OPENING ADDRESS

W. Emrys Jones
President of the British Weed Control Council

Mr. Chairman, Ladies and Gentlemen,

I would first like to thank you for the honour you have bestowed on me in inviting me to become your President. I am only too conscious of the responsibilities of the office.

My first task is to welcome all the delegates, and this year there are nearly 800, of whom 265 are from overseas. We are particularly pleased that so many visitors from many countries have felt it worth while to attend the Conference and make their contributions which are most interesting and valuable to us.

As this is my first Conference as President I have, as you might suspect, been reading what my predecessors have said on similar occasions and, having done so, I find that there is very little left for me to say. It seems customary however for the President to look back a little and to comment on possible future developments. Before doing so I feel I must make reference to the late Sir James Scott Watson. He was the first President of the British Weed Control Council and with his death a few months ago a great man was lost to British Agriculture. Few men had such a wide and deep knowledge of British farming and agricultural science. There must be many people in the audience to-day who have benefited from his advice and guidance.

An advantage of having a biennial Conference is that a period of two years is short enough to recall the mood and theme of the last Conference and yet is long enough to contemplate and discuss developments that have occurred since. The clear trend towards higher productivity in agriculture has not only continued but has been accelerating. Technical efficiency has not been impaired yet by the steady decline in the labour force, but it has been accompanied by massive investment in machinery and equipment. Clearly the modern successful farm has become highly mechanised but increasingly expensive to operate. New ideas there are in plenty, but we must not lose sight of the fact that their adoption, or the installation of new farming systems to incorporate new techniques, calls for ever increasing investment in plant, machinery and equipment. It calls also for men trained in the skills required to use the new products.

I am sure the Council is right to devote a session to "Education in Crop Protection". The efficient use of herbicides will depend (and indeed does now) on the way in which they are used on the farm. Education and training at farm level is becoming increasingly important and should receive the attention of all those concerned as a matter of urgency. The agricultural education authorities, as well as the herbicide industry should be aware of the limitations in the farmer's capabilities and, in circumstances beyond his control, to carry out the rather refined and sophisticated application techniques now demanded by some chemicals. It is possibly better to have a less efficient chemical but easier to use then a very exacting efficient chemical.

The economic pressures on the farming industry create new demands on scientists, technologists and all those concerned with development in agriculture. The high capital investment and higher operating costs create more exacting conditions for the farmer. This means greater precision all round - he is demanding a clear statement and evaluation of the financial benefits likely to accrue from any items of expenditure he is asked to make. We must therefore give more attention to the economic presentation of recommendations in the field of herbicide use. Already farmers are asking whether and to what extent they can tolerate certain levels of weed populations in crops rather than embark on a total weed eradication programme.

I think that the British Weed Control Council can justly claim much of the credit that the developments in crop protection have been so speedily applied in British Agriculture. Indeed it is the very speed at which these fundamental changes have been implemented that have led to public reaction. Now the fears of the general public must be allayed, unfounded though they may be. This is not an easy task for this uneasiness stems from a lack of understanding of scientific explanations and indeed from a fairly general suspicion of the progress of modern science. However, I am sure that this Council must continue its encouragement of the research effort in this field and to provide the scientific evidence which will help people understand the implications of herbicides in agriculture. It would be tragic if such factors were to hinder the progress of research and its application to food production when there is so much malnutrition in the world.

In this country then we can forsee that intensification of farming systems will continue, with more specialisation and simplification. The farm labour force will continue to decline and farmers will require more capital to install new labour-saving equipment and techniques.

I can do no better than to end with some words written by the late Sir James Scott Watson exactly ten years ago:

"What will the future historian have to say about these, our own times? He will surely remark that this was a time of unexampled progress in farming techniques - of progressive mechanization, with the disappearance of the horse and the relief of the labourer from back-breaking toil. He will note the other new resources that had been made available - improved crop varieties, new weedkillers and insecticides, new and successful measures for the control of animal disease. He will record the departure from old-established systems of cropping . . . He may wonder that the farm worker, with all the new skills that he had so quickly acquired, should still have been the most poorly paid member of the community. He may argue that we should sooner have realized the growing disadvantages of the small man. He may question whether the state was doing enough, by the best means, to enable the farmer to realize his ambition - to produce progressively more food at progressively less cost in terms of human toil."

THE ROLE OF WEED CONTROL IN AGRICULTURAL DEVELOPMENT

LeRoy Holm

Food and Agriculture Organization of the United Nations
Rome, Italy

INTRODUCTION

The growth of this conference and the number in attendance today quietly underlines the fact that the study of weeds and their control has now become a proper science. Similar conferences meet regularly in other parts of Europe, the Soviet Union, several parts of North America, Brazil, Japan, New Zealand and Australia. Several weed conferences have been also held in Africa since 1958. This conference will devote 3 days to a discussion of weed problems of the British Isles. From this it is clear that the role of weeds in food and industrial crop production in the world cannot be properly discussed within the short time allocated to the speaker.

I have chosen to reduce the problem to more manageable proportions in two ways. I shall, wherever possible, omit North America and Europe from the discussion. These areas are well known to you, and Mr. John Fryer and others here and in America have recently spoken about the profound changes which have come into our agriculture as a result of better weed control. Secondly, I have chosen to avoid a tedious recitation of the several weed species in each of the world's major crops, together with all of the herbicides which are recommended or promising. This would be the subject of an entire symposium.

Next, as I am attending your conference as the representative of the Food and Agriculture Organization of the United Nations (FAO), I should like to speak briefly of its activities. This is one of a family of organizations of the United Nations. Its work reaches into all the countries of the world, its operations are many and varied, but in the time we have I can give only examples of the work in progress. In the FAO there are divisions which deal with problems of nutrition, forestry, fisheries, land and water development, economic analysis, etc. Weed control is the responsibility of the Crop Protection Branch of the Plant Production and Protection Division, of which I am a member.

There is a regular, continuing program through which training programs, technical meetings, advisory services, and publication and information dissemination are carried out. Many subsidiary bodies, such as the International Rice Commission, working parties on pesticides, regional commissions on plant protection and locust control, deal with specific subjects in agricultural developments. A number of international agreements aiming mainly at the strenghthening of inter-governmental co-operation are also administered by FAO.

Many agricultural projects, financially assisted by the United Nations Development Programme (UNDP) are executed by FAO. In the field of pest control the projects in operation now include the research on desert locust control in which over 40 countries participate, rice protection research and training in Thailand, research on control of rhinoceros beetle on coconut in the South Pacific, and a pesticide research laboratory in UAP. Under such projects experts as well as research facilities are provided.

The UNDP also finances the technical assistance program, under which experts are provided by FAO to developing countires to assist and advise on various subjects in accordance with the requests of the governments concerned. At present there are nearly 100 experts scattered throughout many countries, covering various branches of the plant protection sciences.

There are many other activities in FAO, but these examples will give you some idea of the manner in which work is carried out.

During the remainder of the period I will discuss three dimensions of the world weed problem and will use specific examples wherever possible. Frequently I can illustrate the point with the use of photographic slides. The first portion concerns weed problems which are not on arable land but which are serious for developing countries, the second concerns weeds in crops, and finally I can tell you something of the present status of weed control in developing countries and of tasks for the future.

The news media of the world present us each morning with a daily crop of disasters. Tragedies which engulf an entire nation and claim thousands of lives may be reported in a small space at the bottom of the front page occasionally, while the loss of a few lives or a fortune in another area of the world may merit several columns in the same paper for several days. Finally, tragedy becomes a great soup; we weary in our attempt to sort out the significant events and the gravity of some of them will escape us.

An attempt to be precise about the role of agriculture in the development of countries, and more particularly the role of weeds, can lead to the same frustrations. An effort to become acquainted with the weed problem leads one through a mass of statistics in which herbicides may be grouped with general pesticides, and these with fertilizers, and all may be reported simply as agricultural chemicals. Or one comes upon great agricultural plans in which there is no reference of any kind to the weed problem. The technical knowledge and planning about soils, seeds, and water has far outdistanced that on weed problems. In the period ahead it will be increasingly difficult to lift out of this annual crop of facts and opinions on world agriculture the significance of the weeds of grasslands, waterways, and arable land.

I will spend most of the time on technical details. But it would be a deception if I leave the impression that I feel that technical answers are enough. Our technical discoveries and the practical application of them are subject to the inspiration, but also to the infirmities, of men's minds. No god, or army of them will come down to plant our crops and tend them. Man must perform these tasks with his two hands. Thus the fact of our technical discoveries may seem important to us, but it is what other men believe about them and are willing to do about them that will determine whether they will be useful for mankind. Whether the farmer will have control of his land and be free to decide, whether he will have the cash to buy inputs such as herbicides for his fields, whether there will be a truck or a road to move his crop to market if he can produce more than he needs, whether he will be literate enough to learn how, and whether he will want to try to make such improvements with his neighbors watching - all this will be decided by the social, cultural, and economic fabric of the time in the place where he is.

Finally, as weed scientists, we ought to be open to the possibility that sheer enthusiasm for our little technical miracles may not be enough. In the field of agricultural development, there are many persons who stand tall on the world scene, including your own Prof. Bauer at the London School of Economics, who believe that inter-governmental technical aid may draw attention away from the human qualities and the appropriate institutional framework essential to a lasting solution of agricultural problems.

WEED PROBLEMS NOT ON ARABLE LAND

Bush Control

Fifteen percent of the world's lands are used for grazing. In the temperate zone we know much about pastures from our research. In the tropics and sub-tropics pasturing is more extensive than intensive and returns are low. In Africa, Australia, and North and South America bush or brush encroachment is serious for it reduces the savannah or grassland. Experiments have shown that in North America the yield of native or sown grasses may be doubled or tripled if bush is controlled for 3 to 5 years.

A large part of Africa, south of the Sahara, is savannah. Often the trampling, overgrazing, and poor management of fires not only encourages the bush but brings on erosion. Bush control is also needed for better care and control of cattle, elimination of poisonous plants, and reduction of tse-tse fly populations.

Savannahs have been burned for centuries but the bush species persist. Where rainfall is low and the grass is therefore thin and short, or if land is overgrazed, the heat of fires is not intense enough to injure the bush. But fire is cheap and if properly used may be one of the tools for some species.

Mechanical devices are expensive and do not give lasting control. 2,4-D and 2,4,5-T are used, as is fenoprop on a restricted scale, and now picloram is promising on some species which are resistant to the above. The latter is used on brush in Australia and North America, but is not yet cleared for rangeland.

With most control methods, coppicing is a problem with some species and makes the problem worse.

The use of aircraft gives the greatest hope but on land giving low return this seems a long way off. In the U.S., control of some species for 3 to 5 years is down to $ 1.50 to $ 2.50 per acre.

Some of you may know that Dr. Ivens has recently returned to East Africa to take up his work on bush control in connection with an FAO project.

Irrigation Scheme

Thousands of fresh water reservoirs, great and small, have been constructed in the past two decades and with them have come great new irrigation schemes, several covering more than one million acres. People move to the vicinity of the canals and streams, and the effluent from their towns plus the fertilizer added to their farms enrich the waters. The distributaries are often shallow, clear, rich in nutrients, and weed growth follows. One example will suffice.

India has more miles of irrigation canals than any other nation. One day's train ride from Delhi is an irrigation scheme which is to have a command area of 1.4 million acres. The canals and main breastworks are magnificient for the Indian engineers are very capable. But the distribution of the water, drainage, and agricultural development are in trouble. Eighty thousand acres were put under irrigation 1961-65 and one-half of them the water table is now within 5 feet of the surface, with varying degrees of salinity showing up. Five thousand acres have gone out of production in the areas adjacent to the main canals. One main arm of the canal system is 240 miles in length and with its distributaries totals 1,000 miles. The discharge at the head if 6,600 cu.ft. per second which is equal to that of the Seine as it flows through Paris. Submerged aquatic weeds have already cut the flow in this large canal by 80%. The result is that the reduced flow encourages seepage from the canal and thus contributes to water-logging and salinity. Finally, water cannot be moved to crops, animals, and people in sufficient quantity on schedule, and this is the naked purpose of any irrigation scheme.

Man-made Lakes

Some man-made lakes are so large that we must now enter them on maps of the world. Through them great new sources of electrical power and agricultural production are acquired. Climates are changed. Public health problems are created. Towns and villages must be abandoned and re-built, and the human beings involved must re-order their lives and often be re-trained.

These lakes differ from natural lakes and we know little about them. Their water chemistry is unlike that of natural lakes. The Sennar and Rosieres reservoirs in Sudan empty and fill each year. Kainji Lake in Nigeria may fill in one season. Lake Kariba on the Zambesi river in southern Africa filled in 4 ½ years. It has been estimated that Lake Tanganyika, a great natural lake, would take 1,500 years to fill from its natural inflows. And there are weed problems.

Lake Kariba, which now covers 2,000 sq.miles, began to fill in 1958. By 1960, 200 sq.miles of its surface were covered with Salvinia auriculata, a water fern.

When I visitedthe lake in 1965 the weed had subsided somewhat but still covered 8% of the surface. We entered the edges of permanent mats which covered hundreds of acres in river estuaries. I saw harbors so blocked that ships could scarcely move. Life is uncertain on the lake because the wind and current moves the mats unpredictably. Fishing nets placed at night may become hopelessly entangled and shifted by morning. Fishing camps may be forced to move if the shore is blocked by weed mats to prevent the use of canoes.

An infestation of the weed was reported about 35 miles above Victoria Falls one the Zambesi River in 1949 and it was not a problem in this fast-flowing river. The creation of a lake with quiet, warm water provided an ideal habitat and it exploded.

An excellent study on chemical control was carried out by Mr. Ray Hattingh of South Africa in 1960-61. Paraquat at ½ lb or sodium arsenite at 10 lbs per acre could bring the weed under control without harm to fish. A technical solution is available. For economic reasons, and because of polital turmoil in the area, nothing has been done to control the weed.

There has been an alarming growth of Pistia stratiotes (water lettuce) in Lake Volta in Ghana during the past year. No-one can say whether it will get out of hand.

Rivers

The water hyacinth problem in some of the world's major streams is known to all of you. This is the most massive, the most terrible and frightening weed problem I have ever seen. It is in the Nile and Congo rivers, in the delta of the Mississippi, it is found all along the coast of Southeastern U.S., and it is distributed all across south Asia.

It stops ships. Villagers on rivers who need the protein from fish to supplement their grain diets cannot reach their fishing grounds. Hydro-electric schemes and irrigation pumps are affected. Bridges are pushed over, and in the Far East the floods cause great islands of the weed to go crashing through the fences placed in rivers for fish culture. Insects which are vectors of human and animal diseases are harbored in the weeds, and the dangers from snakes and crocodiles are increased. Fishing is reduced because there is no light and oxygen under the thick weed mats.

How are such weeds spread so quickly? When they enter a stream they are carried up the river by boats. The wind, floods, and currents push them into back-waters and pools and swamps. The river people use water hyacinth plants as pads in canoes, and to plug holes in their charcoal sacks as they are transported from the bush. The seeds may be carried in mud on the legs and fur of wildlife. Finally, man is the worst offender. He has carried it around the world because he liked the flowers.

The first infestation was seen in the Congo river in 1952 and by 1955 it covered 1,500 kilometers. Using 2,4-D, planes, helicopters, and boats the Belgian scientists cleaned up several thousand kilometers of the river by 1957 at a cost of 50 million Belgian Francs. But after all of this effort, it was estimated that 150 tons per hour were still passing Leopoldville down near the sea.

The first infestation was seen in the Nile in 1958. The government of Sudan has also created a large organization to fight the weed at a cost of 1 $\frac{1}{2}$ million dollars per year. Previously, the weed was contained above the Jebel Aulia dam near Khartoum. We now know that seedlings have been found at least 100 miles below this point. The remaining distance to the new Nasser Lake should be a matter of grave concern.

WEEDS IN CROPS

Crop weed control is the most complex, but also the most important dimension of weed control activity, for it is from our immediate efforts here that we may have more food and fiber. Quite unseen and with the dreary, stubborn patience of evil, the weeds in crops suck night and day at the soil and moisture to deprive our plants of the vigor and dry matter needed to feed and clothe the world.

Because they do not strike violently at leaves or fruits as insects and diseases do, or because they do not force men to turn back his ship or shut down his hydro-electric plant as aquatic weeds do, man has often chosen to put these problems off, to stick to the old ways of weeding or not weeding crops, or to simply wait for tomorrow.

If you have been working in weed science long enough it becomes easy to think that all the world's lands must be weedy and that the task is impossible. This is not so, of course, but one of the things we must do is bring our problem down to the proper size, to put some handles on it, and to decide which things must be done first because they are most important.

There are three points which I should like to make about the weed problem on cultivated land. They may easily blend into one another and thus it may be helpful if I state them before I begin. At the onset we may say that it is possible to describe some general limits to the portion of the world needing help with the weed problem. Next I should like to show you, or emphasize the point again if you already knew it, that it is the developing countries of the world that produce the largest share of the world's food and fiber. Finally, I will show you something about the world's worst weeds.

There are 33 billion acres of land surface and from a land use map one may become aware that most of the area is in ice, rock, desert, forest, or it is used only or mainly for grazing. Three billion acres, or about 10% is in cultivated crops each year. Ninety three per cent is in food crops and most of the other 7 per cent is in cotton. Argentina has 28 acres of arable land per person, India 1, and Mainland China 0.3. For the most part the temperate zone crops are in areas where we know a great deal about the weed problem. Much of North America and Europe, and parts of Australia, South Africa, and Argentina are the areas I have in mind. There are large areas of temperate crops in the U.S.S.R. and mainland China and we may hope that

Fig. 1

Production of Major World Crops by Developing Countries (1964)

(Figures are world totals in 1000 metric ton units)

	Sugar cane	Potatoes	Rice	Wheat	Corn	Barley	Millet and Sorghum	Coconut	Banana	Peanuts	Cotton	Coffee	Palm oil	Cocoa
	441,000	277,000	258,000	250,000	226,000	103,000	77,000	28,000	23,000	15,000	11,000	4,000	1,000	1,000
Continent of Greatest Production	ASIA		ASIA				ASIA	ASIA	SOUTH AMERICA	ASIA		SOUTH AMERICA	AFRICA	AFRICA
Continent of Second Greatest Production	SOUTH AMERICA		SOUTH AMERICA				AFRICA	AFRICA	CENTRAL AMERICA	AFRICA	ASIA	AFRICA	ASIA	SOUTH AMER.
Country Producing Largest Amount	INDIA		INDIA				INDIA	INDONESIA	BRAZIL	NIGERIA		BRAZIL	NIGERIA	GHANA

communications about weed problems in these areas may improve. The arable land remaining is largely between 30 degrees north and south of the equator and this means that we shall have to deal mainly with mixed tropical and sub-tropical farming and with tropical plantations. It is here that our help will be needed in the decade ahead.

In these warm regions the weed problems differ from those in the temperate zone. Weed plants grow more vigorously and regenerate more quickly because of the abundance of heat and light. Perennial plantation crops, of which there are few examples in the temperate zone, generate severe perennial weed problems, particularly grasses. In addition there is a lack of tools to do the work, there is poverty and illiteracy, there is the prevalence of diseases and parasites in men and animals, and with all this a different attitude of the worker toward his work.

Next we may inquire about the particular continents and countries within this area where major world crops are produced. The production of the world's major crops for 1964 is shown in Figure 1. On the left you may see the continent of greatest production. On the second line is the continent or area which was the next largest producer. Following this is the country which was the greatest producer in that year. In those instances, however, where the largest producers were in Europe and North America, I have left the squares blank. These were removed in order to point out to you that those remaining to dominate these tables are the developing continents and countries, and that they do indeed produce most of the world's food and fiber. If the losses from weeds in these production areas are of thesame magnitude as those estimated for the agriculture of Canada and the United States, the waste is significant in a hungry world. What are the important weed species that are found in these crops? I wish I knew whether there are 7 or 70 weed species which cause 90% of the crop losses in the warm regions of the world. This knowledge would be of value in organizing our research and in planning for control measures. One is impressed with the frequency with which a few species are seen in the fields of our most important crops. In the scattered reports of research on weed problems in developing countries one can again find the names of the same few species. One example of this is Echinochloa crusgalli (barnyard grass), which must be present in every rice growing area. Another is Cyperus rotundus which must be one of the most widely distributed weeds in the world. When I first noticed this I began plotting the distribution of several species from my reading, my visits to fields and waterways, and my conversations and correspondence with FAO personnel in the field. I have worked mainly with aquatic weeds and some of the perennial grasses thus far.

I want to be certain that you understand that the examples shown in Figures 2, 3, and 4 arenot completebut represent only the present state of the work. The discs on the maps represent the occurrence of the species as a weed in that area. As other areas are studied more closely I am certain that many more discs can be added. I recongnize the hazard of releasing such data into the hands of scientists who like their world to be black or white. I think we can agree, however, that even in the unfinished state of these maps - the point is made. Figure 2 shows the distribution of Cyperus rotundus. It is so widely distributed that further comment is unnecessary. Figures 3 and 4 show that Cynodon dactylon (Bermuda grass) and Eichhornia crassipes (water hyacinth) have a similar distribution. In short, one can say that with the exception of the northern part of the temperate zone, these weeds are all over the world. A similar map of the distribution of Echinochloa crusgalli (barnyard grass) (not shown here) does indeed show that it is present in all of the major rice growing areas. Sorghum halepense (Johnson grass) is on all the continents, in Hawaii, is widely distributed in the islands of the South Pacific, and has begun to exhibit a disturbing capacity to adapt itself for survival far into the temperate zone. It is already present in Canada, for example. It is a native of India and the Eastern Mediterranean so it is now quite far from home. Pennisetum clandestinum (Kikuyu grass) is the last one to receive mention here. It is a native of the Kenya area in Africa and thus far I have found that it is present, as a weed, on all continents except Europe and I expect I shall find it there with more searching. It

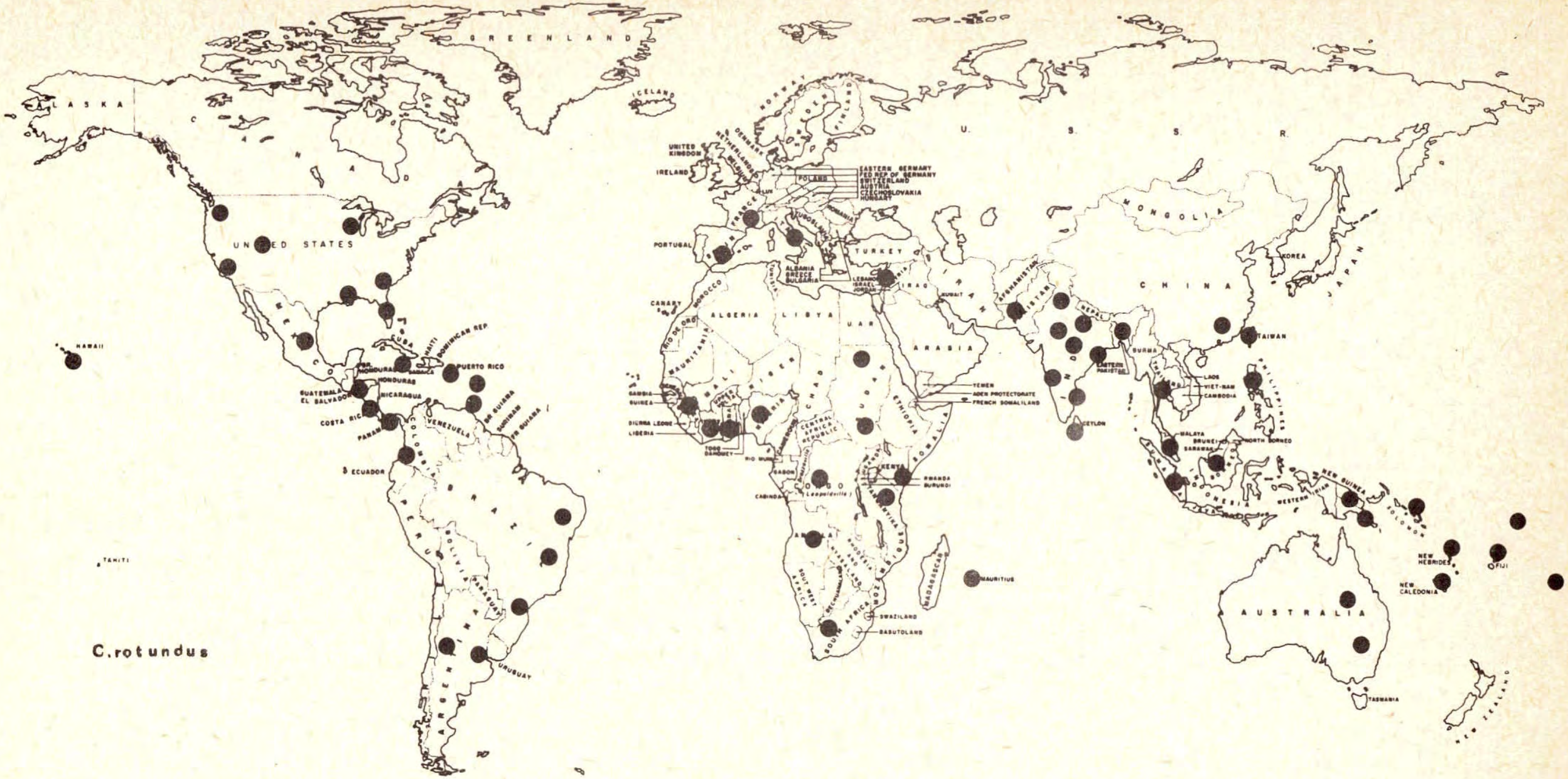

Figure 2. A preliminary map showing the extent of the spread of Cyperus rotundus through the agricultural areas of the world. (See text for explanation)

Figure 3. A preliminary map showing the extent of the spread of *Cynodon dactylon* through the agricultural areas of the world. (See text for explanation)

Figure 4. A preliminary map showing the extent of the spread of <u>Eichhornia</u> <u>crassipes</u>, water hyacinth, through the waterways of the world. (See text for explanation)

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has travelled also to Hawaii, New Zealand, and several islands of the South Pacific.

In summary, this presents a sobering picture of the way we have managed to distribute some of the worst weeds throughout the world's agriculture. Perhaps this is the point at which we ought to be reminded that we should make a greater effort to think in terms of understanding and controlling individual species. It is true in dealing with other pests that the control measures selected are more often directed at a particular insect or a particular disease. Too often we speak only of "weeds" - and it sometimes appears that they are unspecified in number and that all are without names. Finally, I should like to bring all this together by saying that I believe our help can only be poor and haphazard until we have determined which species of weeds are causing the major portion of the losses in the world's major crops. This would not be an easy decision in the temperate zone, and we have much less information about the weeds of the tropical and sub-tropical areas.

THE PRESENT USE OF HERBICIDES

An attempt at a world summary of present herbicide use was perhaps my greatest single effort in preparing material for this meeting. It was also the least productive. I know the situation only in a general way, and because some of you have insisted it would be worth the while, I shall try to describe it briefly. Picture if you will a map of the world with the Americas on the left. We shall begin at the upper left and proceed clockwise. The use of herbicides in Canada, United States, and Europe is well known to you. There is research on the use of herbicides in the U.S.S.R., regional and national conferences have been held, and a beginning has been made in field application. With the increased emphasis now placed on agricultural efficiency we may expect good news about the effort against weeds, as well as greater use of herbicides. I have no information about mainland China. Outside of Europe and North America, Japan is the largest user of pesticides. Forty-five per cent of the paddy rice is sprayed with 2,4-D and 45% is sprayed with pentachlorophenol (PCP). This means that about 2 million acres are sprayed with each chemical.

In Taiwan and the Phillippines about 50% of the rice is sprayed with 2,4-D or MCPA. The islands of the South Pacific have reported herbicide use in small amounts for the past 10 years but the total quantity is not large. About 50% of the rice in Malaysia is treated with 2,4-D if the area is near a supply point. For several years Malaysia has imported staggering amounts of sodium arsenite for vegetation control in plantations. Because of the fear of toxicity an effort is being made by the government to curb the use of this chemical. In Burma and Thailand about 2% of the rice is sprayed with 2,4-D or MCPA at present. In the latter country about one-half million pounds of herbicides were imported 1960 but by 1964 this had jumped to 1 million pounds. Dr. Donald Seaman of the United States is in Thailand on a temporary assignment with FAO to work on rice weed control.

Australia is a large producer and user of all pesticides, including herbicides. We have not time for details here but the statistics are well reported annually for those who are interested. In the fourth 5-year proposal for development in India, it is planned that 14,5000 tons of 2,4-D and other herbicides will be used in the final year (1970-71). This would mean the treatment of about 10 million acres. About 2% of the rice acreage is now sprayed with 2,4-D. Of all the agricultural area now treated with pesticides, only 1% receives herbicides. Salvinia auriculata at one time infested 20,000 acres of riceland in Ceylon. The first success against the weed was with PCP. There is now a well-organized program for keeping the weed under control with paraquat.

As we move to the Near or Middle East we find that Israel is a very large user of herbicides as well as other pesticides. In Iran, 10,000 acres of sugar cane were treated with herbicides in 1965 and in the near future they will be used on wheat and sugar beets. There is little use of herbicides on cultivated crops in Egypt and Sudan. Very large quantities of 2,4-D are purchased by Sudan, however, for the fight against water hyacinth.

In East Africa, Kenya, and Tanzania in 1965 treated 225,000 acres of cereals with 2,4-D and MCPA. Thirty thousand acres of tea, coffee, and sugar-cane were treated with dalapon or the triazines. Twenty thousand acres of sisal were treated with dalapon, the triazines, or MCPA.

South Africa is a large user and producer of herbicides. Forty thousand acres of sugar-cane and much corn and other grain are treated with herbicides. The use of herbicides has almost ceased in the Congos. In West Africa there is little use of herbicides except in a few plantations.

In Argentina, there has been considerable use of 2,4-D in the long grain belt on the eastern side of the country. Much of the sugar-cane in the northern part of the continent is treated with herbicides applied by aircraft. In Colombia where little use was made of herbicides in rice before 1964, withing two seasons almost all of the rice in the country was brought under treatment iwth propanil. In Mexico, largely due to the efforts of Dr. Nieto who is with us today, the increase in acreage treated with herbicides in the past 5 years is remarkable.

THE TASKS OF THE FUTURE

What of the future? The need for weed control, just as the need for food, is not something that will develop at some future time. The time was yesterday. I anticipate, however, that the appreciation of the need will mount rapidly in the decade ahead, and this for very specific reasons. The first is that the extra food and raw materials we produce in the future must come from land already in cultivation. World land inventories show that with the exception of small areas in South America and in Africa, man can no longer follow the age-old practice of producing more by opening up new land. From this it follows that we must increase the yield per acre and this cannot be done by magic or by just working harder. It is certain that yields can only be boosted now by making inputs of better seeds, fertilizers, irrigation water, pesticides such as herbicides, and the minimum machinery to get the job done. More and more it will be shown, as has already been shown in rice culture, that there is little advantage in using fertilizer if the weeds are not controlled.

But the removal of weeds will be increasingly important not only because they steal water, light, and nutrients. In the Philippines, the elimination of some weed species appears to offer an effective way of controlling the spread of the destructive disease of coconut known as cadang-cadang. In Egypt, the egg masses of the cotton leaf worm are picked with human hands every four days as far into the growing season as possible in order to avoid the purchase of costly insecticides. As the cotton plant grows, however, the leaves become less palatable for the insect and the egg masses are deposited on the leaves of weeds. It has now been found that unless the weeds are controlled the insect cannot be controlled. The parasitic weeds such as Orobanche spp. (Broomrape) and Striga spp. (witchwood) cannot be controlled effectively with human hands in India and other warm regions. This can also be said of Cyperus rotundus and several species of perennial grasses which grow so vigorously in the heat of the tropics. We must add to this the massive aquatic weed problems which directly effect agricultural schemes.

Some things other than control methods will be required of us in the future if we are to meet the challenge presented by weeds in the developing countries. We need manuals for the identification and description of weed species in important agricultural regions. We need simple weed control texts in many languages for training and advisory work. We badly need training centers for country personnel. It will be very difficult to bring about significant progress until there are persons in the governments who can explain the need for weed control, carry responsibility for experimental trials, supervise demonstrations in different areas, and organize programs for field scale control. Before we can fully understand the dimensions of the weed problem we must know more specifically what the losses are in major food and fiber crops. In the autumn of 1967, at FAO in Rome, there will be an international meeting on losses due to pests in major crops, and weeds will receive an appropriate share of attention. Finally, we need to know, on an annual basis, the extent of the use of herbicides in the developing countries. This would tell us of the growing need for the supply points of herbicides and this may have a significant bearing in the development of weed control programs. We understand that in several places in Asia, for example, 50% of the rice fields are treated with herbicides in places near the supply points, but only 2% is treated at more distant places. These data could also tell us something of the need for herbicide production and formulation facilities. Such information may also indicate where we may find individuals who are experienced in the use of herbicides. Technical experts from both commercial firms and aid programs would find this knowledge useful. Without the tools, techniques, and information we have discussed this morning, we shall find ourselves practising science in a kind of limbo where it may be difficult to find our way.

If we are going to speak to men and agencies about planning and support for weed problems, the details and the validity of our requests must be at least as sophisticated as those presented on other aspects of agriculture. Weeds have been man's constant companion. Indeed, most of us here are aware that it was from the weeds of his refuse heaps that many of his crops have come. Man's acceptance of them is understandable, but this does not excuse us, as practioners, from bringing this science and its application into sharp focus on crops and weed species in such a way that there can be a better harvest for a hungry world.

I am certain that great good can come without waiting for scientific breakthroughs. There is information all over the landscape just waiting to be used. There are some things which can be done now with little cost. Crops can be planted in rows so that they may be weeded more efficiently. More proper timing of weeding practice can be very important in raising yields. The use of rotation systems and proper management of fields can check the spread of parasitic and perennial weeds. I recognize that it may be difficult to generate enthusiasm for these very ordinary measures. Some of you will say that these measures are for the small farmer whose harvests will not be significant for the nation's economy. But this is the largest group of people in most developing countries, and until they too are lifted up into the social and economic life of the nation, the future will remain uncertain.

To close this talk in a meaningful way is as difficult as it was to know where to begin. Many of the weed species which inhabit the grasslands, waterways, and cultivated lands are so widely distributed, and have entered such varied agricultural systems and environments, that their biology will not be easy to comprehend and their control may not be easy to standardize. The texture of the economic, political, and social life of the communities we have discussed are as varied as their landscapes, but it is here that persuasion, and demonstration of the usefulness of our tools, must be worked out. We have reason to be proud of the improvements in temperate agriculture which have come through better weed control. Our hopes for the developing countries must be tempered, however, with the knowledge that many of them cannot purchase herbicides now and may be unable to do so for many years to come. A call for help therefore represents a new kind of challenge for weed scientists.

ECONOMIC ASPECTS OF HERBICIDE USE

Gwyn James

University College of North Wales, Bangor

It is a privilege to have been invited by your Committee to present a paper at this plenary session of the 8th British Weed Control Conference. No one can deny that the rapid increase in the use of herbicides, as a means of weed control, has been one of the notable features of British farming in recent years. The Agricultural Chemicals Approval Scheme has produced a list of approved chemicals which are both safe and dependable, and no one can doubt their effectiveness. But less is knownabout, and indeed less attention has been paid to the economic aspects of herbicide use. It is to these aspects that I particularly want to refer in this paper.

Economics and Science

In his Presidential address to the 5th British Weed Control Conference in 1960, this morning's Chairman (Sir Harold Sanders) had this to say - "In farming developments are determined by the sordid realities of economics ..... Herbicides have to pass many tests in regard to safety, selectivity and effectiveness, but they will be judged more and more in the future by their cost in relation to the job they do." This awareness by agricultural scientists of the existence of a cost-benefit relationship in respect of herbicide use - this relationship exists, of course in respect of the use of any other farm input - is of special importance in present-day agriculture, for the acceptance by farmers of new techniques or new ideas is more and more the result of their expected net financial gain than of their proven technical effectiveness. A sledge hammer may be an effective means of cracking a nut, but its use is clearly less economical than that of a nut-cracker. Yet, although an increasing number of agricultural scientists pay lip service to the economist, the assimilation of economics into agricultural research is, in many instances, more a pious hope that a 'fait accompli'. In the preparation of this paper, I read a very interesting article, in a recent issue of the N.A.A.S. Quarterly Review (No. 63, Spring 1964 p. 106) by P. J. Boyle on the functions and organisation of the A.R.C.'s Weed Research Organisation at Kidlington. The Organisation, so I read, comprises a number of component sections, all of which undertake research on herbicides 'in order to assess and develop their value to British agriculture and horticulture'. There is a field evaluation, application and machinery section, a horticulture section, a weed practice section, a botanical section, a chemistry section, an information section and an overseas section. But there is no economics section; yet the 'assessment of value' is essentially an economic function. In this respect, the Weed Research Organisation is, of course, in no way exceptional; a similar criticism may be levelled against the majority of agricultural research centres in this country. I have singled out this particular organisation only in respect of the interest and concern that this Conference has in weed control research. The Directors of many agricultural research centres often plead, in mitigation, that all their scientific staff have a thorough training in statistics; others employ professional statisticians. But the statistical interpretation of the results of scientific experiments is essentially different, both in regard to its method and its purpose, from an economic interpretation of such results. The experimental results of a new technique may be statistically significant; yet its adoptation by practicing farmers may be significantly uneconomic.

During the past thirty years, the bulk of the research work into the economics of agriculture has been undertaken, in this country, by the Provincial Agricultural Economics Service, under the sponsorship of the Ministry of Agriculture, Fisheries and Food. This Service is at present assimilated within University Departments of

Agriculture or Economics or Agricultural Economics. Government might profitably consider the possibility of transferring a part of the funds, and the staff, currently assigned for economic research in these Departments, to the various agricultural research and experimental centres. There is a clear need for such a development, which would considerably strengthen the organisation of these centres in a number of ways. The economists so attached to research establishments would more easily become especially acquainted with the peculiar and characteristic technicalities of specific scientific projects than is often possible under the present arrangements when, over time, their interests and energies tend to be dissipated amongst a variety of widely differing projects, ranging from an investigation into the economic aspects of crop spraying during one year to one into the economic implications of British entry into the European Economic Community during the next year. Moreover, co-operation between economists and scientists in the design and planning of field or laboratory experiments is important, so as to allow a better interpretation of their results in economic terms. Often the physical results of scientific experiments are incapable of any rational economic interpretation due to an insufficiency of the data required by the economist. This can be obviated if the scientist is aware of the economist's requirements at the design stage of the experiment. Although the technical results of scientific experiments are interesting and informative to practical farmers, they are not conclusive unless or until they have been subjected to economic analysis.

The Benefits of Herbicide Use

The control of weeds in any crop is economically justifiable if the net benefits attributable to such control exceed in value the cost of the control. The benefits of herbicide use are of two main types - direct and indirect. The most obvious direct benefit is the expected increase in physical yield but other benefits which enhance crop revenue include the achievement of a cleaner grain sample, an increase in the proportion of the crops actually harvested and an earlier ripening of the crop, which enables the producer to take advantage of the higher prices which often prevail in 'early' markets - particularly in horticultural and vegetable markets. Probably the most important indirect benefit of herbicide use is the substantial savings in labour use afforded by chemical weed control over manual and mechanical methods, but other indirect benefits include a reduction in the weed population of the succeeding crop, a reduction in the moisture content of the grain and ease of harvesting.

Both these direct and indirect benefits have an economic meaning in that they can be measured in mometary terms, either in respect of an increase in income (direct benefits) or of cost reductions (indirect benefits). It is possible therefore to consider the economic aspects of herbicide use from two different standpoints. The narrower approach considers only the direct benefits of herbicide use and assesses their economic value purely in terms of the increased physical yield expected from the suppression of weeds. This approach enables the economist to determine the optimum (and the scientist, the maximum) dose applicable for a specified herbicide in respect of a specific crop under given environmental and climatic conditions. But the fact that many farmers spray even when they expect no yield increase suggests that, under certain circumstances, the value of the indirect benefits alone may be a sufficient reason to justify, on economic grounds, the use of herbicides. The broader approach, therefore, considers the whole range of benefits (direct and indirect) evaluates them in monetary terms, and assesses the overall net worth of herbicide use.

Optimum Output and Yield Effect

The yield effect of the use of herbicides to control weeds is assessed by measuring the physical relationship which is observed between successive increments of herbicide use and the incremental additions to output. This relationship is usually expressed as a simple, single-variable production function of the type, $Y = f\ (X/X^1 X2x^3 \ldots X^n)$, where Y represents total output, X the variable resource

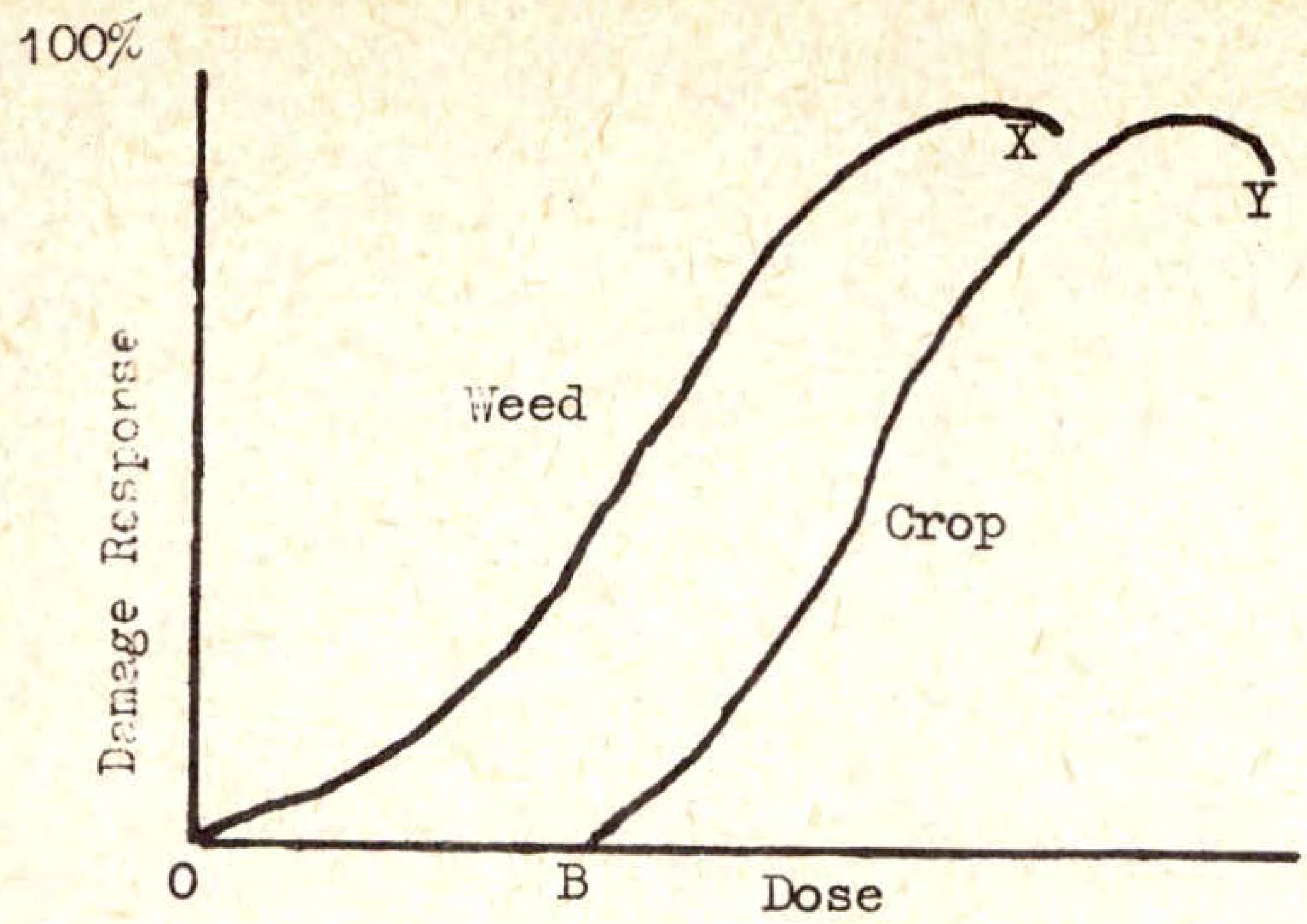

Figure 1.

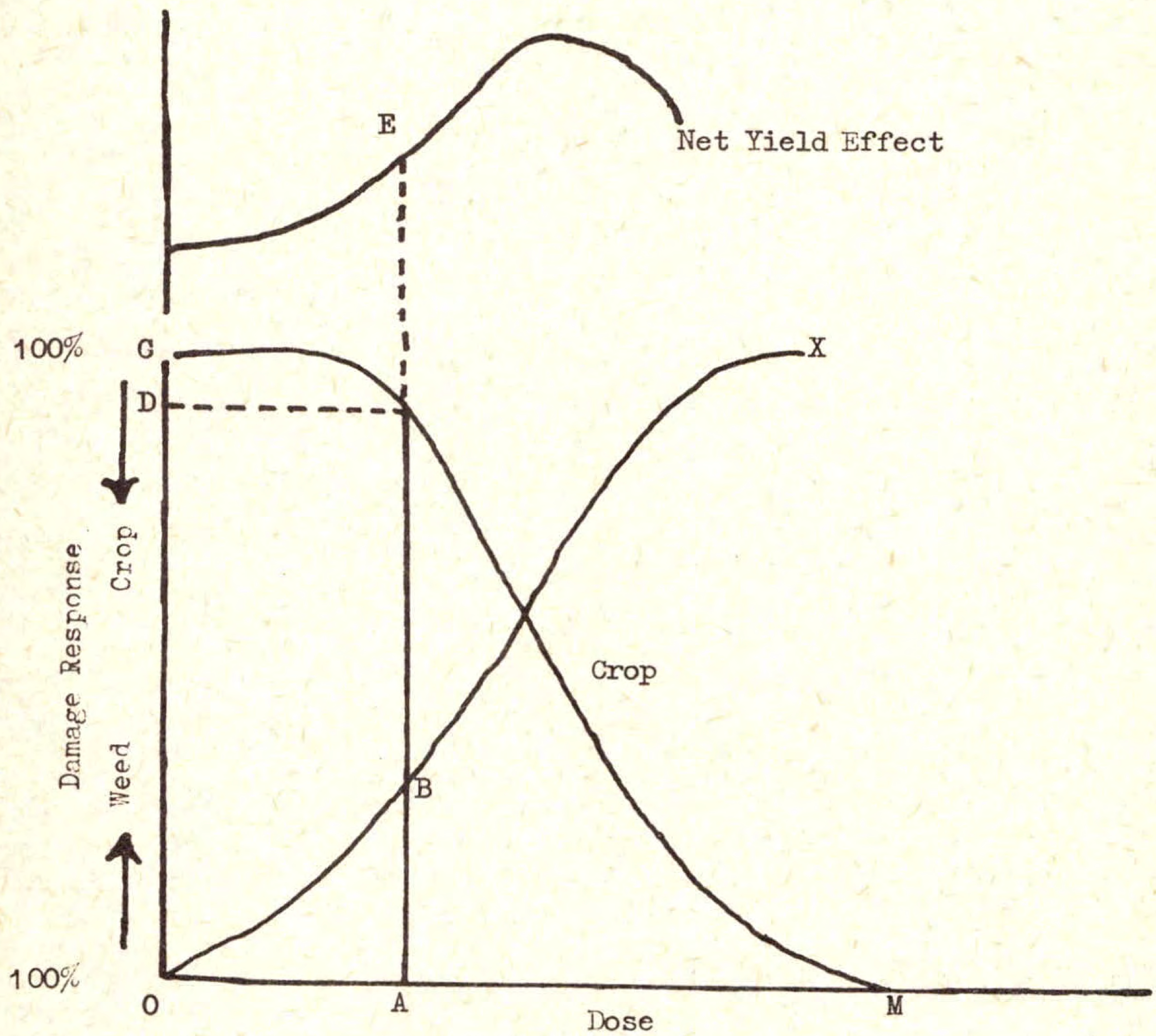

Figure 2.

(in this instance, herbicide) and $X^1 \ldots X^n$ the remaining resources which, in combination with X, are involved in production, but those levels of application, for the purpose of experiment and economic analysis, are held constant. With regard to the majority of resources used in agricultural production, variations in their level of application, up to a given point, have a wholly beneficial effect on the level of physical output. Output increases, albeit at a varying rate, with given increases in the rate of input use. Variations in the level of herbicide use, however, have only a partially beneficial effect on the level of physical yield, due to the toxic effects of herbicides both on the weed and on the crop. At low doses the crop is tolerant of these toxic effects, and the suppression of weeds increases the level of yield. But as the dose is increased, this tolerance factor is progressively reduced and crop damage is proportionally increased, with a consequent reduction in the level of physical yield. Typical dose response curves, defined in terms of damage to weeds and crop respectively, are illustrated in Figure 1.

The net yield effect of herbicide use is the sum of the individual damage affects of these two opposing forces and is illustrated in Figure 2. The response curve CM is a mirror image of BY in Figure 1. At any dose OA, the net yield effect (AE) is the sum of the gross increase in yield resulting from the percentage kill in weeds (AB) and the gross reduction in yield resulting from the percentage damage to the crop (CD).

The net yield effect, or dose response curve is a physical relationship between herbicide use and output. It is however, the basis upon which the answer to the two fundamental economic questions relating to herbicide use are found. First, is the use of herbicides economically more or less justified than other methods of weed control? Second, what is the optimum (as distinct from the maximum) dose to which farmers should conform? In answering these questions, it is convenient for analytical purposes, to reverse their order, and to consider first the optimum dose.

The primary requirement is to translate the dose response curve into financial terms by ascribing a price schedule to the yield function. The macro effect of an increase in total output is, of course, a fall in price, but under micro conditions changes in the volume of output have no perceptible effect on aggregate total supply. We may therefore safely assume that the price schedule of an individual farmer is unaffected by changes in his level of production, and that consequently the total revenue curve (AM in Figure 3) will be of identical shape to the dose response curve. Here allowance has been made for the volume of output (and hence revenue) obtainable from an untreated crop (the 'controlled' revenue), so that at any dose OY, YC represents total revenue, YE the revenue from the untreated crop and EC the marginal (or extra) revenue directly attributable to the use of the herbicide. In respect of the cost schedule facing a farmer, it is assumed again (as in the case of his price schedule) that the cost per unit of herbicide is unaffected by changes in the quantity purchased. Thus, the total cost of herbicide will be a linear function of dose, represented by a straight line FX, after allowance is made for the costs incurred in producing the untreated crop (the 'controlled' costs) and the additional fixed costs associated with the use of the herbicide BF. Thus, when no herbicide is used, the net profit from the crop is BA (total revenue OA less total costs OB). The use of herbicide increases both total costs and, assuming a positive net yield effect, total revenue. At a dose OY, total costs increase by HP from YH to YP and total revenue by EC from YE to YC, and the net profit from the treated crop is PC. The optimum dose is that at which profit is maximised, and is determined at that point where the factor-product price line (F^1X^1) is tangental to the total revenue curve. At this point C, the marginal revenue (EC) will be exactly equal to the marginal cost (HP) and the output (YC) will be the optimum (or most profitable) obtainable from the use of herbicide. We may therefore identify two critical doses; OY represents the optimum dose, at which profit is maximised, while OY^1 represents that dose at which total output, and hence total revenue, is maximised. At any dose in excess of OY^1, the rate of yield reduction resulting from crop damage is greater

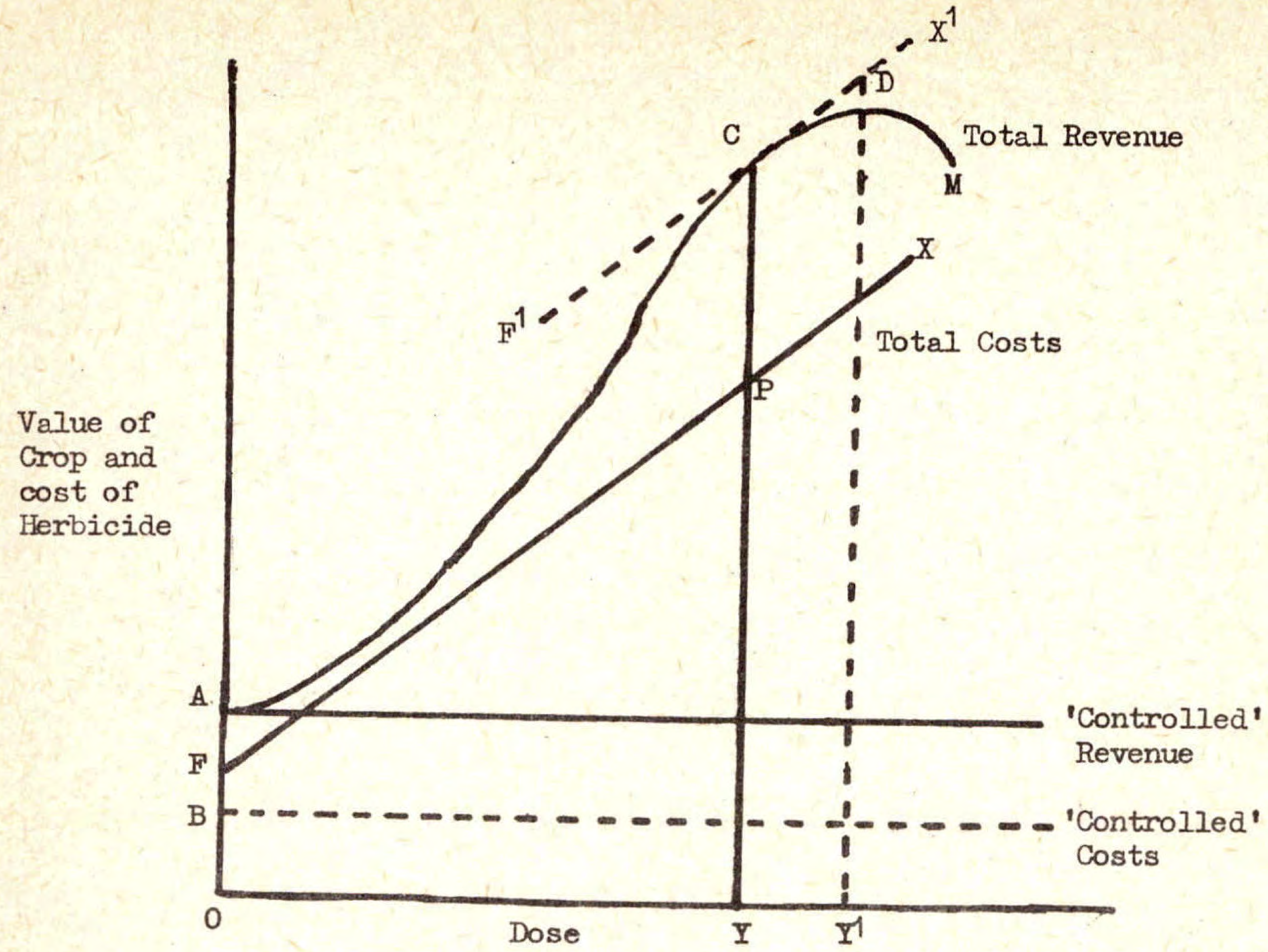

Figure 3.

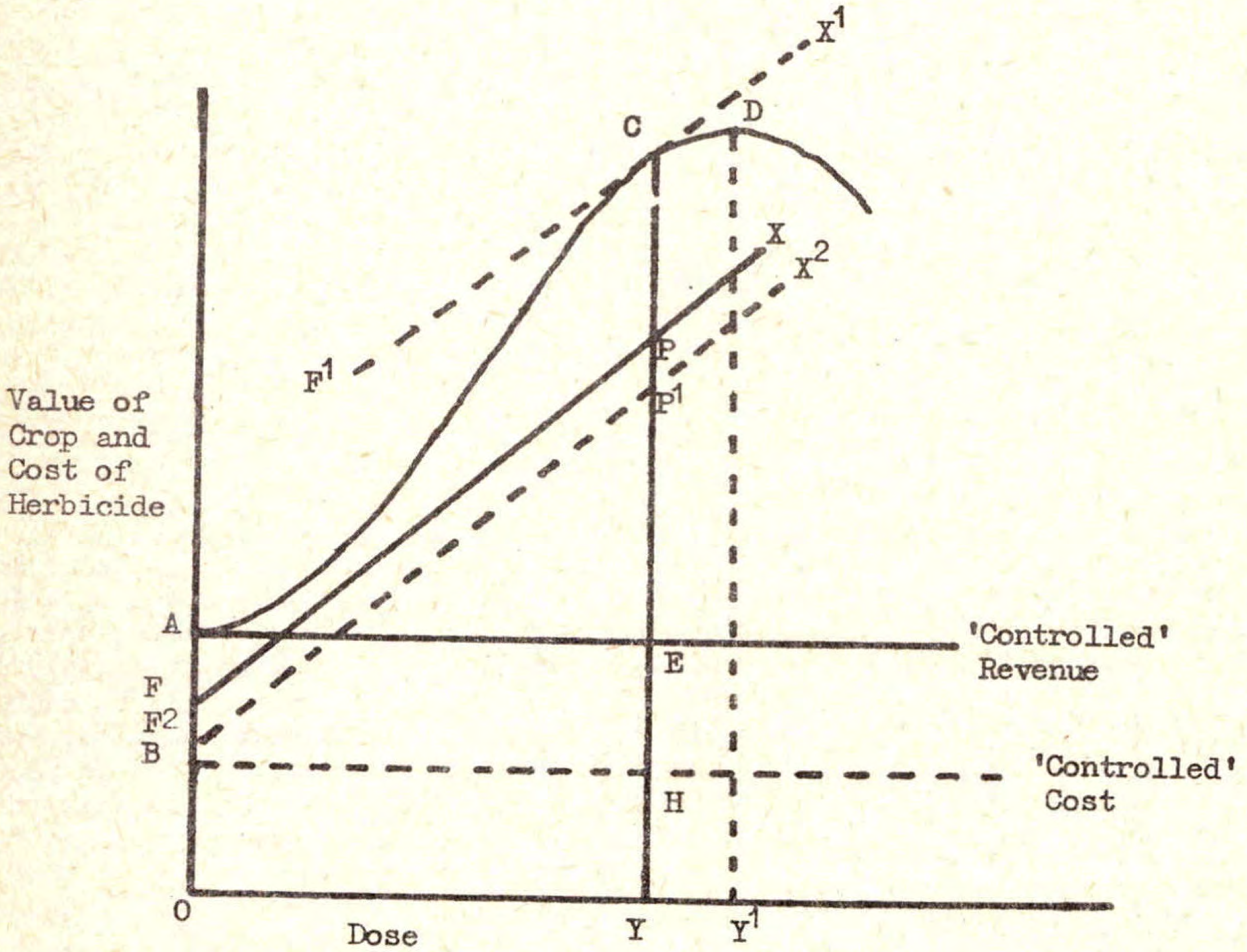

Figure 4.

than the rate of yield increase resulting from weed kill, and total output falls. These two doses are quite distinct; indeed, the maximum dose could only become the optimum if the price of the herbicide fell to zero, so that the price-line F^1X^1 were horizontal.

Optimum Output and Non-Yield Effects

At this optimum level of output, the net profit from the crop is maximised. But this does not, in itself, determine whether or not the control of weeds by the use of herbicides is economically to be preferred to alternative methods. It does not, in other words determine whether the profit obtainable from the use of herbicide (PC) is greater or less than that obtainable from other methods (HE). If the use of herbicides is to be economically justifiable, PC must be greater than HE. But if we consider the implications of the situation presented in Figure 3 closely, we shall find that in fact PC = HE at the optimum dose, for if the optimum dose

Marginal Revenue = Marginal Cost

Then, EC = HP
But EC = (EP+PC) and HP = (HE+EP)
Therefore when EC = HP, then PC = HE

and the use of herbicides is no more, nor no less, profitable than other methods of weed control.

This situation arises from two facts implicit in Figure 3.

1. The yield from the untreated crop produces a revenue which is more than sufficient to meet the costs incurred in its production. In Figure 3, OA is greater than OB. This implies a relatively low degree of weed infestation in the crop. If competition between weeds and crop for the available supplies of nutrients, moisture and light enery was such that the total yield, expressed in money terms, was insufficient to cover production costs, clearly the use of any form of weed control would be economically justified, provided that its marginal revenue exceeded its marginal cost, and its optimum use would be determined at point C, as in Figure 3. Thus in assessing the economic implications of herbicide use the degree of weed infestation in the crop is of critical importance.

2. The second fact implicit in Figure 3 is that the evaluation of herbicide use has been assessed solely in terms of its net yield effect; no allowance has been made for any ancillary benefits that the use of herbicides might afford. This new situation is presented in Figure 4, when it is assumed that the use of herbicide, in addition to increasing the yield of the crop further benefits the farmer by reducing the cost of labour. Hence total costs are reduced from YP to YP^1 and the total profit is increased by P^1P from PC to P^1C. Insofar as the cost of the herbicide has remained unchanged, the slope of the price line F^1X^1 will be the same as in Figure 3, and the optimum dose will be unaltered at OY. Similar conditions would apply on the revenue side if the use of herbicide increased the selling price of the crops, by either improving its quality or by reducing the number of days to harvest - this latter effect would be of considerable importance in horticultural production. Where weed infestation in a crop is relatively low, therefore, the use of herbicides (although it may increase yield) will be economically unjustified unless it simultaneously affords other indirect benefits, which either reduce total costs or enhance the market value of the product. An increase in yield by itself is an insufficient benefit. It is for this reason that the use of herbicides can be economically attractive even though its net yield effect is zero.

Herbicide Use and Labour Economy

A major indirect benefit of herbicide use is that it is invariably less intensive in its labour requirements than other methods of weed control. A Bavarian forest case study (1) indicated projected saving for a 111 hectare reforestation area of DM 20,000 and 15,000 man hours when chemicals were substituted for traditional methods (Table 1). But there can be instances where, in economic terms such economies in the use of labour are more apparent than real.

Table 1.

Comparative Reforestation Pre-Plant Costs
Dowpon and 2,4,5-T vs. Mechanical Methods
(per hectare)

Mechanical Treatment	Man hours	Wages DM	Chemical Treatment	Man hours	Wages DM
Basal Dressing	16	40.00	Dowpon 2,4,5-T	8	34.94
Tilling	8	34.94	Basal dressing	16	40.00
Mechanical weeding (in 6 years)	148	582.53	Tilling	8	34.94
Top dressing	9	35.42	Top dressing	3	11.87
Total:	181	1692.89		35	121.75

Regular farm labour is a bulky, indivisible input, which is employed on weed control operations spasmodically during certain months of the year. Thus, even if the use of herbicide reduces labour requirements by exactly one man, the total labour requirement of the farm remains unchanged for the labour saved on weed control will be required for other work at other times of the year. This apparent saving of labour only becomes effective, in economic terms, if productive farm work can be found for the redundant labour at the time when spraying is being carried out. Alternative productive employment opportunities, at these critical, and often short, periods are not always available. Where they do not exist, the economic advantage that herbicide use may appear to have over other, more traditional methods is considerably weakened. Similar considerations of course apply if the reduction in labour is effected at harvest time, although in this instance, casual labour may be employed, which can be more easily dismissed than regular labour.

This immobility of regular farm labour, in the face of a reduction in the labour requirement of a specific farm operation, is a particularly strong deterrent to the adoption of new farm practices in the newly developing countries. In Britain, the rapid increase in the use of herbicides during the last twenty years was much facilitated by the drift of labour from farms to factories, which forced farmers to accept new, labour saving techniques. But in many of the newly developing countries, employment opportunities outside agriculture are relatvely few, and on most peasant farms labour is in fact under-employed and invariably comprises family labour only. In such situations, the control of weeds, by the use of herbicides, may be an uneconomic proposition even though, on technical grounds the need for such a method may be greater than in the more advanced countries.

Conclusion

In conclusion, the economic aspects of herbicide use are in many respects more complicated and thought-provoking than those which relate to the use of many other farm resources. Yet, the essential function of the economist in agriculture is the same regardless of the resource under consideration; it is to assess whether or not practices which the agricultural scientist has shown to be technically feasible are economically justifiable. If he is to perform this function satisfactorily, the economist requires of the scientist adequate data. In respect of herbicide use, the required data can be conveniently grouped under two heads. First, the agricultural scientist, in designing his experiment, should consider a wide range of doses. This need arises in part from the fact that the two critical doses - the maximum and the optimum - are not necessarily the same, and in part from the fact that while the maximum dose for a specific herbicide applied to a specific crop tends to be relatively fixed over time, the optimum dose varies over time with changes in economic conditions. If the range of doses is limited, the economist is confronted with either a very small segment of the total product curve, or a few widely spaced points on the curve, and it is virtually impossible to make a valid economic interpretation of the physical results obtained. This situation suggests that the agronomist's interest in the use of herbicides is confined to its effect on weed kill, and his ideal objective is a completely weed-free crop. But the farmer is interested in the death of a weed only if it is instrumental in increasing his profit, which is the monetary measure of the benefits which weed control affords. This leads to the second major requirement of the economist - a complete account of the benefits of weed control through herbicide use, in physical terms, to which the economist can apply monetary values. These benefits have been cited earlier in this paper. They include, in addition to the net increase in yield (if any) over the 'controlled' crop, any savings in labour effected, and the times when such savings occur, differences in the number of days of harvesting and differences in the moisture content of the treated, as compared with the untreated crop. Only if this data is adequately available can any investigation into the economic aspects of herbicide use be undertaken, by relating its cost to the jobs it does.

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SESSION II

Discussion

Mr. J. G. Elliott felt that Dr. James approach was based on a fallacy as there was one dose of herbicide appropriate to a situation and the farmer had little scope for reducing costs by reducing dose. Dr. James agreed that the opportunities of reducing costs in this way were limited, but pointed out that yield levels were not the only economic factor and that herbicides provided opportunities for reducing costs in other directions. These economies are not always indicated by research experiments. Moreover farmers may have a choice of treatments at different cost levels. In reply to Dr. Allen's question on how to translate the results of experiments to determine optimal doses, Dr. James said that the optimum dose would vary according to field conditions about which scientists had given insufficient information to economists. Dr. Dore queried the long-term economic effects of herbicide use caused by, for example, changes in weed population.
He felt that annual assessment of profitability was not an adequate way of assessing the value of herbicides.

FUTURE TRENDS IN BRITISH AGRICULTURE WITH SPECIAL REFERENCE TO THE ROLE OF HERBICIDES

J. G. JENKINS

Childerley Farm Estates, Cambridge

I think I can claim at least one advantage for this audience - and that is that I haven't as yet contributed to these ghastly volumes which were dished out yesterday! You may like to read them, but I certainly wouldn't! I am going to talk about a few general aspects and facts of agriculture without any specific reference to herbicides, but I took it that this audience is intelligent enough to want a general background picture from someone like me and that you will interpret these general remarks in the light of your own trade.

What I am going to say is extremely elementary. I felt terribly conscious of this when I was asked to do the paper and then when I wrote it I felt even more conscious of it - and when you hear it that will be the third time. I console myself with the thought that in fact all the speeches from the platform are totally unimportant and that it is outside the Conference Hall that all the useful work is done.

Future trends of the industry

The paper by Dr. Holm does put into perspective some of the problems of British agriculture. When we think that we have a serious twitch (Agropyron repens and Agrostis gigantea) problem - but perhaps we haven't really got a serious problem at all by world standards. Dr. Holm's paper does, perhaps, bring out two lessons. The first is that British agriculture is good, and is becoming more and more competetive. And secondly, perhaps it is more and more important to develop British agriculture (I mean European agriculture too, of course, but I am a British farmer!) in view of the extraordinary troubles and tribulations which tropical agriculture is facing. I think we are likely to play a more and more important part, over the next decade anyway, in food production for the world.

We are going to have to deal for the next number of years at any rate, with a whole host of small farms. Farms are getting bigger, this is true, but even the uneconomic ones are going to be there as a very powerful factor over the next few years. Larger farms are coming, and will continue to come. The question really is - how large? Well, it is worth noting, I think, that the non-land using enterprises have in fact got very large indeed in some cases. This is primarily because they are not using land. In agriculture the price of land is an enormous factor in production costs. At the moment returns on investment are not such as will attract outside capital, and this consequently limits the size of agricultural holdings.

Now, of course, we have got various advantages attached to the ownership of land at the moment - and you may cite estate duty as one. But this has a double-edged effect, because although estate duty relief in some respects inclines people to buy land, on the other hand estate duty itself is so large that it is going to encourage and enforce the splitting up of landholdings as we know them today so long as they are primarily owned by individuals or by family companies. There is not going to be a lot of development in the size of farming businesses until we do get some method of bringing in capital from outside agriculture. It wasn't, of course, until this point was reached that industry went ahead, and agriculture is is very much at the same point today. At any time it always looks impossible to make a break-through of this sort. I think the time will come and that outside investment will occur in agriculture. Then we shall get a more permanent development of the big farming corporation.

We know very little about this development, of course, and the whole host of problems that will have to be solved - what the actual size of unit should be in agriculture: what the size should be per manager, and so on. In the past we have just tended to throw more and more on to certain people's plates. We have had no read break-up of specialised management problems in hardly any agricultural enterprise that I know; and whoever is managing an enterprise is expected to be an expert marketeer, and an expert production man, an expert economist and so on. This is obviously a field which has not been explored at all and will have to be explored if the larger corporation comes along. However, this point is quite clear, that managerial quality generally is going to become more and more important than it has been, and that farming generally is going to become more and more a business.

It is an obvious thing to say, but none-the-less true, that agriculture has become, and farms have become more and more specialised in their activities. I can see quite clearly that this trend will continue. It is becoming more and more a full-time job for a production manager to look after the complex problems involved in the production of any one crop or form of livestock today. I suspect that for this reason alone we shall get even more specialised than we are now. There is also the vast problem of capital, and this alone will accentuate the trend towards specialisation. We are going to have to pay very much more attention to the problems of capital in agriculture in the future. As an industry we have now just about got to the stage of realising that gross margins and simple forms of cash analysis like this are extremely valuable. We have done very little work as yet on the capital growth formation in agriculture, the study of capital profiles, capital requirements in individual crops and so on. All this is going to play a very much greater part in future in agriculture.

Now specialisation doesn't necessarily mean monoculture. It obviously can do. It has done to some extent in parts of Hampshire and Berkshire where barley has been grown more or less continuously for the past 16 years on the Downs; and on the whole I gather that they have run into quite a bit of trouble. We ourselves have three cereal crops out of four, and do stick fairly rigidly to that rotation (the fourth crop is occasionally oats, but oats are, comparatively speaking, a break crop). But when we go in for specialised systems of grain farming, it is possible to bring in a break crop which uses the same machinery and the same management skills as the corn crop. Indeed at a time when the world is short of protein and short of oil it is hard to believe that we can go on very much longer ignoring the virtues of the bean crop or indeed of the oil-seed rape crop. There must be a distinct possibility that these two crops will play a more and more important part in British agriculture in the very near future.

The problems associated with specialisation and monoculture are clearly there but there are also certain advantages in that you will get potatoes, for example, concentrated in those areas of land which are most favourable to the potato crop. Crops will be growing in conditions which will allow the crop itself to be a major factor in weed control; for there is nothing better, as you know, for deterring weeds than a full crop. There is also the fact that you are probably going to be dealing with fewer soil types for any one crop in the future, with crops being more and more concentrated in the sort of areas in which they grow well.

The European Common Market

Perhaps I should finish this general review with just a word on the European Common Market. Whether we should go in or not, I am not going to discuss - I personally am in favour, but that's another story. But there are two things which one might say: Firstly, would it make big changes in what we are growing today? I don't honestry think it will. There would clearly be large "shake-ups" as a result of entry into the E.E.C., and I of course grow corn, so naturally you will say this is going to favour me and encourage more corn growing. Well, initially it will, but the quite absurdly high prices for cereals ruling in the Common Market - and if any of you Common Market people are here I would like you to take that back - can only be a temporary phase! Prices must come down or we will get gross over-production of cereals on the Continent. There are already signs of it. Lower prices will keep the edge on our search for efficient and cost consciousness in this country as well as maintaining a proper balance of production. The greater emphasis on business methods, inherent in the spread of the larger corporation type of farming business, is something which will ensure that there will be a keen-eyed look at costs in the future, whatever system of farming or agricultural support we go in for - even what looks like at the moment the lucrative Common Market system of support.

Cereals

Now I am really a cereal farmer and the only thing which I know anything about is perhaps cereals - and one realises more and more how little one knows. I will discuss some of the problems which I associate with cereals. The cereals crop is becoming a more and more important in this country and is likely to go on being so. What we are going to do about the production of barley when we grow too much to consume in this country I don't know, unless we join the Common Market; but here one has to understand and realise that livestock are going to be finished more and more on cereals; the problems of grass production are go great that more and more food of livestock generally is going to come from the cereal acreage. So what, even though it has increased enormously, I think it might well increase even further.

What are some of the problems associated with this crop? Fertility is not one that we as farmers are particularly worried about: it is unlikely that the level of organic matter content is going to drop below levels which are critical. So far as the other nutrients are concerned we seem to be able to supply them artificially with considerable efficiency.

When it comes to weeds we have got considerable problems. Now the ordinary weeds are largely under control, although it is worth pointing out - as was pointed out by a speaker at the end of a previous paper - that there are a number of weeds which are of course rearing their ugly heads more easily, now that the more common weeds have been controlled. Grass weeds are becoming a very serious problem indeed, particularly in areas where virtually no rotation at all is practiced. So far as twitch is concerned, this is a weed which can get out of hand very, very easily. I took a trip through the west and north of the country during harvest time, and I was quite shocked (it is the only word to use) by many of the fields of barley in the west of the country which were really taken over by twitch. The yields I am quite sure must have been reduced to something at best no greater than two-thirds of the total potential yield, and in many cases to below half; and this to me was really quite frightening.

At the moment there are very few chemicals that I know of which deal with this weed at all satisfactorily, and even when you think you have dealt with it satisfactorily, two years later you find that you haven't! Certainly when someone was talking earlier on about the cost of perfection being too high, I thought that as far as I am concerned the cost of any of our present herbicides at all for twitch is too high. I would regard this as the primary weed problem in this country for which there is virtually no chemical control at the moment.

Wild oats and blackgrass. Blackgrass is much more damaging to the crop than wild oats - but it is slightly easier to control in the sense that one can usually defeat it with a succession of spring crops. The wild oat problem is worse in the sense that it is more difficult to control. Now we are just beginning to make a break-through in the control of wild oats, but at this point I would like to say quite categorically that those people who think that if they produce an efficient pre-emergence spray they have solved the problem, are quite wrong, because what we need is a post-emergence spray. It is all very well to put on an expensive spray costing 95/- per acre in the belief that you may have got some wild oats that you are going to control, but if you haven't then it's a pure waste of money; and this is the sort of thing that we cannot afford to do. So I would say quite categorically that we need a post-emergence control for these weeds. We ourselves have been using the technique of late sowing of spring wheat with some degree of success, but even this only achieves a partial control.

"Break" crops for cereal growers

Disease problems are of interest to people interested in herbicides. The two problems are very much tied up together. The most important and the most difficult disease to control is "take-all" to which at the moment there is no answer except the introduction of a break crop. Here we have an enormous variety of opinion within the industry as to whether one or two break crops are needed, and how long the effects of a break crop will last anyway. Very little factual information is to hand. It seems that the third crop - and I am talking about wheat particularly - following the break crop is about the worst. There is at least some evidence that there then may be a build-up of anti-pathogens and eventually after about ten years the crop will be back up to at least a reasonable level of production. Whether we can afford to go through this cycle is one thing and whether we ought to go through it is another; the introduction of profitable break crops would clearly help this problem enormously.

Then there is "eye-spot" which may be controlled by varietal means or again by a break crop, but this, too, is a very serious problem. At this point one cannot help wondering how far the grass weed problem is something which is severely accentuating the problem of diseases by carrying them over through break crops into the following run of cereals. Cereal root eelworm is an important factor on some of the lighter lands. Airborne diseases are going to become more and more important, and this year the rusts have really created havoc in some of the winter wheats and, even more important, in some of the spring wheats. Over the last few years Rynchosporium and mildew have been major problems with the spring barley crop, particularly in the wetter west of the country.

So that my own view is that there is going to be more and more demand and need for the break crop, and, as I mentioned before, we have got these two crops of beans and rape which are both really on the point of break through. Neither very great increase in yield nor a very great increase in price is needed to become reasonably profitable crops. The increase in yield is very likely to come in the case of beans with the hybrid varieties which have now been produced. In the case of rape, there are some excellent Swedish and Canadian varieties, (which if they do not come into this country officially will certainly come in the trouser turn-ups of various people!) and here again we have got possibilities of useful increasing yield and quality. I am even hopeful that this Government might think fit to encourage the production of protein and oil as two commodities which we need and can produce in this country. Beans and oil-seed rape may well be the two major break crops in the main cereal growing areas over the next ten years or so.

In addition there are oats, and the newer varieties of oats are extremely good and produce very high yields. There is perhaps conceivably in the south-east the possibility of maize, which those of you who know the crop will realise is a marvellous crop from every point of view, if it could be introduced as an economic crop

At this point I would like to make a plea - a direct plea - that with these break crops becoming more and more important, this is the place in the rotation to kill the grass weed. There are virtually no herbicides at all that we can use on rapes or mustards and even on beans the pre-emergent simazine is often unsatisfactory. On heavier land clod break-down after using simazine produces a lovely secondary growth of blackgrass. The break crop is the place surely at which to concentrate on the control of grass weeds: and if we could do that successfully, then we would be a long way towards solving the problems of grass weeds in cereals.

CCC

Just a word on CCC. This, I think, must be potentially useful. Will it allow us to use long-strawed, high yielding varieties as freely as the shorter strawed varieties? All this is quite apart from any side effects which it may have. It is something which we certainly must explore. I hope it proves successful economically. We shall then put on a bit more nitrogen and put the crop down again. This is admirable!

Changes in cereal cropping

There are two final points that I would like to say on cereals. Firstly as we have now reached nearly the limit so far as this country's requirements for barley are concerned, I think that we shall get a reduction of emphasis on barley relative to wheat. The Ministry of Agriculture has said this himself. The price of wheat will have to rise relative to barley since the cost of growing wheat and the difficulties of growing wheat are definitely greater than barley. But the consumption requirements at the moment call for more wheat to be grown rather than more barley, and wheat can certainly be more nearly a replacement for maize with its higher energy value for the higher production rations. So that I would have thought that there is going to be an increasing emphasis on wheat over the next few years.

Secondly - and this is perhaps contradictory - as farmers we would like to see an increasing emphasis on spring crops. Now this at the moment militates against wheat. We had two very good spring wheat varieties. Unfortunately one of them this year was very badly attacked with yellow rust; the other one is at least susceptible to the same strain of yellow rust, and also has potentially a shedding characteristic which makes it less attractive. Otherwise I think it is still a very good spring wheat, and we shall continue to grow it.

I understand from plant breeders that most winter varieties have a higher yield potential than spring varieties, and that is why to some extent they have concentrated on improving winter varieties. But there are so many factors in favour of spring sown crops, apart from the yield factors, that we may well see a swing towards spring crops. The autumn peak labour period, when ploughing and lifting roots are going on,make it difficult to sow large acreages of winter corn or winter beans. Moreover, there is the distinct possibility of frost damage to beans and to cereals, the danger of pigeon damage to winter rape. The problems of "take-all" and "eye-spot", which are reduced, at least, by the growing of more spring corn. Finally the problem of weed control is greatly eased by the introduction of spring corn, through late sowing to control wild oats, or the ability to control blackgrass. Even with twitch you have a very much longer period to control it between harvesting one crop and sowing the next one.

Reduced cultivations

I would like to finish by saying a few words on minimum cultivation. This technique which is to my mind one of the few really exciting possibilities which face us in the future. This is the baby of one of the major firms of this country who pushed it perhaps a little bit too hard at first, but I gather that they are now back-pedalling on this one. It would be a great tragedy if they really did back-pedal at this early stage. No doubt other firms are working on the technique too, because it has enormous and exciting possibilities.

There are a number of disadvantages: There is the cost of the chemical. Well, that will come down. There is the efficiency of the chemical and the possibility of it creating permanent damage to the soil - well, at the moment there is no evidence of this but again, if this method becomes popular, one would expect better chemicals to become available as time goes on. At the moment the whole technique is be-devilled by completely inefficient machines for sowing the seed. This again is something which will be remedied if the method proves successful.

There are problems associated with weed control. But while on the one hand one might fear that twitch is going to be more difficult to control because of lack of cultivations, on the other hand we may well get the rhizomes nearer the surface because the soil has not been disturbed and in this way may be more easily controlled. The biggest disadvantage with minimum cultivations is the effect on the soil structure. How are we going to keep the underground structure right in the long term? Well, we may be able to put a tine down and disturb it. And how are we going to keep the top structure in good order after, say, the combines have been squashing it down and making ruts all over the place? This structural problem is the main problem that has to be faced, I am sure, but I believe myself it is not incapable of solution.

The potential advantages are clearly tremendous. At the moment we carry labour all the year round in order to put the plough in right behind the combine at harvest time in order to get a sizeable acreage of winter corn in. Now I said that if we went more over to spring corn, we would not need to have this large labour peak at harvest time: but of course, an alternative would be to use the minimum cultivations method, not plough the ground at all but put it straight into wheat after harvest. Imagine, too, the advantages of doing away with the enormous costs of cultivation, the enormous costs of ploughing - turning this huge volume of soil over. So far as the cost of the chemical is concerned, after a number of years it might well be that you wouldn't need to spray, or only need to spray every other year or every third year, after the weeds were under control. There is at least a possibility that one would have a better control of "take-all". And finally you have got the fact that plant roots do largely grow in the top four inches of the soil, and here you would have the top four inches undisturbed and therefore able to be brought into a very high state of fertility for the growing of the crop.

Technical improvements

Mr. Chairman, those are a few brief remarks on the technical side, and now a few general remarks in conclusion. We are clearly going to need more skilled technicians on farms. We are clearly going to need more skilled technicians off farms. I would like to see a lot more money spent on applied research, particularly on the Experimental Husbandry Farms which are about the only places where you can today do any multi-discipline research.

And finally we could I think, well make more use of farmers, particularly of their records. There are today quite a lot of farmers who do keep accurate records, and these could be extremely useful if they were tapped more scientifically and methodically to reach a wider audience.

SESSION II

Discussion

Dr. H. P. Allen assured Mr. Jenkins that his company was not back pedalling on the development of crop production with reduced cultivations, but were stepping up development as fast as the availability of suitable "direct-drills" allowed. Mr. Holroyd felt that future development in herbicides would be in favour of pre-emergence herbicides.

Dr. van der Zweep from Holland supported this on the grounds that pre-emergence herbicides were most suited to the"programmed" production of crops under controlled environment. Mr. Jenkins replied that spending £5 an acre where it was perhaps not needed didn't seem to make sense. Programmed production methods were not likely to be a reality for a considerable time. Dr. Nieto from Mexico said that one must not pre-judge what the herbicide requirements of a crop were: the period during which weed control was most required amongst crop may differ and should first be determined by experimentation.

In reply to Dr. van der Zweep, Mr. Jenkins said that on speaking of beans he meant field beans (Vicia faba).

Mr. Elliott felt that perennial grass control was required within the cereal rotation and the easiest control would be in the autumn when the land was free of a crop. Mr. Jenkins replied that this was a busy time and not a period when farmers want extra work although he agreed that they may have to accept it if twitch was to be kept in check: but there were so many other arguments in favour of break crops that these crops might also be utilised for controlling twitch. Mr. J. M. King mentioned dried peas as a possible break crop.

Mr. A. Abel disagreed with Mr. Jenkins' views about the need for break crops. He felt that one of the advantages of mono-culture for example was the ability to persist in a herbicide treatment for weeds without fear of residues affecting a susceptible crop in rotation. There was hope that there would be solutions to the problems of monoculture in due course. Mr. Jenkins said that the conflict of views was only a matter of timing - he did not disagree with Mr. Abel in the long-run, but said that within the next 10 or 20 years greater hope lay in the "break" crop.

Mr. M. S. Barber commenting on the need for more applied research said that the Natural Research Development Corporation exists to support the application of fundamental research, but cannot exist on the adoption of systems of husbandry.

CHEMICAL WEED CONTROL IN POTATOES

(A summary of Regional National Agricultural Advisory Service trials in 1963 and 1964)

J. R. A. Neild
(Crop Husbandry Adviser Yorkshire and Lancashire Region)

Summary: At twelve sites in 1963 and ten sites in 1964 a series of herbicide trials was carried out to control annual weeds in the potato crop. Two contact herbicides, six residual herbicides [most with some contact action] and one contact/residual herbicide, together with mixtures of some of these herbicides are involved. The majority of the chemicals are available commercially and they were applied pre-potato emergence. Paraquat was superior to MCPA as a contact herbicide but gave wide variation in weed control as a result of incomplete weed emergence at the time of spraying. Residual herbicides alone gave reasonably good results on mineral soils. These, on the whole, were improved by the addition of paraquat which in 1964 enabled good results to be obtained from lower rates of the residual herbicides. Dinoseb acid-in-oil forms an alternative to these mixtures but is however toxic to operators and requires high volume. On peat soils all treatments failed to give satisfactory results.

INTRODUCTION

This trial series follows National Agricultural Advisory Service work reported at the Weed Control Conference in 1962 [Neild and Proctor].

This work suggested that herbicides of two types may be useful:- contact action herbicides with little or no residual action, and residual herbicides preferably with some contact action. The best time of application of these chemicals was immediately prior to the emergence of the potato, thereby avoiding foliar damage to the potato and giving as much effect as possible by contact action on emerged weeds.

Therefore in 1963 and 1964 work was carried out with suitable chemicals and combinations of chemicals of these types. The choice of chemicals was based on previous work by the Weed Research Organisation, Commercial Firms and the National Agricultural Advisory Service.

METHODS AND MATERIALS

The trials were conducted in small plots set out in duplicate or triplicate randomised blocks. The treatments were carried out by the use of hand spraying equipment at volumes between 20 and 45 gals/ac. In all cases the dinoseb acid-in-oil treatment was at 40-45 gals/ac.

(i) Treatments

All treatments were designed for use immediately before the potatoes emerged and were contact pre-emergence herbicides, residual herbicides (most with some contact action) and a mixture of both. In the case of the mixtures the contact herbicide was applied separately to avoid compatibility difficulties. The treatments are listed in Tables 1-8 and varied according to soil type.

On Mineral Soils

In 1963 where linuron, prometryne or desmetryne was used, either alone or in a mixture with contact herbicides, the lower dose was used on sand or sandy loam soils whilst the higher dose was used on medium and heavy loams, silts and chalks. At some sites both rates of use were included and where this occurred the mean is recorded in the appropriate tables. In 1964 the dose varied similarly but only in the case of linuron used alone.

On Peat soils

In 1963 the main emphasis was on the contact herbicides, however, in the single site in 1964 the emphasis was on residual herbicides as a result of the poor results with contact chemicals and the slightly encouraging results with residual chemicals in 1963.

(ii) Assessments

Weed counts were made at the time of spraying. The control of weeds was measured on two occasions, one 3-5 weeks after spraying, the other at or near to harvest. The assessment was carried out by means of scores on a scale 0-10 where 0 = no weeds and 10 = maximum density of weeds. At the time of first assessment of weed control the unsprayed plots were examined to see if weeds had germinated since the time of spraying.

Yields were not taken, but the foliage growth was observed.

In some instances it was not possible, for various reasons, to carry out the assessment of weeds at or near harvest.

RESULTS

Weeds

The mean weed control scores for "all weeds" at each site is given in Tables 1-8.

The type and variety of potato, the soil type, the number of weeds and an assessment of weeds at the time of spraying together with the mean weed scores at the first assessment (3-5 weeks after spraying) are given for mineral soils in Tables 1 and 2 (1963), Tables 4 and 5 (1964) and for peat soils Table 7 (1963 and 1964).

The mean scores for the second assessment ("at harvest") are given for mineral soils in Table 3 (1963) and Table 5 (1964) and are comparable with Table 1 and Table 4 respectively as they cover the same sites. Table 8 gives the mean "at harvest" scores for peat soils and is comparable with Table 7.

On Mineral Soils

Residual Herbicides

Linuron (1963 and 1964), Prometryne (1963), Desmetryne (1963) Prometryne + Simazine (1963 and 1964) and Desmetryne + Trietazine (1964) gave fairly good initial control of weeds which persisted and this is reflected in the "at harvest" figures. Exceptions being:-

Desmetryne	at Site 2 (1963) Light Loam
Linuron (particularly); Prometryne & Desmetryne	at Site 3 (1963) Heavy Clay Loam
Linuron	at Site 9 (1963) Clay Loam
Linuron; Prometryne + Simazine	at Site 5 (1964) Medium Loam
Prometryne + Simazine; Desmetryne + Trietazine	at Site 7 (1964) Medium Clay Loam
Linuron; Desmetryne + Trietazine	at Site 8 (1964) Clay Loam

These sites are mainly where the heavier soils occur.

Simazine (used at a few sites in 1963) gave moderate weed control at first assessment, being particularly poor at Site 7 (1963) although its persistance is demonstrated with relatively low "at harvest" scores at Sites 4 and 5 (1963).

Monolinuron used alone or mixed with paraquat is comparable with linuron in general performance. Comparison of two doses of monolinuron with paraquat is possible in Tables 4, 5 and 6 and it appears that the higher, 24 oz/ac, did not appreciably improve weed control over the lower, 16oz/ac.

At eight sites in 1963 linuron, prometryne and desmetryne were used at two doses, either alone or with added paraquat or MCPA. The higher only slightly improved weed control in the majority of comparisons (34 total). Exceptions occurred in five comparisons, [4 at Site 11 and 1 at Site 9] where the improvement was greater than 1.0 in the scoring system.

Contact Herbicides

Paraquat - Initial weed control was as a whole poor and in both years weeds did not emerge before the crop at many of the sites. At thirteen out of twenty-two sites where the majority of weeds had not emerged the results are poor. [At sites 4 and 9 in 1964 a second application of paraquat was made]. At the remaining nine sites where the majority [but not necessarily all] the weeds were considered to have emerged, good weed control was achieved in all but Sites 7 and 10 in 1964. Good weed control at the first assessment did not persist as well as with the residual herbicides.

MCPA (2,4-DP at Site 7 1963) gave poorer weed control than paraquat at all sites except Site 4 (1963) where results from both herbicides were poor.

Mixtures of Residual and Contact Herbicides

The mixtures with MCPA (2,4-DP in Site 7) did not appreciably improve weed control by the residuals alone, either at the first assessment or at harvest. There is one exception, Site 2, where at harvest the MCPA mixtures were superior both to the residuals alone and with paraquat.

The mixtures with paraquat on the whole improved the weed control at the first assessment but by only a slight amount in 1965, although this was more appreciable by harvest time in both years. However, the scores at individual sites indicate that:-

(a) where weed control was poor with paraquat alone [weeds not present at spraying] there was little or no improvement of the residual by the paraquat mixture;

(b) where weed control by paraquat alone was good:- [weeds present at spraying] poor results by residuals alone were appreciably improved whilst good residual weed control was not appreciably improved.

In 1964 the mixtures with paraquat contained less residual herbicide than the residual alone, despite this, weed control by the mixtures was in most cases as good as the residual alone both at first assessment and at harvest. Exceptions being Sites 3, 5 and 8.

Dinoseb acid-in-oil which, whilst mainly contact in action has some residual property, gave better initial results than paraquat when the majority of weeds had not emerged at spraying, but slightly poorer results when the weeds were present. The degree of weed control achieved persisted better than with paraquat.

On Peat Soils

Moderately good initial weed control was obtained by some of the treatments in both years, however this did not persist and weed control mid season and at harvest was poor, with the exception of Stam F 34 at Site 14 (1963). Even in this case the weed remaining was considerable and greater than the weed in the farmers cultivated crop.

Individual Weeds

The variation in weed species over individual sites encountered in the trial series as a whole makes it difficult to systematise the reaction of weeds to the various herbicides. However, this has been attempted in Table 9 where the susceptibility or otherwise of nineteen weeds to most of the herbicides is given.

It is important to remember that failure or success of the treatments in controlling a weed may be due to the stage of growth of the weed at the time of spraying. This is particularly so in the case of paraquat, which could be expected to control all annual weeds if hit, and the list very probably only represents the degree of emergence of the weeds. This point must also be borne in mind when considering the residual herbicides, as a weed may be resistant in the young plant stage but susceptible as a germinating seed.

The mixtures of residual and contact herbicides appear to give the results expected from the individual components.

Couch, a perennial weed not expected to be controlled by these herbicides, was avoided as far as possible when choosing the sites. It nevertheless occurred in the trial series, and in some instances, presumably where shoot growth was present at spraying, the effects of paraquat were useful in that season, in other instances [few shoots present at spraying] the effect was negligible.

Crop

Paraquat, with or without residual herbicide, in both years scorched the leaves of the potato crop at a number of sites, this was felt to be only those plants which had emerged (or were close to emergence) at the time of spraying. The scorch was not heavy and the crop soon recovered.

MCPA (1963) with or without residual herbicide, caused distortion of the potato plants at a number of sites, again this was felt to be those plants emerged (or close to emergence) at the time of spraying.

In the crop vigour assessments the majority of sites, in both years, showed no difference between treatments. The exceptions where slight reduction in vigour was recorded are as follows:-

1963

Site 5. Prometryne 26 + simazine 6, prometryne 32 and simazine 8

Site 10. Prometryne 32 + paraquat 16, and linuron 32 + paraquat 16

1964

Sites 6, 7 and 10. Prometryne 16 + simazine 4 + paraquat 8

Table 1 Mineral Soils 1963 General information and Weed Control after Spraying. Sites 1-6

	Site 1 CARDS.	Site 2 PEMBS.	Site 3 SOMERSET	Site 4 SUFFOLK	Site 5 NORTHANTS	Site 6 YORKS(W.R.)	Mean Sites 1-6
Crop - Type	Early Maincrop	Early	Maincrop	Early	Maincrop	Maincrop	
- Variety	Craig's Royal	Home Guard	Majestic	Ulster Prince	Majestic	Majestic	
Soil Type	Medium Loam	Light Loam	Heavy Clay Loam	Sandy Loam	Medium Loam	Medium Loam	
Weeds - No. per ft^2	48	7	30	70	11	1	
- Majority emerged at spraying?	Yes	No	Yes	No	No	No	
Weed Assessment 3-5 weeks after spraying. 10.0 = Full weed 0.0 = Nil weed							
Treatment and dose oz/ac							
Linuron 16 or 32	3.0	1.5	9.0	0.5	2.0	1.7	3.0 (6)
Prometryne 16 or 32	3.0	2.5	4.0	0.8	1.0	2.0	2.2 (6)
Desmetryne 16 or 32	1.0	4.5	4.0	0.6	0.5	2.7	2.2 (6)
Simazine 8				1.0	4.0		2.5 (2)
Prometryne 26 + Simazine 6				0.7	1.0		0.9 (2)
Paraquat 16	1.3	4.0	0.8	8.5	7.5	7.7	5.0 (6)
MCPA 16	7.0	6.5	10.0	7.5			7.8 (4)
Linuron 16 or 32 + Paraquat 16	0.4	2.0	1.5	0.5	2.0	2.0	1.4 (6)
Prometryne 16 or 32 + Paraquat 16	0.2	3.8	1.5	0.4	1.3	2.0	1.5 (6)
Desmetryne 16 or 32 + Paraquat 16	0.2	2.9	0.5	0.8	0.8	1.0	1.0 (6)
Simazine 8 + Paraquat 16				0.8	1.5		1.2 (2)
Linuron 16 or 32 + MCPA 16	2.3	2.0	4.0	0.5			2.2 (4)
Prometryne 16 or 32 + MCPA 16	3.0	3.2	2.0	0.4			2.2 (4)
Desmetryne 16 or 32 + MCPA 16	1.8	2.9	2.0	0.8			1.9 (4)
Unweeded Control	10.0	7.0	10.0	10.0	10.0	10.0	9.5 (6)

Table 2 Mineral Soils 1963 General information and Weed Control after Spraying. Sites 7-12

	Site 7 ESSEX	Site 8 CORNWALL	Site 9 LINCS.	Site 10 YORKS(N.R.)	Site 11 LINCS.	Site 12 YORKS(N.R.)	Mean Sites 1-12
Crop - Type	Maincrop	Early Maincrop	Maincrop	Maincrop	Maincrop	Maincrop	
- Variety	King Edward	Ulster Ranger Dr. McIntosh	Majestic	Majestic	Majestic	Majestic	
Soil Type	Silt Loam	Medium Loam	Clay Loam	Medium Loam	Sandy Loam	Sand	
Weeds - No. per ft^2	15	150	?	19	60	8+	
- Majority emerged at spraying	Yes	No	No	Yes	No	No	
	Weed Assessment 3-5 weeks after spraying. 10.0 = Full weed 0.0 = Nil Weed						
Treatment and dose oz/ac							
Linuron 16 or 32	0.7	1.0	5.3	0.0	0.6	2.3	2.3 (12)
Prometryne 16 or 32	0.1	2.5	2.6	1.5	2.1	1.6	2.0 (12)
Desmetryne 16 or 32	0.0	2.0	3.4	0.0	1.6	1.3	1.8 (12)
Simazine 8	9.9				3.9		4.7 (4)
Prometryne 26 + Simazine 6	1.8				0.8		1.1 (4)
Paraquat 16	0.0	3.5	2.8	0.5	6.3	2.6	3.8 (12)
MCPA 16 *Dichloprop	*5.6		5.3	2.0	7.7		6.5 (8)
Linuron 16 or 32 + Paraquat 16	0.1	0.5		0.0	0.5	2.3	1.1 (11)
Prometryne 16 or 32 + Paraquat 16	0.4	1.0		0.0	1.6	2.3	1.3 (11)
Desmetryne 16 or 32 + Paraquat 16	0.0	2.0		0.5	1.9	2.0	1.1 (11)
Simazine 8 + Paraquat 16	0.2				4.2		1.7 (4)
Linuron 16 or 32 + MCPA 16	*0.0			0.0	0.7		1.4 (7)
Prometryne 16 or 32 + MCPA 16	*0.3			1.5	1.5		1.7 (7)
Desmetryne 16 or 32 + MCPA 16	*0.1			0.0	1.6		1.3 (7)
Unweeded Control	10.0	10.0	7.1	10.0	10.0	10.0	9.5 (12)

Table 3. Mineral Soils 1963 Weed Control at Harvest. Sites 1-6

(10.0 = Full weed 0.0 = Nil weed)

Treatment and dose oz/ac	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Mean Sites 1-6
Linuron 16 or 32	7.5	2.3	10.0	0.3	0.8	3.7	4.2 (6)
Prometryne 16 or 32	8.0	2.8	9.5	1.3	1.3	2.0	4.2 (6)
Desmetryne 16 or 32	8.0	6.5	10.0	0.5	0.8	5.0	5.5 (6)
Simazine 8				1.3	2.0		1.7 (2)
Prometryne 26 + Simazine 6				0.5	0.5		0.5 (2)
Paraquat 16	2.5	6.5	9.0	9.5	3.3	7.5	6.4 (6)
MCPA 16	8.5	7.0	10.0	8.0			8.4 (4)
Linuron 16 or 32 + Paraquat 16	2.5	2.7	7.0	0.0	1.2	3.3	2.8 (6)
Prometryne 16 or 32 + Paraquat 16	2.9	6.3	9.0	1.2	0.5	2.3	3.7 (6)
Desmetryne 16 or 32 + Paraquat 16	0.8	4.0	5.5	1.2	1.3	1.3	2.4 (6)
Simazine 8 + Paraquat 16				1.0	1.3		1.2 (2)
Linuron 16 or 32 + MCPA 16	5.5	1.8	9.0	0.0			4.0 (4)
Prometryne 16 or 32 + MCPA 16	7.0	2.3	7.0	1.0			4.3 (4)
Desmetryne 16 or 32 + MCPA 16	7.5	2.4	8.0	1.4			4.8 (4)
Unweeded Control	8.0	7.0	10.0	10.0	10.0	9.0	9.0 (6)

Table 4 Mineral Soils 1964. General Information and Weed Control after Spraying Sites 1-8

	Site 1 CHESHIRE	Site 2 WORCS.	Site 3 YORKS(N.R.)	Site 4 PEMBS.	Site 5 LINCS.	Site 6 YORKS(W.R.)	Site 7 WARWICKS	Site 8 SOMERSET	Mean Sites 1-8
Crop - Type - Variety	Early Ulster Prince	Maincrop Majestic	Maincrop Majestic	Early Ulster Premier	Maincrop Majestic	Maincrop Majestic	Maincrop King Edward	Maincrop Majestic	
Soil type	Sandy Loam	Loamy Sand	Medium Loam	Medium Loam	Medium Loam	Medium Loam	Med.Clay Loam	Clay Loam	
Weeds - No. per ft^2	17	10	17	27	6	14	50	38	
- Majority emerged at spraying?	Yes	Yes	No	No	No	No	Yes	Yes	
	Weed Assessment 3-5 weeks after spraying. 10.0 = Full weed: 0.0 = Nil weed								
Treatment and dose oz/ac									
Linuron 24 or 32	1.5	1.0	0.5	0.0	4.0	4.0	2.5	3.5	2.1 (8)
Monolinuron 24				1.5					1.5 (1)
Prometryne 26 + Simazine 6	1.5	3.0	1.0	1.0	3.0	5.0	9.0	2.0	3.2 (8)
Desmetryne 26 + Trietazine 6	1.5	2.0	3.3	1.0	3.0	3.0	4.0	4.5	2.8 (8)
Paraquat 8		1.0	6.5	*1.0	6.0	4.0	3.0	1.8	*3.7 (6)
Paraquat 4 + Diquat 4	1.0	1.5					4.0		2.2 (3)
Linuron 16 + Paraquat 8	0.0	0.5	1.0	0.0	4.0	1.0	1.0	2.0	1.2 (8)
Monolinuron 16 + Paraquat 8	0.0	0.5	0.5	1.0	3.5	1.0	3.0	4.0	1.7 (8)
Monolinuron 24 + Paraquat 8	0.0	0.0	0.0		4.2	1.0	2.0		1.2 (6)
Prometryne 16 } Simazine 4 } + Paraquat 8	0.0	0.5	2.0	0.0	4.0	1.0	2.0	2.5	1.5 (8)
Trietazine 16 + Paraquat 8	0.5	1.0	1.0	2.0	4.0	3.0	2.5	1.5	1.9 (8)
Desmetryne 16 + Paraquat 8	0.0	1.0	4.5	0.0	4.0	1.5	1.0	1.0	1.6 (8)
Dinoseb Acid in Oil 40	3.0	1.0	1.5	2.0 (36 oz)	4.0		5.0		2.8 (6)
Unweeded Control	4.8	6.8	9.5	8.0	7.0	10.0	9.5	6.0	7.7 (8)

*First Paraquat treatment ineffective, therefore treated again. Excluded from means.

Table 5 Mineral Soils 1964 General information and Weed Control after Spraying. Sites 9 and 10

	Site 9 CAERNARVON	Site 10 HEREFORD	Mean Sites 1-10
Crop - Type - Variety	Early Arran Pilot	Maincrop Dr. McIntosh	
Soil type	Medium Loam	Light Loam	
Weeds - No. per ft^2	?	13	
- Majority emerged at spraying?	No	Yes	
	Weed Assessment 3-5 weeks after spraying. 10.0 = Full weed 0.0 = Nil weed		
Treatment and dose oz/ac			
Linuron 24 or 32	0.0	1.0	1.8 (10)
Monolinuron 24	0.3		0.9 (2)
Prometryne 26 + Simazine 6	0.3	1.5	2.7 (10)
Desmetryne 26 + Trietazine 6	0.3	2.0	2.5 (10)
Paraquat 8	*0.6	4.0	*3.8 (7)
Paraquat 4 + Diquat 4		4.0	2.6 (4)
Linuron 16 + Paraquat 8	0.0	1.5	1.1 (10)
Monolinuron 16 + Paraquat 8	0.0	2.5	1.6 (10)
Monolinuron 24 + Paraquat 8		2.5	1.4 (7)
Prometryne 16) Simazine 4) + Paraquat 8	0.3	2.5	1.5 (10)
Trietazine 16 + Paraquat 8	0.0	3.5	1.9 (10)
Desmetryne 16 + Paraquat 8	0.0	3.0	1.6 (10)
Dinoseb Acid in Oil 40	2.0 (36 oz)	1.8	2.5 (8)
Unweeded Control	8.2	4.4	7.4 (10)

*First Paraquat treatment ineffective, therefore treated again. Excluded from means.

Table 6 Mineral Soils 1964 Weed Control at Harvest. Sites 1-8

(10.0 Full weed: 0.0 = Nil weed)

Treatment and dose oz/ac	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Mean Sites 1-8
Linuron 24 or 32	4.0	1.5	1.0	0.3	5.0	5.5	1.5	8.5	3.4 (8)
Monolinuron 24				3.3					3.3 (1)
Prometryne 26 + Simazine 6	4.0	2.5	0.5	1.7	6.0	9.5	9.5	5.5	4.9 (8)
Desmetryne 26 + Trietazine 6	4.0	2.0	3.5	0.7	4.0	3.5	2.5	7.5	3.5 (8)
Paraquat 8		4.5	7.0	*4.7	7.0	8.0	4.0	5.5	*5.9 (6)
Paraquat 4 + Diquat 4	3.0	5.0					5.0		
Linuron 16 + Paraquat 8	0.0	2.0	0.0	1.3	6.0	2.5	0.5	6.0	2.3 (8)
Monolinuron 16 + Paraquat 8	0.0	1.5	0.0	2.7	5.0	1.5	5.0	9.0	3.1 (8)
Monolinuron 24 + Paraquat 8	0.0	1.0	0.0		5.0	2.0	5.5		2.3 (6)
Prometryne 16) Simazine 4) + Paraquat 8	0.0	2.0	2.0	0.3	4.0	1.0	2.5	7.0	2.4 (8)
Trietazine 16 + Paraquat 8	0.5	2.5	0.0	2.3	6.0	6.5	1.0	7.0	3.2 (8)
Desmetryne 16 + Paraquat 8	1.0	1.5	5.0	7.0	6.0	2.0	1.0	5.0	3.6 (8)
Dinoseb Acid in Soil 40	4.5	2.5	0.5 (36 oz)	6.7	6.0		2.5		2.8 (6)
Unweeded Control	5.8	7.7	9.0	10.0	8.0	8.0	10.0	9.1	8.5 (8)

*First Paraquat treatment ineffective, therefore treated again. Excluded from means.

Table 7. Peat Soils 1963 (Sites 13,14,15) and 1964 (Site 11) General Information and Weed Control after spraying

	Site 13 CAMBS.	Site 14 LANCS.	Site 15 CAMBS.	Mean Sites 13 & 14	Mean all Sites		Site 11 LANCS.
Crop - Type - Variety Soil type Weeds - No. per ft^2 - Majority emerged at spraying?	Maincrop Majestic Peat 49 Yes	Maincrop King Edward Peat 80 No	Maincrop King Edward Loamy Peat 12 Yes			Crop - Type - Variety Soil type Weeds - No. per ft^2 - Majority emerged at spraying	Maincrop King Edward Peat 55 No
Weed Assessment 3-5 weeks after spraying 10.0 = Full weed: 0.0 = Nil weed							1 week*
Treatment and dose oz/ac						**Treatment and dose oz/ac**	
Stam F 34. 32 Stam F 34. 64 /48	1.6 2.2/	1.7 1.0	5.0 8.5	1.7(2) 1.6(2)	2.8(3) 3.9(3)		
Paraquat 12 Paraquat 24	4.0 1.7	4.0 2.3	7.0 6.0	4.0(2) 2.0(2)	5.0(3) 3.3(3)	Diquat 16 Diquat 8+ Paraquat 8	0.0 0.0
MCPA 16 MCPA 32	6.5 4.9	9.3 9.0	7.5 4.0	7.9(2) 7.0(2)	7.8(3) 6.0(3)		
Linuron 32 Prometryne 32 Desmetryne 32 Simazine 8 Prometryne 26 + Simazine 6	1.6 1.7 2.1 10.0 1.4		3.0 2.0 2.0 6.0 1.0	1.6(1) 1.7(1) 2.1(1) 10.0(1) 1.4(1)	2.3(2) 1.9(2) 2.1(2) 8.0(2) 1.2(2)	Linuron 16 Linuron 32 Linuron 64	2.0 1.0 1.0
Linuron 32 + Paraquat 16 Prometryne 32 + Paraquat 16 Desmetryne 32 + Paraquat 16 Simazine 8 + Paraquat 16	2.8 0.5 1.9 1.7		4.0 2.5 1.0 4.5	2.8(1) 0.5(1) 1.9(1) 1.7(1)	3.4(2) 1.5(2) 1.5(2) 3.1(2)	Monolinuron 24 + Diquat 16 Monolinuron 32 + Diquat 16	0.5 0.5
Unweeded Control	10.0	10.0	10.0	10.0(2)	10.0(3)	Unweeded Control	10.0

*These figures relate to contact action on the seedling weeds present at spraying. Newly germinated seedlings were present in all plots although Linuron 64 temporarily retarded these.

Table 8 Peat Soils 1963 and 1964 Weed Control at Harvest - Compare with Table 7

Treatment and dose oz/ac	Site 13	Site 14	Site 15	Mean Sites 13 & 14	Treatment and dose oz/ac	Site 11
	Weed Assessment at Harvest 10.0 = Full weed: 0.0 = Nil weed					
Stam F 34. 32	6.7	1.3		4.0 (2)		
Stam F 34. 64 ≠48	5.7≠	1.3		4.5 (2)		
Paraquat 12	7.5	8.6		8.1 (2)	Diquat 16	8.0
Paraquat 24	6.0	6.6		6.3 (2)	Diquat 8 + Paraquat 8	9.5
MCPA 16	8.5	8.3		8.4 (2)		
MCPA 32	6.3	7.3		6.8 (2)		
Linuron 32	6.6			6.6 (1)		
Prometryne 32	5.3			5.3 (1)	Linuron 16	9.5
Desmetryne 32	7.3			7.3 (1)	Linuron 32	10.0
Simazine 8	6.6			6.6 (1)	Linuron 64	7.5
Prometryne 26 + Simazine 16	6.3			6.3 (1)		
Linuron 32 + Paraquat 16	5.0			5.0 (1)		
Prometryne 32 + Paraquat 16	5.0			5.0 (1)	Monolinuron 24 + Diquat 16	8.0
Desmetryne 32 + Paraquat 16	5.6			5.6 (1)	Monolinuron 32 + Diquat 16	7.5
Simazine 8 + Paraquat 16	5.0			5.0 (1)		
Unweeded Control	9.5	10.0		9.8 (2)	Unweeded Control	10.0

Table 9 Response of Weeds to herbicide treatments

S = Well controlled
V = Variable
R = Not controlled

		Linuron	Prometryne	Prometryne + Simazine	Desmetryne	Desmetryne + Trietazine	Paraquat	Dinoseb Acid in Oil
Sinapis alba	(Charlock)	S	S	S	S		S	
Spergula arvensis	(Spurrey)	S	S		S		S	
Chenopodium album	(Fat-hen)	S	S	S	S	S	V	S
Polygonum persicaria	(Redshank)	S	S	S	S	V	S	S
Stellaria media	(Chickweed)	S	S	S	S	S	S	S
Veronica spp.	(Speedwell)	V	V	S	S	S	V	R
Polygonum aviculare	(Knotgrass)	V	V	V	S	V	V	S
Matricaria spp.	(Mayweed)	V	V	S	V		S	
Anagallis arvensis	(Pimpernel)	S	S	S	S	S	V	S
Viola tricolor	(Viola)	S	S	S	S	R	V	
Linaria vulgaris	(Toadflax)	S	S	V	S		V	
Polygonum convolvulus	(B. Bindweed)	V	V	S	S	S	V	S
Fumaria officinalis	(Fumitory)	R	S	S	S		V	
Aethusa cynapium	(Fools Parsley)	S	S	R	S		S	
Senecio vulgaris	(Groundsel)	S				S	S	S
Gallium aparine	(Cleavers)	S				R	R	
Solanum nigram	(B. Nightshade	S				S	R	S
Hordeum spp.	(Barley)	R	R	R	R	S	S	R
Lolium spp.	(Ryegrass)	S		R		S	S	R

DISCUSSION

The scoring system used in assessing weed control is an attempt to combine weed numbers and weed size into one figure appropriate to comparing a large trial series but the plain scores give no indication of the competitive effect of weed on the crop. A few weeds per plot when assessed after spraying will have a very low score as compared to the unsprayed control, full of similar weeds. The same situation at harvest does not necessarily apply, as the few weeds will have grown very large in relation to the weeds in the control which have been struggling for survival amongst themselves. At this stage the score will be much higher than earlier yet the competition to the crop has been little at the early stage when it can be expected to have the greatest adverse effect. Therefore it is suggested that an "at harvest" score of less than 50% of the control can be viewed favourably in comparison to the cultivated farm crop which normally contains some weed at harvest.

The probable exceptions to this viewpoint are the peat (or high organic soils) where very rapid further germination of weed and the lack of residual effects from the herbicides may mean early weed competition despite good control of the first flush of weeds.

Mineral Soils

Contact Herbicides

The weather in the two years concerned was such that the majority of weeds had not emerged before the crop and it is therefore not surprising that the weed control by contact herbicides was variable. Whilst some seasons may be more amenable, these variations in weed at spraying make the commercial use of paraquat at the pre-potato emergence stage open to doubt as a means of controlling weeds for the whole season. It may however be useful as a method of controlling the first flush of weeds in suitable seasons, leaving labour free at that time for other work, or it may form mixtures with other herbicides [see below]. The scorching effect of paraquat on emerged potatoes seems to be short lived and to have no lasting effects. MCPA does not control weeds as well as paraquat which coupled with undesirable distortions of emerged potato plants does not make it a suitable alternative.

Residual Herbicides

Most of these gave reasonably good initial and persistant weed control which in many cases is sufficient to form a commercial technique for the control of annual weeds. The individual weeds controlled vary from chemical to chemical but a sufficient number of candidate chemicals are available for a reasonable choice. Initial weed control although reasonable is not very high and it may be that limitations exist in the contact action ability of these chemicals. It is indicated that weed control is not as good on the heavier potato soils. In some cases slight effects on crop vigour may occur.

Mixtures of Contact and Residual Herbicides

These have the advantage that the added contact herbicide counters the deficiencies in contact action of the residual herbicide alone. Where weeds are present increased control can be expected but with little or no weed at the time of spraying the contact herbicide will be wasted. However, the results in 1964 show that a reduced rate of the residual herbicide with a contact can be at least as effective as the higher rate of residual alone, and form a less expensive alternative. Control of grass weeds and defoliation of couch spp. is improved by the presence of paraquat. Dinoseb acid-in-oil, with good contact action and some residual ability, forms a possible alternative to these mixtures. However, on the basis of these results the contact action is not quite as good as paraquat nor the residual effect as good as the residual herbicides and as it requires a relatively high volume of water for application and is a toxic chemical it is less desirable commercially.

Peat Soils

Neither group of chemicals is successful on these soil types. The residual herbicides even at very high rates have very short lived residual action and with the contact herbicides allow subsequent heavy germination of weeds in such soils.

Session III(A) - POTATOES

Discussion

Mr. D. E. Zalichi, (British Petroleum Co. Ltd.) said that his company had been conducting field trials with flame cultivation equipment across most of Europe for various farming applications including weed control and destruction of potato haulms. They would still consider that flame cultivation is at an early stage of development but they are already in a position to see that flame cultivation can be used with advantage in a number of applications and promised to be a useful general purpose farmers' aid, which could be used throughout the year in conjunction with mechanical and chemical treatments.

Mr. J. G. Elliott, Weed Research Organisation considered that the situation regarding the effects of cultivation compared with herbicide treatment on yield of potatoes was very confused and that the papers had done little to clarify the situation. There was a need to be specific about the type of cultivation in experimental reports since they could vary from a light harrowing to a deep grubbing. He wondered whether Mr. Bremner's conclusions about moisture loss and effect of cultivations were equally applicable to all soil types. Mr. Bremner pointed out that he did limit his comments to light and loamy soils and that there was little information on the reaction of potatoes to cultivation on heavy soils. He expressed the opinion that crop damage from cultivations would be greater on heavy soils because they are more cohesive leading to more bursting and cracking in cultivation with consequent damage to roots. He considered that moisture loss following cultivation was not serious although he had shown greater yield reduction when cultivations were followed by dry weather. Mr. North supported Mr. Bremner's views on moisture loss although there was an obvious need for more work on this subject.

Mr. J. G. Elliott asked whether Mr. North's observations on the effect of residual chemicals on the crop might have been somewhat different if they had been applied in a more truly pre-emergence situation. Mr. North explained that their crop emergence counts were based on a severe standard. Plant stations were carefully examined on a vertical axis and any signs of sprout emergence, even if still white and shielded by clods, was counted as an emerged plant.

Mr. W. Cowan (Farm Protection Ltd.) queried whether there was sufficient care taken in experimental technique and particularly in recording the growth of the crop from seed size, sprouting and maturity aspects. He suspected that yields could be influenced by a host of variables thus giving rise to the contradiction of results which is so common in the potato crop. He asked the speakers about sprouting and time of harvesting of their trials. Mr. Shotton said that the E.H.F. maincrop trials had, except in one case, been planted with sprouted seed and harvested at maturity. It is known that the effects of such factors as sprouting may vary according to the stage of maturity of the crop. The effect of herbicides on yields might vary in a similar way and this had been suggested in his paper as a possible cause for the variable results in the Arran Pilot trials at Terrington. Mr. Eddowes and Mr. North said that their main crop trials were harvested at maturity and the early potato trials at Harper Adams were harvested according to local commercial practice. This would inevitably lead to variable results because of harvesting at different growth stages.

The Chairman said that it is now clear that current herbicides gave much the same results as sensible cultivation; the issue was not between herbicides and cultivation but to find why there was such a tremendous variation between yields in different years and different places. However, there was still need for a safer chemical controlling a wider spectrum of weeds.

FRUIT, ORNAMENTALS AND FORESTRY

SESSION III B

Discussion

Dr. D.W. Robinson, Kinsealy, asked if any overseas delegates could report on experiments with lenacil on strawberries. Mr. van Staalduine, IBS Wageningen, replied that experiments had been carried out in Holland since 1963 and doses between 1 and 2 lb a.i./ac had been found to be satisfactory under a range of conditions. Approval was expected during 1967 but the problem of persistent soil residues had not yet been solved.

Miss H.M. Hughes, Efford E.H.S. considered that though doses of 2 - 3 lb a.i./ac were effective and apparently safe the cost of lenacil was high (80/- lb) and a programme based largely on lenacil would be much more expensive than one in which simazine formed the main herbicide. Mr. T.G. Marks, Pan Britannica Industries reported that lenacil was unlikely to become any cheaper in the immediate future. It was however, active against knotgrass, a weed which was becoming increasingly dominant in established strawberry plantations through the introduction of seed in straw used for strawing down and the inability of simazine or chloroxuron to control it.

Mr. P.J. Smith, Staffordshire, asked whether lenacil controlled Atriplex patula and whether it had been used in blackcurrants. It was reported that P.B.I. hoped to carry out trials in this crop during 1967. Dr. Robinson said that some experiments had been done at Loughgall using 2 - 4 lb a.i./ac on Wellington XXX.

Mr. D.J. Allott, Loughgall, replying to a question concerning the soil type on which simazine at 10 lb a.i./ac had caused no damage to strawberry plants dipped in charcoal before planting said that it was a medium heavy loam in which plants normally showed a fair degree of tolerance.

In a discussion on the influence of moisture on the activity of lenacil it was said that in work on sugar beet moist soil conditions were essential for good weed control, although with strawberries Miss Hughes reported that at Efford good control resulted despite dry conditions. It was felt that the variation in degree of weed control shown in the reports could be due to differences in soil moisture. To some extent this might be overcome by increased doses.

Mr. P.J. Smith asked if Heracleum spondyllium (Hogweed) could be controlled with chlorthiamid. Mr. M.G. Allen, Shellstar Ltd. said that it did not control this weed. Mr. van Staalduine reported that chlorthiamid was used on a very limited scale in Holland and it appeared that raspberries were more susceptible than blackcurrants. This was confirmed by representatives of Shellstar Ltd.

Mrs. E.D. Turquand, Kirton, referred to experiments at Kirton using lenacil on narcissus and tulips. Preliminary results were promising. Mr. van Staalduine said that lenacil had been tested for two years in Holland on tulips, narcissus and iris.

Mr. A.G. Biggs, Hadlow College, asked for information on the use of lenacil and chlorthiamid on nursery stock. In reply, Mr. R.I.C. Holloway, East Malling, said that in his experiments chlorthiamid when fully incorporated into the soil killed the roots of apple and plum rootstocks potted into the treated soil and when applied to the soil surface the upper parts of the roots were malformed. Mr. van Staalduine, reported that in Holland chlorthiamid had received approval in 1965 for use in apples more than 3 years old. Doses of up to 6 lb a.i./ac annually from 1963 had caused no damage and in 1965 treated trees gave a higher yield than those not treated. Dutch recommendations are to use chlorthiamid only for special purposes, e.g. when weeds resistant to residual herbicides are a problem.

Mr. C. Parker, Weed Research Organisation asked whether the formulation of chlorthiamid was important and whether incorporation gave better control of perennial weeds. Mr. M.G. Allen replied that the granular material was more effective than the wettable powder. Incorporation did not improve the performance of granules but could improve that of the wettable powder.

Mr. J.L. Soyez, Du Pont drew attention to the similarity between lenacil and neburon in respect of their solubility, dependence on soil conditions, moisture requirements and range of selectivity. Lenacil appeared to be 4 - 6 times more active than neburon as well as being more effective against grasses and was worth further investigation for strawberries, nursery stock, phlox, alfalfa, bulbs and ornamentals.