place and mode of their action. The influence of light and other environmental factors is also studied. The experiments are not confined to crop plants: Lemna minor (lesser duckweed) for example is used when the exigencies of the work require it. Over a hundred papers have been published by the team: fortunately it is unnecessary for me to attempt any summary as Professor Blackman is addressing you later himself. It is sufficient to say that the action of the hormone herbicides appears to be not so much a direct poisoning as an upsetting of the metabolism of the plant.

Various disturbing effects of this kind are known. Blackman and colleagues have found that the hormone having entered the plant cells reduces the entrance of the nutritive ions nitrogen, phosphate and potassium. Some herbicides prevent the formation of chlorophyll. Since the metabolism of the plant is largely operated by enzymes it may be supposed that some herbicides somehow put them out of action. Much work is being done to find relationships between the action of the herbicide and its chemical constitution. Reference has been made to the considerable data that have accumulated in the countless screening tests but direct fundamental investigations are essential. These are being made by R. L. Wain and an Agricultural Research Council Unit at Wye who are also studying the fate of herbicides that enter the plant. Starting with auxins like 2,4-dichlorophenoxyacetic acid, homologues differing in the numbers of methylene groups in the acetic acid chain are found to be active if the numbers are odd and inactive if they are even. The explanation is that the compound is broken down within the plant by oxidation of the carbon atom in the chain - the second from the carboxylic group — if the number of methylenes is odd a toxic substituted acetic acid is finally produced, if the number is even the product is different and inactive. The oxidation is brought about by an enzyme which, however, occurs only in certain plants: these therefore are killed while those not containing the enzyme escape. Clover and some vegetables are in this latter group while some of their associated weeds are in the

susceptible group and are therefore killed. The simplest of the odd-numbered homologues are the butyric compounds and these are coming widely into use.

Wain has made an ingenious deduction likely to have far reaching consequences. A toxic chemical X can be combined with a smothering group Y to produce a non-toxic combination XY. Plants and other organisms containing an enzyme that can break the combination and release X will be killed; those that do not will escape injury.

Among a wide range of compounds selectiveness thus turns on whether the plant does or does not contain the particular enzyme that will liberate the active group. The interaction of enzyme and herbicide is modified by the substitution groups; some of these can even inhibit β oxidation. The enzyme and the herbicide are related structurally as a key to a lock, and this simile emphasises the fact that the interaction is a three dimensional affair, while we are brought up to think in terms of two dimensional blackboard drawings. Planning of research would probably be simplified if structure models could be built up as Lawrence Bragg did for the silicates, but this is at present a difficult operation.

Fundamental work on the mode of action of the herbicide and the relation of chemical structure to activity is difficult and progress is bound to be slow. But it is vitally important to the development of the subject; until it is more advanced the vast array of facts and observations accumulated empirically cannot be properly sorted out but remain as indigestible masses of apparently unrelated data that have not yet yielded up all the information they contain.

Agronomic experiences and problems

In the meantime remarkable results have been obtained in farm practice in all advanced countries. We shall no doubt have figures during this meeting showing present day consumption; it runs into thousands of tons a year and is bound to increase, and as a result farmers will acquire much useful information about them, especially on the relationship between soil and meteorological conditions, and efficacy of the herbicide. Investigators will do well to gather up as much of the farmers' knowledge as they can. In the parallel studies of fertilizers we found farmers' observations most helpful; frequently they had seen something which we had missed and they were able to provide us with those most useful aids to all scientific work; exceptions to what at first look like well founded rules. My advice to young research workers has always been to treasure the exceptions: they sober inflated ideas and may even open the way to an important discovery.

Already farmers have raised a certain number of problems. One of the most important lies outside the field of the herbicide investigator: the effects of curtailing cultivation operations. Already it is reported that herbicides have caused the disappearance of the cultivator from the sugar cane fields of Hawaii and are eliminating it from the orchards of California. The problems thus raised will be for the agronomists, who will thus have an opportunity of studying one of the most actively debated questions of today: how much cultivation is necessary for successful cropping? In any event they furnish another instance of the well known rule that every new improvement in agriculture devised by one man creates problems that will provide work for a colleague.

Another problem of increasing importance directly affects the makers of herbicides: the damage done by drifting of chemical sprays to a neighbour's crops. A few weeks ago aggregate damage to the extent of more than £10,000 had been reported during this season: the total damage is said to be much higher, Essex seems to suffer particularly; articles on the subject regularly appear in the Essex Farmers' Journal: 27 cases are reported this year. Not all of this is herbicidal spray, but MCPA and 2,4-D get in for much of the blame. We learn from the Handbook issued annually by the British Weed Control Council that the drift is most pronounced with the lower alkyl esters, and that there is very little with the ethyl butyl ester or the amine derivatives.

A further problem discussed in the Annual Report of the National Institute of Agricultural Botany is that herbicides may cause malformations in plants which are a serious detriment where crops are grown for seed. The Handbook states that this does not usually happen if the spraying is done sufficiently late, but varieties differ in their behaviour, and the matter is so important that the co-operation of the Institute might well be sought for an experimental enquiry to arrive at some general rules for the guidance of growers. At the 1954 Conference Dr. Petersen reported complaints from growers of certified seed potatoes in Denmark that the malformations of the leaves after spraying made it impossible to recognise plants affected by virus diseases and so they cannot be rogued effectively.

At the present time the use of herbicides is very patchy and includes only few out of the vast number proved to be valuable. B. M. Church's survey showed that in 1954 in the arable regions of England between a quarter and a half of the cereal acreage was treated with herbicides but in the grass regions the proportion was much lower: where less than a third of the farm land was in tillage only about 10 per cent of the cereal area was treated. About 80 per cent of the treated area had received MCPA; most of the rest had had 2,4-D or DNC. This great preponderance of MCPA over 2,4-D does not mean that it is intrinsically superior to that extent: indeed E. K. Woodford told the Essex Farmers Conference last February that 2,4-D might be cheaper and better for their winter cereals though MCPA would still be preferable for the spring sown cereals, oats and barley. In any case I understand that in the United States 2,4-D is far and away more popular than MCPA.

The farmer's problem is not necessarily the same as the investigators. His purpose is not so much to destroy every weed but rather to reduce the competition between the weed and the crop to negligible proportions. Dr. Templeman discussed this problem of competition at an earlier conference and raised the question whether killing the weeds was essential: whether it would not suffice to weaken them so as to shift the balance in favour of the crop which could then exterminate them. A weaker application of the herbicides might suffice, it might even thus become more selective.

In further investigations on pre-emergence treatments it will be interesting to see whether the herbicide has any partial sterilising effect on the soil resulting in the increase of bacterial numbers and the production of more ammonia in the soil whereby plant growth is improved. Experiments with compounds closely related to some modern herbicides were made at Rothamsted some 30 years ago and observations on the growth of the plant were recorded which could not then be explained.

The great merit of the hormone herbicides, their selectivity, is also the cause of a serious difficulty. No single substance deals with all weeds, and to

eliminate some may simply give those left untouched a better opportunity to develop and build up a formidable population. Instances of this ecological shift on farms in the United States were given by Warren Shaw in the paper I have already quoted. The wide use of 2,4-D greatly reduced the broad leaved annual weeds but left a clear field for wild grasses and broad leaved perennial weeds, which consequently increase, not infrequently, creating a new problem more difficult than the old one. Some of my friends are complaining of increased growth of couch in their fields and moss on their lawns since they started using weedkillers. There is undoubtedly real danger in relying too much on one herbicide. There is even the possibility as Professor Blackman hinted - though we hope only a very remote one - that persistence in one type of herbicide might result in the emergence of resistant strains in the weed population. Dr. Harper has developed this subject and is speaking about it later on. Farmers have already been advised to practice a rotation of herbicides, and both here and in the United States it is recognised that a larger selection of specialized herbicides should be used to deal more directly with specific weeds.

Meanwhile the most satisfactory procedure is to work out a proper partnership between the use of herbicides and cultivation. Dr. Aberg, whom we are delighted to welcome once more among us, spoke of herbicides at an earlier Conference as the "complements" of the mechanical operations; and Professor Sanders, with his usual capacity for hitting the nail on the head, emphasised the fact that no chemical treatment would make up for bad cultivation. Fortunately, the modern cultivating implements are now so speedy and so effective that they require much less man power than in the old days, and cultivation can be completed within a short spell of suitable weather instead of dragging on for weeks as used to happen. Here, however, timing is all important to ensure tackling the weeds at their most susceptible stage, and as Buckman pointed out more than a hundred years ago and many agricultural botanists have emphasised since, a knowledge of the biology of weeds is essential. Joan Thurston has been working on this aspect of the wild oat problem and we shall be interested to hear what she has got to say.

Time does not permit any account of the improvement of spraying techniques studied at Oxford and elsewhere and of the contribution of the engineer to the problem of weed control: that would require an address to itself which I am not competent to give. But just as the engineer has completely revolutionised cultivation in recent times so he has improved spraying operations out of all recognition. A degree of control unimaginable a few years ago has been attained: sprays ranging from fine mists to droplets of a desired size can be produced, allowing effective control of the volume of spray needed for a given area, an important economic consideration greatly facilitating the extension of chemical control.

It is quite certain that herbicides will take their place among agricultural and horticultural appliances just as fertilizers have done. There were not wanting people who, in the early days of fertilizers, saw them completely ousting the traditional farmyard manure. But they did not: they fitted in with farmyard manure, and raised plant nutrition to such a level that yields are now far higher than ever they were. So it may happen that weed control agents will be combined with modern rapid tillage methods to give us cleaner crops than we have had before so further increasing crop yields.

I shall attempt no forecast: prophecy in these days is a hazardous occupation. Chemists have given us not only plant foods, pest control agents

and herbicides, but also soil conditioners to do much of the work of cultivation. Engineers and physicists have given us not only our wonderful new implements and tractors, but also that staggering invention, the electronic controller, which threatens to usher in a new industrial revolution and completely change our mode of life. It may be that some of the younger members here today may live to see automation invading our farms and gardens. An electronic controller programmed to respond to changing weather and soil conditions as revealed by self recording instruments, to changing plant conditions and weed invasions recorded by photographic devices operating light cells, may yet by remote control send the proper agent to the proper spot and direct its operations, never making a mistake itself but being eternally watchful to correct those of any human intruder who thinks he knows better. Whatever happens however, we may be sure that the husbandman's path will always be beset with troubles: Virgil's words written two thousand years ago are eternally true:

The Father of Agriculture

Gave us a hard calling; he first decreed it an Art
To work the fields, sent worries to sharpen our mortal wits
And would not allow his realm to grow listless from lethargy.

There is little fear of the farmers ever suffering from lethargy.

CHEMICAL WEED CONTROL AND FARMING METHODS

R. E. Slade

Summary

Developments in the use of fertilizers, pest control chemicals and selective weed killers have made it unnecessary for us to stick closely to the rotations of crops, which have been customary and necessary for the last two or three hundred years. In place of a fixed rotation, we have knowledge which enables us to grow more of the crops, which we want to grow, either to suit our soil or to suit the market or to suit the vagaries of a fickle Ministry of Agriculture.

The introduction of expensive special machinery for each type of crop has enabled us to save labour and to produce more cheaply. But it does confine the farmers activities to as few branches of agriculture as possible, especially during a credit seqeeze.

The introduction of selective weed-killers and of other new methods of weed control is beginning to have a profound effect on our systems of farming. It is not just a question of whether the increase in the crop, due to weed control, justifies the trouble and expenditure on spraying. Weed control is one of the factors which has made it necessary to have a rotation of crops.

Thousands of years ago farmers found that they could not grow the same crop year after year on the same land and obtain good crops. The most primitive system, still practised in Africa, is to cut down trees, burn them on the land and then grow crops for two to five years before moving on to new ground. In England two thousand years ago the chalk downs were ploughed up, the turf burned and then crops of corn grown for a few years. When the corn crops began to fail they went on to new land and left the worn out land for some years to recover. In this country for centuries the most important rotation of crops was the three course system of the open fields of the manor - spring corn, fallow, winter corn. This rotation was an essential part of the manorial system and the manor was not only the agricultural unit but also the unit of government and of the military system.

When the manorial system of government was replaced by another system - the land was gradually enclosed and it became possible to use the systems of agriculture of ancient Rome. These systems were known from the writings of Pliny and Columella which had been preserved in the monastries.

About 200 years ago Arthur Young toured the country and wrote about the rotations which he found in different counties. In Norfolk they marled the light land and grew wheat, turnips, barley, clover and rye grass - feeding sheep on the turnips. On heavier land in Essex he found wheat, bare fallow, barley, clover. And in Essex near London he found wheat, oats, turnips, barley, clover, potatoes. He considered all these to be good rotations but in Glamorganshire they grew (1) wheat, (2) barley, (3) oats, (4) oats and (5) fallow - four corn crops and a fallow and he says:

> "It is absolutely impossible that good crops can be gained by such husbandry: for the last two must be overrun with trumpery and weeds without any strength (in the land) to get the better of them".

In those days the corn crops were usually hand hoed to destroy weeds.

The reasons why we use a rotation of crops are:-

(1) To include a crop which can be properly weeded such as bare fallow, turnips, potatoes or sugarbeet.

(2) To include a crop which will allow farmyard manure or sheep droppings to be ploughed in to fertilize the soil.

(3) To include a leguminous crop to provide nitrogen for the soil - this is usually clover.

(4) Crops often suffer from diseases - especially if the same crop is grown continuously on the same land. So it is safest to grow a different crop each year.

(5) Three year leys of grass in a rotation have been found to improve the fertility and produce clean crops afterwards.

But there are circumstances in which it is possible to grow the same crops year after year. We all know permanent rye grass pastures which have lasted for centuries and now respond well to adequate applications of fertilizers. They have been dunged by grazing animals and the grasses and clovers can beat the weeds, if the grazing and cutting for hay are managed properly.

I know a field in Southern Rhodesia on the farm of Mr. Claude Watkins, which has grown maize for 38 years without a break and now gives a greater yield than ever, because more artificial fertilizers are now applied. The particular conditions that have made this possible are probably (1) the field is near the homestead and it has received much kraal manure, so the soil is still improving in texture, (2) labour is cheap, so it has been weeded by hand every year, (3) the only serious pest is the stalk-borer - which is controlled by chemical dressings applied by hand to any plant which is attacked.

I also know a field in England which has grown barley for fourteen years. It still yields a reasonable crop but there will soon be more wild oats than barley on that field.

In recent years we have acquired new knowledge which I believe could give us much greater freedom in cropping.

We know how to profit by the use of, at least, three times as much artificial fertilizer on our land as we used to do twenty years ago.

We know more about plant diseases and how to avoid them. We have chemicals which protect the seed and the plant from many fungus diseases. We have insecticides which have made our crops safe from the wireworm the flea beetle and many other pests. We are learning that some plants are the hosts of certain fungus diseases and what plants are immune to these fungi. If we find "take-all" in our wheat, we can grow oats on that field in the next year.

We have a range of chemicals which are selective weed killers. They enable us to kill many weeds without hurting the crop and without any hand hoeing.

This new knowledge has been used by us to improve the yields of our crops - but this is not enough. I suggest that it should help us to a greater freedom of cropping so that we can grow more of the particular crops which are required - or for which our particular soil is most productive. In the four course rotation - wheat, roots, barley, clover, only 50% of our arable land is under cereals and the arable farmer does not always want 25% of his land under clover. In the five course rotation - barley, barley, roots, wheat, clover, only 60% of the land is under corn. Can we, if we want to, grow corn continuously for, say 3, 4 or 5 years? Can we keep up the fertility of the land by ploughing in all our straw and using fertilizers? I think we can. But we may eventually see signs of trouble due to some disease or some pernicious weed. If we do, we shall have to act at once and stop growing corn on that particular field for perhaps three years or even four. During these years we should grow a series of such crops as potatoes, sugar beet, peas, kale, lucerne, clover or fallow - or put the land down to grass for 3 years and keep sheep or cattle on it.

I once asked an advisory officer of the N.A.A.S. whether he had found that when a third or fourth corn crop was grown the yield was very much less than other crops on the farm. He said - "No. That crop always gets the maximum of fertilizer and is sometimes one of the best on the farm". I have also discussed this with a few of the leading farmers in my district, who agree that continuous corn cropping is reasonable if it is interrupted at once for a few years if the presence of weeds or disease necessitate the change.

As we become able to control more and more of the diseases and weeds of corn crops, we shall be able to make longer runs of corn crops if we wish to do so. But we shall always have to be ready to change to another type of crop if we meet disease, pest or weeds which we cannot control with such a change.

On farms where we grow potatoes we often have some fields which are better than others for this crop and there are farms which are all good potato land - but we cannot yet grow potatoes continuously owing to eelworm and some diseases. So we generally grow about three other crops before growing potatoes again.

Farmers are now employing less labour for the production and harvesting of crops than they used to do a few years ago. To do this they have had to buy machines and equipment. Unfortunately different equipment is needed for different crops. For corn growing they need combine drills, combine harvesters, balers, corn dressing machines, storage bins and sack loaders. For potatoes they need potato planters which also distribute the fertilizers, spinners or diggers, potato elevators, stores and sorters. If they wish to grow sugar beet they need a different equipment. So unless they are farming several hundreds of acres they are not equipped to grow and harvest many different crops. But the large farmer, no less than the small farmer, must grow on his farm a balance of crops to keep his labour force and his equipment fully employed but not overloaded.

Farmers, both large and small, therefore benefit from their newly gained freedom to arrange their cropping of the land to suit the capacity of their equipment and of the available labour. This is not easily done with the old fixed rotations of crops.

Let us consider the rotations on a corn and potato farm. It might be three corn crops and then potatoes, then four corn crops and potatoes.

This would be suitable for the potatoes - but if in any field the corn crops showed signs of disease or weed infestation, or if the corn or potatoes showed a fall in the general fertility of the land, it would be necessary to grow a series of "curative crops" for pernaps three years. These would be chosen from crops for which the farmer has the implements and labour to grow them economically. They might be a combination of any of the following crops - potatoes, sugar beet, kale, clover, lucerne, maize, cabbages, brussel sprouts, bare fallow, bastard fallow or a three year ley of grass.

WEEDKILLER USAGE IN ENGLAND AND WALES: INFORMATION FROM SURVEYS OF FARM PRACTICE

D. A. Boyd
Rothamsted Experimental Station, Harpenden, Herts.

(Read by E. R. Bullen, N.A.A.S., Anstey Hall, Trumpington, Cambridge)

For many years now the Provincial Soil Chemists of the N.A.A.S. and their predecessors in the old advisory service have been carrying out periodical surveys of what fertilizers farmers apply to their crops; the results, which are analysed by the Statistical Department at Rothamsted, have proved to be of considerable value both for local advisory work and as a guide to those responsible for decisions on agricultural policy. From time to time the Advisory Soil Chemists have agreed to include in the survey certain additional questions not directly connected with fertilizer use, for example on crop varieties or at what seed-rate they were sown. In the surveys carried out in 1954 and subsequent years supplementary questions on weedkillers, fungicides and insecticides have been included, and it is the information from this source which I propose to summarize today.

The survey information on the use of weedkillers on cereals is summarized in Table 1. Taking the past three seasons together, it appears that in the mainly arable districts of the eastern and northern counties between one third and two thirds of the cereal acreage has been sprayed each year with some form of weedkiller. The surveys in the eastern and east midland counties were all carried out in 1954 and there may well have been appreciable changes since then. Whilst the use of weedkilling sprays is most widespread in arable districts, recent surveys in Gloucestershire, Somerset and Wiltshire show that even in some typical dairying districts the practice of spraying cereals is becoming common. In Wales and much of the south-west, however, the use of weedkillers is still exceptional, none of the surveyed areas having more than a tenth of their cereal crops sprayed. The figure for the south-west is affected by the large acreage of dredge corn; in the Truro area of Cornwall about one-fifth of the spring barley and oats was sprayed, but under 5 per cent of the dredge.

In the surveyed districts there was no major difference between the different corn crops in respect of the percentage treated with weedkillers. Taking all the districts together it would be fair to conclude that the proportion of spring wheat sprayed was somewhat higher and that of spring oats somewhat lower than that of cereals as a whole. We have not yet had time to make this comparison within the same farm, however; very probably the apparent difference is in part a reflection of the fact that, within a district, the acreage of spring oats tends to be higher on the smaller (dairy) farms, which at present make less use of weedkillers. Another factor is the tendency for spring barley and oats to be more often under-sown than spring wheat.

Estimates of the relative frequency of the different types of weedkiller for the total sprayed acreage of cereals is given in Table 2. The data for 1954 and for 1955-56 are presented separately. Unfortunately there was a substantial number of fields for which no information or only incomplete information was provided. The chief source of difficulty was over a particular proprietary brand for which the 2,4-D and MCPA (amine) type are

distinguished only by letters. Since it is now too late to fill in the deficiencies by reference back to the farmers concerned we have arbitrarily assigned these fields to the 2,4-D and MCPA columns in the ratio of 1:3. Such an uncertainty does not greatly affect the general conclusion from Table 2 that all but one-tenth of the acrage in the surveyed counties in 1955-56 were sprayed with MCPA; in comparing the 1954 and 1955-56 figures it must be borne in mind that a different group of counties is involved.

In 1954, the first year in which the information was sought, spraying of undersown cereals was uncommon; in four counties where the use of weedkillers was fairly general (Isle of Ely, East Suffolk, Northamptonshire, West Riding) about half the cereals not undersown were sprayed, compared with only one-tenth of the cereals undersown. For S.W. Lancashire and the Cotswolds of Gloucestershire, surveyed in 1955, the proportion of undersown cereals sprayed had risen to 25 per cent and in 1956 (Humber Warpland and N.W. Wiltshire) to 40 per cent. The materials used on the surveyed farms in 1954 and 1955 were almost always the MCPA (sodium) but in the 1956 surveys they were almost equally divided between MCPA and MCPB.

Information on the use of weedkillers on peas is available for four districts in 1954 and one district in each of the two following years. Table 3 shows that in some of the more intensive arable districts half the acreage of peas for human consumption may be sprayed. There were no records of spraying being carried out on peas grown for stock feed. The material used was usually dinoseb and, in 1956, MCPB.

Information on whether the weedkiller was applied by the farmers' own outfit or by contract was obtained in 1956 but not in the earlier surveys. Weedkillers were widely used only in two of the districts surveyed in 1956 - the area of warp soils lying on either bank of the Humber and the Chippenham-Swindon area of Wiltshire. As might be expected, a greater proportion of the fields on a farm are sprayed where the machine is owned; for creeals the percentage of fields sprayed on farms owning and hiring contractors respectively, were 80 per cent and 60 per cent on the Humber warp soils and 60 per cent and 40 per cent in Wiltshire.

There were miscellaneous records of the use of weedkillers on root crops, potatoes, kale and on leys and permanent grass, but they were not sufficiently numerous to permit any detailed account to be given. It is evident that the use of weedkilling materials on these crops has not as yet been widely adopted. As might be expected, the use of weedkillers on these crops seems to be more common on farms where the equipment has already been bought to deal with cereals or peas.

There is still a very substantial difference between the large and the small farm in respect of weedkiller usage. Thus Church (1), in reporting the results of the 1954 survey, noted that, taking the same arable districts as those given in Table 3, only a fifth of the cereals on holdings under 50 acres were sprayed, compared with half the fields on holdings over 150 acres. Similarly in S.W. Lancashire, surveyed in 1955, spraying took place on only a quarter of the holdings under 50 acres, but on 85 per cent of the holdings over 150 acres.

The Statistics Department, Rothamsted has had little connection with research on weedkillers, and in presenting the results so far obtained from this survey we should be very pleased to have your frank opinions on the

usefulness or otherwise of this kind of information. Its collection has imposed a considerable extra burden on both the Soil Chemists' staff who carry out the fieldwork and on the farmers who supplied the information and it would be unreasonable for the Survey of Fertilizer Practice to carry this additional load indefinitely. Under present arrangements this survey will function on a co-ordinated basis, with surveys in each N.A.A.S. province, every third year; in the intervening years the work is restricted to such local enquiries as the Provincial Soil Chemist may consider to be useful. The last effort on a national scale was in 1954 and there will probably be a survey of similar extent in the coming year. Quite possibly the Soil Chemists will agree to continue the collection of this information on weedkillers for a further season, if this seems worth while, but now that the use of weedkillers is becoming so widespread, we feel that we cannot recommend that they continue the inquiry beyond 1957. I am sure it will be generally agreed that to attempt to collect too much data from a farmer can only lead to a loss of goodwill and to a reduction in the reliability of the data so obtained.

In the remaining few minutes it may be worth while to give some guidance on the factors which must be considered in designing an independent survey of weedkiller usage, with which, perhaps enquiries on insecticides and fungicides might be combined. It is important to realize at the outset just what information can and cannot be expected from such a survey. A detailed picture can be obtained of the extent to which different types of weedkillers are used on the various farm crops and how far practice varies from district to district and farm to farm. If desired, direct observations could be made of the weed flora of a sub sample of fields, whether or not they had been sprayed. Observations made both before and after spraying could give useful information on the effectiveness of the sprays, although at the expense of a substantial increase in the surveyors' time. Information on the use of weedkillers on such crops as cereals and peas, which in many parts of the country it is now common practice to spray, can be obtained fairly easily and cheaply; on the other hand, it may be a long and expensive job to obtain the same type of information for, say, permanent grass, since the number of farms where spraying is carried out is at present relatively small. Whilst the survey can give a useful picture of farming practice or even of the effect of different sprays on the weeds or on the crops themselves, it must be stressed that no useful estimate of the effect of sprays on crop yield can be obtained, other than by direct experiment. The difference in yield of sprayed and unsprayed fields will be due only in part to the effect of spraying, and will be affected to a considerable extent by other factors: taking cereals as an example, progressive growers who use weedkillers no doubt also tend to grow the newer varieties, they probably apply more than the average amount of fertilizers, and so on.

For the fertilizer survey we have found it more informative to survey a limited number of districts in detail rather than to spread the inquiry thinly over the whole of a province and no doubt this would be true also for a survey of weedkiller usage. Each district is more or less representative of a larger farming area and the boundaries of the districts are chosen so as to make each district correspond as far as possible to a single farming type. From within this district a sample of about 60 farms is selected, the selection being made at random within size groups; the effect of this is to include in the sample a higher proportion of the large farms, so that each farm visit tends to elicit a greater amount of information. Unless about this number of farms can be surveyed it is hardly worth embarking on a survey at all. Information is obtained from up to two fields of each crop grown on

the farm, except grass for which more fields are required. The time taken on the actual survey varies considerably according to the individual surveyor. At present the fertilizer survey information, together with that on weed-killers, insecticides and fungicides may take fully an hour to complete on an average farm and on large farms, with a wide range of cropping, up to two hours. Some surveyors find it difficult to survey more than two farms per day, while others can maintain three or even four a day. Thus one surveyor visiting 60 farms may be expected to take 4-6 weeks, at a cost of perhaps £2 per farm visited. Much of the fieldwork in the fertilizer survey is done by soil samplers whose work is rather seasonal, so that the true cost per farm is probably less than this; possibly a similar economy could be made in the case of a survey of weedkiller usage.

Reference

(1) CHURCH, B. M. (1955). Weed-killers and insecticides used on cereals, peas, swedes and kale, 1954. Plant. Path., 4, 131-133.

Table 1A. Use of weedkillers on cereals

District surveyed	Year	No. of fields	% of cereals sprayed				
			All cereals	Winter wheat	Spring wheat	Spring barley	Spring oats
Yorks. & Lancs.							
S.W. Lancashire	1955	188	46	43	60	35	44
Yorks., W. Riding (E. half)	1954	274	29	-	34*	36*	25*
Yorks. (Humber Warp soils)	1956	282	68	75	(92)	64	65
East and South East, East Midlands							
Isle of Ely (Peat & silt soils only)	1954	232	61	-	68*	60*	57*
East Suffolk	1954	303	42	-	47*	40*	35*
Northants. (N.E.)	1954	137	45	-	46*	48*	45*
Northants. (S.W.)	1954	129	25	-	32*	27*	11*
E. Sussex (Hailsham area)	1954	154	11	-	-	-	-
Western							
Gloucs. (Cotswolds)	1955	188	23	10	28	24	25
Somerset (Frome - Wincanton area)	1954	54	7	-	-	-	-
Somerset (Taunton area)	1955	118	21	-	44	17	-
Wilts. (Chippenham - Swindon area)	1956	109	34	34	(53)	39	29

* Spring and winter-sown cereals not differentiated.

Table 1B. Use of weedkillers on cereals

District surveyed	Year	No. of fields	All Cereals (% sprayed)
Wales			
Cardigan	1954	140	2
Flint (excl. Cheshire Plain and Vale of Clwyd)	1956	123	8
Glamorgan	1956	40	2
Radnor	1956	130	6
South Western			
Cornwall (Truro area)	1955	137	9
Cornwall (North)	1955	121	10
Devon (Tiverton area)	1954	140	7
Devon (Holsworthy area)	1954	111	5

Table 2. Materials used on cereal crops in surveyed districts 1954-56

Crop	Percentage of fields sprayed with:					No. of fields
	MCPA		MCPB	2,4-D	DNC	
	metal salt	amine				
1955-56						
Winter wheat	82	7	0	3	8	99
Spring wheat	78	7	5	5	5	57
Spring barley	83	6	9	2	0	81
Spring oats	78	14	4	3	1	111
All cereals	80	9	4	3	4	348*
1954						
All cereals	72	10	0	10	8	429*

* Not included in this table are 38 sprayed fields in 1954 and 51 fields in 1955/6 for which detailed information is not available.

Table 3. Use of weedkillers on peas

District	Year	No. of fields sampled	% sprayed
Isle of Ely	1954	47	40
East Suffolk	1954	29	17
West Riding	1954	49	10
Northants. (N.E.)	1954	8	(50)
S.W. Lancs.	1955	38	45
Yorks. (Humber Warp soils)	1956	40	50

DISCUSSION ON THE PREVIOUS PAPERS

Mr. J. R. Macdonald. (Introduction to discussion.)

Thank you very much for giving me this opportunity of opening the discussion. I will quite briefly give an indication of the sort of damage that is being caused by spray drift now, when I say damage I do not mean specifically crop destruction, but interference with crop production or yield reduction.

In 1956 there were over 50 and probably nearer 70 reported cases, involving claims, spread all over the country and outstanding in 1955/56

probably nearer 100. There is a great deal of unreported damage, and much of it is settled over the hedge.

The cash value is difficult to arrive at, but certainly the total figure involved at the moment is well over five figures, and in my view it is now approaching six figures for outstanding claims in 1955 and current claims for 1956. In Essex, there are, we believe two impending bankruptcies which we may be able to stave off; there is certainly one near nervous breakdown of a man who has had his crop substantially wiped out three years in succession, and is unable to obtain compensation for a variety of reasons. I think the problem is far and away the most acute in Essex and Norfolk. It is entirely dependent at the moment on the agricultural pattern where you get most arable, market garden and glasshouse crops growing together. The problem is very acute in the great monoculture districts; indeed you have seen from the percentage of spraying that you will not get the problem in anything like the same degree everywhere. At the moment the crop most seriously affected is outdoor tomatoes which seem to be highly susceptible. I don't want you to think that what I am saying is that we horticulturalists don't accept happily the tremendous advances in agricultural practice brought about by selective weedkillers. We accept them as part of the current good husbandry practice, but we do not accept the persistence of uncompensated damage, we do not think that is either permissible or reasonable. In the Battlesbridge area it is probable that the growing of susceptible crops is going to disappear altogether. I don't think that is an exaggeration, certainly the growing of outdoor tomatoes will have to cease and possibly the bulk of market garden crops. What is the solution? As far as the N.F.U. is concerned we don't know, we have not got the answer, but we have got some suggestions. Incidentally, we do consider that this problem is one of the more serious ones facing the horticultural industry at the present moment and I am not talking lightly. There are two aspects, one the prevention which is fairly obvious, and the other cure, in other words what can we do for the unfortunate victim once he has had some trouble.

Now as far as prevention is concerned education is obviously the first step, but I think we are lacking in information for this education. It is quite clear that conditions under which it was considered safe to spray two or three years ago are now known not to be. I am not sufficiently a technician to say exactly what the causes are, but I am certain that the introduction of low volume spraying is one of the reasons, another is that applicators as a whole lack knowledge as to the range at which these selective weedkillers can remain lethal. With reference to blow-off, I do not believe it is quite clear that damage is happening two or three days after spraying. A damage range of half a mile is established definitely, and my personal belief is that it may occur up to at least one mile. More exact knowledge is needed and that is a job for you people. I think you can do a great deal more by bold and definite warnings on your containers and leaflets. I do not think you should be ashamed that your products may be dangerous to other people; if you say so, and everybody knows, there can be no excuse that damage is done in ignorance.

Prevention is being talked about in the horticultural industry as a means of self-protection. It has been suggested that in suitable cases people should seek an injunction to restrain their neighbours from using weedkillers altogether. It would be a great pity, I think, but I can well sympathise with the chap whose crops have been wiped out three years in succession. There has been a suggestion that there should be a regulation

to prohibit spraying within one mile of susceptible crops. The third suggestion is notification to the police before spraying takes place anywhere. These are not considered ideas they are just suggestions that various frightened people have put up. The fourth and I think this is probably a good one as far as this country is concerned is the absolute prohibition of aerial spraying, the pattern of agriculture and horticulture in this country probably makes this desirable.

When you have established that the damage is caused by a selective weedkiller, you have then got to establish the man who did it. The grower is surrounded by arable farmers - there may be five within range of him of whom sprayed within 7 days. The grower does not recognise that he has got this damage until 3 weeks after. What hope has that chap got in saying which farmer did it? If he cannot, he will get no compensation by applying to the courts or underwriters. We thought a year or so ago that perhaps our answer would be to ask for compulsory third-party insurance for all people using sprays. Obviously third-party insurance is not going to meet our problem.

We seek now, if it can be established, a fund from which people can be compensated, provided that they can prove the damage has been done by one or other of these sprays. To enable this proof of damage by sprays to be obtained, Essex in conjunction with the Lea Valley, have thought of putting up a small annual sum of money to foster research. We thought possibly that it might be a practical proposition for microscopic examination of the cell structure of parts allegedly damaged by sprays to be made. This could be identified by scientists who would say - "here is characteristic formation which we have learned to attribute to MCPA or 2,4-D". This would establish beyond doubt that it was hormone damage and not a plant disease of some kind. I am wondering whether this Conference thinks that this is a good idea and, if they did, whether they would join with Essex and the Lea Valley and make some more money available for this research. I don't think our two organisations are going to be able to put up more than £250 or £300, which will not go very far.

We don't think that we should be the only people contributing to this fund. We think that the chaps who do the damage should bear a portion of it and we think the manufacturers should make a contribution. A suggestion has been made - just an idea which would have to be carefully considered - it might be possible to raise such a fund by a charge per container, per gallon or 5 gallons on the containers of the weedkillers.

We believe that the N.A.A.S. is the representative body to tell us whether, in fact, our crops have been damaged by chemical weedkiller or whether by our own negligence or by the use of faulty seed etc. It has been suggested that it is improper to ask the N.A.A.S. because they don't like appearing in court. We cannot see any objection to asking them to make a statement on a question of fact. I hope you will do your best to see that this is established. I am sorry to take up so much time on this one-sided outlook, but to us it is very important and I hope you people here will treat it as equally important.

Mr. K. Wilson Jones

In experimental work in the Sudan in which only knapsack sprayers were used it proved possible to spray grain crops without more than very

occasional damage to nearby cotton. In 1952 we used ethyl and butyl ester formulations of 2,4-D and MCPA, whereas previously we had only used the sodium salts. In those cases severe damage was caused to nearby cotton. At another site near the Abyssinian border we treated a small plot of grain and as a result had a trail of damaged cotton up to a mile downwind. In this instance we believe that it was a vapour trail not drift of actual spray droplets. In other words, no amount of care would probably have saved that crop.

I suggested to the firm concerned that ester formulations were not safe and we could not recommend them for use in the Sudan. The firm replied that they had often sprayed non-susceptible crops within 3-4 feet of susceptible ones and got no damage. I pointed out that the conditions were rather different, with higher temperature etc. I would seriously suggest that prohibition of ester formulation would help in avoiding damage to susceptible crops.

Mr. M. J. Zwijns

When cereals are sprayed in an area where susceptible crops are grown like tomatoes, it would be far better policy not to use hormone substances and stick to DNC formulations.

Dr. W. Plant

I have been called in to make clinical diagnoses of several so-called cases of spray damage in horticultural nurseries, and I think the farmer is often made the scapegoat of bad horticultural husbandry. We must realise in the first place that in giving any diagnosis of so-called spray damage, we must be in a position to identify damage due to pests and diseases.

I would suggest that horticulturalists might grow a series of indicator crops so that diagnosis of so-called spray damage be correlated with damage to indicator crops which research has shown to be particularly sensitive to hormone herbicides.

Mr. T. E. Fletcher

One important point appears to me to have been completely overlooked, and that is the horticulturalist himself is often responsible for a good deal of damage to his own crops, due to using sprayers which have been contaminated with hormone weedkillers but not washed out thoroughly. Also I have seen many cases where fertilisers have been contaminated by hormone dusts. It would seem to me that this is an important point which should not be overlooked. I myself have seen many cases where butyl esters have been left in tins in glasshouses and the vapour from the tins has caused considerable damage to tomato crops. In one case a small amount of material was left in the ridge at the top of the tin. In another case where a tin was left in a glass-house for a long time, the material had eaten through the seam of the tin and the vapour had caused considerable damage to many pot plants in the glasshouse.

Mr. F. Wright

I would just like to endorse what the previous speaker has said. I know from my experience as a contractor that rubber hoses seem to become impregnated

with hormone weedkillers for considerable periods. I have not been able to find any method of cleaning them after using esters or MCPA, and I have to use separate hoses for different substances. I think there should be some research into this.

I also believe that surveys of the use of weedkillers are very valuable. I think contractors could be of considerable help in surveys. Co-operation from contractors would reduce the cost and give a lot of information; we will be glad to help in that way as far as we can.

Miss P. M. Hillebrandt

I should like to make one or two comments on the weedkiller surveys undertaken by the N. A. A. S. and Rothamsted and to say first of all how valuable this type of information is.

It is, I think, a pity that the surveys might not be carried on over a continuous period because a large part of their value lies in obtaining a continuous record over several years. I should like to make a plea, if I may, for information, not only on the extent of the usage of weedkillers, but also on the extent of usage in relation to the yield of crop. I suggest this not with the object of finding out how much the use of weedkillers actually increases the yield of crop, but rather with the object of discovering the relationship between the use of weedkillers and the total proceeds of the farmer from the crop. I think there is probably a very distinct relationship which is independent of the actual increase in yield attributable to the use of weedkillers. One of the difficulties of any economist working in this field is to establish the extent of the rational and irrational reasons for farmers use or non-use of weedkillers. If we had the data on the economics of the crop including weedkiller usage, it would enable us to determine whether certain courses of action, which at the moment appear irrational, have in fact a rational basis or are attributable to lethargy or muddled reasoning.

Chairman: Mr. R. E. Longmate

FACTORS INFLUENCING THE FARMER'S ACCEPTANCE OF NEW TECHNIQUES

G. P. Hirsch

Agricultural Economics Research Institute
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A recent report on an extension weed control programme in Michigan, U.S.A., bluntly asserted:-

> "Most farmers are not taking full advantage of the information available on herbicides and weed control methods. With few exceptions there is too long a delay between the development of a new weed control practice and its use on the average farm."(1)

It is an established fact that there is a considerable delay between the discovery of a new technique in farming and its translation into everyday use by the majority of farmers. A study in the U.S.A., for instance, in relation to the use of hybrid maize seed found that there was an average time-lag of about 5.5 years between first hearing of and first use of this new type of seed despite an intensive extension campaign encouraging farmers to make the recommended change. Significantly, however, early adopters waited only 1.6 years while the later ones waited 9.2 years(2).

In this country we find the same kind of variation if we take the possession of a ground sprayer by farmers as an indication. The table shows a variation in the number of ground sprayers owned by farmers per 1,000 acres of fieldcrops from 0.1 in Merioneth to 3.5 in Kent. If we postulate that a holding of 150 acres of crops and grass (of which at least 50 acres can be reckoned to be under corn crops) would justify the possession of a ground sprayer we find that in 1954 only the counties of Cambridgeshire and the Isle of Ely can claim to have fulfilled this target but that there are many counties with a ground sprayer on only 1 of every 10 holdings of over 150 acres. The increase of these sprayers between 1946 and 1954 in the various counties shows an equally wide range. The Map shows significantly that it is the counties in East Anglia, the South-East and those lying in a band through the Midlands which have the highest numbers of these machines. These are the counties which have at the same time the highest percentage of larger holdings, a higher density of agricultural employment, and a higher proportion of their land under crops.

Thus the question arises as to which factors are responsible for the time lag and for the wide variation in the ratio at which farmers accept new techniques. No studies of this subject have been undertaken in this country so far as can be ascertained.* This paper has, therefore, to be based on findings of work carried out over a number of years in the U.S.A.

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*At the meeting of the British Association at Belfast in 1952 a symposium was held on "Changing Human Behaviour in Agriculture" but none of the papers presented was a "research report" (see "Factors Influencing Change in Human Behaviour" in 'Nature' (1952), 170, 688-690 and Harper, Roland, "Changing Human Behaviour in Agriculture" in 'Agricultural Progress' 1952, 27, (2), 167-175.

Any going business like a farm enterprise is characterised by innumerable processes that are habitual. They are being performed because they have been performed before on the same farm and on similar farms. Routine action, following rules of thumb or inertia, prevail frequently in business life in the same way as in every-day life. It is, therefore, important to recognise that acceptance of a new technique involves essentially learning, deciding, and acting purposefully. It is a process composed of a number of stages:-

(1) at first the farmer hears about the new technique and becomes aware of and interested in it in a general way.

(2) he then seeks specific information about it and weighs up the pros and cons, and

(3) if satisfied, tries it out on his own farm,

(4) finally accepts it completely as a routine operation.

It is obvious, that different factors will influence the progress of the process from one stage to the next and that a variety of factors - positive and negative - may be operative at each stage.

Each change in whatever sphere creates a lack of knowledge about some specific future event and thus to uncertainty of varying degree with regard to it. A recent study by the Farm Economics Branch, Cambridge University, on the 'Economics of Crop Spraying' found that

> "among the farmers interviewed there was some conflict of ideas on the effects of spraying on yields. Some believed that it had little effect either way, unless the field was badly infested with weeds. Others thought that apart from yield increase due to the elimination of weed competition, the crop was given a direct stimulus by spraying, especially with DNOC, and still others thought that yields were actually reduced by spraying."(3)

Even if farmers obtain early "scientific" information on the productivity of new techniques, the new data will be viewed with a high degree of subjective uncertainty as they are often based on experiments on extremely small plots of land or on groups of animals over short periods of time. There may even be a divergence of 'opinion' among the 'experts' in the early stages. Thus the advice given by a well-known farmer to his sons: "Be not the first to don the new nor yet the last to cast the old aside".

Not knowing how a new technique may affect his farming influences the farmer's planning and action. The lack of knowledge introduces an additional element of risk apart from the already present and known risks inherent in farming. Risk always has an unpleasant connotation; it implies the possibility of a risk loss without the necessarily corresponding possibility of a high risk gain(4). The farmer in this situation is confronted with a choice of risk action or inaction. How he will react will depend in the first instance on his own personality, his psychological make-up. It was found that there were three basic personality types in this context; those who were by nature averse to change and new things; those who would accept new ideas but who needed a specific incentive to do so; and, finally the "aggresive seekers after new knowledge and techniques, who are prepared to take risks and to try anything once.(5) The world is full of pioneers not less among farmers than

in any other section of the community. This differentiation in basic type finds its corresponding expression equally in other situations. In a number of studies in the U.S.A. it was found that it was those who accepted new techniques who participated more actively in community affairs and in farm organisations(6). All this is an indication of personalities who are generally awake, sociable, and interested in affairs. In addition social status and the maintenance of his prestige in the community, i.e. what he considers his neighbours expect of him, his personal pride, will influence a farmer's rate of response to a new stimulus. On the other hand, where local or kinship ties are most highly developed resistance to change was found also to be highly developed(7). Similarly farmers who had learned most of their farming from their fathers or on whose farms almost all the labour was provided by the family had adopted fewest improvements in their farming.(8)

Of equal importance is the economic status of the farmer, i.e. his position with regard to the availability of capital for those innovations which require comparatively large investment. There are, however, those innovations like artificial insemination which require less capital than the previous practice and those which only demand the same or very small additional capital outlays. These latter are more easily accepted by all. An example is the use of many improved varieties of seed in contrast, for instance, to an increased use of fertiliser or lime, not to speak of new implements or machinery. Not only the availability of capital, however, influences the farmer but equally a whole gamut of other economic considerations like expectations of demand and price. Wilkening goes so far as to state that

> "the rationalisations of farmers with respect to their approval and disapproval of new practices tend to be based upon economic considerations."(9)

We saw how knowledge or the lack of it influences the process of acceptance. The question is, where do the farmers obtain the necessary knowledge and on what information do they rely? A number of important answers have been given to this question in the U.S.A.

The different types of sources of information serve apparently different functions in connection with the stages in the process of acceptance (see above).

Stage 1. The institutionalised agencies of information, i.e. the State Colleges, and the mass media tend to be the first contacts of information about innovations. For instance, these sources were given more frequently than 'other farmers' as the contact for first knowledge about 2,4-D weed control.(8)

Stage 2. A large percentage of farmers seek specific information from experts, the State Colleges, the Farm Bureau.(10)

Stage 3. A large number of farmers was stimulated to use fertiliser by 'noticing better stands on other farms' or by being told by other farmers about their higher yields. The acceptance was here based on seeing for oneself or by relying on trusted fellow farmers. There is, however, apparently even a difference between the sources of information relied upon for an entirely new practice and those for a further development of an already accepted one, e.g. the use of fertiliser and the use of a new fertiliser. In the latter case the public agencies or experts were relied upon.(10)

Stage 3. (contd.)

Another difference seems to exist between early adopters who use the agricultural agencies and mass media and the late ones who relied more upon their neighbours.

In addition, it appears that the relative importance of a source of information depends on the subject matter concerned. Another report states that

> "livestock information was significantly more often identified with agricultural teachers, evening classes, and veterinarians. On the other hand, crops-soil information was significantly more often identified with container labels or operation manuals, county agents, 4-H programs, magazines or newspapers, and SCS programs."(11)

Enough has been said to show that we are dealing with a highly complex process. Its rate of progress depends on the quality and make-up of all who are involved in it, scientists, the members of the official agricultural agencies, dealers and merchants and their agents, contractors and last but not least the farmers themselves. Some of the farmers are involved in a double role, as early adopters and disseminators of information to their fellow-farmers.(12)

In conclusion I wish to stress that we have in this country no firm knowledge based on research about this whole process of 'communication' and 'acceptance'. I suggest, however, that the time has come to spend some effort and money on finding out about it. Such a study would not be a mere academic exercise but would be of immediate practical consequence to the productivity of agriculture.

Use of ground sprayers, counties of England and Wales, 1954*

	Ground sprayers, numbers	No. of ground sprayers per 1,000 acres field crops (including fallow)	No. of ground sprayers per holdings of 150 acres and over (crops and grass)	Increase 1946:1954 per cent.
NORTHERN AREA				
Cumberland	55	0.6	0.1	244
Durham	159	1.2	0.2	413
Lancashire	275	1.9	0.5	310
Northumberland	246	1.7	0.7	324
Westmorland	46	2.2	0.1	283
Yorks - E.R.	648	1.8	0.4	945
Yorks - N.R.	592	1.9	0.4	1,133
Yorks - W.R.	539	1.7	0.3	798
E. MIDLAND AREA				
Derby	121	1.2	0.2	246
Leicester	347	2.4	0.4	269
Rutland	83	2.1	0.4	730
Holland	351	2.2	0.9	101
Kesteven	460	1.8	0.6	567
Lindsey	922	1.9	0.6	609
Northants	418	2.3	0.3	564
Nottingham	314	1.6	0.3	415
EASTERN AREA				
Bedford	259	2.0	0.5	398
Cambridge	633	3.4	1.2	274
Isle of Ely	372	2.3	1.0	313
Essex	987	2.4	0.6	509
Hertford	381	2.5	0.6	747
Huntingdon	234	1.8	0.9	736
Soke of Peterboro'	79	2.9	0.8	888
Norfolk	1,495	2.3	0.8	717
E. Suffolk	583	2.1	0.6	1,115
W. Suffolk	380	1.8	0.6	567
S. EASTERN AREA				
Berkshire	300	1.9	0.4	456
Buckingham	269	2.2	0.3	274
Hampshire	564	2.1	0.6	588
Isle of Wight	36	1.6	0.3	125
Kent	837	3.5	0.6	282
Middlesex	-	-	-	-
Oxford	313	1.9	0.4	526
Surrey	216	3.1	0.6	218
E. Sussex	338	3.3	0.6	405
W. Sussex	323	3.0	0.6	909

Table continued on next page.

Use of ground sprayers, counties of England and Wales, 1954* (continued)

	Ground sprayers, numbers	No. of ground sprayers per 1,000 acres field crops (including fallow)	No. of ground sprayers per holdings of 150 acres and over (crops and grass)	Increase 1946:1954 per cent.
W. MIDLAND AREA				
Cheshire	120	0.9	0.2	26
Hereford	244	2.1	0.2	201
Shropshire	366	1.7	0.2	732
Stafford	190	1.4	0.2	494
Warwick	405	2.4	0.4	575
Worcester	292	2.7	0.4	300
S. WESTERN AREA				
Cornwall	226	1.4	0.3	259
Devon	497	1.9	0.3	268
Dorset	166	1.6	0.2	374
Gloucester	335	1.9	0.3	347
Somerset	418	3.3	0.3	506
Wiltshire	421	1.9	0.3	836
S. WALES AREA				
Brecon	24	0.9	0.1	0
Cardigan	16	0.3	0.1	-24
Carmarthen	15	0.3	0.1	- 6
Glamorgan	40	1.2	0.2	14
Monmouth	74	2.2	0.2	95
Pembroke	47	0.6	0.1	2
Radnor	12	0.4	0.0	71
N. WALES AREA				
Anglesey	17	0.8	0.1	31
Caernarvon	11	0.5	0.1	-73
Denbigh	31	0.6	0.1	107
Flint	23	0.9	0.2	92
Merioneth	1	0.1	0.0	-86
Montgomery	30	0.7	0.1	50
ENGLAND AND WALES	18,259	2.0	0.4	430

*The Biennial Machinery Census has been discontinued; figures for Ground Sprayers will shortly be available for September 1956 on a sample basis.

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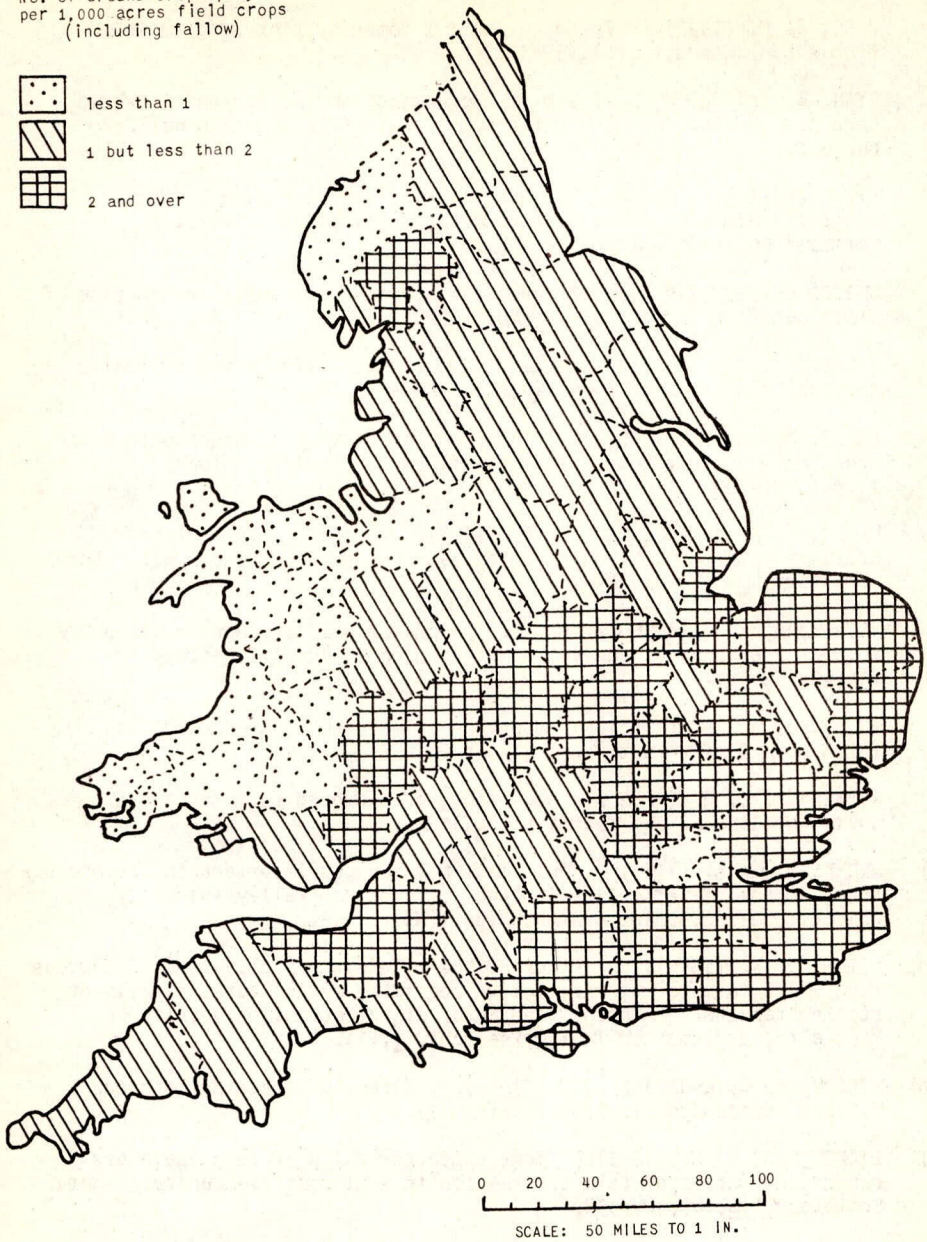
No. of Ground Crop Sprayers per 1,000 acres field crops (including fallow)
less than 1
1 but less than 2
2 and over
0 20 40 60 80 100
SCALE: 50 MILES TO 1 IN.

DISCUSSION ON THE PREVIOUS PAPER

Mr. J. Rhys Thomas (Short Introductory Paper)

Mr. Hirsch has given us a most interesting paper, but he has fallen into the trap of overplaying his hand in endeavouring to prove that farmers as a whole are slow in adopting new techniques, in my view this is not a true inference to draw from the information available.

I submit that farmers as a whole (and I speak for some 300,000 representing all degrees of ability) have not been slow in adopting new practices over the very wide field of agriculture.

Current examples to prove this can be found in the mechanical equipment commonly found on British farms, two examples will suffice, the very rapid application of the diesel power unit and the popularity of the pick-up baler.

Cereal strains provide a further practical example, thousands of farmers throughout the country are prepared to grow new varieties even before they are on the recommended list of the N.I.A.B.

The general adoption of new ideas and techniques in industry takes, so I am told, 25-30 years, the very rapid development of weed spraying practice during the last 10 years indicates that the farmer is no less receptive of new ideas than his counterpart in industry.

There would appear to be a school of thought which maintains that spraying should be part and parcel of the production cycle in any season, my annual reaction is not shall all crops by sprayed, but, how little must I spray. May I give a personal example to make the point? In an undersown field of winter wheat 20 acres in extent, 16 man hours sufficed to dispense with a few thistles and charlock that could have been unsightly. I will leave you to compare the difference in cost between this method of treatment and using a weed killer.

Sir John Russell, earlier this morning, projected his thoughts into the future, and suggested that spraying techniques could well advance at sometime in the future to such a degree that some of the acceptad husbandry cultivations could be omitted.

At this point in time it is not so and, spraying as such is no substitute for sound cultivations and rotations, we should only endeavour to make the maximum economic use of spraying materials.

The average farmer today is confused by the great variety of products on the market having a proprietary name but at the same time active material. The MCPA group is an outstanding example in this regard, with over 80 proprietary names, and having widely differing rates of application. I hope that the manufacturers will soon realise that they should state on the container the amount of active ingredient per unit, this step forward is long overdue.

Naturally as farmers we have a duty to march forward in step with the scientist as rapidly as possible.

Some of the older farmers will not be prepared to do this and it is to the younger generation that we must turn for an even increased rate of technical progress.

Unfortunately far too many young men start farming with a background of knowledge that is too narrow. I should like to see an exchange scheme operated in such a way that a farmer in one area could exchange his son or daughter with another farmer who has a child of a similar age, this type of exchange would automatically overcome the difficulty of accommodation.

The industry is not loath to accept and adopt new ideas; to speed up the rate of progress we must look to the younger generation.

Mr. A. J. Cannon (Short introductory paper)

Most of us here including Mr. Hirsch, are thinking about weed killers for a very large part of our time whereas the farmer is only concerned with such matters for, at most about one week in the year.

The average farmer is a man of the soil, dealing with basic practical problems on a minute to minute basis as the weather and the whims of politicians dictate. He is not directly interested in highly technical theories and what happens in laboratories or in 2 x 4 plots. Go for a walk round the farm with him, forget your laboratory terms and talk to him in his own language, and he becomes interested in anything new that you show him. Follow up your visit with a good spraying outfit and demonstrate to him the modern way to deal with weeds in his crops and you will have achieved something which the scientist, the manufacturer's salesman or the merchant will never do on their own.

I am amazed that Mr. Hirsch has omitted to mention the contractor. (I know that there are contractors good and bad but time will always sort them out.) In almost every new technique in farming it is the contractor who buys the first machine and develops the best way to use it. How true it is that you always find the most extensive spraying, particularly with DNC and toxic chemicals, in areas where you have a good contractor who is well-known for his farming background and for giving good service. The contractor is a neighbour, a merchant, an advisory officer, a supplier of credit and one who is always on the spot when things don't look just right.

Speaking on a broader issue I feel that farming in this country must organise itself into larger units as a means of stepping up efficiency and getting a larger output for the capital invested. Only in this way can men give the time and study required to become specialised in any one or two of the very many subjects entailed in the efficient running of a mixed farm. Only in this way can the average farmer ever hope to be well equipped with all the modern machinery and the know-how to operate it and to make full use of the enormous amount of scientific discoveries that are now available to him. Whether co-operative farming, company farming, machinery pools, marketing boards or contractors are the answer is not the concern of this conference.

"Be not the first to don the new" etc. Farmers have learned this through the ages of experience and one has only to reflect for a moment to realise this. Where are the plants for treating straw with acid to make cattle feed? How many stationery balers, side-cut trailer combines, hay and straw elevators and sweeps, atomiser type spraying machines are stopping gaps on the farm or are in some contractor's graveyard to-day?

The farmers have already borrowed £230 million from the banks alone and a very large part of this has gone into modernising their buildings and equipment. Can we wonder that he listens many times and looks at least once before he borrows still more capital. I feel that the progressive farmer (and if he is not progressive he is on the way out) is making as much use of new techniques as his individual status can cope with.

There is no doubt that the judicious use of chemical weed-killers can be extremely useful in lowering man hours per unit of production, lower the overall cost of production and it can also increase yields per acre. The most important point is to obtain the maximum benefit at the minimum cost. I have tried to show that the average farmer with 50 acres under arable crops cannot hope to achieve this effect without some help, at least of an advisory nature, from the outside.

Where is he to get that help? The travelling salesman is not and cannot be at the farm often enough to deal with this problem and in my opinion is often rather under suspicion as only being interested in the sale of his firm's products. The merchant can never be expected to have the specialised knowledge required for this as chemical sales are only one side of his business and he also suffers the same disadvantages as the manufacturer's salesman. The N.A.A.S. is costing us £5 million per year and I would pose the questions - 'Are we making the best and fullest use of their services?'

They are not tied to any one section of the weed control industry; they are on the spot (or could be) at the critical times; they know the district, the type of land, the individual farmer and the services available in the district. Their services are also free of cost to the individual farmer.

The contractor - not all districts are covered by specialist spraying contractors and although we travel many miles in our own business and dispense advice freely whether we are doing the work or not, it must be admitted that such work does take up a lot of time and money. We do feel, however, that no contractor who has at heart the real interest of the farming community of which he is himself a part, can afford to give other than sincere advice, not only to his customers, but to all who ask for it, even when it entails telling a farmer to keep his money in his pocket or to 'top it off with your own mower'.

I would suggest that a farmer's best friends are his neighbours and they include, or should include, the N.A.A.S. Officer for his district and his contractor. If I might reiterate and apply to the farming community a well-known slogan for the future - 'Together we stand, divided we fall'.

In conclusion I would agree with Mr. Hirsch that there is too long a time lag between discovery of a new technique and its adoption by many of the smaller farmers. I feel that the answer to the problem lies in the farmer's end of the chain and anything that can be done to encourage the smaller average farmer to adopt the same principles in business that have been followed in industry i.e. to pool their resources and their knowledge, must be investigated very seriously by the farming community in the future.

Mr. F. R. Scovell (Introduction to discussion)

My remarks come from 10 years of what I might term farmer contact. We have heard the other side of the picture and I think this must be put. It is quite true to say, as Mr. Hirsch does: that there is no organisation engaged

on this subject in this country, but there is a vast amount of practical experience from such people as myself, who have been contacting farmers, continually over such things as selective weed control. From my own observations I find, taking the field of selective weed control only, that one can almost always find a ratio of 10-20% of farmers interested in some degree, who are prepared to have a go, and 70-80% not fundamentally interested in weed-killing. I think we tend to feel the proportion is 50/50 because the 10-20% who are more vocal turn up to conferences and Farmers' Club meetings. I was struck, where selective weed killing is concerned, by the fact that generally the manor farm in each village has the first sprayer, and after it has been watched over the fence by the neighbours for a year or two, the practice spreads gradually in the neighbourhood. That was a very striking example of how acceptance first comes about. It gradually seeped down to the 70% who did not like it till it had been tried over and over again and could not be ignored.

I agree with Mr. Cannon's opinion that the active contractor, by getting about and spraying on farms does spread the idea of selective weed killing. It would take very much longer without an active contractor, and would put the acceptance of weed killers back considerably.

I do suggest there is a mentality amongst farmers very difficult to get over. Many farms which would benefit from spraying machines and selective weed control, do not employ them when they could easily afford to do so. Even supposedly progressive farmers are often conservative in this way.

Further, I would say that apart from this pioneering influence the spread is really by what farmers see: roadside demonstrations by commercial organisations or N.A.A.S. where people can come along and look for themselves without any fuss - particularly those people who never turn up to conferences and organised "farm-walks".

Rhys Thomas raised a very interesting point about the exchange of farmers' sons, because I was patrolling an area partly arable, and another predominantly grass and the difference in handling was remarkable. It seems to me that there are a number of very conflicting and complex influences at work, and the further acceptance of this weed control technique will gradually come about through visual aids in the main - e.g. better stands on neighbours' fields, road-side demonstrations, etc.

Dr. R. K. Pfeiffer

I agree with Mr. Thomas that the farmer is not so much interested in the statistically analysed results of one experiment as in the percentage risk or percentage reliability of a recommended treatment. Only a large number of trials covering a wide range of conditions can provide such information. We have adopted this method in the last stage of our wild oats trials and regard it, if successful, as a useful way to convince farmers that a new treatment is worthwhile adopting.

Mr. J. S. W. Simonds

We were interested to find last year how large was the number of farmers who were willing to provide sites for experimental purposes. An increasing number of farmers seem to be prepared to do so. Many merchants now have technical representatives to assist them in the weedkiller problems.

Farmers want to have a statement on containers about the active ingredient. There are of course pros and cons and this is not the whole story, sometimes a little knowledge is a dangerous thing.

Mr. J. Rhys Thomas

Mr. Simonds says that a little knowledge is often a dangerous thing - no knowledge at all must of necessity be even more dangerous.

Mr. A. J. Cannon

The merchants and contractors consider that the manufacturers are making a mistake in using trade names for so many different products which are fundamentally the same, and in not printing the amount of active ingredient on the labels. The farmer does not know what he is buying. The farmer would understand much better if the salesman or merchant was trying to sell him an article which he knew by a common standard or a common name.

Mr. M. Bradford

The question of declaration is important. The farmer rightly wants to know what is in the drum, however there are various methods of arriving at the analysis, which do not give the same result. Formulation can also make a very considerable difference. If we want to embody all the necessary factors in making a declaration the logical result would be a molecular diagram completely incomprehensible to the farmer.

With regard to the N.A.A.S. officer, he, in the same way as the merchant, cannot possibly by a specialist in chemicals. He must be capable of dealing with a multitude of problems if he is to be of use as an agricultural advisory officer. Merchants do often organise a special department within themselves whose object it is to find out the product best suited to the particular problem of the individual farmer, irrespective of the name of the product.

Mr. A. J. Cannon

The problem is bigger than that. The first thing is to get over the suspicion in the farmer's mind, and to get their confidence. Surely there is somebody who can do this. The farmer is not interested in long technical names and details of chemical structures but surely someone could provide a common standard. A body should be appointed to do this.

Mr. J. Rhys Thomas

The previous speaker has suggested that a body should be appointed to go round and keep the farmers informed, however, it is the farmers who have to pay in the end. There is a suggestion that the manufacturers would be willing to maintain a technical staff to do this, however, after building their sales to a certain level, there is a danger that they may not continue to do so. Therefore this suggestion would not appear to be the long term solution.

Mr. F. C. Cooke

The difficulty of spanning the gap between the scientists and farmers is even greater overseas than in Britain due to the language difficulty and the lack of education. It is necessary to educate the young farmers in the schools,

particularly in the tropics where we have a great responsibility. It should not be forgotten that the tropical market is potentially many times greater than the home market.

Dr. E. Åberg

Referring to a declaration of the ingredients in products, the position in Sweden is that tins and drums are marked with amount of active ingredient, e.g. whether MCPA formulations contain 76, 228 or 250 g/l of active ingredient.

Dr. G. L. Hogben

In my opinion Mr. Hirsch, over optimistically, has depicted the farming community as a happy band of brothers striving earnestly after knowledge, whereas in fact, they are very different from this. Mr. Scovell said that only 20% of farmers are anxious to learn something and these I fear are the ones about whom Mr. Hirsch was talking. Good pupils will always learn whatever the quality of the teaching. Of the rest 30% are willing to benefit from the efforts of the others and 50% are resistant. The whole problem is how to get at this 50%. The less progressive farmer loves a routine that someone else carries out for him. For this reason I would suggest that in our field the greatest steps forward have been the invention of the low volume sprayer in 1949 and of contractors. I would suggest, however, that in the long run personal approaches are necessary and that if everyone here were to go out and talk about selective weedkillers to five people who had never heard of them every month the 50% of indifferents would soon be reduced in numbers.

The types of people who adopt new ideas early have plenty of contact in the community. The other slower adopters read nothing, meet nobody, and hear nothing; indeed only occasionally do they look over their fences. There is only one sure way to reach them apart from the personal approach. We can get at them by getting at their children, through schools and through Young Farmers' organisations.

I think the suggestion made by Mr. Rhys Thomas about exchange of Young Farmers between counties was a most imaginative one and well worth pursuing.

On the whole, however, I feel that we must take a long term view of this whole problem - and resign ourselves to taking, say, 20 years to solve the problem of the 50% whose acceptance of our doctrines is so vital and I suggest that a combination of personal approaches and the winning over of their children is most likely to do the trick.

Mr. G. P. Hirsch

In reply to Dr. Hogben's statement that I had depicted the farming community as "a happy band of brothers striving after knowledge" I can only say that he has, unfortunately, completely misunderstood my paper. I clearly stated its purpose to be an attempt to unravel the factors which "are responsible for the time lag and for the wide variation in the rate at which farmers accept new techniques".

Dr. Hogben is, on the other hand, quite right that it would be much better if the average farmer were better educated. I only wish to say that it is not always his own fault if he is not. It is important to do what Dr. Hogben calls

"to get at the children" as farmers very often accept new ideas from their children.

Mr. Rhys Thomas's suggestion with regard to the exchange of farmers' sons is not a new one. Exchange visits have always been made between different County Federations of Young Farmers' Clubs. I am however sorry to inform you that over the past few years the number of such exchanges has declined, for two reasons. First, there is not enough money available to finance such exchanges, and secondly it is very difficult these days to arrange for young people to stay in farmers' houses because the farmers' wives have often no domestic help. But the main need is availability of money and what is needed here is an appeal to the bigger manufacturers to make grants to the National Federation of Young Farmers' Clubs so that more exchange visits between counties in this country can be carried out.

Mr. R. E. Longmate

I would like to emphasise the very great confidence that exists in this industry between the farmer, the spraying contractor, the manufacturer and all who have anything to do with the production and usage of weedkillers.

As an instance of this a farmer friend of mine having read in the trade press of the introduction of a new material immediately 'phoned me and asked me to supply him with sufficient of the material to spray 150 acres in spite of the fact that the press notice remarked that the material was still in the experimental stage.