SESSION 1

THE TWELFTH BAWDEN LECTURE

CHAIRMAN MR R. F. NORMAN

SESSION ORGANISER MR D. TYSON

FARMING FOR THE PUBLIC, NOT FOR OURSELVES

LORD MELCHETT

Courtyard Farm, Hunstanton, Norfolk

Introduction - agricultural policy all at sea

A year ago, in an article in the 'Countryman' magazine, I drew an analogy between current British agricultural policy and a supertanker trying to change course. I have been interested to see in the last year that a number of other commentators, including William Waldegrave, now Minister of State at the Department of Environment responsible for conservation, and two well-known farmers, Hew Watt and David Richardson, have also compared current British agricultural policy with some sort of ship. These three, in turn, suggested that agricultural policy is like a supertanker, taking some time to turn around, or that it is a rudderless ship, or finally that it is like a ship wallowing in an ocean full of icebergs with a captain who declines to steer. I have a rather more detailed image in my mind of this ship, and I would like to start by describing it.

I think of British agricultural policy as a supertanker. It is getting on in years - formally launched in 1947, it had actually been at sea for a few years before that. In the early years of its life, this was a fine ship, and little went wrong with it, but in recent years things have changed. At first the plates simply began to bulge and crack, and the cargo started seeping out almost unnoticed. Recently the ship has started to strike a number of objects, and it has been holed in numerous places. The cargo, which is increasingly in excess of any possible customer's requirements, has, as I have said, been seeping out of the ship for many years. Like an oil slick in the ocean, it has had devastating consequences on the landscapes and wildlife habitats through which this ship sails, and apart from destroying those on an increasing scale, it has also destroyed jobs and caused ever increasing suffering for farm animals.

One of the most recently retired captains of the ship, Peter Walker, insisted only a few years ago that absolutely nothing was wrong, and even urged his crew to produce more for the ship to carry. It was obvious to many observers even then that the ship was sinking under the weight of its unwanted cargo, and that is certainly the general view today.

It is true, as William Waldegrave suggests, that the ship is now trying to change course. Unfortunately, there is no clear view on the bridge as to which way the ship is actually turning. Indeed some people still insist that either it is not changing course, or that if it is, it does not need to. As David Richardson has said, the captain declines to steer, which does not make changing course any easier. In any event, as the captain said himself, even if he was prepared to steer he would not know which way to go. To quote Michael Jopling "It is not how to say what we want that is the difficulty, but what to say".

Three things are clear. First, whether the supertanker is changing course or simply veering wildly around the ocean, it still continues to do terrible damage to the countryside it passes through. Second, very few people believe that it can go on careering round the ocean in this confused state for much longer, although I fear that may be too optimistic a view. Third, the state of confusion on the bridge of the ship is total. Not only is the captain declining to steer, he has no idea where the ship is going, or where it ought to be going. His crew and various pilots that board the ship from time to time to give him advice, all contradict each other. What few decisions are made are themselves contradictory. For example, swingeing cuts in drainage grants are announced, and a new scheme started to protect traditional grazing in the Broads, while at the same time people on the bridge vigorously defend a decision taken, finally earlier this year, to drain one of the few remaining wetlands of importance for wildlife outside nature reserves in Cambridgeshire. New initiatives are successfully taken at the European level to introduce a modest new conservation element in the Structures Directives, while at the same time, the long drawn out and painstaking work of the Countryside Commision on a better future for the uplands is rejected almost in its entirety.

What is also sure, in this confused and confusing situation, is that inaccurate rumours about what is really going on abound on the bridge of the ship. I want to start what I have to say by looking at some of these rumours in a little more detail, before going on to discuss the future course the supertanker will have to steer if it is going to avoid total destruction.

I do not, therefore, intend to try and summarise the full conservation case against current agricultural policy, still less to trace the course this debate has followed during the last five years. Things have moved very quickly in that period, and positions continue to change rapidly. In these circumstances, it seems to me most useful to try and look at the arguments that have come to the fore recently.

The old myths linger on

Some of the most persistent myths around on the confused bridge of the supertanker concern the attitudes of conservationists. The view that all conservationists are bearded, be-sandled weirdos, and that the sooner they are all extinct the better, which I saw expressed in a letter to Farmers Weekly several years ago, still persists. So does the view that conservationists all have a wholly negative and unrealistic view of agriculture. For example, Hew Watt, writing in Farmers Weekly this year, said "the conservation lobby still feels farmers should be unpaid park-keepers". This despite the fact that conservationists have strongly supported farmers in the Broads being paid significant amounts of public money to agree to continue traditional grazing practices, and conservationists' support for the Minister of Agriculture's partially successful initiative in Brussels, aiming to provide funds to maintain existing, traditional farming practices where they benefit conservation. As I have already said, the advice available on the bridge is contradictory, and it was interesting to see an editorial in Big Farm Weekly in March this year say what had previously been unthinkable in such quarters, that "Park-keeping may, seriously, be a sensible role for some farmers"

No 'Victory for the Greens' - yet

There are certainly those on the bridge that have a very muddled view of what sort of changes conservationists actually want to see. Some are busy telling the captain that all conservationists want to do is slow down the rate of agricultural 'progress', but not halt it. This has led the captain to make some strange statements in recent years. For example, recent cuts in farm capital grants have been heralded by the Government as a major concession to conservationists, prompting one farming paper to headline another round of cuts as a 'victory for the greens'. Nothing could be further from the truth.

Conservationists are not interested in slowing down the rate of agricultural change, they want something that is both more complex and more radical. I will be saying more about this later, but, for example, conservationists want not a slowing down but a total halt to all further intensification of extensively farmed land. On the other hand, they have never, to my knowledge, argued for simple cuts in agricultural support, but rather for a redirection of public support to agriculture with cuts in some areas matched by new initiatives in others. Overall cuts in public support for agriculture are much more likely to be a 'disaster for the greens', because they reduce the options available for money to be put into agricultural systems that benefit conservation interests.

Conservation causes conflict?

When conservationists are not being confused with militant monetarists, the militant tendancy are called in instead. Reassuring voices suggest that any conflict between agriculture and conservation is being exaggerated by militant conservation organisations making wildy exaggerated claims, which are eagerly lapped up by the press, TV and radio. In fact, it is frequently very difficult for conservation organisations to be critical of the policies pursued by farmers and landowners. There are a number of reasons for this. First, throughout the 1960s and 70s, conservationists generally saw agriculture as beyond attack - too powerful an enemy to try and take on, and too popular with the general public. Second, very few conservationists adopt the simple and single-minded approach which they criticise in agricultural policy. Conservationists want to see a varied countryside. Many are interested in a countryside where there are more jobs than at present, and better public services, as well as attractive landscapes and more wildlife. Complex objectives of this sort are not easily turned into a swingeing attack on farming. Third, even in the last few years, when farmers have started to lose public and political sympathy, most conservationists have continued to believe that, if for no other reason, political expediency dictates that they should pursue policies designed to reach agreement with farmers, rather than to create a conflict in which the winner takes all.

Finally, and this may be the most significant factor, many conservation bodies have a number of farmers, foresters or landowners, or people with interests in farming or forestry, on their governing bodies. Indeed, I am an example of this myself, and while I may not be typical, I still feel very strongly - because of my close connections with farming, to say nothing of receiving my livelihood from it - that a compromise between farming and conservation is not only desirable, but should be achievable.

My own view is that conservationists, and particularly the major conservation organisations in this country, have adopted a very cautious and conciliatory approach to agriculture over the last few years. This is certainly so compared to conservation campaigns on other issues, considered against the background of the scale of the losses that conservationists have actually suffered at agriculture's hands, and when you consider the depth of feeling amongst the members of these organisations about the issues involved.

Farming is not the only problem

Despite the mildness of much of the debate between agriculture and conservation, it is this conflict which has dominated discussion in recent years. However, conflicts with conifer afforestation and activities covered by planning control, such as road building and other developments, have been going on for longer than the conflict with agriculture, and those problems are still very much with us. Indeed, this autumn will see a major parliamentary row over the Government's proposals to go ahead with a road scheme bypassing Okehampton, with a route that threatens the integrety of the Dartmoor National Park. And the continued massive, new conifer afforestation that is going on in the uplands, particularly in Scotland, and the highly irresponsible way that the sites for such despoilation are chosen, seem bound to revitalise the conflict between conservation and afforestation. However, the debate about conservation and agricultural policy now has a momentum of its own - supertankers take a long time to stop or change course, and the one representing British agricultural policy and its difficulties with conservation interests will keep moving for many years to come.

We are all conservationists now

Continuing my review of the current state of the debate about agriculture and conservation, I want to turn from myths about conservationists, to look at three myths that are especially popular with the Ministry of Agriculture. Of all the wildly inaccurate rumours circulating on the bridge of the supertanker these are the ones most often repeated by the captain. First, there is the assertion that all farmers are conservationists now. If there ever was any conflict between farming and conservation, it is now all over. Indeed, for some the conflict never even started. Sir Emrys Jones said earlier this year that "The countryside has never looked better - it has improved year by year", and Farmers Weekly said in a recent edition, with evident delight, that a recent Government White Paper "reckons that, over the years, farmers have got it about right".

I am not sure whether these views involve the suggestion that, for example, 95% or more of the flower-rich meadows which were present in this country just after the last war have not actually disappeared, or simply that their disappearance does not matter, and the majority of the population, who clearly believe it does matter, should be ignored. In any event, it is perfectly clear that farmers have not got it about right, and anybody stopping to look at the state of the agricultural industry today, whether in terms of its current or likely future profitability, or in terms of the way it is seen by the general public, would realise that something has gone badly wrong.

And, of course, farmers are not all conservationists, and hardly any are conservationists first, farmers second. The fact is that farmers are in business to make a profit, something that is going to become increasingly difficult in the years ahead, as it has for many of us this year. I simply do not believe that anything like a majority of individual farmers will agree, voluntarily, to forego potential additional profit by not, for example, ploughing more moorland or draining further wetland. The fact is that the conflict is still there, and it will continue.

It would be hard to find a smugger attitude than the one that considers that conservation is something best left to farmers who, it is suggested, are the real conservation experts. As someone involved in both farming and conservation, I am constantly reminded of how much I have to learn about both. I do not imagine there are many successful farmers around who have not been prepared to listen to advice from other people, and to learn from other people's mistakes. I, like most other farmers, benefit greatly from the expertise of organisations like ADAS, from the consultants who advise me, from what I read in the farming press, and from innumerable other sources. I suspect that it is only the most inefficient farmers who think they can do without such advice.

If farming is a complex business, the natural world is certainly no simpler. In fact, managing the countryside to protect areas of high wildlife or landscape interest, to say nothing of managing it to maintain this interest or even enhance it, is an extremely complex business. Farmers and MAFF recognise this in endorsing the need for an organsation like FWAG to give farmers advice on conservation, and now in their long awaited acceptance of the Strutt report's recommendation that ADAS should also be in a position to play this role.

No (more?) inefficiency

Buoyed up by the mistaken belief that all farmers are conservationists, and so no problem exists, the captain goes on to resist any suggestion that change is possible. For example he suggests that any alternative to current policy is likely to be inefficient, or lead farmers to being inefficient. Lord Belstead, the Minister of State at MAFF responsible for conservation, wrote in a recent article that "it would be a foolhardy Government which sought to promote inefficient farm structures and practices on any significant scale". That seems to me to be a fairly foolhardy statement. It is absurd to suggest that current agricultural policy is efficient, bearing in mind the gigantic cost of disposing of EEC surpluses, something which the Government themselves have said must be eliminated because of the waste of resources that it represents. To make UK agriculture more efficient, we need to eliminate surpluses, not encourage still greater production.

A prosperous agriculture vital?

Finally, the captain's favourite myth is that he has been right all along, and that conservationists are gradually starting to realise this. It used to be suggested by many farmers that conservationists were simply anti-agriculture, wanting to condemn all farmers to the horse-drawn plough, poverty and worse. This was never true, but out of that inaccurate myth another myth has arisen. This was put simply by Lord Belstead in his recent article:
"There has been a climate of change ....amongst conservationists. Conservationists accept the vital role played by farmers in creating our countryside. They now recognise that a prosperous farm sector is essential.... for effective conservation......It is now widely understood

that a countryside afflicted by agricultural decline would be far less interesting and attractive than the countryside with which we are familiar".

As I have already said, conservationists have tried to find a policy on which they and farmers could agree for a variety of reasons, including political expediency, and because many conservation bodies contain farmers and landowners on their governing bodies or amongst their members. Conservationist have not sought this agreement because a prosperous farm sector is essential for conservation. In fact conservationists may start to question their pragmatic approach, if farmers (and even some conservationists) start to believe that the farming systems that we currently have are really vital for conservation, rather than being generally inimicable to it - as they in fact are.

It is true that some areas of the countryside need a particular sort of grazing regime, and occasionally hay cutting, to maintain their conservation interests but the provision of this sort of grazing is increasingly coming to depend on payments made by conservation agencies, or special payments made jointly by conservation bodies and MAFF, as in the Broad's experimental grazing scheme. What is certain is that maintenance of these wildlife habitats and landscaping does not depend on the farming industry overall remaining prosperous, and it is almost certainly true that were agriculture over most of lowland England, Scotland and Wales to go into serious economic decline, massive improvements from a wildlife point of view would occur quite quickly. For example, if fields that are currently intensively farmed ceased to be farmed with high levels of chemical inputs, or ceased to be farmed altogether, wildlife would benefit immensely. I suspect that many people would also feel the landscape had improved a great deal. There would certainly be many more wild flowers and wild animals to see, the rich variety of sights, sounds and smells of a country walk would start to return. At present a deep, depressing silence, uniform green and the smell of the last pesticide application is all that is likely to greet many walkers in the countryside.

Consensus to the rescue

I want to end my look at the rumours or myths that are confusing the current debate about agriculture and conservation by looking at three of the most important. First, the suggestion that what we need to solve these problems is 'consensus', in fact an attempt to paper over the cracks in the supertanker's hall that will not succed. Second, the suggestion that people should not worry too much, as the worst is now over; not a sensible view for people on a slowly sinking ship to take. And third, the much loved cry of anyone who does not want to face the fact that their policies are not working, that 'there is no alternative'.

The myth that probably has most supporters up on the bridge, is that what is needed now is a consensus between the supertanker and the interests that have caused her so much difficulty. Conflict is counterproductive, it is claimed - a claim that it is impossible to square with recent history. As I said earlier, when the supertanker of British agricultural policy was launched, it sailed on a relatively untroubled sea. This continued for many years, but the calm surface did get disturbed by some conservation ripples in the 1960s, when a major effort in consensus-finding was launched. This led to the setting up of the Farming and Wildlife Advisory

Group, and the Countryside Commission's demonstration farms, among other initiatives. The sea continued to get choppier, despite all this good will and consensus, and in the late 1970s, two reports appeared which should have told the people on the bridge of the supertanker clearly of the difficulties they were sailing into. Neither of these reports attacked agriculture, they were both modelled on the consensus approach to reconciling conflicts between agriculture and conservation, and the warnings they contained were ignored.

In November 1977 Lord Porchester presented his report 'A Study of Exmoor' to the Secretary of State for the Environment and the Minister of Agriculture. Lord Porchester looked at a problem which he described as "a conflict between increased agricultural production from moorland and the need to maintain the existing balance of the Exmoor landscape". His solution to this clear-cut conflict included themes which have been taken up on many occasions since. For example, he said that MAFF's "officers should themselves take account of the need to conserve the natural beauty of the countryside at a much earlier stage of their contact with the farmer". He said that the rate of moorland reclamation would continue, because agricultural subsidies and current price trends "will prompt farmers, over the years, to turn to their rough grazing as a means of improving profitability", although he found it difficult to believe that the rules governing the application of the Less Favoured Areas Directive "were ever intended to be so rigid as to preclude reconciliation of farming and amenity objectives". Lord Porchester's conclusion was that "if the balance of Exmoor scenery is not to be adversely affected, a category of land must be defined where change from the traditional appearance should be firmly resisted".

In the next year, 1978, the Advisory Council for Agricultural and Horticulture in England and Wales produced a report on Agriculture and the Countryside, known as the Strutt Report after the Chairman of the Advisory Council, Sir Nigel Strutt. The Strutt Report recognised that the sea was getting rougher: "There is an evident concern about the harmful effects of many current farming practices upon both landscape and nature conservation, coupled with a widespread feeling that agriculture can no longer be accounted the prime architect of conservation nor farmers accepted as the 'natural custodians of the countryside'." But Strutt also found consensus between agriculture and conservation alive and well, and the report continued by stressing that these views were not intended, on the whole, "to cast any reflection upon farmers, who it was acknowledged were under economic pressures to maximise productivity". Strutt reported the "virtually unanimous view that MAFF, which tended generally to adopt a low profile in many matters affecting conservation, should now assume a much wider, and more openly committed, role."

None of these modest conclusions were accepted at the time. If they had been, maybe consensus would have continued. What, however, is clear is that any consensus prevailing in the 1960s and 70s, and the reports based on that approach in the late 1970s, did not lead to the changes that the reports themselves advocated. Many of the recommendations made by Strutt and Porchester, although by no means all, have now been accepted, and some even implemented by the Ministry of Agriculture. But they were implemented, not after the reports were published, but after the publication of books like Marion Shoard's 'Theft of the Countryside', and Richard Body's 'Agriculture - the Triumph and the Shame', and during and after the acrimonious debate about conservation and agricultural policy that built up during the passage of the Wildlife and Countryside Act 1981 through Parliament, and that has continued ever since.

We had consensus in the period since the end of the last war when 95% of flower-rich meadows in lowland England and Wales were destroyed. We had consensus during the same period, when half a million acres of moorland were destroyed in Wales, and 1.2 million acres in Scotland. We had consensus for most of the five years between 1976 and 1981, when the rate of loss of freehold moorland in England, Scotland and Wales was running at 76,800 hectares a year, nearly three times above the average rate of loss per annum in the years between 1946 and 1981. We had consensus in the thirty years we have taken to lose the area of ancient woodland that had previously taken four centuries to destroy. We had consensus in the fourteen odd years that it took for the population of breeding snipe in lowland England and Wales to decline from up to 20,000 pairs to only 2,000. We have had consensus during the years in which the grey partridge has declined to the extent that the Game Conservancy predict it will be extinct in 1997, if the current population decline continues.

I would not claim that the mild conflict of the last four or five years, inhibited as it has been on the conservation side by the factors I have already mentioned, has led to any appreciable decrease in all this death and destruction, but it has certainly led to an increased awareness of the problems, and to some significant signs that change might be possible.

<u>1984 - Over the worst?</u>

I want to now turn to one of the most misleading myths about the present state of agricultural policy, namely that 1984 marked a 'watershed', and that the worst is now over. Nothing could be further from the truth, but it is still widely believed. For example, Chris Righton, a former deputy-president of the NFU, said in December last year "Now farmers know the worst about how Government cuts will affect them, we may be able to see the way ahead a little more clearly." With the benefit of hindsight, we now know that the only thing that those first round of cuts should have enabled us to see more clearly were the further cuts on the way in subsequent years.

More generally, a number of people have suggested that 1984 marked the year when both national and European policy changed from, to quote Strutt and Parker's Preview for 1985, "production to limitation and from maximisation to conservation". I think 1984 marked a much more limited begining. 1984 was probably the year in which farmers and policy-makers first began to realise that these sorts of changes would be needed, but I do not believe in either 1984 or 1985 anyone really grasped the scale of change that was going to be required, and that will inevitably come in future years.

First, I should like to look briefly at the current position. The latest figures I have for agricultural production, the forecasts for 1984, show that the UK was going to produce 104% of the wheat required, and 143% of the barley - and the figures for the EEC are 150% and 132% respectively. We are already more than self-sufficient in oilseed rape in the UK - the 1984 forecast is 112%. Of our major crops, only potatoes and sugar are not oversupplied in the UK, but the figures for the EEC are 99% and 123% respectively. On the livestock side, things are no better, with the 1984 forecast for the UK for beef and veal standing at 101%, and the dairy sector puts other statistics to shame, with skimmed milk powder standing at 224% of UK requirements, and full cream milk powder at a staggering 667%. If anyone thinks that the imposition of milk quotas was the end rather than the beginning of the story, they should bear in mind not only these figures, but the Minister of Agriculture, Michael Jopling's statement in February of this year that "the milk surplus is still...desperate".

Farmers nowadays are constantly being urged to think about the marketplace. If few of us do so, it is because it is simply another source of depressing statistics. If we look at some of the markets for the products that are already in surplus in the UK and EEC, we find that, for example, the amount of sugar purchased by households and caterers in the UK fell by 40% between 1960 and 1987, and the increase in the use of sugar in manufactured foods and drinks in no way compensated for this fall. With liquid milk there has been a steadily declining consumption for at least twenty years, and there was a 30% decline in the consumption of butter between 1960 and 1981. The only foods that people are consuming more of are potatoes, vegetables and fruit. In general we can expect little or no growth in the market for our products through population growth, and a steady decline in the market for many products due to changing eating habits.

If consumption at home is static or declining, what about the world market? We are all now well aware that there are plenty of other countries around the world, the USA in particular, who have their own surplus problems, and who are also looking to the world market for some salvation. And salvation is not there, unless it is at the expense of some other food exporter, who is unlikely to agree to us offloading our problems onto them. Not only is there scope for expansion, but the market is already oversupplied.

But our tendency simply to look at current figures grossly underestimates the scale of the problems we face, because, each year, production overall increases, although on a personal note I must say after the summer we have had this year I find this harder than usual to believe. At this year's Oxford Farming Conference, Bryon Fawcett, Managing Director of Dalgety Agriculture, reminded delegates that food production in the developed world was rising at a spectacular rate, while consumption lagged far behind. In the UK, total cereal production has doubled in the last 15 years, and milk output in the UK had increased by 30% in ten years, simply by individual cow yields increasing from 3,700 litres in 1973 to 5,000 litres in 1983. UK beef, veal and lamb production had increased by 18% between 1970 and 1983, with consumption dropping by 21%. Our national barley crop has increased from around 8.5 million tons in the mid 1970s to around 11 million tons, despite a fall in the area planted of over 10%. One conclusion is fairly clear from all this, and it was drawn last year by Professor Frank Raymond, a former chief scientist at MAFF, when he pointed out that price restraint is not effective in curbing cereal overproduction. He said that a 26% fall in the real price of wheat since 1976 has resulted in production doubling.

Current surpluses have led various commentators to estimate how much land we would need to take out of production to rid either the UK or Europe of our surplus production of wheat, barley, sugar and other agricultural products. For example, earlier this year Professor Allan Buckwell, from Wye College, estimated that Europe would need to take 5.25 million hectares of land out of production, involving the UK taking nearly half a million of hectares of wheat, around 400,000 hectares of barley and 32,000 hectares of sugar beet out of production, to get rid of current surpluses. However, these estimates do not take account of the continuing growth in output – one estimate suggests that grain output in the EEC could grow by another 20 million tons by 1990, and other factors seem certain to make matters worse.

The USA is cutting back on its farm support expenditure and it is worth remembering that, criticised as it was, the USA set-aside programme took 82 million acres out of production in 1984. In addition we are all aware that developments in technology will continue to push output up, regardless of other factors. For example, research in America has suggested that dairy output might increase by 20% during the next five years through the use of hormones developed through biotechnology. The same report notes that the long-heralded era of hybrid wheat has arrived with limited supplies of high-yield seed already available, and in any event, yields continue to increase steadily through improvements in traditional seed. The same technology that brought hybrid wheat can be used to hybridize barley, and no doubt other crops in due course. In addition, all farmers know that major increases in output are possible if only all of ue could perform as well as the top 10 or even 25% of producers growing the same crops on similar soils manage to do. On our own farm, we have always managed to do well at sugar beet, and less well at cereals when judged against other farmers on similar soil, and it is clear that we could increase our own output simply by doing better what we already do.

There are a number of other factors which I have omitted from this gloomy, but brief, look at the factors that are likely to continually increase the problem of surpluses in the foreseeable future, for example the possibility that the USSR will have a steadily declining use for imports from the EEC and USA. What does seem reasonably certain is that no fairy godmother is likely to appear on the horizon, wanting to buy two or three hundred million tons of grain or some other commodity, to solve all our problems. As I have said, these problems are only just beginning.

There is no alternative?

It is not surprising that the huge scale of these problems have prompted several people on the bridge of the supertanker to suggest that some huge but simple solution must be found, and from there it is a short step to convincing yourself that such a solution will indeed be found, and nothing more needs to be done. The sort of things I have in mind include: the suggestion that farmers should stop using all artificial fertiliser, or at least all nitrogen fertilisers; that no more public money should be spent on agriculture at all, and the industry should be left to the mercy of market forces and international competition; that all the surplus grain production can be used for fuel, or all of it sent to developing countries that need more food. I do not think any of these simple solutions command a great deal of support, least of all from conservationists, so I do not intend to spend much time dismissing them.

It is worth noting in passing that even if all the cash, government and private, raised in the UK to help the starving in Ethiopia were to be spent on buying and shipping UK grain to Africa, it would probably account for about a quarter of a million tons, a small dent in our surplus of ten million tons. Christian Aid has pointed out that the cost of getting grain from Ipswich to Eritrea is about £70 per ton, and some estimates put it higher than that. Spending very large sums of money to dump our surpluses on developing countries will not help their own agricultural industries, and certainly is not the best way of solving their real problem - poverty. Turning grain or sugar into fuel looks an even more expensive option, at current prices, with one estimate suggesting that to make this competitive, price cuts for cereals and sugar beet of the order of 90% would be needed, or, of course, subsidies on the same scale.

One other 'solution' to the problem of surpluses which seems to me to be gaining increasing favour, and which has certainly been favourably commented on by the Country Landowners Association, and by the NFU in the 'Way Forward' document published earlier this year, is forestry. Indeed, the NFU suggest that "an afforestation programme....could play a useful role in augmenting farming incomes and rural employment". I have already mentioned the long-running conflicts between conservation and conifer afforestation, which have been concentrated mainly in the uplands, but which have also occurred in areas of low agricultural productivity, like coastal and other lowland heaths, and the Brecks of Norfolk and Suffolk. However, areas that are intensively farmed now, mainly in the lowlands, are probably of such low interest to conservationists that conversion to commercial conifer cropping would make little difference, and might even bring some improvements from a wildlife point of view, although landscape interests might have rather more mixed feelings. In any event, afforestation is not going to be a solution free of any possible conflicts.

Nor is it going to create many jobs. I recently obtained some figures which show rather dramatically that as the Forestry Commission has acquired a larger area of land planted with conifers, so the number of people it employed has declined. Between 1955 and 1985 the area of land owned or controlled by the Forestry Commission planted with conifers has increased from roughly 400,000 hectares to 850,000 hectares, an increase of 53% in thirty years; in the same period, the number of people employed by the Commission has declined by about 60%. In 1955, 56 hectares of conifer afforestation provided a job for one person; in 1985 it will take over 130 hectares of conifer afforestation to employ one person, with the figure rising all the time. Incidentally, the figure of 130 hectares of conifers providing one job compares to somewhere between 65 and 90 hectares per job on our Norfolk farm.

Back on the bridge, these sorts of difficulties give rise to some of the crew suggesting that there really is no alternative to current policies. So, in danger as the supertanker of British agricultural policy may be, all other possible courses bring with them greater dangers. There are, of course, several alternative policy options available for British agriculture. I have already mentioned one of them, namely the market place, a solution favoured by many farmers in theory, but very few in practice - a point I want to return to later. There is a kinder, some might think softer, others more sensible, option which was first set out in the Strutt Report, that I have already referred to. Strutt suggested that the wider responsibility for MAFF that he wanted would require changes in grant-aided policy including the payment of "grants to farmers and landowners for certain conservation works". Strutt also wanted to see the "integration of farming and tourism through the establishment of permanent management services" in all the National Parks, as well as in other appropriate areas of the countryside. The difficulty with this alternative approach, one consistently argued for by conservationists, is that it looks increasingly inadequate to cope with the problems we face, the longer its implementation has been delayed. Some of the sorts of things Strutt forshadowed in 1978 have started to be implemented, on an extremely modest scale, seven years later - too little, too late. Something more radical will be needed now, and I want to return to this in my conclusion.

No cash for alternatives?

However, I should deal with one of the arguments consistently raised against alternative policies, namely that any alternative will cost too much. Of course, whether alternative policies cost too much depends not only on what alternative policies are being advocated, but on what basis the costs are being assessed. In addition, the sums seem to be changing very rapidly. Let me take one example, namely the possibility of taking land out of agricultural production in the UK and putting it to some other use. Let us assume that the land taken out of production is put to another use that produces no income, but, for the sake of this argument, incurs no costs, at least costs which fall legitimately on the agricultural budget.

The first question to be answered is what sort of income the farmer or landowner should expect from land taken out of production. This is not easy, when, for example, net farm income from specialist cereal farms, in 1983-84, varied from a low of -£38 per hectare to a high of £222 per hectare. Writing last year, Oscar Colburn, suggested that to take between one and a half to two million acres of cereal out of production would cost the public purse £150 million, around £100 per acre, which he reckoned was needed to cover farmers' high fixed costs.

Professor Buckwell's figures, which I gave earlier, suggested that something like one million hectares of land would need to be taken out of production in the UK, to get rid of all our excess wheat, barley and sugar production. This estimate of nearly2½ million acres compares to other estimates made recently, for example one by David Scott at last year's NAC Outlook Conference, of a total of four million acres, if surplus cereals are added to milk and beef surpluses.

If we take this assumption, of four million acres needing to come out of production, and allow farmers Oscar Colburn's generous £100 an acre in payment, we come up with a total bill of £400 million, and it is this sort of cost which commentators suggest is not supportable. In fact it is by no means insupportable. To justify this, you need only look at the likely level of government cuts in agricultural expenditure between the financial year 1984-85, and the financial year 1987-88. Total UK public expenditure on agriculture in that period is estimated, by the government, to fall by £475 million at constant 1983/4 prices. So the cuts that the government are planning in agricultural support in just three years would themselves be sufficient to pay for taking four million acres of land out of production, and this calculation does not include the savings in public support which would be made by reducing over-production in this way. In addition, the cost would be lower because some land which was taken out of production would not warrant a payment of £100 an acre, and because some land taken out of production would be put to uses that would generate some other income, and finally because I do not believe that taking land out of production is going to be anything more than part of a complex solution to the problems of agricultural surpluses, and conflicts with other interest such as conservation.

Given this, a more realistic, but still probably high figure would be two million acres taken out of production. If we keep the payment to farmers at a £100 an acre, the cost of £200 million could be met from the cuts which the Government expect to make not in all UK public expenditure on agriculture, but simply in the areas of expenditure under UK control such as land drainage grants, research and advisory services, Water Authorities' expenditure and so on. Agricultural support excluding market regulation and production support is set to fall by £213 million between 1984-85 and 1987-88, again at constant 1983/84 prices. These admittedly rough and ready calcualtions do support something that conservationists have constantly said, and which I have already noted, namely that while cuts in public expenditure on agriculture are likely to exacerbate problems, switching expenditure into alternative methods of support could provide satisfactory solutions, while maintaining farm incomes.

Agriculture - an industry like education, or engineering?

It would be reasonable to pause at this stage to ask how there could be such confusion on the bridge. After all, there is nothing very new in these arguments; many of them were rehearsed in the Strutt Report and especially by Lord Porchester, in the late 1970s. There are a number of reasonable explanations for the confusion. First of all, the supertanker of British agricultural policy is not the only ship on the sea. It is receiving contradictory signals from a number of sources. There are the commands of Government economic policy - some might see this as a largely non-existent vessel, which is in any case disappearing down a whirlpool of its own making, but it is still sending out signals. Then there are signals coming from GATT, and countries involved in international trade of agricultural products. There is the CAP itself, and the interests of other EEC members' agricultural industries, especially pressures from new members and the agricultural interests of the Mediterranean region.

Finally, in this category, I need to mention UK policy towards the EEC, and particularly towards the cost of the CAP. Here the Government have to face two ways. They want to cut the costs of the EEC, and this means cutting the costs of the CAP. At the same time they want to get the most they can out of the EEC for the UK, and this means that they want MAFF to milk the CAP for all it is worth. None of this provides a particularly calm sea for the stricken supertanker of British agricultural policy to sail through.

But I believe there is a more fundamental problem, namely the confusion over what exactly the British agricultural industry really is. Is it economic and efficient with thousands of small businesses striving in the market-place to maximise productivity and output, the shining example of free enterprise capitalism working at its best, as the Prime Minister has been heard to say in years gone by? Or, on the other hand, is agriculture a publicly-funded 'industry' like the education industry or the health industry, as MAFF civil servants have claimed before a House of Commons Select Committee in recent years?

The fact is that farmers want to behave as if they were like the engineering industry, shining examples of free enterprise at its best, succeeding magnificently in the market, and free of public controls and public responsibilities. On the other hand, they expect to be treated like the education or health service, protected from general Government economic policy, with no reductions in the level of public expenditure either on grants and price support, or on research and advisory services, and with marketing and promotional expertise provided, at least in part, at public expense. I believe agriculture is a public service, and that it should receive support from the tax-payer, but that means it should operate to benefit the public. Agriculture should not be run solely to benefit farmers, any more than schools are run only for the teachers' benefit, or the police only to help and protect themselves.

Before coming to my conclusions, I want to point out two practical consequences of the contradictory view of the agricultural industry, which affects farmers and MAFF, and frequently the rest of the community alike. First, in such a confused situation, it would be a very very foolish Government that tried to set out a detailed policy for agriculture or rural areas, unless they had a radically different policy for agriculture to announce. The Government clearly does not have this, and they are unlikely to respond to the calls that are frequently made from farmers for clear guidance on future agricultural policy, just as they are unlikely to respond to the call that has been made by the Chairmen of the Nature Conservancy Council and Countryside Commission for what is called a 'White Paper on the rural estate'.

Second, given the confusion about agricultural policy, and in particular the twin pressures of conservation interests and surpluses, what is good policy for the agricultural industry as a whole will frequently be against the economic interest of individual farmers. For example, at this year's Oxford Farming Conference, Bryan Fawcett made the point that with many agricultural products in surplus "grants in any form, which encourage production increases are not merely poor use of public funds, but against the interest of farmers in general". But that same week in January, Farming News was reporting an Orkney farmer as saying that a threatened cutback in Government grants for land drainage would be a "major setback" for farming in Orkney. Apart from being against the individual interests of some farmers on Orkney, cuts in drainage grants are not only in the interests of agriculture in general, because they will do something to reduce the increase in surplus production, but as the same Farming News piece reported, the cuts in drainage would "placate conservationists" who are extremely concerned about the rapid loss of exceptionally good wildlife habitats on Orkney.

This conflict means that organisations which represent individual farmers and landowners, like the NFU and CLA, will never be able to give a real lead in providing policies which at a national level might solve some of the problems that agriculture faces, and in particular, the problems caused by overproduction. It is, almost by definition, impossible for an organisation which truly represents the sum total of its individual members' views to do this, and I therefore do not think it is particularly surprising that neither the NFU nor CLA have succeeded, despite some excellent efforts from various NFU staff, and a CLA committee.

Just to return to my analogy with the tanker again for a moment, it is important to note that while the supertanker represents agricultural policy, the policy is actually implemented by thousands of little boats which follow in the tanker's wake. The little boats are, needless to say, very varied, both in their size and power, and in the experience and ability of their skippers. They change hands from time to time, and often when they do their course changes as well. A steadily increasing number seem to be owned by fleet operators, who are usually based some way from where the boats are working. In amongst this fleet of little boats, some will be going backwards when they should be going forwards, and many at right angles to the general course. It is also possible to spot some particularly flash, high-powered vessels, some might say over-powered vessels, like HMS Velcourt, dashing about all over the place causing a fair amount of disturbance and some confusion, for example when they first plant cereals where there were trees, and then trees into growing crops.

The basis for a genuine consensus between agriculture and conservation

I want to try and end on a more positive note, although I confess I find this difficult. However, I do believe that it would be possible for agriculture and conservation interests to work together, but it would have to be on the basis of a radically different agricultural policy from anything currently contemplated. I am well aware of the constraints of the CAP, but the CAP has to change, and many other EEC members are keener than the UK on keeping cash going to farmers. As no one believes production-orientated support can continue, the CAP may cause less problems than is sometimes suggested. I do not pretend that the list of policies that follows is comprehensive, but I do believe any genuine consensus would have to include these points.

First, there should be no overall cuts in the amount of public money spent in supporting agriculture; recent cuts and the cuts that are already planned should be restored.

Second, no more land should be "improved" in an agricultural sense, in a way that would lead to any further increase in production, or losses for conservation.

Third, because the supertanker does not wholly control the course followed by the thousands of little boats in its wake, controls would have to be introduced to ensure that no individual farmers made changes which would allow them to increase output, for example by removing trees and hedges, filling-in ponds, ploughing land that had not been ploughed in the last twenty years, or intensifying their agricultural systems on areas that are currently farmed extensively.

Fourth, much stricter controls should be introduced on pesticide and fertiliser use, leading to lower inputs. Controls should be introduced in the interests of human health and safety, wildlife and wild plants. Controls should be much stricter not only over the range of products used, but also over methods of application.

Fifth, substantial areas should be taken out of agricultural production, and used for conservation or recreation. This would include hardwood timber production, and possibly some use of land for growing crops for fuel, if this ever proves economic. Areas should come out of production for a reasonable period of time, say twenty years, and public money should be available to ensure that individual farmers are not unfairly made worse off.

All this leads to the sixth point, that there should be no further increases in the production of agricultural products already in surplus. Even if there is no more intensification of agriculture, no more removal of agricultural production, technical developments in agriculture which clearly will, and should, continue, will lead to further problems of surplus produce. So more agricultural production will have to be controlled through quotas, price restraint and mechanisms like co-responsibility levies.

Seventh, to make such a radically different agricultural policy work, it is clear that conservationists and other interests would have to be fully involved in developing and implementing agricultural policies, including the making of grants, the commissioning of research and allocation of funds for strategic research, supervising and training advisory services and so on. All these areas tend to be dominated, frequently to the exclusion of any other interests, by the agricultural industry. In future, I would expect to see a wide range of interests, including consumers, conservationists, people whose main concern was rural employment or animal welfare in a majority on organisations responsible for dispersing public funds for agriculture, although of course people whose primary interest was in agriculture would continue to be well represented.

Eighth, and finally, as substantial sums of public money will still be available for agriculture, but none will be spent on increasing production, a whole new set of objectives will have to be introduced. Again, I do not pretend the list that follows is comprehensive, but public money should clearly be available, as it is just starting to be, to maintain traditional, extensive agricultural systems which benefit areas of high public importance like wetland grazing marshes and heather moorland. Indeed, in the future I would expect grants to be available to encourage farmers to allow areas to revert, or to positively manage them so that they do revert, to this type of habitat. Public money should back up much stricter controls to ensure a radical improvement in the way we treat farm animals, in particular to ensure conversion to less cruel systems of keeping animals like pigs and chickens. Funds should be available for more general environmental protection work, to avoid pollution from farming operations, for example. I am quite clear that money should also be available in the form of income support, to help maintain the standard of living of small and part-time farmers, who may be particularly vulnerable to the price cuts and curbs on production which we have started to see in the last couple of years. Money should be available to encourage access and recreation in the countryside, and to improve facilities and opportunities for people when they get there. For example, farmers could be paid for creating new footpaths and picnic areas, designing new circular walks involving new rights of way and paths linking existing routes, and for providing other facilities for quiet, informal recreation. Greater provision should also be made for the more intrusive types of recreation like motorcycle scrambling, in areas where little disturbance to other interests will be caused.

Finally, a major priority in spending public money on agriculture in future should be to create new jobs in the countryside, and to maintain those we already have. We have almost completely lost the tax concessions which did so much to encourage farmers to invest in new machinery. I believe these should be replaced by subsidies for labour as opposed to capital. In future I hope it will suit farmers to provide better paid and worthwhile jobs for more people, rather than investing large sums of capital in some form of intesification of production, which will push more and more people away from working on the land.

A future full of danger

At the end of the paper which I gave at the Oxford Farming Conference in January 1983 I said "I believe that the immediate future for farming is full of danger. We are desperately unpopular and becoming more so by the minute. In a number of vital respects we face head-on clashes with interests that, certainly in the medium to long term, we cannot hope to overcome. In the face of all these pressures, I believe that the leadership of the farming community and conservative conservation interests are walking together hand in hand towards the downfall of British farming."

I know a great deal has changed since the beginning of 1983, and in particular both the conservative conservation interests, which I criticised then, and many leaders of the farming industry have changed their policies. For example, the Countryside Commission has agreed that changes, not only in farm support but even in some of the controls placed on agricultural development, are now necessary. But even these modest conversions have been spurned by the Government. Earlier this year, all the voluntary wildlife and landscape conservation bodies, the Countryside Commission, the Nature Conservancy Council, the National Farmers Union and the Country Landowners Association all agreed on a Clause in Dr. David Clark MP's Wildlife and Countryside Act 1981 (Amendment) Bill, that would have placed a duty on the Ministry of Agriculture to further conservation interests in the countryside. A modest proposal, but one that would have provided a useful new inpetus, and possibly some useful new powers to MAFF, to allow them to respond to what is clearly a changing climate for the agricultural industry. The Government rejected the Clause out of hand in the House of Commons.

So, I regret to say, both from the point of view of my own livelihood as a farmer, and from the point of view of my passionate interest in conservation, that I still feel very gloomy about the future, and see no reason to substantially change the conclusions I came to in 1983. Indeed, in some respects, things have got worse.

Supertanker becomes Titanic?

I said, at the start of what I have had to say today, that I am not the only person who has drawn an analogy between British agricultural policy and a ship at sea. David Richardson, writing in August this year, said "British agriculture is like a ship wallowing in an ocean full of icebergs with a captain who declines to steer". He went on to say "Those icebergs keep growing larger and they are coming closer. The longer decisions on direction are delayed the less likely the possibility of avoiding a Titanic-scale disaster." Wherever the supertanker of British agricultural policy is going, she seems to me to be heading for the icebergs. I do not think there will be any sudden catastrophe, so the analogy with the Titanic is not necessarily a good one. I am afraid we are much more likely to go on wallowing around the ocean in a climate of conflict and confusion, for many years to come. But while the supertanker may avoid a sudden sinking, the same is not going to be true for many of the little boats in her wake. Individual farmers are going to start hitting the icebergs with increasing frequency, and when they do, they will sink.

SESSION 2

NEW HERBICIDES AND PLANT GROWTH REGULATORS

SESSION 2

CHAIRMAN MR J. D. FRYER

SESSION ORGANISER MR D. V. CLAY

INVITED PAPERS 2-1 to 2-15

DIFLUFENICAN-A NEW SELECTIVE HERBICIDE

M.C. CRAMP, J. GILMOUR, L.R. HATTON, R.H. HEWETT, C.J. NOLAN AND E.W. PARNELL.

May and Baker Ltd., Agrochemical Research, Ongar Research Station, Ongar, Essex. CM5 OHW.

ABSTRACT

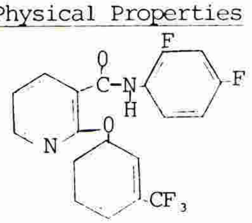
Diflufenican, N-(2,4-difluorophenyl)-2-(3-trifluoromethylphenoxy) -3-pyridinecarboxamide is a new persistent, wide spectrum pre- and post- emergence herbicide with excellent selectivity in winter wheat and barley. In the glasshouse and field it has proved successful in controlling both broad-leaf and grass weeds including the problem broad-leaf species of *Galium*, *Veronica* and *Viola* at dose rates of 62-250g a.i./ha. Soil persistence studies have shown it has a satisfactory pattern of degradation ensuring weed-free conditions into the late spring following autumn application. The particular weed species it controls make it ideal for use in mixtures with other herbicides, particularly the substituted ureas. Diflufenican has low mammalian toxicity. Acting as an inhibitor of carotenoid biosynthesis diflufenican indirectly interferes with plant photosynthesis.

INTRODUCTION

Diflufenican, code number M&B 38,544 is a new pre- and post- emergence herbicide for the selective control of broad leaf and grass weeds in winter cereals. It was selected for development from a series of phenoxypyridine carboxamides discovered by May and Baker in 1979, which were the subject of a synthetic programme investigating the relationship between structure and biological activity (Cramp *et al*. 1985). Currently it is being developed in mixtures with traditional cereal herbicides to enable a single autumn application to give complete control of germinating weeds in winter wheat and barley until late spring.

Chemical and Physical Properties

Structure:



Chemical name: N-(2,4-difluorophenyl)-2-(3-trifluoromethylphenoxy)-3-pyridinecarboxamide

IUPAC name: 2',4'-difluoro-2-(α,α,α,-trifluoro-*m*-tolyloxy)nicotinanilide

Common name: diflufenican (BSI accepted)

Molecular formula: $C_{19}H_{11}F_5N_2O_2$

Molecular weight: 394.3

Appearance: white crystalline solid

Melting point: 161 to 162^{o}C

Solubilities: at 20^{o}C

Aromasol H	1%	Acetophenone	5%
Xylene	2%	Kerosene	1%
Acetone	10%	Isophorone	3.5%
DMF	10%	Cyclohexane	1%
Ethylcellosolve	1%	Water	0.05mg/l

Toxicology

Acute oral LD50 (mouse)	> 1000 mg/kg	
Acute oral LD50 (rat)	> 2000 mg/kg	
Acute dermal LD50 (rat)	> 2000 mg/kg	
Ames test (mutagenicity)	negative	

Long term toxicity studies show diflufenican to have low mammalian toxicity.

Mode of action

Diflufenican is not leached and is taken up principally by the shoots of germinating seedlings. Susceptible species germinate but show immediate and extensive chlorosis. The chlorosis spreads with growth, the plants becoming necrotic and dying. The compound acts as an inhibitor of carotenoid biosynthesis (Sandmann et al. 1985; Wightman & Haynes 1985) and indirectly interferes with plant photosynthesis.

MATERIALS AND METHODS

Evaluation in the glasshouse (min. temp. 15^{O}C, max. temp. 25^{O}C with 16 h. daylength) was carried out in 1980. Diflufenican was sprayed in a volume of 260 l/ha on to the surface of unsterile loam soil in 100cm^2 pots sown with an appropriate number of weed or crop seeds to give an even population of plants. Assessment of % phytotoxicity was made visually 28 days after spraying.

The field trials reported in this paper were carried out in France and the U.K. in the autumn and winter of 1981-82 and 1982-83 and U.S.A. in spring 1983. Diflufenican, formulated as a w.p. or aqueous s.c. containing 50% a.i. was applied pre- and early post-emergence at a range of dose rates to small (8-15 m^2) replicated randomised plots in spray volumes of 200-500 l/ha. Spraying was carried out with a knapsack sprayer in France and a motorised small plot sprayer in the U.K. and U.S.A. Weed control assessment was made by visual estimation of % phytotoxicity compared with untreated plots in the spring following autumn/winter treatment.

For preliminary soil persistence studies six replicate intact soil cores were taken at different time intervals from U.K. winter cereal field plots sprayed with diflufenican at a rate of 500g a.i./ha. The top 1 cm of soil was removed from each intact core and replaced after sowing with oilseed rape and assayed in the glasshouse within a few days of sampling (Luscombe 1981). Phytotoxicity was measured 3 weeks after sowing by calculating the % reduction in fresh weight compared with plants growing in soil cores from untreated plots.

RESULTS AND DISCUSSION

The results from glasshouse evaluation (Table 1) indicated the considerable potential of diflufenican for the control of problem weeds in cereals, especially wheat. Detailed post-emergence treatments were not made because earlier screening information indicated the best activity was pre-emergence. The margin of selectivity for controlling difficult broad-leaf weeds such as Xanthium strumarium in maize was small.

Field screening data for diflufenican was obtained from field trial work in 1981 to 1983 in France and the U.K. (Tables 2 and 3) and the U.S.A. (Table 4). Field tests were made pre- and early post-emergence to test the flexibility of the compound.

TABLE 1

Pre-emergence activity of diflufenican in glasshouse experiments on wheat and maize and associated problem weed species.

Doses (g a.i./ha)	125	250	500	1000
Test species	% phytotoxicity 21 days after treatment			
Wheat	0	2	8	17
Avena fatua	50	80	90	95
Alopecurus myosuroides	33	63	93	100
Galium aparine	47	70	80	100
Viola arvensis	90	97	100	100
Veronica persica	90	97	100	100
Maize	0	0	15	33
Setaria viridis	100	100	100	100
Echinochloa crus-galli	27	50	87	93
Abutilon theophrasti	30	70	97	100
Ipomea purpurea	30	60	80	100
Xanthium strumarium	0	10	30	77
Chenopodium album	53	70	80	87

TABLE 2

Performance of diflufenican applied pre-emergence in winter cereals in France and the U.K. (average of seasons 1981-82 and 1982-83).

Doses (g a.i./ha)	250	500	1000	2000
Test species	mean % phytotoxicity in spring			isoproturon
Winter wheat	2 (7) *	5 (4)	13 (4)	0 (3)
Winter barley	3 (6)	9 (3)	17 (3)	0 (3)
Alopecurus myosuroides	42 (4)	70 (2)	79 (4)	79 (2)
Poa annua	87 (4)	83 (3)	88 (3)	95 (1)
Galium aparine	63 (6)	90 (3)	90 (3)	0 (3)
Veronica hederifolia	100 (3)	100 (3)	100 (3)	-
Veronica persica	97 (4)	99 (3)	100 (3)	0 (1)
Viola spp.	95 (1)	100 (1)	100 (1)	-
Stellaria media	99 (6)	100 (3)	100 (3)	59 (3)
Myosotis arvensis	100 (2)	100 (2)	100 (2)	-
Matricaria inodora	94 (2)	95 (1)	95 (1)	100 (2)
Sinapis arvensis	89 (3)	100 (3)	100 (3)	-
Centaurea cyanus	40 (1)	90 (1)	90 (1)	-

TABLE 3

Performance of diflufenican applied post-emergence in winter cereals in France and the U.K. (average of seasons 1981-82 and 1982-83)

Doses (g a.i./ha)	250	500	1000	2000
Test species	mean % phytotoxicity in spring			isoproturon
Winter wheat	0(5)*	3(5)	13(3)	0(3)
Winter barley	0(5)	1(5)	3(2)	0(2)
Alopecurus myosuroides	9(3)	16(3)	40(1)	83(2)
Poa annua	75(3)	85(3)	87(3)	-
Galium aparine	64(6)	72(6)	96(4)	2(3)
Veronica hederifolia	78(3)	90(3)	100(1)	25(2)
Veronica persica	96(3)	99(3)	99(3)	-
Viola spp	72(3)	87(3)	90(1)	15(2)
Stellaria media	65(4)	72(6)	97(3)	40(2)
Myosotis arvensis	100(2)	100(2)	100(2)	-
Matricaria inodora	72(3)	88(3)	100(3)	100(2)
Sinapis arvensis	100(2)	100(2)	100(2)	-

*The number of trials is indicated by the figure in parenthesis

TABLE 4

Performance of diflufenican applied pre- and post-emergence in maize (2-4 leaf stage) and sorghum in U.S.A. - 1983

	% phytotoxicity 14-21 days after application							
	Pre			atrazine	Post			atrazine
Doses (g a.i./ha)	125	250	500	1000	125	250	500	1000
Maize	3	8	9	3	8	11	14	3
Sorghum	3	3	3	12	5	6	10	5
Abutilon theophrasti	100	100	100	100	100	100	100	100
Amaranthus retroflexus	98	100	100	100	100	100	100	100
Digitaria sanguinalis	88	91	100	100	7	47	38	70
Echinchloa crus-galli	100	99	99	100	25	38	32	98
Ipomea purpurea	96	89	100	100	94	93	99	100
Sesbania exaltata	99	96	100	100	100	100	100	100
Sida spinosa	97	96	100	100	100	99	100	100
Xanthium strumarium	38	52	31	92	89	96	92	93

The early indications from the glasshouse were confirmed by the results in the field. Diflufenican gave excellent control of broad-leaf and grass weeds, particularly the problem broad-leaf weeds Galium aparine, Veronica hederifolia, Veronica persica and Viola spp. Any slight phytotoxicity recorded in the crops was in the form of small transient chlorotic patches on basal leaves which had no adverse effect on crop development (Kyndt et al. 1985). Although control of broad-leaf and grass weeds was satisfactory in maize, diflufenican showed no significant advantages in the control of weeds over atrazine.

Additionally, examination of the soil persistence data (Figure 1) indicated that diflufenican had a satisfactory pattern of soil degradation and was able to maintain weed free conditions into the spring with no adverse effects on following crops.

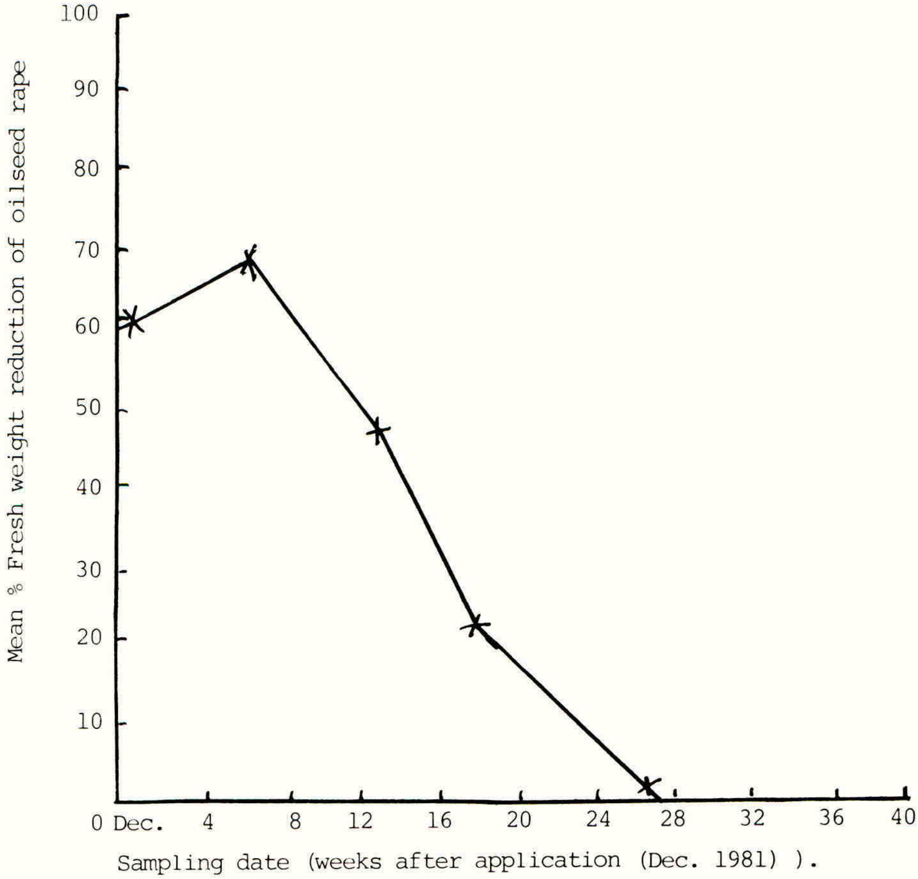


Fig. 1. The rate of soil degradation of 500 g/ha diflufenican following winter application as measured by bioassay with oilseed rape

Conclusion

Diflufenican is a novel, pre-and post-emergence herbicide effective against broad leaf and grass weeds with selectivity in winter wheat and barley. In particular diflufenican shows excellent control of the broad-leaf weeds Galium aparine, Veronica hederifolia, Veronica persica and Viola spp. which are resistant to substituted urea herbicides. With its persistence in soil diflufenican can provide lasting control of autumn-and winter-germinating weeds with only one autumn application. The weed species controlled by diflufenican makes it ideal for use in mixtures with other herbicides, particularly the substituted ureas.

ACKNOWLEDGEMENTS

The effort of our colleagues in France and U.S.A. for carrying out of the field tests is gratefully acknowledged.

REFERENCES

Cramp, M.C; Gilmour, J; Hatton, L.R; Hewett, R.H; Nolan, C.J; Parnell, E.W; (1985). The design and synthesis of N-2,4-difluorophenyl)-2-(3-trifluoromethlylphenoxy)-3-pyridinecarboxamide, Diflufenican Pesticide Science (in press).

Luscombe, B.M. (1981) Field persistence of an isoproturon/triallate mixture in a granule formation. Proceedings European Weed Research Society Symposium. Theory and Practice of the use of Soil Applied Herbicides, 170-177.

Sandmann, G; Bramley, P.M; Boger P. (1985) New herbicidal inhibition of carotene biosynthesis. Journal of Pesticide Science (Japan) 10,19-24.

Wightman, P; Haynes, C. (1985) Mode of action and basis of selectivity of diflufenican. Proceedings 1985 British Crop Protection Conference-Weeds, (in press).

Kyndt, C.F.A; Turner, M.T.F; Rognon, J. (1985). Diflufenican - a new selective herbicide for use in winter cereals. Proceedings 1985 British Crop Protection Conference - Weeds, (in press).

DIFLUFENICAN - A NEW HERBICIDE FOR USE IN WINTER CEREALS.

C.F.A.KYNDT, M.T.F.TURNER

May & Baker Ltd, Agrochemicals Division, Fyfield Rd, Ongar, Essex CM5 OHW

J.ROGNON

Rhone-Poulenc Agrochimie, 14-20 Rue Pierre Baizet, 69009 Lyon, France.

SUMMARY

Diflufenican is a new herbicide being developed for pre- and early post-emergence use in winter cereals. The results from three season's field trials conducted with this herbicide throughout the UK, Ireland, Scandinavia and Western Europe are summarised.

Diflufenican has been shown to be selective in a large number of autumn-sown wheat and barley cultivars. Also, it possesses high levels of activity on a wide spectrum of broad-leaved weeds, including _Galium aparine_, _Viola_ and _Veronica_ spp. In mixtures it has been shown to complement the activity of other herbicides.

INTRODUCTION

Diflufenican is a new herbicide currently under development by May & Baker Ltd., and other members of the Rhone-Poulenc Group. The initial laboratory and glasshouse studies of the molecule are described in the previous paper by Cramp, Hatton, Hewett, Gilmour, Nolan and Parnell (1985).

The new chemical first entered field trials in 1981, these showed the molecule to be very effective at relatively low doses against a wide spectrum of weeds, mainly broad-leaved species, and some grasses, in particular _Poa annua_ and _Apera spica-venti_.

Since the autumn of 1982 a very extensive programme of trials has been conducted throughout the UK, Ireland, Scandinavia and Western Europe to establish the technical prospects of diflufenican alone and in combinations with grass herbicides.

MATERIALS AND METHODS

Since Autumn 1982 a total of 291 small plot efficacy and 126 replicated yield and selectivity trials have been conducted with diflufenican alone and in mixtures. The formulations tested were as follows:-

EXP 4005 - 50% wt/vol diflufenican (aqueous, s.c.)
EXP 4072 - 56.25% wt/vol diflufenican + isoproturon (aqueous, s.c.)
EXP 4087 - 55% wt/vol diflufenican + isoproturon + neburon (aqueous, s.c.)

The majority of these trials were conducted in the UK and France. Applications were made with either single-wheeled motorised plot sprayers or by pressurized knapsack sprayers at a pressure of 200-300 kpa, in spray volumes of 200-400 l/ha. Plot sizes were between $15m^2$ and $45m^2$, replicated two, three or four times. In addition, in the UK, some 244 farmer-applied trials, were conducted with diflufenican in combination with appropriate herbicides.

In other countries, diflufenican, when used in mixtures, was either co-formulated or tank mixed with appropriate herbicides to complement its weed control spectrum. In all trials comparisons were made with reference products at appropriate recommended rates.

Weed control assessments were taken by quadrat count (3 x $\frac{1}{2}m^2$ per plot) or by visual estimation of percentage control; usually in both late autumn and spring.

Selectivity was assessed visually on a percentage basis for crop phytotoxicity symptoms, at emergence, 7, 14 and 28 days after application and at one monthly intervals until harvest. Yield trials were conducted on sites with no or minimal weed infestations. Harvest yields were taken either with a Claas Compact 25 combine or by weighing sub samples from swaths cut with standard farm machinery.

RESULTS AND DISCUSSION

Table 1 indicates the susceptibility of commonly occurring annual grass weeds and a range of important annual broad-leaved weeds to diflufenican alone and in appropriate mixtures. Table 2 gives a list of other less commonly occurring annual broad-leaved weeds which are also susceptible to diflufenican (i.e. giving greater than 90% control). Tables 3 and 4 relate to the selectivity of diflufenican alone and in mixtures with urea herbicides, and are representative examples from a large number of winter wheat and barley yield and tolerance trials, conducted throughout the UK and France. Table 5 indicates some of the weed-free cereal cultivars which have been treated with diflufenican alone, and in mixture with isoproturon and have shown no significant loss in yield as a result at twice the normal field use rate.

It can be seen from Table 1 that diflufenican controls a spectrum of weeds, comparable to that of both isoxaben and pendimethalin, when applied at between 180-250g a.i./ha. It is however, stronger on grass weeds and G.aparine than isoxaben and marginally weaker on grasses than pendimethalin. Activity is primarily by contact action on young shoots of plant seedlings and evidence indicates that at the biochemical level diflufenican acts as an inhibitor of carotenoid biosynthesis, thus interfering with plant photosynthesis. It is therefore generally more active when applied pre-emergence. When applied post-emergence, its activity decreases as the size of weeds increase, and whilst retaining high levels of activity on a large number of weeds, such as Veronica spp. and Viola spp, the activity on compositae and Papaver spp. decreases rapidly with continued plant growth.

TABLE 1

Susceptibility of key weed species to pre-emergence applications of diflufenican alone, and in mixtures, with other herbicides.
(Summary of work in autumn sown cereals from the UK, Ireland, France, West Germany, Holland, Belgium, Spain, Denmark and Sweden)

Chemical	Diflufenican		(a) + Isoproturon	(b) + Isoproturon	(a) + Chlortoluron	(b) + Chlortoluron	(a) + Methabenz thiazuron	Isoxaben	Pendimeth-alin
g a.i./ha	75-150 (a)	180-250 (b)	1000-1500	1500-2000	1000-1500	1500-2000	2100-2800	125	1700-1980
Species									
Alopecurus myosuroides	R	MR	MS-S	S	S	S	S	R	S
Apera spica-venti	MS	MS-S	S	S	S	S	S	MR	S
Avena fatua	R	R	MS	MS-S	-	-	R	R	-
Lolium spp.	MR	MR-MS	MS	MS-S	MS	S	MR-MS	R	-
Poa annua	MS	MS-S	S	S	S	S	-	MR	S
Fumaria officinalis	MR	MS-S	MS	MS-S	-	-	-	-	S
Galium aparine	MS	S	MS	S	MS	S	MS	R	MS
Lamium spp	MS	S	S	S	S	S	-	-	S
Matricaria spp	S	S	S	S	S	S	S	S	S
Papaver rhoeas	S	S	S	S	S	S	S	S	-
Stellaria media	S	S	S	S	S	S	S	S	S
Veronica spp.	S	S	S	S	S	S	S	S	S
Viola arvensis	S	S	S	S	S	S	S	MS-S	S

Basis for classification of susceptibility

S - Susceptible - complete or almost complete kill (91-100% control)
MS - Moderately susceptible - effective suppression with or without mortality (76-90% control)
MR - Moderately resistant - temporary suppression or partial kill (51-75% control)
R - Resistant - no useful effect (0-50% control)

From the trials it has been observed that some soil moisture is needed for optimum activity, particularly on some of the less sensitive species of weeds, such as G.aparine, Fumaria officinalis and Lamium spp.

The general lack of herbicidal activity of diflufenican on grasses, other than on P.annua and A.spica-venti, lends itself to being used in conjunction with urea herbicides. Thus it can be seen that by co-formulating diflufenican with products such as isoproturon and chlortoluron etc., any deficiencies in grass weed control can be overcome. Work has also been conducted with three-way combinations of diflufenican and isoproturon + neburon and the indications are that this exhibits a similar spectrum of weed control to diflufenican + isoproturon with slightly better persistence particularly on grass weeds. All these mixtures give better control of the compositae, F.officinalis and G.tetrahit than diflufenican alone.

TABLE 2

Pre-emergence efficacy of diflufenican in cereals - Additional weed species controlled >90% at dose of 75-150g a.i./ha

Anagallis arvensis	Montia perfoliata
Aphanes arvensis	Myosotis arvensis
Arabidopsis thaliana	Polygonum aviculare
Arenaria serpyllifolia	Ranunculus arvensis
Capsella bursa-pastoris	Ranunculus repens *
Cerastium fontanum	Raphanus raphanistrum
Chenopodium album	Rumex obtusifolius*
Descurainia sophia	Senecio vulgaris
Erysimum cheiranthoides	Sinapis arvensis
Galeopsis tetrahit	Spergula arvensis
Geranium molle	Volunteer oilseed rape
Kickxia elatine	Volunteer sugar beet
Legousia hybrida	

* from seed

Table 2 gives an indication as to the wide spectrum of weeds controlled by diflufenican at low dose rates.

Tables 3 and 4 show that diflufenican alone and in mixtures with isoproturon and neburon possesses a high degree of selectivity, particularly in winter sown wheat and barley.

The range of treatments applied at twice the normal field use-rate have been selected from a larger number of trials and are representative of the data which has been generated in both France and the UK. In all cases, there was no significant reduction in final yield and the results compared favourably with those for reference products. Experience with other cultivar trials has shown that wheat is slightly more tolerant than barley.

TABLE 3

Pre-emergence selectivity of diflufenican in mixtures with isoproturon and neburon.
Representative yield data from winter barley and wheat trials - France 1984

Data expressed as percentage yield of untreated control

Treatment	Location cv g a.i./ha	Bertu Plaisant Barley	Chessy Sonja Barley	Montgermont Fidel Wheat	Amberieux d'Az Talent Wheat
Control yield t/ha		7.28	5.22	6.68	5.79
Chlortoluron	5,000	100	98.6	102.9	107.1
EXP 4072 (isoproturon + diflufenican)	4,500*	100.5	100.2	110.5	110.1
EXP 4087 (isoproturon + neburon + diflufenican)	5,500*	98.2	103.4	112.6	102.3
Co-efficient of variation		4.01	8.43	5.61	6.38
Level of significance		N.S.	N.S.	N.S.	N.S.

* Selected from total of 7 treatments and applied at twice normal use-rate.

TABLE 4

Pre-emergence selectivity of diflufenican and diflufenican + isoproturon mixture.
Representative yield data from winter barley and wheat trials - UK 1983

Data expressed as percentage of untreated control

Treatment	Location cv g a.i./ha	Essex Tipper Barley	Essex Igri Barley	Essex Longbow Wheat	Suffolk Avalon Wheat
Control yield t/ha		6.06	8.61	7.83	8.26
Isoproturon	4,000*	105.5	108.8	101.9	109.8
EXP 4072 (isoproturon + diflufenican)	4,500*	103.4	113.3	103.7	109.0
EXP 4005 (diflufenican)	500*	100.3	102.5	104.6	100.0
Co-efficient of variation		4.66	4.16	4.15	8.01
Level of significance		N.S.	1%	N.S.	N.S.

* Selected from total of 7 treatments and applied at twice normal use-rate.

Under conditions of heavy rainfall following application, some symptoms of transient chlorosis may be apparent, but usually disappear rapidly as the crop develops, wheat is much less prone to this effect than barley. Table 5 shows the good selectivity of diflufenican alone and in mixtures by giving a representative list of cultivars tested in France and UK; where twice the normal usage of diflufenican has resulted in no significant yield loss. The majority of trials were conducted in as near weed-free situations as possible.

TABLE 5
Cereal selectivity - list of cultivars which have shown no significant yield suppression to twice normal dose of diflufenican or diflufenican + isoproturon

Winter barley		Winter wheat	
Alpha	Nevada	Ambassador	Fidel
Barberousse	Opera	Arminda	Gala
Capri	Panda	Avalon	Galahad
Concert	Plaisant	Camp Remy	Hammer
Copain	Mission	Capitole	Longbow
Gerbel	Pirate	Castan	Lutin
Halcyon	Robur	Cocagne	Mardler
Igri	Sonate	Copain	Mission
Maris Otter	Sonja	Corin	Moulin
Metro	Thibaut	Courtot	Norman
Monix	Tipper	Darius	Stetson
Natalie	Viva	Fenman	Talent

Soil persistence

The half-life of diflufenican in a clay loam soil is in the region of 16-20 weeks and in usual crop rotations there is no harmful effect on the crop following cereals. French and UK trials with following spring crops have shown that maize, sunflower, peas, barley, carrots, field beans, lentils, French beans, soybeans, lucerne, potatoes or chicory can be grown without ploughing the land. Ploughing is, however, recommended for subsequent cropping of rapeseed, sugarbeet, cabbage, and onions following an autumn-sown cereal failure.

Crop residues

Grain harvested from wheat and barley trials in the UK and France, 17-46 weeks after being treated with 0.25 kg a.i./ha contained less than 0.05 mg/kg of diflufenican, which was the limit of recovery.

ACKNOWLEDGMENTS

The authors wish to thank the Field Operations Department of May & Baker Ltd., Rhone-Poulenc Agrochimie, and other members of the Rhone-Poulenc group for their work in obtaining data from the field trials summarised herein, also the farmers on whose land these trials were conducted.

REFERENCE

Cramp, M.C.; Gilmour, J.; Hatton, L.R.; Hewett, R.H.; Nolan, C.J.; Parnell, E.W. (1985) Diflufenican - a new selective herbicide. BCPC - Weeds 1985, Brighton, November 18th-21st.

SMY 1500 - A NEW SELECTIVE HERBICIDE FOR WEED CONTROL IN WINTER CEREALS

H. HACK, L. EUE

Bayer AG, D-5090 Leverkusen, West Germany

R.H. STRANG, W.M. ZECK

Mobay Chemical Corporation, Kansas City, Mo. 64120, U. S. A.

ABSTRACT

SMY 1500, 4-amino-6-tert-butyl-3-ethylthio-1,2,4-triazin-5(4H)-one, is a new herbicide with pre-emergence and post-emergence activity against a wide spectrum of annual broadleaf and grass weeds in winter cereals. Best activity and selectivity in the control of important weeds such as *Bromus* spp., *Alopecurus myosuroides*, *Apera spica-venti*, *Lithospermum arvense*, *Matricaria chamomilla*, *Papaver rhoeas*, *Sinapis arvensis*, *Stellaria media*, and *Veronica* spp., is obtained with early post-emergence applications. SMY 1500 is active due to uptake through both foliage and the root system of emerged plants. Rates required range from 0.75 - 1.5 kg a.i./ha, depending on weed species and soil type. Control of *Bromus* spp. is enhanced by combining SMY 1500 with low rates of metribuzin (0.07 - 0.14 kg a.i./ha).

INTRODUCTION

SMY 1500 is a new herbicide for cereals discovered by Bayer AG, D-5090 Leverkusen, West Germany. The herbicide exhibits both pre-emergence and post-emergence activity against a wide range of important broadleaf and grass weeds occuring in winter cereals in Europe and the USA. The greatest commercial potential for SMY 1500 is the selective control of *Bromus* spp. (*B. secalinus*, *B. tectorum*, *B. japonicus*, *B. rigidus*) in winter wheat in the USA.

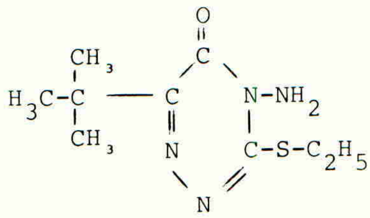
This paper provides general information on SMY 1500 and reports a summary of results from field trials conducted in the USA and Europe in 1982-84.

Additional performance, toxicological, metabolic and residue studies are in progress to support registration and commercial development of SMY 1500. An Experimental Use Permit for the 1985/86 U.S. winter wheat crop has been applied for. Full registration of SMY 1500 in the USA is expected in 1987.

2—3

CHEMICAL AND PHYSICAL PROPERTIES

Structure:



Chemical name:	4-amino-6-tert-butyl-3-ethylthio-1,2,4-triazin-5(4H)-one
Proposed common name:	Ethiozin
Code number:	SMY 1500
Trade name:	Tycor® (Registered trademark of Bayer)
Empirical formula:	$C_9H_{16}N_4OS$
Molecular weight:	228.3
Appearance:	colourless crystalline solid
Melting point:	95 °C
Solubility at 20°C:	water 420 mg/l hexane 2500 mg/l dichloromethane > 50 % 2-propanol > 15 % toluol > 25 %
Vapour pressure:	1×10^{-3} Pa at 20 °C
Formulation:	SMY 1500 can be formulated as a w.p., s.c., or water dispersable granules.

TOXICOLOGICAL PROPERTIES

Acute oral LD 50 (mg/kg) of technical material

Rat: male 2470 female 1280

Acute dermal LD 50 (mg/kg) of technical material

Rat: male >5000 female >5000

Subchronic toxicity (3-month feeding study)

Rat: male/female 'no effect'-level 2500 ppm

MODE OF ACTION

SMY 1500 is a photosynthesis inhibitor which is taken up through the roots and shoots of treated plants and transported primarily in the xylem. This dual mode of uptake results in the most consistent herbicidal activity being obtained with early post-emergence applications. Adequate moisture (rainfall, irrigation or snow cover) is required following pre-emergence and post-emergence applications for optimum herbicidal activity.

The effective rates required in pre-emergence applications and, to a lesser extent, post-emergence applications, are influenced by soil type. Higher rates are generally required on heavier soil types (clay soils), but performance of pre - emergence applications is often more consistent on such soils than on sandy soils, where SMY 1500 may be more subject to leaching.

MATERIALS AND METHODS

The field trials reported in this paper were carried out in the USA and Europe. All trials were of randomized block design using two to four replicates. Plot size ranged from 10 m^2 to 1000 m^2. Applications were made with various types of plot sprayers delivering a spray volume of 200 to 500 l/ha. Visual assessments and/or plant counts were made to determine the herbicidal efficacy and crop selectivity.

RESULTS

U.S.A. - Winter wheat

Data on crop selectivity and the control of *Bromus* spp. from three years of trials in winter wheat (1982-84) are summarized in Table 1.

Crop selectivity

Winter wheat tolerance to SMY 1500 was generally good. However, differences were observed when comparisons were made between methods of application and also crop cultivars. In general, the most consistent crop selectivity was obtained with post-emergence applications. There tended to be more crop damage with applications incorporated pre-planting (ppi) than with pre-emergence or post-emergence applications.

In direct comparisons with metribuzin, SMY 1500 was significantly more selective with respect to both the number of tolerant cultivars and also the timing of application. Most of the major commercial winter wheat cultivars showed good tolerance to SMY 1500, particularly with post-emergence applications. However, several metribuzin-sensitive cultivars, such as Vona, Lindon, Wings and Triumph 64, also exhibited sensitivity to SMY 1500. These sensitive cultivars currently account for less than 10 % of the total U.S. winter wheat acreage.

Bromus control

SMY 1500 provided control of *Bromus* spp. in ppi, pre - emergence and post-emergence applications. However, because the herbicide is taken up through both the roots and shoots of treated plants, the best selective control of *Bromus* spp. is obtained at rates of 1.0 or 1.5 kg a.i./ha applied between the 3-leaf and mid-tillering stages (Zadoks 13-25) of *Bromus* development. Combinations of SMY 1500 (0.5 to 1.0 kg a.i./ha) with low rates of metribuzin (0.07 - 0.14 kg a.i./ha) often provided higher levels of *Bromus* control than either herbicide used alone. Such combinations were significantly safer than higher rates of metribuzin used alone.

TABLE 1

Winter wheat selectivity (Sel.) and Bromus control (Con.) following SMY 1500 applications at different timings (USA field trials 1982 - 1984)

Treatment	Dosage (kg a.i./ha)	Growth stage (Zadoks) of wheat and Bromus at herbicide application									
		0		10-12		13-22		23-25		26-29	
		Sel.*	Con.**	Sel.	Con.	Sel.	Con.	Sel.	Con.	Sel.	Con.
SMY 1500	1.0	++	74(47)***	+++	72(19)	+++	85(30)	+++	85(11)	+++	43(15)
	1.5	++	85(47)	++	76(16)	++	96(25)	+++	93(13)	+++	61(19)
Metribuzin	0.14	-		++	33(7)	++	63(5)	+++	14(6)	+++	9(3)
	0.28	-		+	59(10)	+	81(12)	++	59(12)	+++	32(13)
	0.42	-		-	72(4)	+	84(7)	++	79(5)	++	57(8)
	0.56	-		-		-	95(3)	++	85(4)	++	66(12)
SMY 1500 + Metribuzin	0.75+0.07	-		++	70(7)	+++	91(5)				
	0.75+0.14	-		+	79(11)	++	92(7)	+++	88(8)	+++	65(11)
	0.75+0.21	-		+	93(4)	+	96(4)	++	90(7)	+++	68(7)
	1.0+0.07	-		++	82(8)	+++	99(4)				
	1.0+0.14	-		+	89(11)	++	97(13)	+++	93(13)	+++	59(19)
	1.0+0.21	-		+	99(2)	+	98(4)	++	95(9)	+++	75(9)

* Crop selectivity scale
- \- = poor
- \+ = variable
- ++ = acceptable
- +++ = good

*** Figures in brackets denote number of trials from which means were derived

** Bromus, % control, 100 = complete kill.

Some pre-emergence applications, or very early post-emergence applications (1-2 leaf stage Zadoks 10-12) which were made prior to the complete emergence of all Bromus plants, resulted in poorer levels of control than were obtained when applications were made to fully emerged Bromus populations. Late post-emergence applications (Zadoks 26-29) generally provided marginal or poor control.

The effectiveness of all methods of application was improved by timely moisture for herbicide activation.

Control of other weeds

In addition to activity against Bromus spp., SMY 1500 was active against a wide range of broadleaf and grass weeds. These weeds are listed in Table 2.

TABLE 2

Relative control of various weeds with rates of SMY 1500 at or below those required for Bromus control

Good to excellent control	
Amaranthus spp.	Lamium amplexicaule
Capsella bursa-patoris	Sinapis arvensis
Chenopodium album	Sisymbrium altissimum
Chorispora tenella	Stellaria media
Erodium cicutarium	Thlaspi arvense
Erysium cheiranthoides	Veronica hederaefolia
Acceptable control	
Amsinckia lycopsoides	Hemizonia pungens
Eupatorium capillifolium	Bilderdykia convolvulus
Helianthus annuus	Secale cereale
Inconsistent or poor control	
Aegilops cylindrica	Descurainia trifida
Ambrosia trifida	Galium aparine
Avena fatua	Lolium spp.

Europe

SMY 1500 has been widely tested in Europe over the past three years and has exhibited pre-emergence and post-emergence activity against many important broadleaf and grass weeds in winter cereals. Best results were obtained with early post-emergence applications, although pre-emergence applications also showed promise for the control of Alopecurus myosuroides on heavy clay soils.

Crop selectivity

In winter wheat, significant differences in cultivar tolerance were observed. While most cultivars exhibited good tolerance to SMY 1500, the following were found to be sensitive:

France: Arminda, Top, Capitole, Caton, Beauchamps, Scipion, Rivoli, Rotonde, Cocagne, Aquila, Clement, Pursang, Courtot, Festin and Florence Aurore. These sensitive cultivars currently account for approximately 35 % of the planted area.

United Kingdom: Aquila, Rapier, Stetson and Virtue (12 %).

West Germany: Carimulti, Aquila, Granada, Jubilar, Kormoran, Rektor and Disponent (20 %).

Belgium: Aquila, Arminda (15 %).

Netherland: Arminda, Nautica (50 %).

Many durum wheat cultivars grown in France and Spain were sensitive to SMY 1500, while in Italy several important cultivars (Capeti 8, Appulo, Creso, Valuoza, Isa) appeared tolerant.

In winter barley no significant cultivar differences were observed. Post-emergence applications to tillered barley were safe in the autumn or spring.

Crop selectivity in winter rye was poor.

Weed control

Optimum application rates and timings varied depending on the weeds to be controlled and also on soil and climatic factors. Data from various countries are summarized as follows:

United Kingdom: The results of trials conducted in the U.K. have been summarized by Bolton et al. (1985).

France: Best results have been obtained with early post - emergence applications in February - March. On alkaline soils common in France, SMY 1500 at 1.2 kg a.i./ha controlled Alopecurus myosuroides, Apera spica-venti, Poa spp. and many broadleaf weeds. Higher rates (1.5 - 1.8 kg a.i./ha) were required to control Avena spp. and Lolium spp..

West Germany: Early spring post-emergence applications provided good control of Alopecurus myosuroides, Apera spica-venti and many broadleaf weeds. Applications rates ranged from 1.4 to 1.75 kg a.i./ha, with the higher rates being required on heavy clay or marsh soils. Autumn post-emergence applications are generally less frequently used in West Germany, but autumn applications of SMY 1500 at 1.4 kg a.i./ha provided selective weed control in early planted, tillered cereals.

A significant number of broadleaf weeds were also controlled by SMY 1500 (Table 3).

TABLE 3

Relative control of various broadleaf weeds with rates of SMY 1500 at or below those required for grass control

Good to excellent control	
Aphanes arvensis	Lithospermum arvense
Anthriscus caucalis	Matricaria chamomilla
Androsace maxima	Papaver rhoeas
Arabidopsis thaliana	Polygonum persicaria
Bilderdykia convolvulus	Ranunculus arvensis
Centaurea cyanus	Sinapis arvensis
Chamomilla recucita	Stellaria media
Fumaria officinalis	Thlaspi arvense
Lamium purpureum	Veronica hedereafolia
Legousia hybrida	Veronica persica
Inconsistent control	
Adonis aestivalis	Lapsana communis
Galium aparine	Polygonum aviculare
Lamium amplexicaule	
Poor control	
Senecio vulgaris	Viola spp.

Activity of SMY 1500 against Galium aparine varied from poor to excellent, and appeared to be dependent on weed stage and temperature. Smaller plants were more easily controlled and activity was improved when warm temperatures (15 to 20 °C) followed application of the herbicide.

Broadleaf weed control with SMY 1500 was improved by mixtures with herbicides such as ioxynil, 2,4-DP, Mecoprop, or fluroxypyr. Since SMY 1500 provided partial control of problem weeds such as Galium aparine, the application rate of the mix-partner could often be reduced.

DISCUSSION

U. S. A.

Over the past 15 years cheatgrasses (Bromus spp.) have become a major weed problem in winter wheat in the USA. Over 9 million hectares of winter wheat are estimated to be infested with Bromus spp., with 3-4 million hectares being reported as heavily infested. However, less than 400,000 hectares are currently treated with herbicides for Bromus control. A major reason is the lack of an effective, safe herbicide for the selective control of Bromus in cereals.

Metribuzin is currently the major herbicide used for Bromus control in cereals but possesses a relatively narrow margin of crop selectivity. It may only be applied to a limited number of relatively tolerant wheat cultivars, when plants have reached the 3-tiller stage of development (Zadoks 23) and have developed four secondary roots which are at least 5-cm in length. These restrictions due to cultivars and application timing limit the efficacy and widespread use of metribuzin. SMY 1500 is more selective than metribuzin and can be safely applied pre-emergence or post-emergence to most winter wheat cultivars currently grown in the USA. However, a limited number of metribuzin-sensitive wheat cultivars have also been found to be sensitive to SMY 1500.

Early post-emergence applications of SMY 1500 are the most selective and effective for the control of Bromus in cereals. Because of greater crop selectivity, SMY 1500 applications can be timed to the required growth stage of weeds for optimum control, rather than, as in the case of metribuzin, to the growth stage of the crop. This provides a wider application window for the selective control of Bromus than is currently possible with metribuzin.

Use of SMY 1500 has major advantages in cultivar selectivity and flexibility in the timing of application compared with existing herbicides used for the control of Bromus spp.. This makes SMY 1500 a promising herbicide for commercial use in winter cereals.

Europe

The European results show that SMY 1500 is an effective herbicide for the control of Alopecurus myosuroides and other weeds in winter cereals. Limited data suggest that the herbicide has useful activity against Avena spp., but rates required are generally higher than those needed to control blackgrass. The excellent activity of SMY 1500 against Bromus spp. could be of future importance in England if Bromus sterilis continues to spread. This weed is currently largely restricted to the headlands. SMY 1500 also exhibits good activity against many broadleaf weeds. Tank mixes with reduced rates of other broadleaf herbicides can be used to provide a wider spectrum of weed control.

REFERENCES

Bolton, B.J.G.; Rose, P.W.; Fisk, A.P.; Richardson, W.G. (1985) SMY 1500 for the control of blackgrass and other weeds in winter cereals. Proceedings 1985 British Crop Protection Conference-Weeds.

Morishita, D.W.; Thill, D.C.; Callihan, R.H. (1985) Broadleaf and grassy weed control in no tillage winter wheat. Western Society of Weed Science Research Progress Report, 307.

Ratliff, R.L.; Peeper, T.F. (1985) Bromus control in winter wheat with BAY SMY 1500. Proceedings Southern Weed Science Society, 38, 111.

Rydrych, D.J. (1985) Ethyl metribuzin for downy brome control in small wheat. Western Society of Weed Science Research Progress Report, 315.

Zadoks, J.C.; Chang, T.T.; Konzak, C.F. (1974) A decimal code for the growth stages of cereals. Weed Research, 14, 415-421.

DPX-L5300 - A NEW CEREAL HERBICIDE

D. T. FERGUSON, S. E. SCHEHL, L. H. HAGEMAN, G. E. LEPONE

E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware, USA

G. A. CARRARO

Du Pont de Nemours International S.A., Geneva, Switzerland

ABSTRACT

At 10-20g ai/ha, DPX-L5300 has a wide spectrum of activity on many broadleaf weeds in cereals, including the perennial *Cirsium arvense*. Applied early postemergence in the spring, DPX-L5300 has selectivity in most cereal types and varieties grown in the world. Its rapid soil dissipation allows for complete flexibility in crop rotations. DPX-L5300 moves rapidly throughout susceptable plants disrupting cell division by inhibiting acetolactate synthase production. Its low toxicity to mammals, fish, and wild life coupled with nonvolatility and a low use rate make DPX-L5300 safe to the user and the environment.

INTRODUCTION

Previously, three sulfonylurea herbicides for cereals have been introduced; chlorsulfuron (Palm et al 1980), metsulfuron methyl (Doig et al 1983), and DPX-M6316 (Hutchison et al 1985). The mode of action and structure activity relationships of the sulfonylureas have been reviewed by Levitt (1982). Du Pont continues to develop cereal herbicides in the sulfonylurea family which provide complimentary activity to those mentioned above.

DPX-L5300 has been field-tested as a cereal herbicide candidate since 1982 in the major cereal growing areas of the world. Results from these studies indicate DPX-L5300 is a highly active, broadleaf herbicide with excellent cereal crop tolerance and rotational crop flexibility.

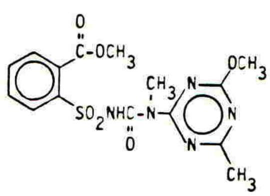
CHEMICAL AND PHYSICAL PROPERTIES

Chemical name

Methyl 2-[3-(4-methoxy-6-methyl-1,3,5,-triazin-2-yl)-3-methylureidosulphonyl]benzoate

Chemical structure

DPX-L5300



Physical properties

Molecular weight:	395.39
Physical form:	Solid
Melting point:	141°C
Vapour pressure:	2.7 10^{-7}mm Hg (25°C)
Acid dissociation constant:	pka = 5.0

Solubility in water:

pH	Solubility (mg/L)
4.0	28
5.0	50
6.0	280

Toxicology

DPX-L5300 has demonstrated a low level of acute mamalian toxicity. The oral LD_{50} (rat) is >5,000 mg/kg while the dermal LD_{50} rabbit is >2,000 mg/kg. The product is not a skin irritant or sensitizer. DPX-L5300 is a mild eye irritant which is reversible one-day after dosing. It is not mutagenic in the Ames test. DPX-L5300 also shows very low toxicology to fish and wildlife. Long-term feeding studies are in progress.

Mode of Action

The mode of action of DPX-L5300 is similar to that of chlorsulfuron (Ray, 1982). The product can be absorbed through both the roots and foliage, although in practice, the latter is dominant due to the short soil-residual nature of DPX-L5300. Translocation is rapid with both acropetal and basipetalmovements occurring. As DPX-L5300 moves throughout the plant, it inhibits the acetolactate synthase enzyme, indirectly causing disruption in cell division. The affected plant displays a severe growth inhibition of root and shoot tips followed by general necrosis and death up to 14 days later.

Selectivity

The tolerance of cereals to DPX-L5300 is due to the rapid metabolism of the molecule by the cereal plant. At normal use rates, the parent material is undetectable within a few days of application.

Environmental Fate

In the soil, DPX-L5300 is primarily broken down by hydrolysis. This reaction is pH dependent and relatively fast with half-lifes of one day in nonsterile silt loam soil (pH 4.3, OM 1.0%) and six days in a different nonsterile silt loam soil (pH 7.5, OM 5.0%). Increasing levels of soil moisture and warmer temperatures accelerate the rate of disappearance. Recropping experiments in North America show that rotational crops such as lentils, sugarbeets, and oil seed rape could be safely grown at their normal planting intervals after spring applications of DPX-L5300 at proposed use rates . In warmer regions, crops such as cotton, soybeans, and vegetables were safely double-cropped after cereals that have had DPX-L5300 applied at anticipated use rates.

MATERIALS AND METHODS

Formulations of DPX-L5300 used included a 75% WP, and a 75% dry flowable. Standard treatments varied slightly between countries, but included various 2,4-D formulations, hydroxybenzonitrile + mecoprop mixtures, and other products containing mixtures of phenoxy herbicides.

Applications were all with hand-held plot sprayers using an inert gas propellant. Operating pressure was approximately 200 KPa and application volumes varied between 200 and 450 l/ha in Europe and as low as 100 l/ha in the US and Canada. Plots for weed control evaluations were generally between 2 m x 5 m and 3 m x 8 m, replicated 3 or 4 times. Weed assessments for broadleaf weeds were made by a visual scoring of biomass reduction versus untreated plots on a scale of 0-100%. Evaluations were made 2-3 times during the growing season at approximately 10-20, 20-40, and 60 days or more after treatment.

Timing of application varied between growth stages Zadoks 13 and 32. Crop vigour scores were made in all trials on a 0 to 100% scale as a visual assessment of damage. Yield trials were established using larger plots replicated four times, mostly 3 m x 15 m harvested with a small plot combine; sites were chosen with low weed populations. Application rates in these crop safety trials included the anticipated use rates and 2 x and 4 x rates.

RESULTS

Efficacy

Table 1 demonstrates the wide spectrum of dicotyledon weed control given by DPX-L5300, including such troublesome species as those in the genera Papaver, Silene, Matricaria, Sinapis and Stellaria. Table 1 also shows the tolerance of grass weeds to DPX-L5300. One weed to note in particular is the perennial broadleaf Cirsium arvense. From thirteen studies in North America, DPX-L5300 has given an average of 84% control from spring postemergence applications at 16g ai/ha. Evaluations were made near harvest and showed that the DPX-L5300 treatments were able to keep the C. arvense plants below the normal height the crop is cut for harvest. Studies continue to define the degree of C. arvense control one year or more after treatment.

In 1983, early screening trials in Spain indicated the beneficial activity of DPX-L5300 on the dominant broadleaf weeds in cereals. Subsequent years have confirmed this effective weed control, particularly on Papaver rhoeas, Sinapis arvensis, Silene spp. and Stellaria media (Table 2). DPX-L5300 also offers a very low hazard to adjacent, non-cereal crops because of its non-volatile character. This is especially important to many areas of Spain where cereals are often bordered by crops such as grapes and sugarbeets which are sensitive to hormone type herbicides. Tabel 3 shows results of DPX-L5300 activity in winter cereals versus a standard rate of the premix ioxynil + bromoxynil + mercoprop on selected dicotyledon weeds in the U.K.

Crop Tolerance

Most major varieties of barley and wheat grown throughout the cereal producing regions of the world have demonstrated acceptable crop tolerance to twice or more the proposed use rates of DPX-L5300. These variety tolerance studies have shown that both autumn and spring planted barley and wheat can be safely treated spring-postemergence with relatively high rates of DPX-L5300. The few exceptions to this are durum spring wheats, and Mexican parentage cereal varieities grown in the extreme southwest deserts of the U.S.. Crop vigour studies continue in order to evaluate local cereal variety responses to DPX-L5300 applications.

2—4

TABLE 1

The effect of DPX-L5300 applied at 10 to 20g ai/ha on weed species in worldwide trials, 1983-85.

>80% CONTROL	
Agrostemma githago	Lamium amplexicaule
Amaranthus retroflexus	Lithospermum arvense
Amsinckia intermedia	Matricaria inodora
A. lycopsoides	Montia perfoliata
Anthemis arvensis	Oxalis spp.
A. cotula	Papaver rhoeas
Arenaria spp.	Polygonum convolvulus
Bifora radians	P. erectum
Boreava orientalis	P. persicaria
Brassica nigra	Raphanus raphanistrum
B. spp.	Salsola kali
Capsella bursa-pastoris	Silene conica
Centaurea nigra	Sinapis arvensis
Chenopodum album	Sisymbrium altissimum
Cirsium arvense	S. irio
Descurainia sophia	Spergula arvensis
Erysimum repandum	Stellaria media
Eupatorium capillifolium	Thlaspi arvense
Galeopsis tetrahit	Veronica persica
Kochia scoparia	Viola arvensis
Helianthus annuus	V. tricolor
Lactuca serriola	
60-80% CONTROL	
Anagallis arvensis	Polygonum aviculare
Calandrinia ciliata	P. persicaria
Cerastium arvense	Primula spp.
Camelina microcarpa	Veronica peregrina
Descurainia pinnata	V. persica
Fumaria officinalis	
< 60% CONTROL	
Allium vineale	Galium aparine
Alopecurus myosuroides	Lolium spp.
Apera spica-venti	Poa annua
Arabidopsis thaliana	P. bulbosa
Avena fatua	Secale cereale
Bromus rigidus	Setaria viridis
B. secalinus	Veronica arvensis
B. tectorum	V. hederaefolia
Convolvulus arvensis	

TABLE 2

The percentage weed control given by postemergence applications of DPX-L5300 in winter cereals in Spain, 1984-85.

Weed	Number of Trials	% Weed Control DPX-L5300, gai/ha 11.25	18.75	2,4-D ester 490g ai/ha
Agrostemma githago	4	100	100	0
Anagallis arvensis	2	51	68	12
Anthemis arvensis	6	53	68	42
Arenaria spp.	3	88	100	0
Fumaria officinalis	4	52	60	3
Papaver rhoeas	18	97	100	95
Polygonum aviculare	10	48	64	47
P. convolvulus	10	83	91	26
Silene inflata	4	100	100	92
Raphanus raphanistrum	4	3	12	84
Ridolphia segetum	4	99	92	98
Sinapis arvensis	8	98	100	99
Stellaria media	4	100	100	27
Veronica hederaefolia	10	0	0	0
V. persica	4	24	34	4
Viola arvensis	6	74	82	16

TABLE 3

The percentage weed control observed by spring postemergence applications of DPX-L5300 in winter cereals in the United Kingdom, 1983-85.

	% Weed Control (Number of Trials) DPX-L5300 g ai/ha 16	32	Standard*
Aphanes arvensis	99(2)	100(2)	92(2)
Matricaria spp.	100(4)	100(4)	98(4)
Papaver rhoeas	93(3)	97(6)	97(6)
Stellaria media	100(5)	100(11)	97(11)
Veronica persica	75(5)	71(11)	89(11)
Viola arvensis	74(5)	81(10)	80(10)

*ioxynil 252 g ai/ha + bromoxynil 252 g ai/ha + mecoprop 2016 g ai/ha.

DISCUSSION

Applied as a spring postemergence treatment to cereals, DPX-L5300 offers a wide spectrum of activity on dicotyledon weeds, including the perennial Cirsium arvense. Since weed control activity is induced primarily by foliar absorption, warm weather conducive to healthy, actively growing weeds enhances DPX-L5300 performance. Though current studies are underway to define rainfastness, studies showing the rapid foliar uptake of DPX-L5300 indicate performance can be maintained when rain occurs four to six hours after application. Trials conducted on winter cereals in Spain demonstrated the superior weed control of

DPX-L5300 when compared to the standard 2,4-D ester on such weeds as Polygonum convolvulus, Silene inflata, Stellaria media, and Viola aruensis though 2,4-D gave significantly better results on Raphanus raphanistrum. Studies done in the United Kingdom have shown that rates of 16-32 g ai/ha can give control superior or comparable to the premix of ioxynil + bromoxynil + mecoprop on many important broadleaf cereal weeds. To improve the control of some common Northwest European weeds (Galium aparine, Veronica hederaefolia), suitable companion herbicides will be required.

DPX-L5300 is selective to most cereal types and varieties cultivated in the major cereal producing areas of the world. When compared to 2,4-D ester, the application timing window of DPX-L5300 is wider with crop stages Zadoks 12 to 49 being acceptable for application and showing no crop injury in tolerant cereal varieties. Durum spring wheat varieties have been evaluated as having 11%-13% visual crop injury (yellowing and stunting but not stand reduction) to applications of 40 gai/ha of DPX-L5300. Similarly, Mexican parentage varieties (i.e., Yecoro Rojo) grown in the states California and Arizona have shown the same type of crop injury, especially early in the growing season.

The fate of DPX-L5300 in the soil has been investigated thoroughly and found to be very short lived compared to other sulfonylureas (chlorsulfuron, metsulfuron methyl). This short soil-residual nature provides complete rotational crop flexibility. The favorable toxicology, nonvolatility, and low use-rate of DPX-L5300 make it safe to the user and the environment.

ACKNOWLEDGEMENTS

We are grateful to the many colleagues in Du Pont who helped with the development of DPX-L5300.

REFERENCES

Doig, R. I.; Carraro, G. A.; McKinley, N. D. (1983). DPX-T6376 - a new broad-spectrum cereal herbicide. Proceedings 1983 International Congress of Plant Protection, Brighton, England 1, 324-331.

Hutchison, J. M.; Levitt, G.; Hageman, L. H.; Schehl, S. E. (1985). DPX-M6316 a new selective postemergence herbicide for cereals. Abstracts of Weed Science Society of America Conference 1985, Seattle 25, 10.

Levitt, G. (1982). Sulfonylureas: new high potency herbicides. Proceedings 5th International Congress of Pesticide Chemistry (IUPAC) Kyoto, Japan, 243-250.

Palm, H. L.; Riggleman, J. D.; Allison, D. A. (1980). Worldwide review of the new cereal herbicide - DPX-W4189. Proceedings 1980 British Crop Protection Conference - Weeds 1, 1-6

Ray, T. B. (1982). The mode of action of chlorsulfuron: a new herbicide for cereals. Pesticide Biochemistry and Physiology 17, 10-17.

DPX-M6316 - A NEW SULFONYLUREA CEREAL HERBICIDE

S.D. SIONIS

Du Pont de Nemours International S.A., Geneva, Switzerland

H.G. DROBNY

Du Pont de Nemours (Deutschland) GmbH, Erbach, Odenwald, Germany

P. LEFEBVRE

Du Pont de Nemours (France) S.A., Paris, France

M.E. UPSTONE

Du Pont (U.K.) Limited, Stevenage, Herts, England

ABSTRACT

DPX-M6316 is a new sulfonylurea herbicide with short soil persistance for use on cereal crops throught the world. Its postemergence herbicidal activity is primarily the result of foliar absorption. The use of M6316 in cereals allows maximum flexibility in crop rotations. M6316 has activity on many important broadleaf weeds and the grass weed _Apera spica-venti_. Extensive studies from N.W. Europe demonstrated the benefit of combining M6316 with metsulfuron methyl (referred to in this paper as DPX-T6376) to provide effective postemergence weed control in cereals in spring.

INTRODUCTION

Two sulfonylurea herbicides, chlorsulfuron and metsulfuron methyl, are now used in various cereal growing systems. They were reported by Palm _et al_ (1980) and by Doig _et al_ (1983). The development of herbicides which are complementary to chlorsulfuron and metsulfuron methyl, has continued.

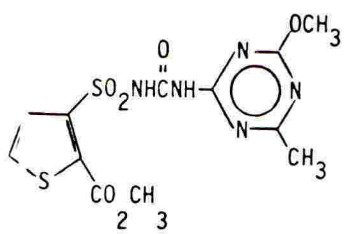
M6316 has been tested worldwide for the past four years. Ambach _et al_ (1984), reviewed M6316 activity for the central plains of North America and Hutchison _et al_ (1985) reported on the chemistry of the herbicide and on North American field results. This paper presents some of the characteristics of the compound and reports the results obtained by using the product either alone or in combination with T6376 in France, UK, and Federal Republic of Germany. M6316 will be introduced this year under the tradename "Harmony" and in combination with T6376 as "Harmony M".

THE COMPOUND

Chemical Name

Methyl 3-(3-(4 methoxy-6-methyl-1,3,5,-triazin-2-yl)ureidosulphonyl) thiopene-2-carboxylate.

Structure



2—5

TOXICOLOGY

M6316 has a low acute oral, dermal and inhalation toxicity in rats and rabbits. It is not a skin irritant or sensitizer. It can cause mild but reversible eye irritation. It is not mutagenic in either Ames or three other mutagenicity tests. Interim results on rat, mouse and dog feeding studies appear very favourable. The compound shows low toxicity to fish and wildlife.

PHYSICAL - CHEMICAL PROPERTIES

Physical form : solid, white
Melting point : 186 degrees C
Vapor pressure : 2.7×10^{-6} mm Hg at 25 degrees C
Dissociation constant pKa: 4.0 at 25 degrees C
Partition coefficient (octanol/water): 0.027
Water Solubility (25 degrees C):

pH	Solubility (mg/L)
4.0	24
5.0	260
6.0	2400

MODE OF ACTION

M6316 stops cell division by inhibiting biosynthesis of the essential amino-acids valine and isoleucene. It is rapidly absorbed by plant foliage and roots and translocated throughout the plant. Susceptible plants cease growth almost immediately after postemergence treatment and are killed in 7 to 21 days. Surfactants increase the activity of M6316 on certain key weeds.

ENVIRONMENTAL FATE

M6316 is rapidly metabolized under aerobic soil conditions. Results from field studies indicate a half-life of less than one week. The compound is broken down to nonactive substances by microbial degradation and chemical hydrolysis. Under normal environmental conditions, the rates of use proposed for M6316 offer complete rotational flexibility with respect to crop selection and recropping interval.

SELECTIVITY

Winter wheat and spring cereals have shown very good crop tolerance to intended use-rates of M6316.

FIELD STUDIES

MATERIAL AND METHODS

Herbicidal activity of M6316 and M6316 + T6376 was evaluated when applied early in the spring to young and fast growing weeds.

Applications were all with hand-held plot sprayers using an inert gas propellant. Operating pressure was approximately 200 KPa and application rate varied between 200 to 400 l/ha. Plots for weed control evaluation were between 2x5 m and 3x8 m replicated three times for UK and F.R. of Germany and, in France, 2.5x10 m replicated twice. Broad-leaf weed control was measured as % control compared with adjacent untreated plots assessed visually.

For grass weeds, head counts were taken at earing. Crop safety was assessed visually as % of crop damage. In yield trials larger plots were used (3x25 m) replicated four times and harvested with farmers equipment. These sites were chosen with low weed populations. Application rates in these yield trials included the anticipated use rate and a double rate. The formulation used was 75% dry flowable. The main companion treatment was T6376 used initially as a 20% dry flowable. In 1985 M6316 and T6376 were used as a final premix in a ratio 10:1 as a 75% dry flowable. The standard herbicides varied in the different countries according to the local conditions, but included a hydroxybenzonitrile + mecoprop mixture and mixtures of phenoxy alkanoic compounds.

RESULTS

Initial results with M6316 alone in 1982-83 showed its activity on Apera spica-venti and on many dicotyledonous weeds. However there was insufficient control of certain important weeds such as Viola sp, Fumaria officinalis, etc. The mixture of M6316 + T6376 gave an average of more than 85% control of the major weed species of European cereals. Table 1 shows the results of M6316 alone and in mixture with T6376; the data are a summary of European trials from 1982 to 1985. Tables 2,3, and 4 present weed control from France, F.R. of Germany and UK in winter and spring cereals.

TABLE 1

The control of weed species in European trials by M6316, 60g a.i./ha (M) and M6316 + T6376, 66g a.i./ha (MT)

	85% Control (+)				
	M	MT		M	MT
Apera spica-venti	-	+	Papaver rhoeas	+	+
Aphanes arvensis	+	+	Polygonum aviculare	-	+
Bilderdykia convolvulus	+	+	Polygonum persicaria	+	+
Capsella bursa-pastoris	+	+	Raphanus raphanistrum	-	+
Fumaria officinalis	-	+	Sinapis arvensis	+	+
Galeopsis spp.	+	+	Stellaria media	+	+
Galium aparine	+	+	Veronica agrestis	+	+
Lamium amplexicaule	-	+	Veronica hederifolia	-	+
Lamium purpureum	+	+	Veronica persica	-	+
Matricaria spp.	+	+	Viola spp.	-	+
Myosotis arvensis	+	+			

TABLE 2

The control of three weeds in winter cereals with postemergence applications of M6316 and M6316 + T6376 in spring (1984-1985 France).

Products	Rates g a.i./ha	% Weed control (number of tests) G. aparine 1984	G. aparine 1985	V. hederifolia 1984	V. hederifolia 1985	V. arvensis 1984	V. arvensis 1985
M6316	60	83(23*)	83(4)	81(27)	76(9)	83(16)	71(3)
M6316 + T6376	60+6	86(6)	83(10)	81(8)	88(14)	90(7)	88(4)
Ioxynil + Bromoxynil + MCPP esters	1313 combined	94(23)	92(10)	94(27)	93(14)	70(16)	72(4)

*Numbers in parenthesis show the number of trials that those weeds were present in significant numbers.

TABLE 3

The weed control in winter cereals with postemergence applications of M6316 and M6316 + T6376 in spring (1985 F.R. of Germany - 10 trials).

Weeds	DPX M6316 60g a.i./ha	DPX M6316 + T6376 60 + 6g a.i./ha	Ioxynil + Bromoxynil + MCPP esters 1313 combined a.i./ha
A. spica-venti	77	90	0
V. arvensis	83	97	55
G. aparine	85	86	88
M. chamonilla	98	100	60
L. purpureum	64	99	70
S. media	85	100	92

TABLE 4

The weed control in spring barley with postemergence applications of M6316 and M6316 + T6376 (1984 - United Kingdom - 3 trials).

Weeds	DPX M6316 45g a.i./ha	DPX M6316 + T6376 45 + 4.5g a.i./ha	Ioxynil + Bromoxynil + MCPP esters 1313 combined a.i./ha
P. aviculare	91	89	85
B. convolvulus	47	82	53
V. arvensis	61	78	82
S. media	97	98	95
C. segetum	47	73	83
T. maritimum	77	100	100
A. patula	93	82	85
S. arvensis	77	65	84

Crop Selectivity Trials

A large number of trials were conducted in Europe in 1984, with M6316 alone and in combination with T6376. On winter wheat 60 and 120 g a.i./ha of M6316 and 66 g a.i./ha of M6316 + T6376 were very safe. At 132 g a.i./ha of M6316 + T6376 some damage occured mainly in the form of yellowing of the crop but it was within the limits of acceptability for a double rate. It was less selective in winter barley. At some sites the above mentioned treatments caused yellowing and a growth delay up to the earing stage. Work continues to define the significance of these symptoms in winter barley. By contrast, in spring barley rates 45 and 90 g a.i. M6316 and 49.5, 99 g a.i/ha of M6316 + T6376 were very safe. A slight yellowing and growth delay were observed for one week after application, at the higher rates but they disappeared rapidly and there was no adverse effect on yields. Tables 5 and 6 summarize results obtained in France in 1984 and 1985 and Table 7 summarizes results obtained in the UK in 1984.

TABLE 5

Crop selectivity in winter wheat with postemergence spring application of M6316 and M6316 + T6376 (France 1984-1985).

Herbicides	Rate g ai/ha	1984 Mean Crop Damage % 30 DAT	45 DAT	No.of Tests	1985 Mean Crop Damage % 30 DAT	45 DAT	No.of Tests
M6316	60	2	1	36	2	1	14
M6316+T6376	66	4	3	28	4	2	28
M6316	120	3	3	5	-	-	-
M6316+T6376	132	13	7	5	12	12	9

TABLE 6

Crop selectivity in winter barley with postemergence spring application of M6316 + T6376 (France 1984-85).

Herbicides	Rate g ai/ha	1984 Mean Crop Damage % 30 DAT	45 DAT	No.of Tests	1985 Mean Crop Damage % 30 DAT	45 DAT	No.of Tests
M6316	60	3	2	25	-	1	-
M6316+T6376	66	8	8	18	5	10	5
M6316	120	15	10	2	-	-	-
M6316+T6376	132	32	17	2	12	18	5

TABLE 7

Effect on crop yield in spring barley with postemergence application of M6316 and M6316 + T6376 (UK - 1984 - 4 trials).

Herbicides	Rate g a.i./ha	Yield t/ha
Untreated (weed-free)	-	6.35
M6316	60	6.35
M6316 + T6376	66	6.14
M6316	120	6.23
M6316 + T6376	132	6.25

DISCUSSION

M6316 is a further advance to weed control technology in cereals. Its favourable soil dissipation allows complete rotational crop flexibility. The herbicidal activity of M6316 on such weeds as G. aparine, V. hederifolia makes it an ideal partner product for use in a mixture with T6376. The results reported in this paper show that the combination is very effective as a spring postemergence treatment in winter and spring cereals. The very good and consistant control of A. spica-venti emphasizes the particularly high value of this combination in the F.R. of Germany.
M6316 will be used alone in areas where the environmental conditions and weed spectra favour such a use, primarily in North America.

REFERENCES

Ambach,R.M.; Toole, B.M.; Zadorozny, S.A.; Johnson, K.D.; Ulrich, T.S.; Gorell, R.M.; Schehl, S.E. (1984) DPX-M6316, A new herbicide for use in cereals, Proceedings North Central Weed Control Conference Winnipeg, Canada. Volume 39, 120

Doig, R.I.; Carraro, G.A. (1983) DPX-T6376, A new broad spectrum cereal herbicide, Proceedings 1983 International Congress of Plant Protection, Brigthon. Volume 1, 324-331

Hutchison, J.M.; Levitt, G.; Hageman, L.H.; Schehl, S.E. (1985) DPX-M6316, A new selective postemergence herbicide for cereals - Meeting of Weed Science Society of America, Seattle USA, 1985. Volume 25, 10

Palm, H.L.; Riggleman, J.D.; Allison, D.A. (1980) Worldwide review of the new cereal herbicide - DPX 4189. Proceedings 1980 British Crop Protection Conference - Weeds. Volume 1, 1-6

CGA 131'036: A NEW HERBICIDE FOR BROADLEAVED WEED CONTROL IN CEREALS

J. AMREIN, H.R. GERBER

CIBA-GEIGY Limited, Agricultural Division, Research & Development,

CH-4002 Basle, Switzerland

ABSTRACT

CGA 131'036 (3-(6-methoxy-4-methyl-1,3,5-triazin-2-yl)-1-[2-(2-chloro ethoxy)-phenylsulfonyl]-urea is a new herbicide being developed by CIBA-GEIGY Limited for use in small grain cereals. CGA 131'036 provided excellent pre- and postemergence activity against a wide spectrum of broadleaved weeds including Viola tricolor and Galium aparine. Depending on application timing and species to be controlled the application rate of CGA 131'036 varied between 10-20 g a.i./ha. A partial effect on grasses such as Apera spica-venti and Lolium spp. was obtained as well. Although the final control level of susceptible weed species was generally not influenced by the application timing, the best and most rapid effects were achieved when CGA 131'036 was applied to young actively-growing weeds. Less susceptible species such as Veronica spp., were inhibited and suppressed throughout the whole season. CGA 131'036 applied in combination with chlorotoluron and isoproturon at or shortly after vegetation regrowth in the spring, provided excellent broad spectrum weed control including grasses and dicots. CGA 131'036 was excellently tolerated in small grain cereals, when applied postemergence to either winter or spring varieties. Preemergence applications with CGA 131'036 were better tolerated in wheat than in barley. Three years experience indicates that CGA 131'036 can be used in intensively-grown European small grain cereals without affecting subsequent crops.

INTRODUCTION

CGA 131'036 is a new herbicide discovered and currently being developed by CIBA GEIGY LTD for use in small grain cereals. CGA 131'036 has been tested worldwide in the major cereal growing areas for the control of broadleaved weeds. CGA 131'036 provides excellent pre- and postemergence activity against a wide spectrum of dicot weeds at rates as low as 10-20 g a.i./ha.

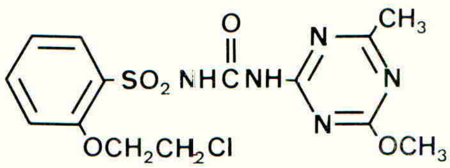
This paper describes chemical and physical properties of the active ingredient and the biological results from field trials carried out in the most important cereal growing countries of Europe. Results from field trials in overseas countries will be published separately.

CHEMICAL AND PHYSICAL PROPERTIES

Common name	:	none given yet
Chemical name (IUPAC)	:	3-(6-methoxy-4-methyl-1,3,5-triazin-2-yl)-1-[2-(2-chloroethoxy)-phenylsulfonyl]-urea

2—6

Chemical formula



Empirical formula	:	$C_{14}H_{16}ClN_5O_5S$
Molecular weight	:	401.83

Physico-chemical properties

Appearance	:	white crystals
Melting point	:	186^{o}C
Vapour pressure	:	7.5×10^{-13} mm Hg at 20^{o}C
Solubility	:	1.5 g/L in water (pH 7) at 20^{o}C

Toxicity of technical material

LD 50 oral (rat)	:	> 5000 mg/kg
LD 50 dermal (rat)	:	> 2000 mg/kg
LC 50 inhalation (rat, 4h)	:	> 5185 mg/m^3
Skin irritation (rabbit)	:	slight
Eye irritation (rabbit)	:	none

Wildlife : as the basic data on CGA 131'036 indicate the application of this compound is not hazardous to wild life.

Additional toxicology studies are in progress.

METHODS AND MATERIALS

Small plot field trials were carried out with CGA 131'036 over a period of 3 years in European small grain cereals. The experimental design was a randomized complete block with three or four replicates. Plot size varied from 10-20 m^2. All treatments were applied with CO_2 pressurized small plot sprayers. Spray volume ranged from 200-500 L/ha. CGA 131'036 was formulated as wettable powder or water dispersible granule. Weed control and crop tolerance were assessed visually in comparison with untreated control plots using a percent rating scale (0% = no weed control or no crop damage; 100% = complete weed control or death of crop).

Investigations on the degradation rate of CGA 131'036 were carried out using bioassay methods described by Gerber (1975). The soil used in these experiments originated from Möhlin (Switzerland) and had the following properties: pH at 6.4; organic matter 4.2%; 37% of clay; 32% of silt and 31% of sand.

RESULTS

CGA 131'036 controlled a broad spectrum of important broadleaved weeds after postemergence applications in winter cereals (Table 1). Cruciferous weeds, Myosotis arvensis and Stellaria media were highly susceptible at rates as low as 10 g a.i./ha. Other dicot weeds including Galium aparine and Viola arvensis were well controlled at 15 g a.i./ha. Veronica species were moderately susceptible to CGA 131'036.

TABLE 1

Crop tolerance (% phytotoxicity) and activity (% weed control) after post-emergence applications of CGA 131'036 in winter cereals in France, Federal Republic of Germany, United Kingdom and Switzerland (mean of results from 1983 and 1984 seasons; assessments 30-70 DAT)

Crop/Weed species	Number of trials	CGA 131'036 g a.i./ha			Ioxynil + Mecoprop-ester g a.i./ha
		10	15	20	1200-1400
Winter barley	11	0	0	0	0
Winter wheat	26	0	0	0	0
Alchemilla arvensis	7	88	96	97	81
Arabidopsis thaliana	3	95	97	97	84
Capsella bursa pastoris	7	95	95	97	99
Galium aparine	14	72	85	87	91
Lamium amplexicaule	3	76	94	95	88
Lamium purpureum	7	76	90	93	83
Legousia speculum-veneris	3	84	94	95	87
Matricaria spp.	6	82	96	95	88
Myosotis arvensis	8	95	98	97	83
Papaver spp.	9	88	96	96	90
Stellaria media	15	90	97	97	93
Veronica hederaefolia	17	57	68	72	91
Veronica persica	7	58	72	72	81
Viola arvensis	17	86	92	92	60

In spring cereals CGA 131'036 was very effective against most broad-leaved weed species at rates of 10-15 g a.i./ha (Table 2). Galeopsis tetrahit proved to be highly susceptible. Chenopodium album and Polygonum aviculare were moderately susceptible and moderately resistant respectively.

After application the symptoms of CGA 131'036 began first with a severe inhibition of treated plants. Increasing chlorosis and anthocyanin expression started in youngest tissues. Later, leaves became necrotic and death of plants occurred after 3-6 weeks. Investigations with different application timings of CGA 131'036 in winter cereals showed that this did not influence the final level of control of most dicot weed species provided it was applied postemergence to the crop up to the end of tillering (Table 3).

TABLE 2

Crop tolerance (% phytotoxicity) and activity (% weed control) after postemergence applications of CGA 131'036 in spring cereals in the Federal Republic of Germany and Switzerland (mean of results from 1984 season ; assessments 30-50 DAT).

Crop/Weed species	Number of trials	CGA 131'036 g a.i./ha 10	CGA 131'036 g a.i./ha 15	CGA 131'036 g a.i./ha 20	Ioxynil + Mecoprop-ester g a.i./ha 1440
Spring barley	2	0	0	0	0
Spring wheat	4	0	0	0	1
Chenopodium album	5	76	79	75	100
Chenopodium polyspermum	3	96	99	99	92
Galeopsis tetrahit	4	96	98	96	73
Galium aparine	6	85	87	90	89
Matricaria spp.	6	91	96	97	98
Polygonum aviculare	3	31	32	45	63
Polygonum convolvulus	2	92	98	100	94
Stellaria media	3	94	97	98	95
Sinapis arvensis	2	96	96	96	100
Viola tricolor	4	84	93	93	80

TABLE 3

Influence of different application timings on the performance of CGA 131'036 on broadleaved weeds in winter wheat (mean of results from 1984 season; % weed control)

Weed species	Number of trials	CGA 131'036 at 15 g a.i./ha Crop stage at application (decimal code) Zd 21-25	Zd 25-29	Zd 30-31
Veronica hederaefolia	7	85	72	63
Veronica persica	5	61	48	32
Viola tricolor	6	94	94	80
Lamium purpureum	6	91	84	80
Papaver spp.	4	96	91	88
Stellaria media	5	91	87	85

Tank mixtures of CGA 131'036 and the herbicide isoproturon applied shortly after vegetation regrowth in the spring gave excellent performance against a broad spectrum of weeds including grasses and dicots (Table 4). Although *Veronica* spp. did not completely die after application with CGA 131'036, further growth and seed production of treated plants were completely suppressed (Table 5).

CGA 131'036 also had good residual activity (Table 6). When applied preemergence in small grain cereals in Spain, CGA 131'036 gave broad spectrum weed control against *Lolium rigidum* and major broadleaf weeds.

Both winter and spring wheat and barley were tolerant of postemergence applications of CGA 131'036 at the dose proposed for use and a double dose. Visual assessments of phytotoxicity (Tables 1,2 and 4) did not show any adverse effects on the crop. Mixture with isoproturon or chlorotoluron also proved to be very safe (Table 7).

Preemergence applications of CGA 131'036 in Spain were safe in wheat but barley was more susceptible.

TABLE 4

Crop tolerance (% phytotoxicity) and activity (% weed control) after postemergence applications of CGA 131'036 in tank mixture with isoproturon in France, Federal Republic of Germany, Austria and Switzerland (mean of results from 1985 season; assessments 20-70 DAT).

	Number of trials	CGA 131'036 + Isoproturon	Isoproturon	Standard [1] herbicides
		(g a.i./ha) 15 + 1300	(g a.i./ha) 1300	
Crop stage at application (decimal code)		Zd 21-25	Zd 21-25	Zd 25-29
Winter barley	7	1	0	8
Winter rye	3	0	0	11
Winter wheat	13	0	0	3
Apera spica-venti	9	99	98	88
Alopecurus myosuroides	8	96	94	78
Galium aparine	7	80	13	94
Veronica hederaefolia	12	82	24	95
Veronica persica	7	72	19	95
Viola tricolor	19	93	18	92
Alchemilla arvensis	9	98	59	78
Lamium spp.	11	96	55	98
Matricaria spp.	11	99	94	98
Myosotis arvensis	7	94	63	99
Stellaria media	16	100	82	95

[1] Standards: Isoproturon + Bifenox + Mecoprop; 3500 g a.i./ha
Isoproturon + Bifenox + 2,4-DP; 3000 g a.i./ha

TABLE 5

The effect of CGA 131'036 in tank mixture with isoproturon on growth and seed production of Veronica hederaefolia and V. persica in Switzerland (mean of results from season 1985).

	Veronica hederaefolia (2 trials)		Veronica persica (1 trial)	
	Un-treated	CGA 131'036 + Isoproturon (g a.i./ha) 15 + 2000	Un-treated	CGA 131'036 + Isoproturon (g a.i./ha) 15 + 2000
Number of seed/10 plants	366	3	1403	240
Weight(g) of seeds/10 plants	2.1	0.02	0.93	0.1
Veronica spp.- cover (%)	24	-	12	-
Veronica spp.- control (%)	-	57	-	67

TABLE 6

Crop tolerance (% phytotoxicity) and activity (% weed control) after preemergence applications of CGA 131'036 in tank mixture with chlorotoluron in winter cereals in Spain (mean of results from 1985 season; assessments 30-90 DAT)

Crop/Weed	Number of trials	CGA 131'036 + Chlorotoluron (g a.i./ha) 10 + 750	10 + 1000	Chlorotoluron + Terbutryn (g a.i.ha) 1500
Winter wheat	4	6	9	6
Winter barley	5	7	13	1
Lolium rigidum	8	92	95	91
Papaver rhoeas	5	98	99	97
Cruciferae[1)]	4	95	97	84
Polygonum aviculare	4	78	87	88
Veronica hederaefolia	3	78	79	52
Galium aparine	1	89	93	0
Myosotis arvensis	1	100	100	100

1) Raphanus raphanistrum, Rapistrum spp., Capsella bursa pastoris, Malcomia spp.

TABLE 7

Effect of CGA 131'036 on crop yield in winter cereals in France applied postemergence at single and double proposed efficacy rates on weed-free trial sites (mean results of 1985 season)

	Winter barley		Winter wheat	
CGA 131'036 (g a.i./ha)	dt/ha (6 trials)		dt/ha (2 trials)	
0	73.1	LSD[1)]	58.4	LSD
15	75.6	= 2.2	59.6	= 2.4
30	76.4		59.8	
CGA 131'036 + Isoproturon (g a.i./ha)	dt/ha (7 trials)		dt/ha (3 trials)	
0	75.0	LSD	67.4	LSD
15 + 1320	78.2	= 3.5	68.3	= 2.5
30 + 2640	78.9		62.6	

1) LSD: lowest significant difference; $p = 0.05$

Table 8 shows the degradation behaviour of CGA 131'036 investigated in the laboratory under different levels of soil moisture and temperature. The results demonstrate that both, the soil moisture and the temperature, influenced the degradation to a remarkable degree. Especially at 21°C the increasing soil moisture highly enhances the degradation rate of CGA 131'036.

TABLE 8

Influence of soil moisture and temperature on the degradation rate of CGA 131'036 in the soil under laboratory conditions.

	Time for 50% degradation (days)	
Soil moisture in % of field capacity	Temperature 21°C	35°C
25 %	73	34
50 %	30	23
75 %	20	14

DISCUSSION

CGA 131'036 proved to be an effective chemical for the postemergence control of a number of major broadleaved weeds in European winter and spring cereals. Troublesome species such as Viola arvensis, Galium aparine and Galeopsis tetrahit showed high susceptibility to CGA 131'036. Acceptable control levels were achieved at rates of 10-15 g a.i./ha. Due to the flat dose-response curve of CGA 131'036 only small differences in weed control were obtained applying this compound at higher rates.

CGA 131'036 was excellently tolerated by winter and spring cereals and could be applied after the crop had developed more than two leaves until the booting stage. Differences in cultivar-response to CGA 131'036 have not been observed so far.

The best and most rapid effects were obtained if CGA 131'036 had been applied to young actively growing weed species. The final control level of susceptible weed species was usually not influenced by the application timing. Less susceptible species (e.g. Veronica spp.) did not completely die off after applications with CGA 131'036. However, they were inhibited and suppressed throughout the whole season.

Because of the weed species susceptible to CGA 131'036 this compound was ideal for mixtures with substituted urea herbicides (e.g. chlorotoluron or isoproturon). These combinations applied postemergence, at or shortly after vegetative regrowth in the spring, provided excellent broad spectrum weed control including grasses and dicotyledonous weeds and protected the crop from weed competition early in the season.

The degradation rate of CGA 131'036 is controlled by various factors such as soil type, soil pH and especially climatic conditions (temperature, soil moisture). Since CGA 131'036 also has preemergence activity providing season-long control of late germinating weeds, the safety to following crops had to be carefully analysed. After three years of experiments it appears that CGA 131'036 can be applied without rotational restrictions in intensively-grown cereals in Austria, Federal Republic of Germany, France, Italy, Switzerland and United Kingdom.

ACKNOWLEDGEMENTS

The authors are indebted to field experimentalists throughout CIBA GEIGY's Research & Development network for providing field trial results.

REFERENCES

Gerber, H.R. (1975) Biotests for herbicide development, Crop Protection Agents, N.R. Mc Farlane (Ed), London: Academic Press, pp. 307-321

CHARACTERISTICS OF THE NEW HERBICIDE BAS 518 H

B. WUERZER, R. BERGHAUS, H. HAGEN, R.-D. KOHLER and J. MARKERT
BASF Aktiengesellschaft, Landwirtschaftliche Versuchsstation,
D-6703 Limburgerhof, FR Germany

ABSTRACT

BAS 518 H (7-chloro-3-methyl-quinoline-8-carboxylic acid) is a new selective pre- and post-emergence herbicide which originated at BASF Aktiengesellschaft. BAS 518 H has potential particularly for the control of Galium aparine and certain other weeds in crops such as small grains, oilseed rape and sugarbeet. The visual symptoms of damage are similar to those caused by hormone type herbicides. The availability of the compound via the roots and its residual activity favour the efficacy of this herbicide.

INTRODUCTION

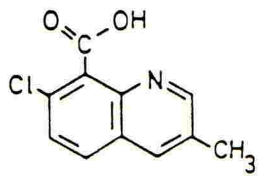
Two new substituted quinolinecarboxylic acids are being developed for the control of two important weed species. BAS 514 H (3,7-dichloro-quinoline-8-carboxylic acid) is aimed particularly at Echinochloa spp. in rice. Detailed results on the development of BAS 514 H will be published elsewhere (Wuerzer & Berghaus 1985). Results from European rice growing areas have also been reported (Haden et al. 1985). BAS 518 H is being developed for the control of Galium aparine. Preliminary data to characterize this experimental herbicide are presented in this paper.

MATERIALS AND METHODS

Chemical and physical properties

Code No.: BAS 518 H

Structural formula:



Chemical name:	7-chloro-3-methyl-quinoline-8-carboxylic acid
Molecular formula:	$C_{11}H_8ClNO_2$ Molecular weight: 221.63
Physical state:	colourless crystalline solid, odourless
Melting point:	244 °C
Vapour pressure at 20 °C:	< 1 x 10^{-7} mbar (< 1 x 10^{-5} Pa)
Solubility at 20 °C g/100 g solvent:	water, 2.1 x 10^{-3}; olive oil, < 0.1; acetone, 0.2; other organic solvents, low
Formulation:	50% w.p.

Toxicity of technical material:

LD 50 mg/kg (rat): acute oral > 5 000, acute dermal > 2 000

Irritation (rabbit) skin: none Irritation eye: none

The compound is not toxic to honeybees.

The other relevant studies are in progress.

Experimental procedures

Greenhouse experiments. Standard screening trials were conducted to test and characterize the compound using published methods (Wuerzer 1983). The soil types in the experiments were: (I) a sandy loam with sand c. 80%, silt 10%, clay 10%, o.m. 3.3%, waterholding capacity 32%, pH ($CaCl_2$) 6.5. (II) a loam soil containing sand 58 %, silt 25%, clay 17%, o.m. 1.7%, waterholding capacity 55%, pH (KCl) 7.5. (III) a light sandy organic soil with 26.1% o.m., pH ($CaCl_2$) 6.6, waterholding capacity 46%. In general 300 cm^3 plastic pots were used. The screening of BAS 518 H included 23 crops, 29 broadleaf and grass weed species grown in soil type I. Pre- and post-emergence treatments were applied to crops and weeds at various rates (0.06, 0.125, 0.25, 0.5, 1.0, 2.0, 3.0 kg/ha a.i.) and at different growth stages. All herbicide rates are given in kg a.i./ha.

Degradation studies followed known methods with some modification (Wuerzer 1983). The untreated controls and the samples treated with the rates shown in Fig. 3 were stored in plastic bags at different temperatures and for various time periods: in one experiment at 20-22 °C for 2, 4, 6, and 8 months, in a further trial at 10 °C, 20 °C, 30 °C for 2 and 4 months. At the same time further samples were stored at - 20 °C and used as references. There were four replications of each sample. Herbicide residues were measured using a glasshouse bioassay method with carrot, cv. Nantaise as the test plant.

Herbicide mobility in the soil was studied in an adapted type of soil plate leaching experiment with 50 x 33 x 7 cm polystyrene boxes. Air dry soil (I, II and III) was evenly packed in the boxes and then placed on a 16° slope. Rows were marked across the soil at 5 cm intervals to mark sections and into which the bioassay plants were sown after leaching. The herbicide rates shown in Table 4 were calculated on the basis of the total area of soil surface in the boxes. The herbicide solution was pipetted on to the soil at the top of the box just above the first row. After that 2 l of water were added slowly within 2 days. Carrots were used as indicator plants for BAS 518 H and *Setaria italica* for pendimethalin which was applied as a standard.

In two experiments (A, B) the activity of BAS 518 H applied to the roots was compared with foliar sprays. Pots filled with soil II were sprayed in a spray chamber at the rates shown in Table 3 and the soil was mixed. Plants of G. aparine (5 per pot) were transplanted into the treated soil. In trial (A) the plants began to develop the 1st whorl of leaves, in (B) the plants already had 2 whorls of leaves. A second set of pots containing transplanted G. aparine were used for the foliar application at the same herbicide rates. Prior to this spraying a layer of activated charcoal was put on the soil surface to prevent herbicide reaching the roots.

Assessments were made visually on a 0 to 100 scale, 0 denoting no damage with emergence and growth like the untreated control, and 100 denoting no emergence or complete death of shoots.

The uptake of ^{14}C labelled 7-chloro-3-methyl-quinoline-8-carboxylic acid was studied in the laboratory with leaf discs using a method modified from that of Quimby & Nalewaja, 1971.

Field experiments using small plots from 2 to 60 m^2 were carried out at different times of the year with pre-emergence and post-emergence treatments at different growth stages of the crops and weeds. Twenty-four species occurring in the experimental field were tested with most emphasis on G. aparine. The crops were barley, wheat, maize, oilseed rape, potato, and sugarbeet. The soil was a light loamy sand with 15% particles < 20 μ, 1% o.m., pH (KCl) 5.2 and 34% waterholding capacity.

RESULTS AND DISCUSSION

Crop tolerance and weed control

BAS 518 H showed good tolerance to barley, wheat and oilseed rape when the compound was applied pre-emergence and post-emergence. Sugarbeets were more susceptible. However, the selectivity of BAS 518 H for sugarbeets was considerably better in the field than under glasshouse conditions (Table 1).

Amongst the weeds associated with these crops G. aparine and Veronica spp. were consistently controlled. The rate response curve was flat. On whole plants the visual symptoms for damage were similar to those caused by phenoxycarboxilic acids, substituted benzoic acids or picolinic acids.

2—7

TABLE 1

Crop tolerance and weed control with BAS 518 H in glasshouse and field screening trials.

Plants	Rate (kg/ha)	Damage (%)			
		pre-emergence		post-emergence	
		glasshouse	field	glasshouse	field
barley	0.5	0 (5)*	2 (15)	0 (6)	0 (31)
oilseed rape	0.5	7 (15)	0 (10)	1 (8)	0 (8)
wheat	0.5	2 (20)	0 (14)	1 (12)	0 (19)
sugarbeets	0.25	25 (18)	8 (19)	7 (21)	0 (32)
G. aparine	0.125	76 (14)	81 (6)	81 (20)	74 (31)
	0.25	89 (13)	93 (6)	87 (25)	87 (31)
	0.5	90 (14)	98 (6)	92 (26)	94 (31)
	1.0	93 (5)	100 (2)	94 (16)	96 (23)
Veronica spp.	0.125	87 (8)		89 (11)	90 (1)
	0.5	84 (7)		95 (11)	92 (5)

* in ( ) no. of pots and plots treated

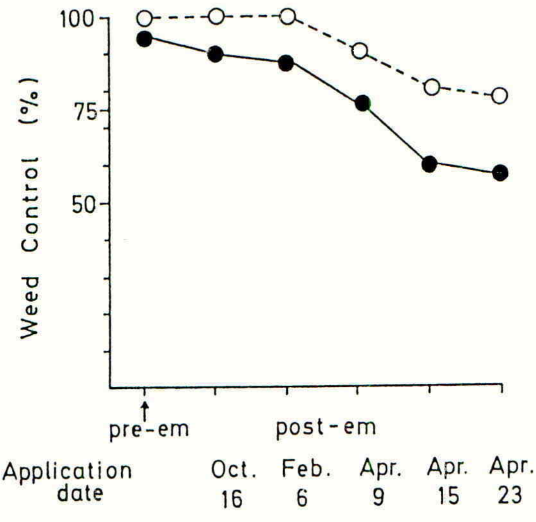


Fig. 1. The effect on G. aparine of application of BAS 518 H at 0.25 (●——●) and 0.5 kg/ha (o- - -o) at different dates in the field.

Application of BAS 518 H to G. aparine in oilseed rape was effective at all growth stages in winter or spring (Fig. 1). However, there was a decrease in efficacy with later applications to larger plants.

Although initial phytotoxicity symptoms could develop rapidly the plants died slowly. A satisfactory level of control was maintained over a considerable length of time regardless of the application date although early scorings were lower (Fig. 2).

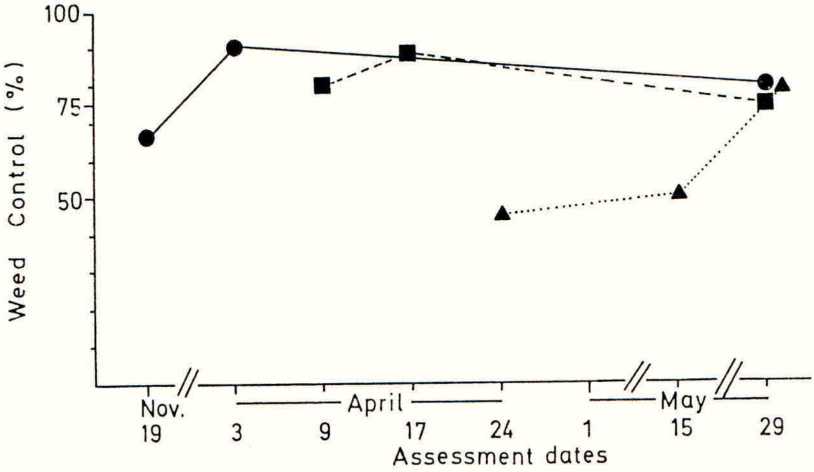


Fig. 2. Time course of the efficacy on G. aparine of BAS 518 H applied at 0.25 kg/ha on Oct. 16/84 (●—●): Feb. 6/85 (■--■); Apr. 9/85 (▲····▲).

Rate and site of uptake

BAS 518 H was taken up slowly by leaf discs of G. aparine and more rapidly by those of wheat (Table 2). In a separate experiment the post-emergence herbicide bentazone was applied in a similar manner to leaf discs of wheat. The equilibrium between the solution and the concentration in the leaf was reached within 40 min. For BAS 518 H this level was eventually achieved after 4 h.

TABLE 2
Uptake of ^{14}C labelled BAS 518 H (10^{-5} M) by leaf discs of G. aparine and wheat.

Plant species	uptake µg/g fresh weight at				
	2 h	4 h	8 h	24 h	48 h
G. aparine	0.58	0.75	0.87	2.07	3.28
wheat	0.89	1.51	2.42	5.57	10.74

2—7

The efficacy of BAS 518 H incorporated before planting G. aparine in pots was superior to foliar sprays when the soil surface was protected by activated charcoal indicating greater activity from root uptake on growing plants (Table 3).

TABLE 3

Activity of BAS 518 H via root exposure as compared with foliar sprays in two glasshouse trials.

Application method	Trial	Damage (%) to transplanted G. aparine rates (kg/ha)	
		0.06	0.125
post-em	A	32	55
	B	42	56
ppi	A	95	99
	B	64	84

TABLE 4

Movement of BAS 518 H in soil plates: herbicide applied above section 1, leached towards section 9.

	Soil type	Rate (kg/ha)	Damage (%) to carrots section no.								
			1	2	3	4	5	6	7	8	9
I	sandy loam 3.3% o.m.	0.125	0	10	80	95	95	98	98	70	15
II	loam soil	0.06	0	25	80	95	98	98	80	65	50
	1.7% o.m.	0.125	0	50	85	95	98	95	98	90	75
	Standard +	0.125	65	30	10	0	0	0	0	0	0
III	organic soil 26.1% o.m.	0.125	30	85	65	30	20	20	15	0	0

+ Standard herbicide, pendimethalin, Setaria italica as test plant

Soil behaviour

In mineral soils (I and II) considerable leaching of BAS 518 H took place whereas in the organic soil (III) the mobility was apparently far less. However, in the high organic matter soil BAS 518 H was also not as active as in soil I and II (Table 4).

Another factor increasing the reliability of BAS 518 H as a herbicide is its persistence in the soil. The inactivation proceeded slowly the 0.5 kg/ha rate still being phytotoxic 6 months after application (Fig. 3). The speed depended upon the soil temperature being much faster at 20 °C and at 30 °C than at 10 °C (Fig. 4).

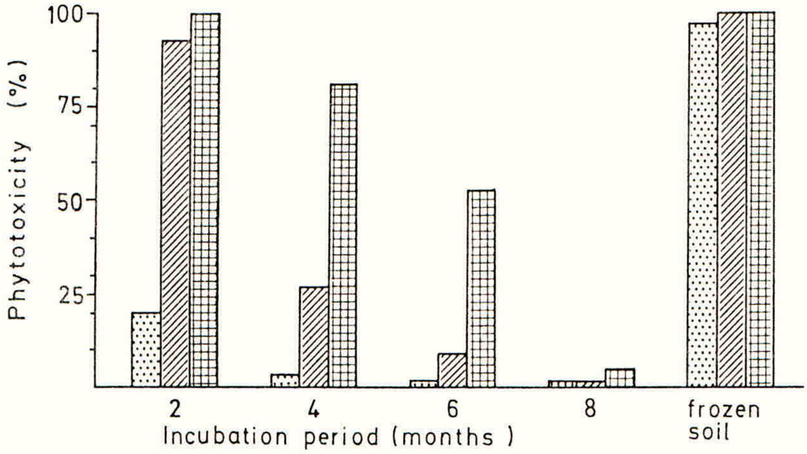


Fig. 3. The loss of activity of BAS 518 H at 0.125 (dotted): 0.25 (hatched): and 0.5 kg/ha (grid) in loam soil (II) at 20-22 °C as indicated by growth of carrots.

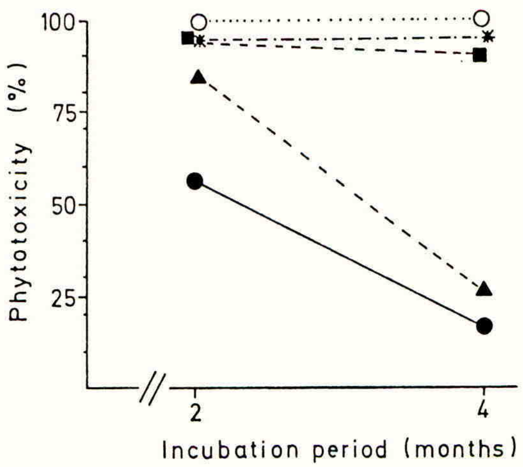


Fig. 4. The loss of activity of BAS 518 H (0.25 kg/ha) in loam soil II kept at various soil temp; frozen (O••••O): 10 °C (■---■): 20 °C (▲--▲); 30 °C (●——●) as compared with simazine 0.5 kg/ha at 20 °C (✱-·-✱)

In conclusion BAS 518 H can be considered as having a specific activity against certain weeds such as G. aparine. Although the time over which treatments can be made is long pre-emergence and earlier post-emergence applications are more preferable. Apart from foliar uptake root exposure appears to be important for effective control. Therefore, the mobility and the relatively slow degradation rate in the soil support its efficacy.

The further development of BAS 518 H particularly in combination with other herbicides is the subject of another report (Nuyken et al. 1985).

REFERENCES

Haden, E.; Menck, B.-H.: Honecker, H. (1985). Quinclorac (BAS 514 .. H) - a new herbicide to control Echinochloa spp. in rice. Proceedings British Crop Protection Conference - Weeds, (in press)

Nuyken, W.; Haden, E.: Menck, B.-H.; Klingenschmitt, D. (1985). BAS 518 H - a new herbicide for weed control in cereals rapeseed and sugarbeets. Proceedings British Crop Protection Conference - Weeds, (in press)

Quimby, P.C.; Nalewaja, J.D. (1971). Selectivity of dicamba in wheat and wild buckwheat. Weed Science 19, 598-601.

Wuerzer, B. (1983). Der Biotest zum Entdecken, Beschreiben und Wiederaufspüren von Wirkstoffen. Berichte Fachgebiet Herbologie der Universität Hohenheim, Heft 24, 13-22 (Symposium, Bioassays in Weed Science March, 15/16 1983, Stuttgart-Hohenheim).

Wuerzer, B.; Berghaus, R. (1985). Substituted quinolinecarboxilic acids - new elements in herbicide systems. Proceedings 10th Conference of the Asian-Pacific Weed Science Society, Chiangmai, Nov. 24-30, 1985.

BAS 518 H - A NEW HERBICIDE FOR WEED CONTROL IN CEREALS, RAPESEED AND SUGARBEETS

W. NUYKEN, E. HADEN, B.-H. MENCK, D. KLINGENSCHMITT

Agricultural Research Station of BASF Aktiengesellschaft, Limburgerhof, Germany

ABSTRACT

BAS 518 H (7-chloro-3-methylquinoline-8-carboxylic acid) is a new herbicide for the control of Galium aparine, Veronica hederaefolia and Lamium purpureum. It can be used in cereals, rapeseed and sugarbeets. Both pre- and post-emergence applications are effective because of root- and leaf uptake. BAS 518 H is a good compound to complement other selective herbicides like metazachlor, chlorotoluron, isoproturon and chloridazon to give improved weed control in different crops.

INTRODUCTION

In the last few years the need to control Galium aparine has increased. Even weed densities of 0.1 plant/m^2 can cause serious problems due to competition and interference with harvesting.

Other important weeds like Veronica spp. and Lamium spp. usually emerge in barley in autumn and flower and develop seeds in early spring. Phenoxy alkanoic herbicides, applied in spring time, are normally effective but viable seeds of Veronica- and Lamium spp. are frequently produced.

BAS 518 H (7-chloro-3-methylquinoline-8-carboxylic acid) is able to control these difficult weeds effectively. Other details for toxicology data and chemical structure have been recorded by Würzer et al (1985).

MATERIALS AND METHODS

All field trials with BAS 518 H alone and in combination with metazachlor, chlorotoluron, isoproturon and chloridazon were conducted between 1982 and 1984 in European countries including Great Britain, France, Sweden, Denmark, Germany, Belgium and the Netherlands.

A randomized block design with three to four replicates was used. With most trials herbicides were applied with a knapsack sprayer at 0.2-0.3 MPa pressure and spray volume rates between 200 and 400 l/ha.

BAS 518 H is formulated as a wettable powder containing 50 % active ingredient. Combinations with isoproturon, chlorotoluron, chloridazon and metazachlor were tankmixed. Assessment of crop damage and weed control performance were made on a percentage scale. Only that made in May is given in tables.

RESULTS

Selectivity and herbicidal efficacy of BAS 518 H

The selectivity of BAS 518 H was excellent in cereals and oilseed rape with more than 1.5 kg a.i./ha by pre- and post-emergence application (Table 1). This is nearly three times the rate which is used for the control of Galium aparine. All wheat, barley, rye and rapeseed cultivars tested were tolerant to BAS 518 H. In sugarbeet herbicide rates up to 0.5 kg a.i./ha were selective with both pre- and post-emergence treatments.

TABLE 1

Maximum rate of BAS 518 H (kg a.i./ha) not causing injury to four different crops

Crops	maximum rate without injury			
	pre-em autumn	post-em autumn	pre-em spring	post-em spring
winter barley	2.0	2.0	-	1.5
winter wheat	2.0	2.0	-	1.5
winter rape	2.0	2.0	-	2.0
sugarbeet	-	-	0.75	0.5

BAS 518 H controlled a number of important weed species, particularly Galium aparine, Veronica spp. and Lamium spp. (Table 2). Both pre- and post-emergence applications were effective.

Combination with metazachlor in winter rape

Metazachlor controls a wide range of grasses and weeds by pre- and early post-emergence application. But there are also a few gaps because of the need to control Galium aparine. BAS 518 H, at low rates, controls this important weed and complements the weed control spectrum of metazachlor. Pre-emergence applications are effective (Table 3) as well as post-emergence application in the autumn. Post-emergence application in spring were very effective on Galium aparine and Sonchus arvensis but not the other weeds.

TABLE 2

The effect of BAS 518 H (0.5 kg a.i./ha) applied in autumn or spring on a number of weed species in winter rape

Weed species	Weed control (%) assessed in May			
	pre-em autumn	post-em autumn	pre-em spring	post-em spring
Galium aparine	90 (6)	89 (8)	100 (2)	97 (7)
Lamium amplexicaule	85 (4)	69 (3)	70 (1)	16 (3)
Lamium purpureum	76 (3)	80 (2)	-	36 (5)
Sonchus arvensis	-	-	-	100 (3)
Urtica urens	-	-	-	63 (3)
Veronica hederaefolia	99 (3)	75 (4)	-	69 (4)
Veronica persica	93 (2)	98 (2)	88 (1)	65 (4)

( ) number of trials

TABLE 3

The effect of pre-emergence application of metazachlor alone or mixed with BAS 518 H on weeds in winter rape and on crop yield (% untreated)

Weeds/yield	Rate (kg a.i. /ha)	Weed control (%) on winter rape		
		metazachlor	metazachlor+BAS 518 H	
	n	1.5	1.25+0.25	1.25+0.5
Alopecurus myosuroides	5	98	98	99
Chamomilla recucita	5	100	100	100
Galium aparine	9	86	97	99
Lamium purpureum	3	99	100	100
Poa annua	3	100	100	100
Stellaria media	6	99	100	100
Veronica hederaefolia	4	100	100	100
Veronica persica	2	99	98	100
Viola arvensis	4	72	72	74
Viola tricolor	2	92	94	94
yield treated (%) untreated = 2.38 t/ha = A	2	117 (B)	117 (B)	121 (C)

n = number of trials
( ) Duncan's multiple range test (α = 0.05)

2—8

Combinations with chlorotoluron and isoproturon in cereals

These two grass killers - chlorotoluron and isoproturon - effective against Alopecurus myosuroides and Apera spica-venti and a few weeds like Stellaria media and Chamomilla recucita are available for cereals.

Chlorotoluron had little or no effect on Galium aparine and Veronica spp. (Table 4) but 0.5 kg a.i./ha of BAS 518 H improved control and can complement the weed spectrum of chlorotoluron applied pre- or post-emergence in the autumn.

The yield increase reflects the efficacy of chlorotoluron against grasses and BAS 518 H against Galium aparine.

Isoproturon is less effective than chlorotoluron against Galium aparine and Veronica spp. applied post-emergence in the autumn or spring. 0.5 kg a.i./ha of BAS 518 H was effective against these weeds (Table 5) and this treatment increased the yield significantly.

Thus a higher rate of BAS 518 H is needed for mixture with isoproturon than with chlorotoluron.

TABLE 4

The effect of chlorotoluron alone or mixed with BAS 518 H on weed control and crop yield in winter barley

		Weed control (%) in winter barley			
	Rate (kg a.i. /ha)	chlorotoluron 2.5		chlorotoluron+BAS 518 H 2.5+0.5	
Weeds/yield	n	pre-em autumn	post-em autumn	pre-em autumn	post-em autumn
Alopecurus myosuroides	12	95	94	95	95
Anthemis arvensis	2	85	82	99	86
Chamomilla recucita	4	100	100	100	100
Galium aparine	19	29	50	93	97
Lamium amplexicaule	6	99	100	99	100
Lamium purpureum	7	98	96	99	98
Myosotis arvensis	3	98	97	100	98
Thlaspi arvense	2	99	-	100	-
Veronica hederaefolia	12	29	44	89	97
Veronica persica	2	26	35	97	90
Viola arvensis	3	38	16	49	50
yield t/ha untreated = 6.4 t/ha = A	6	6.8 (B)	6.8 (B)	6.9 (B)	7.6 (C)

n = number of trials
( ) Duncan's multiple range test (α = 0.05)

TABLE 5

The effect of isoproturon alone or mixed with BAS 518 H on weed control and crop yield in wheat and barley

		Weed control (%) in winter barley and wheat			
	Rate (kg a.i. /ha)	isoproturon		isoproturon+BAS 518 H	
		post-emergence application			
		autumn	spring	autumn	spring
Weeds/yields	n	2.5	1.5	2.5+0.5	1.5+0.5
Alopecurus myosuroides	10	94	80	95	80
Anthemis arvensis	2	98	99	99	100
Apera spica-venti	3	100	86	100	88
Chamomilla recucita	4	100	97	100	99
Galium aparine	13	34	25	91	86
Lamium purpureum	2	64	56	88	90
Myosotis arvensis	2	43	36	75	38
Stellaria media	5	99	87	100	94
Veronica hederaefolia	4	34	23	95	94
Veronica persica	2	33	24	98	95
Viola arvensis	4	16	24	43	58
winter wheat yield t/ha	6	8.1 (B)	8.2 (B)	8.7 (C)	8.3 (B)
untreated = 7.75 t/ha = A					
winter barley yield t/ha	10	6.9 (B)	7.2 (C)	7.6 (D)	7.8 (D)
untreated = 6.0 t/ha = A					

n = number of trials
( ) Duncan's multiple range test (α = 0.05)

Combinations with chloridazon on sugarbeet

Because of the lower tolerance of sugarbeets to BAS 518 H rates of 0.125, 0.25 and 0.5 kg a.i./ha were tested together with chloridazon. Since chloridazon controlled Galium aparine up to 55 % and more, only a relative low rate of BAS 518 H may be needed in the tankmix.

DISCUSSION

BAS 518 H is a new quinoline-carboxylic-acid compound which is selective in cereals, rape and sugarbeets. It can be used in pre- and post-emergence applications.

Because of the limited weed spectrum (Galium aparine, Veronica spp. and Lamium spp.) BAS 518 H will need to be combined with other herbicides.

But commonly-used compounds, such as chlorotoluron and isoproturon in cereals, metazachlor in rape and chloridazon in sugarbeet, do not control these weeds.

BAS 518 H is therefore an ideal herbicide to apply in mixture with them. If the herbicides have some effect on <u>Galium aparine</u>, the rate of BAS 518 H can be lowered (0.125-0.5 kg a.i./ha). If the complementary herbicide however has no effect on <u>Galium aparine</u> at all higher rates of BAS 518 H (0.5 kg a.i./ha) are required.

Because of the short survey we could not give any information about dependencies on weed stage, soil type and soil moisture.

BAS 518 H is generally better uptaken by root than by leaf. Pre-emergence is therefore much better than post-emergence efficacy, when the weather conditions are dry and the temperature is high. A high soil moisture must also be given for good weed control. If the weed has developed more than six whorls it can cause less control of <u>Galium aparine</u>.

TABLE 6

The effect of chloridazon alone or in mixture with BAS 518 H on weed growth in sugarbeet

Weeds	Rate (kg a.i./ha) n	Weed control (%) on sugarbeets chloridazon 2.6	chloridazon+BAS 518 H 2.6+0.125	2.6+0.25	2.6+0.5
Atriplex patula	2	87	89	85	88
Chamomilla recucita	8	99	100	100	100
Chenopodium album	14	79	79	81	80
Galeopsis tetrahit	2	91	95	96	97
Galium aparine	18	55	88	94	97
Lamium purpureum	7	79	88	84	87
Mercurialis annua	8	48	56	55	63
Polygonum aviculare	3	87	82	82	94
Polygonum persicaria	7	74	78	78	79
Sinapis arvensis	3	96	94	92	92
Sonchus arvensis	2	95	95	98	97
Stellaria media	8	86	98	99	99
Viola arvensis	6	53	55	60	55

n = number of trials

REFERENCES

Würzer, B.; Berghaus, R.; Hagen, H.; Kohler, R.-D.; Markert, J.; (1985) Characteristics of the new herbicide BAS 518 H. <u>Proceedings 1985 British Crop Protection Conference-Weeds</u> (in press)

BAS 514 H - A NEW HERBICIDE TO CONTROL ECHINOCHLOA SPP. IN RICE

E. HADEN, B.-H. MENCK, H. HONECKER

Agricultural Research Station of BASF Aktiengesellschaft,
D-6703 Limburgerhof, W-Germany

ABSTRACT

BAS 514 H (3,7-dichloroquinoline-8-carboxylic acid) is a new herbicide with outstanding activity on *Echinochloa* spp. for direct seeded and transplanted rice. The product has been developed on a worldwide scale while in this paper reference is primarily to Southern Europe. The herbicide shows an excellent crop safety and the application timing is independent from the growth-stage of the weed. Best timing is from after the two to three leaf stage up to beginning of tillering. Trials in Southern European rice growing areas demonstrated, that 0.75 - 1.0 kg a.i./ha BAS 514 H or 0.5 - 0.75 kg a.i./ha BAS 514 H + 2.0 - 3.0 kg a.i./ha propanil, provided consistently good weed control. The herbicide can be applied into the water, onto water saturated soil and onto dry soil as well. The efficacy was improved by raising the water level for a short period after application.

INTRODUCTION

Rice is grown in ten southern European countries and the rice-growing area occupies a surface of 336 000 ha, equal to 0.25 % of the world rice growing area. Yields average around 5.1 t/ha indicate an intensive crop management. Total rice production in this area is equal to 1.7 million tons, 0.38 % of world production. Italy is the major European country producing rice, with more than 50 % of that grown on the continent. Next in area of rice-growing is Spain with 40 000 hectares (FAO 1983). In this paper, reference is primarily to rice grown in Italy and Spain.

Echinochloa spp. represent the prime problem for rice growers in Spain and Italy because of the cost of its control and also the extent of the damage it causes. Catizone (1973) found grain losses between 46 and 72 kg/ha for each 100 kg/ha of *Echinochloa* dry matter. The herbicides used are sometimes only moderately effective because the *Echinochloa* spp. have a long emergence period especially in clay soils. The period of emergence tends to be shorter on light soils or soils high in organic matter. The germination times also depend on the amount of water in the paddy. In general, water levels of 3 to 4 cm immediately after sowing favour a rapid germination of the genus, while higher water levels tend to retard its emergence. Thus, a proper water level in the paddy is a fundamental element controlling Echinochloa (Catizone 1983, Batalla Perez 1984).

From greenhouse-trials and initial field-trials there were informations, that BAS 514 H (chemical name 3,7-dichloroquinoline-8-carboxylic acid) was highly active against *Echinochloa crus-galli* and tolerated well by rice. Therefore this product was developed in rice for that purpose.

2—9

In this paper results refer to the control of Echinochloa crus-galli in rice growing areas of Italy and Spain.

MATERIALS AND METHODS

During the trial seasons of 1984 and 1985 the experimental herbicide BAS 514 H was tested in field-trials at several sites in Spain and Italy. Small plots (10 m^2) were used in a randomized block design with three replications. The herbicide was formulated as a wettable powder. The application was conducted by means of a knapsack-sprayer at a volume of 200 - 400 l water and a pressure of 300 kPa.

Rice as well as Echinochloa spp. were treated from crop stage 10 to 25. BAS 514 H was used in pre- and postemergence application. Assessments of crop tolerance, thinning and weed control were made one, two and three weeks after treatment. The final assessment was made after the emergence of the rice-panicle. The herbicide was applied onto the dry or drained field as well as into the water in which case plots were separated by sheets to hinder the product from moving out of the plot. After application two water management-systems were tested. Two or three days after treatment the paddy was flooded to a level of either 3 - 5 cm or 7 - 10 cm. As the crop grew the water level was continuously adjusted to the crop dry or according to local practice.

RESULTS

BAS 514 H a derivative of the quinolinic acid has good solubility in water with no fish toxicity. The active ingredient is taken up primarily through the root system of the plants. In a postemergence spray-application there is also a uptake trough the leaves. As far as the results indicate, BAS 514 H is effective against the following weeds in irrigated rice: Echinochloa spp., Aeschynomene spp., Cassia spp., Monochoria vaginalis, Oenanthe spp. and Sesbania spp. (Würzer and Berghaus 1985, Menck et al 1985).

The product is a herbicide for postemergence application. However promising studies are underway to prove a preemergence use in transplanted and direct-seeded rice.

Selectivity

BAS 514 H was selective on all cultivars of direct-seeded rice. Postemergence applications however showed, that rice-seedlings in an early growth stage were less tolerant.

The symptoms of damage - mainly with overdosage - were a sticking of the edges of the leaflets one to another (so called "onion leave") and a sticking of the top of the leaf to its base. But this damages had diminished at three weeks after treatment (Table 1) and did not cause any yield loss. System-application of BAS 514 H together with insecticides such as Carbaryl, Carbofuran, Monocrotophos and Parathion were also well tolerated.

TABLE 1

Selectivity of BAS 514 H applied at different times in direct-seeded rice with water level 3 - 5 cm after application

Rate (kg a.i./ha)	Growth stage of rice	10 - 12		13 - 17		17 - 21		21 - 25	
		Crop injury in %/thinning in %							
	Assessment	1.	4.	1.	4.	1.	4.	1.	4.
0.25		4/0	0/0	0/0	0/0	-	0/0	-	-
0.5		1/0	0/0	0/0	0/0	5/0	0/0	0/0	0/0
0.75		2,5/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
1.0		0/0	0/0	0/0	0/0	5/0	0/0	0/0	0/0
1.5		2/0	0/0	0/0	0/0	-	0/0	0/1	0/0
Number of trials		3		1		1		2	

Herbicidal efficacy

When BAS 514 H was applied at rates of 0.25 kg to 1.5 kg a.i./ha at several growth stages of Echinochloa crus-galli from two to three leaf stage to shooting) at least 0.75 kg a.i./ha was needed to obtain very good efficacy (95 %). With this rate plants at two to three leaf stage were controlled as well as older growth-stages (13 to 17) of the weed (Table 2). Because of its narrow range of activity, BAS 514 H needs to be used in mixture with other rice herbicides which are ineffective against Echinochloa species, such as 2,4-D, bentazon, propanil, thiobencarb, pyrazolate, simetryne, dimethametryn and pyrazoxyphen. With mixtures with propanil there were the same good results as reported for the BAS 514 H alone, but 0.5 kg a.i./ha BAS 514 H + 2.0 kg a.i./ha propanil performed as well as 1.0 kg a.i./ha of BAS 514 H alone. The results so far indicate that in mixtures the usual application rate of the components can be reduced by 20 - 40 % (Table 2).

To control older Echinochloa crus-galli (GS 21 - 25) 1.0 kg a.i./ha BAS 514 H + 3 kg a.i./ha propanil was needed (Table 3) with a further increase in the amount of herbicides gave good control of plants at the mid-tillering-stage (GS > 25).

2—9

TABLE 2

Efficacy of BAS 514 H and propanil in direct-seeded rice applied to E. crus-galli at two growth stages

Herbicide	Dose kg a.i./ha	Growth-stage 12 - 13 (15 - 21 DAS*) Assessment (DAT) 14	21	28	13 - 17 (29 - 35 DAS*) 7	14	21
BAS 514 H	0.25	86	83	77	73	68	15
	0.5	83	94	85	97	93	92
	0.75	92	97	92	100	100	100
	1,0	91	93	95	99	100	95
BAS 514 H + Propanil	0.25 + 2,0	96	75	84	99	98	95
	0.5 + 2.0	96	88	88	99	100	100
	0.25 + 3.0	95	83	84	100	99	97
	0.5 + 3.0	90	93	82	100	100	100
Propanil	5.4	90	38	38	89	89	91
No. of trials			1			1	

* DAS = Days after sowing
Water level after application = 7 - 10 cm

TABLE 3

Efficacy of BAS 514 H and propanil in direct-seeded rice applied to E. crus-galli at two growth stages

Herbicide	Dose kg a.i./ ha	Growth-stage Assessment (DAT)	21 - 25 (35 - 49 DAS*) 7	 14	 21	> 25 (> 49 DAS*) 7	 14	 21
BAS 514 H	0.5		80	84	83	77	77	82
	1.0		82	93	91	72	80	84
	1.5		95	96	97	83	98	96
BAS 514 H + Propanil	0.5 + 2,0		94	95	89	82	93	88
	1.0 + 2.0		97	97	95	93	97	97
	0.5 + 3.0		96	95	93	94	94	94
	1.0 + 3.0		98	97	96	95	97	97
BAS 514 H + Bentazon + Propanil	0.5 + 1.0 + 3.0		98	95	93	92	97	96
	1.0 + 1.0 + 2.0		98	97	95	91	97	95
Propanil	5.4		83	90	67	62	73	60
No. of trials				2			1	

* DAS = Days after sowing
Water level after application = 7 - 10 cm

2—9

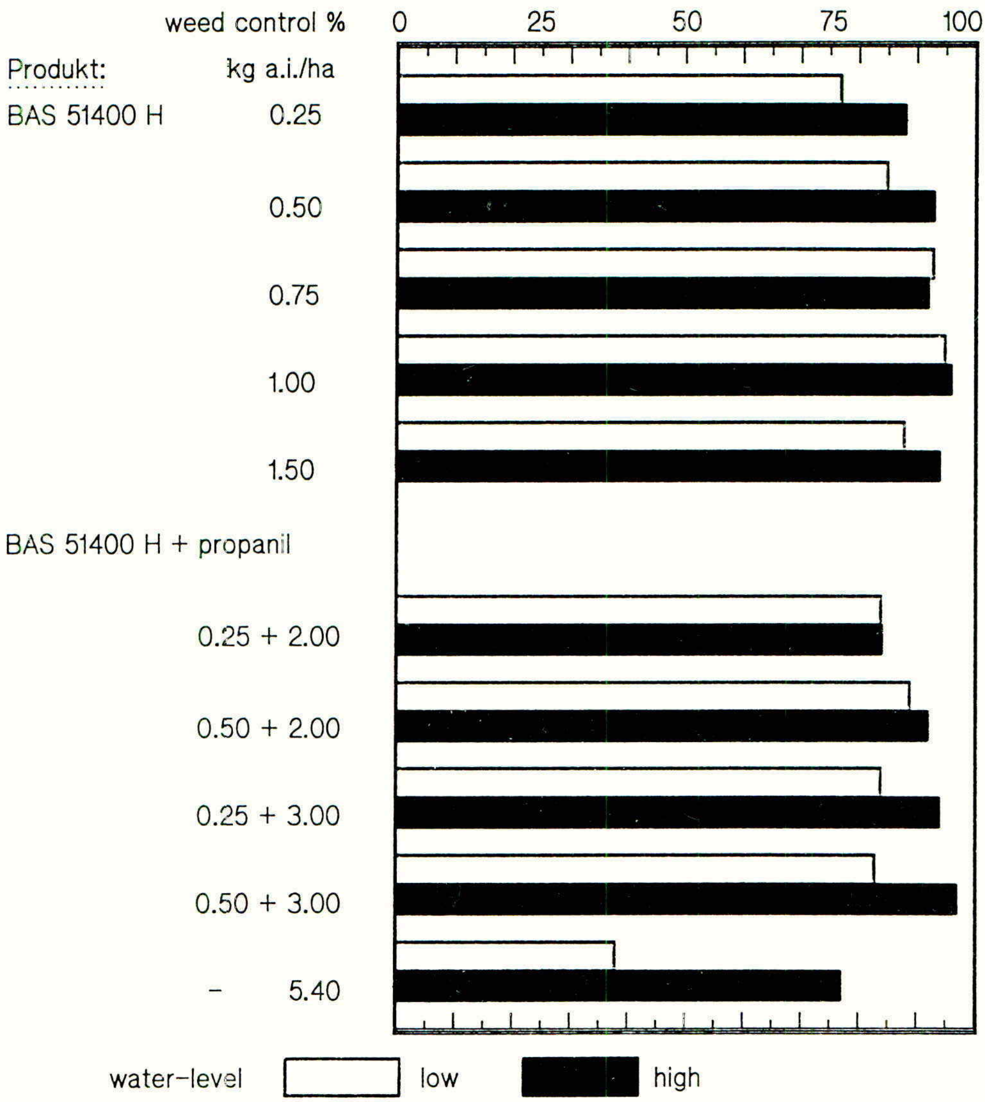


Fig.1 : The influence of water management on the efficacy of BAS 51400H and mixtures with propanil applied to Echinochloa crus-galli at growth stage 13.

Bentazon is used to control weeds of the families Alismataceae and Cyperaceae in the rice-growing system of southern Europe so the possibility of a mixture of BAS 514 H with bentazon was investigated. No antagonism between the components of the mixture BAS 514 H with propanil and bentazon was found (Table 3).

While for BAS 514 H alone no definite effect of different water management was apparent, the mixture with propanil appeared to be influenced by that factor (Figure 1).

DISCUSSION

In the last 15 years, most European rice growers have relied entirely on herbicides for weed control. Weed control today is generally considered to be satisfactory, although there are still unresolved problems.

Weed control in rice in Italy and Spain is basically directed toward meeting four objectives:

1. Control of weeds of the genus Echinochloa.
2. Control of weeds of the Alismataceae and the Cyperaceae.
3. Control of weeds peculiar to specific areas.
4. Control of algae.

Due to its broad weed-spectrum most rice-weeds are controlled by bentazon. This is an integrate part of the herbicide programme in rice-growing countries to meet the objectives 2. and 3. But for the control of the genus Echinochloa satisfactory treatments have not been available.

Independent of local cultivars of Southern Europe BAS 514 H now offers the possibility of controlling these weeds at all growth-stages of the weed and the crop and shows an excellent crop selectivity. Earliest time of application is the one to two leaf stage of the crop. The herbicide provides a rapid and reliable control of competitive weeds and the water-level may as high as is recommendable for an intensive rice-production without affecting performance. For the future BAS 514 H should be a valuable additional herbicide for the rice-producing system in southern Europe. Together with bentazon BAS 514 H provides a real solution to the weed-problems in rice.

REFERENCES

Batalla Perrez, J.A. (1984) Malas hierbas y herbicidas en el cultivo del arroz. 1º Symposium Nacional De Agroquimicos, Sevilla, Espana, pp 22.
Catizone, P. (1973) Results on chemical weed control in rice using oxadiazon (in Italian). Atti Giornate Fitopatologiche, 511 - 517.
Catizone, P. (1983) Weed Control Technology in Southern Europe. Proceedings Conference Weed Control in Rice, ed.: International Rice Research Institute, Manila, Phillipines, 183 - 193.
FAO (Food and Agriculture Organization) (1978) FAO production yearbook, Vol.37, Statistics Division of Economic and Social Policy Department, FAO, Rome, Italy, 110 - 111.
Würzer, B. and R. Berghaus (1985) Substituted quinolinecarboxilic acids - new elements in herbicide systems. 10th Asian Pacific Weed Science Society Conference, Chiang Mai, Thailand.
Menck, B.-H., Rosebrock, H., Unglaub, W. and E. Kibler (1985) BAS 514 .. H - Quinclorac field experience to control Echinochloa crus-galli in rice. 10th Asian Pacific Weed Science Society Conf., Chiang Mai, Thailand.

CYCLOXYDIM (BAS 517 H) - A NEW POST-EMERGENCE HERBICIDE TO CONTROL GRASSES IN BROADLEAVED CROPS, EXPERIENCE FROM FIELD TRIALS

W. ZWICK, B.-H. MENCK, W. NUYKEN

Agricultural Research Station of BASF Aktiengesellschaft, Limburgerhof, Federal Republic of Germany

ABSTRACT

BAS 517 H, 2- 1-(ethoxyimino)butyl -3-hydroxy-5-(2_H_-tetrahydrothiopyran-3-yl)-2-cyclohexen-1-one, is a new post-emergence herbicide for selective control of annual and perennial grasses primarily for use in broadleaf crops.

Safe use (with rates up to 2 kg a.i./ha) in numerous crops and effective control of annual grasses with 0.1-0.25 kg a.i./ha and of perennial grasses with 0.2-0.5 kg a.i./ha have been demonstrated in numerous field trials during the last 3 years.

INTRODUCTION

BAS 517 H was synthesized and developed by BASF Aktiengesellschaft, Federal Republic of Germany, as a post-emergence herbicide which controls most grasses as an overall spray. It is suitable for conventional cropping- and weed control-systems and also for minimum-tillage systems.

This paper reports results of some of the field trials carried out in different agricultural crops and locations in Western Europe, North and Latin America from 1983 to 1985.

MATERIALS AND METHODS

All field trials were randomized block designs with three to four replicates and a plot size of 2 x 6-10 m. BAS 517 H was applied with air- or CO_2-pressurized knapsack sprayers fitted with Teejet nozzles size 8002. Spray volume ranged between 100-400 l/ha with a pressure of 0.25-0.3 MPa.

Visual assessments for crop injury and herbicidal efficacy were made one, three and six weeks after application using a scale of 0-100 %.

RESULTS

Crop tolerance

All non-graminaceous crops tested so far showed excellent tolerance at all growth and development stages to BAS 517 H applied at up to 2 kg a.i./ha (4 to 20 times of effective rates) and 1.5 l/ha oil concentrate.

2—10

TABLE 1

Crops tested so far and shown to be tolerant to BAS 517 H

alfalfa	mangos
phaseolus-beans	mustard
faba-beans	onions
beets	oranges
cabbage	peanuts
cacao	field-peas
carrots	potatoes
chicory	rape
clover	lettuce
coffee	soybeans
cotton	spinach
flax	sunflowers
pome-fruits	tobacco
guavas	tulips
hevea	vine
lemons	

Graminaceous crops like barley, corn, oats, rice, grain, sorghum and wheat are sensitive to BAS 517 H and consequently can be controlled as voluntary cereals in non-graminaceous crops.

Sensitivity of grasses

TABLE 2

Effective control of grass species with BAS 517 H

a) Annual species (0.1-0.15 kg a.i./ha)

Alopecurus myosuroides	Digitaria sanguinalis	Panicum dichotomiflorum
Avena fatua	Echinochloa colonum	Panicum miliaceum
Avena ludoviciana	Echinochloa crus-galli	Panicum texanum
Avena sativa	Eleusine africana	Pennisetum glaucum
Agrostis scabra	Eleusine indica	Secale cereale
Brachiaria plantaginea	Eragrostis cilianensis	Setaria faberii
Brachiaria platyphylla	Eragrostis pilosa	Setaria lutescens
Bromus diandrus	Eriochloa gracilis	Setaria verticillata
Cenchrus echinatus	Hordeum vulgare	Setaria viridis
Cenchrus pauciflorus	Lolium multiflorum	Sorghum vulgare
Dactyloctenium aegyptum	Panicum capillare	Triticum aestivum
		Zea mays

b) Perennial species (0.2-0.4 kg a.i./ha)

Elymus repens (Agropyron repens)
Sorghum halepense
Cynodon dactylon

c) Resistant species

Festuca rubra
Poa annua

Application technique and additives

Being a post-emergence herbicide BAS 517 H should cover the surface of target plants intensively. But lower spray volumes (e.g., 50 l/ha) were more effective than higher volumes (200 and 400 l/ha) if good distribution of fine droplets was achieved. An adjuvant, 1.0-1.5 l/ha of a crop oil concentrate, increased the activity of BAS 517 H.

Application time

The best grass control was achieved when grasses were actively growing. Drought spells as well as cool temperatures (under 15^{o}C) or other stress factors might reduce the herbicidal efficacy. The best control of annual grasses was obtained from applications at one to three leaf stage.

Annual grasses

Results from Spain demonstrated the susceptibility of grass species to different rates of BAS 517 H. Digitaria sanguinalis and Echinochloa crus-galli were more sensitive and were controlled by lower rates than Avena ludoviciana or Bromus diandrus (Table 3).

TABLE 3

Efficacy of BAS 517 H + 1.5 l/ha oil concentrate applied to grasses at the two to three leafstage in Spain

Herbicide Rate kg a.i./ha	Weed control (%) 42 DAT Avena ludoviciana n = 2	Bromus diandrus n = 2	Digitaria sanguinalis n = 3	Echinochloa crus-galli n = 2
0.05	71 (66)	72 (2)	97 (2)	95 (0)
0.10	79 (30)	92 (9)	99 (0)	99 (0)
0.15	96 (5)	98 (2)	100 (0)	100 (0)
0.20	97 (4)	100 (1)	100 (0)	100 (0)

n = number of experiments; ( ) standard deviation

Five important annual grasses in Brazil were controlled effectively at the two to three leaf stage by 0.05 kg a.i./ha and almost completely by 0.1 kg a.i./ha (Table 4).

TABLE 4

Activity of BAS 517 H + 1.0 l/ha oil concentrate applied at the two to three leafstage in Brazil

Herbicide Rate kg a.i./ha	Weed control (%) 42 DAT Brachiaria plantaginea n = 8	Cenchrus echinatus n = 16	Digitaria sanguinalis n = 17	Eleusine indica n = 15	Panicum miliaceum n = 6
0.05	92 (11)	90 (9)	96 (3)	93 (6)	91 (15)
0.1	99 (1)	98 (2)	98 (2)	99 (1)	100 (0)
0.2	99 (1)	99 (1)	100 (1)	100 (0)	100 (0)

n = number of experiments; ( ) standard deviation

Digitaria sanguinalis showed less rate response than the other grasses.

Similar results were obtained in the USA. Common annual grasses in soybean fields could be killed by 0.1 kg a.i./ha. Setarias lutescens needed higher rates in comparison to other important species like S. faberii and S. viridis.

TABLE 5

Efficacy in soybeans of BAS 517 H + 1.5 l/ha oil concentrate applied to grasses at the two to three leafstage (USA)

Herbicide Rate kg a.i./ha	Weed control (%) 25-42 DAT Setaria faberii n = 7	Setaria lutescens n = 1	Setaria viridis n = 1	Sorghum vulgare n = 1
0.05	89 (9)	77 (0)	96 (15)	100 (0)
0.10	97 (4)	99 (2)	100 (0)	100 (0)
0.20	98 (3)	100 (0)	100 (0)	100 (0)

n = number of experiments; ( ) standard deviation

Avena fatua - a typical annual grass of the Canadian prairies was susceptible to 0.1 kg a.i./ha of BAS 517 H whereas volunteer cereals needed 0.15 kg a.i./ha (Table 6).

TABLE 6

Efficacy in rapeseed and flax of BAS 517 H + 1.0 l/ha oil concentrate applied to grasses at the two to three leaf stage in Canola, Canada

Herbicide Rate kg a.i./ha	Weed control (%) 42 DAT Avena fatua n = 7	Volunteer barley n = 3	Volunteer wheat n = 3
0.1	95 (6)	72 (11)	88 (11)
0.15	96 (8)	94 (5)	100 (0)
0.2	99 (2)	100 (0)	100 (0)

n = number of experiments; ( ) standard deviation

Volunteer cereals (wheat and barley) were less sensitiv, but Zea mays could be effectively controlled by 0.1 kg a.i./ha of BAS 517 H.

Perennial grasses

BAS 517 H has proved effective on Sorghum halepense when applied at 20-40 cm height of plants in several countries.

TABLE 7

The effect of BAS 517 H applied to Sorghum halepense (rhizome) in the USA

Herbicide Rate, kg a.i./ha	Weed control (%) Single application 42-46 DAT n = 2	Split application[1] 42-46 DAT n = 2
0.2	92 (12)	
0.1+0.1		72 (15)
0.4	98 (4)	
0.2+0.2		98 (2)
0.5	98 (4)	
0.3+0.2		99 (2)

Sorghum halepene is harder to control when germinating out of rhizomes. The table showes, that 0.2 kg a.i./ha controlled S. halepense already to more than 90 %. A split application could not improve this effect. Obviously 0.1 kg a.i./ha was too low as first treatment. Split application, however, was able to prolong the residual effect on Cynodon dactylon and Elymus repens.

DISCUSSION

BAS 517 H is a highly selective post-emergence grass herbicide with systemic effect. Pre-emergence activity is very low. Applied in an early development stage, when grasses are actively growing, it controls a wide variation of annual and perennial grasses. Timing is important. One- to three-leafstage for annual grasses and post tillerstage for perennial grasses were effective. Inadequate timing can not be compensated by higher rates.

A lower spray volume (50 l/a) was more effective than higher volumes of 200-400 l/ha. The active ingredient of BAS 517 H is taken up by plants within one hour and subsequent rainfalls did not reduce the activity. BAS 517 H can be combined in tankmix or in a sequential application with herbicides used for dicotyledoneous weeds.

[1] 1st application at growth stage 26-30 = formation of tillers - length of leaf sheets;
2nd application = 24 days after first application.
( ) = standard deviation

ACKNOWLEDGEMENTS

The assistance of other members of BASF Aktiengesellschaft in the execution of the trials and for supplying materials and technical data, respectively, is acknowledged.

REFERENCES

Meyer, N.; Jahn, D.; Retzlaff, G.; Würzer, B. (1985) BAS 517 H, A NEW CYCLOHEXENONE GRAMINICIDE. Proceedings 1985 British Crop Protection Conference-Weeds (in press).

BAS 517 H A NEW CYCLOHEXENONE GRAMINICIDE

N. MEYER, D. JAHN, G. RETZLAFF, B. WUERZER
BASF Aktiengesellschaft, Landwirtschaftliche Versuchsstation,
D-6703 Limburgerhof, FR Germany

ABSTRACT

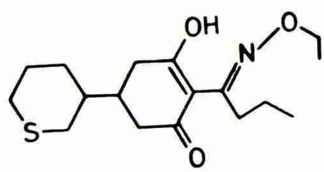
BAS 517 H, 2-[1-(ethoxyimino)butyl]-3-hydroxy-5-(thian-3-yl)cyclohex-2-enone, proposed common name cycloxydim, is a new post-emergence grass herbicide originated at BASF Aktiengesellschaft. BAS 517 H is very effective at low rates against a broad spectrum of grass species growing under various climatic conditions. It controls annual and perennial grasses at a wide range of growth stages. Excellent selectivity has been demonstrated in all non-graminaceous crops.

INTRODUCTION

BAS 517 H is a new herbicide from the chemical group of the cyclohexenones currently being developed by BASF for the post-emergence control of grass weeds in broadleaf crops. This paper provides general information on BAS 517 H and reports on a summary of results from glasshouse trials and laboratory investigations.

Chemical and physical properties

Chemical name: 2-[1-(ethoxyimino)butyl]-3-hydroxy-5-(thian-3-yl)cyclohex-2-enone,



Proposed common name: cycloxydim
Patent : US 4422864
Molecular weight : 325.46
Appearance : colourless, crystalline
Melting point : 37-39 °C
Vapour pressure at 20°C : < 1 x10^{-7} mbar
Water solubility at 20°C : 8.5 mg/100g
Solubility in organic solvents at 20°C: soluble in most organic solvents
Formulation : e.c. containing 200 g a.i./l

Toxicity of technical material

The acute oral toxicity tested in the rat resulted in a LD_{50} of 3490 mg/kg; the dermal LD_{50} in the rat was >2000 mg/kg. No symptoms of poisoning or local irritation occurred. The undiluted compound did not cause irritation when applied to the rabbit's skin and only slight irritation to the rabbit's eye. The technical product is non-toxic to bees and non-mutagenic as determined by the Ames test. First results from a subchronic and chronic rat study indicate a no observed effect level of 100 ppm.

Mode of action

So far the mode of action of BAS 517 H has been only partly elucidated. There is some evidence that it has an effect on lipid biosynthesis.

With highly sensitive grass species such as Setaria italica a cessation of growth can be observed within 8 hours in the glasshouse if the temperature is above 25°C. This is followed by a yellowing of the younger leaves and tissue disintegration. In certain plants e.g. Sorghum halepense anthocyan formation can also occur. The necrosis spreads from the younger leaves to the shoot and slowly the whole plant dies. In contrast to the younger leaves, the colour of the older leaves does not alter. They whither and die as in a normal senescence.

Metabolism

The rapid breakdown of BAS 517 H in the soil and plants occurs via oxydation, conjugation, rearrangement, hydroxylation and reductive ether-cleavage. Degradation shows similarities to the breakdown of sethoxydim {2-[1-(ethoxyimino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one}. (YONG-ZHENG et al., 1983) Since the breakdown of BAS 517 H will be published separately, only the four main metabolites are presented in Fig. 1 (HUBER, 1985).

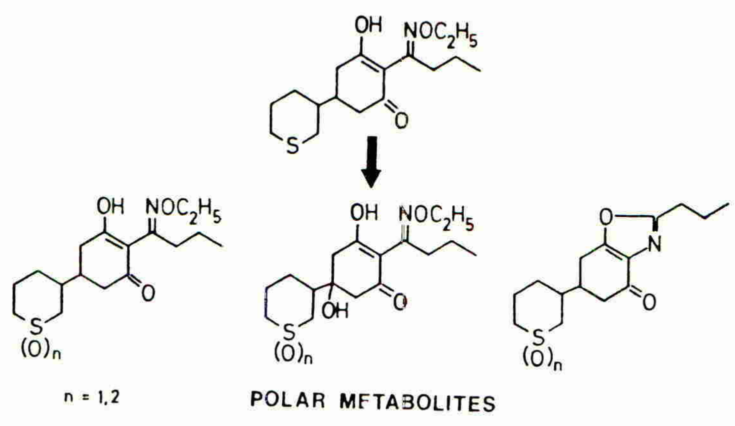


Fig. 1. The main initial metabolites of BAS 517 H

MATERIALS AND METHODS

The uptake of BAS 517 H was examined with radiolabelled herbicide using plants grown under controlled environmental conditions. 0,06 g ^{14}C-BAS 517 H was applied to a constant surface area per leaf and plant (specific radioactivity 10.8 mCi/mM radiolabel: 4.6 -^{14}C).

At different time intervals ^{14}C-BAS 517 H treated leaves were washed with a water/methanol/isooctyl-phenol x 6 ethylenoxid-mixture to remove residues of the herbicide that had not penetrated the leaf. Both the treated leaves and the rest of the plant were combusted in a sample oxidizer (JN 4101, Oxymat). The evolved $^{14}CO_2$ was absorbed in an appropriate liquid scintillation cocktail and radioassayed in a SL 30 Intertechnique Scintillation Counter (KOBAYASHI, 1974).

Experiments to determine the herbicide efficacy and spectrum of activity of BAS 517 H were carried out under normal glasshouse conditions. In the visual scorings 0 denotes no damage and 100 total damage. Residual activity was investigated by methods described by GERBER et al. (1975), but modified to suit own requirements.

RESULTS AND DISCUSSION

Uptake

The uptake of BAS 517 H has been studied in established plants. The active ingredient is primarily absorbed through the green parts but also through the roots. As shown by wash-off trials involving ^{14}C BAS 517 H, the foliar penetration is very rapid (Fig. 2).

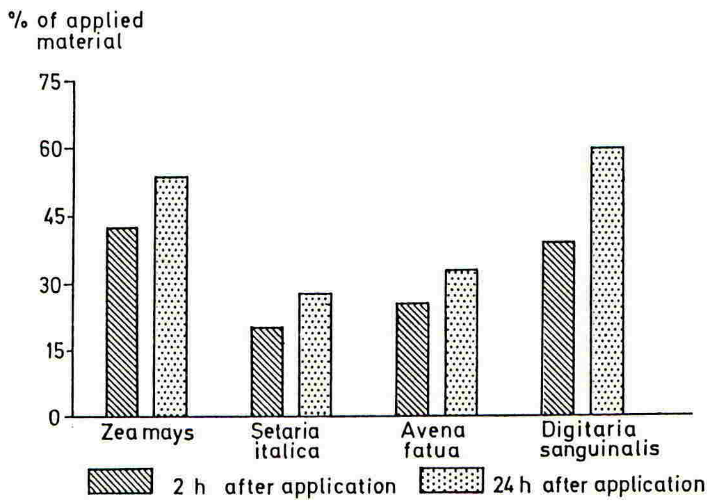


Fig. 2. The foliar uptake of BAS 517 H by four species

The rate of uptake is influenced by the temperature and is approximately twice as high at 35°C compared with 5°C. In both susceptible and insensitive plants the main translocation route of BAS 517 H is acropetal (HAMM, 1985).

Spectrum and level of activity under glasshouse conditions

Nearly all annual and perennial grasses are sensitive to BAS 517 H. The species of weeds controlled in the dose range 0.03-0.25 kg a.i./ha includes those listed in table 1.

TABLE 1

Gramineae sensitive to 0.03 - 0.25 kg a.i./ha

Alopecurus myosuroides	Elymus repens
Avena spp.	Hordeum vulgare
Brachiaria spp.	Oryza sativa
Cenchrus echinatus	Panicum spp.
Cynodon dactylon	Setaria spp.
Digitaria spp.	Sorghum halepense
Echinochloa crus-galli	Triticum aestivum
Eleusine indica	Zea mays

A high degree of tolerance is shown by Poa annua and Festuca rubra. A more comprehensive list of weed species controlled by BAS 517 H has been published (BASF, 1984).

Results of field trials and more precise application rates are dealt with in a separate report (ZWICK et al., 1985).

The level of activity of BAS 517 H is greatly increased by non-phytotoxic crop oils and surfactants.

The selectivity of BAS 517 H has been evaluated in glasshouse trials in many broadleaf crops and those not belonging to the graminaceous family. No injury has been observed with treatments at rates significantly higher than those required for effective grass control (Table 2).

TABLE 2

The tolerance of different crops and grasses to post-emergence applications of BAS 517 H at increasing doses

Plant	kg a.i./ha		% Plant damage			
	0.015	0.03	0.06	0.125	0.25	0.5
soyabean	< 5	< 5	< 5	< 5	< 5	< 5
sugar beet	0	0	0	0	0	0
Alopecurus myosuroides	74	93	95	97	98	99
Avena fatua	84	95	97	98	98	99
Digitaria sanguinalis	95	98	99	99	99	99
Echinochloa crus-galli	76	93	98	100	100	100
Setaria faberii	87	93	98	99	99	100
Sorghum halepense	60	79	87	92	94	95

Soil behaviour

The loss of herbicide activity in a loam soil was investigated using a bioassay with Avena sativa as test plant. In these trials the herbicide was applied to the soil surface of filled glasshouse pots at a rate of 0.125 kg a.i./ha. Thereafter the contents were poured into plastic bags and shaken vigorously to simulate incorporation of the herbicide. This soil was then kept, either frozen at temperatures of 20-22°C below zero, or incubated at temperatures of 20-22°C. At intervals of 2,4,8 and 12 weeks after treatment, soil samples were returned to the glasshouse and planted with Avena sativa (Fig. 3).

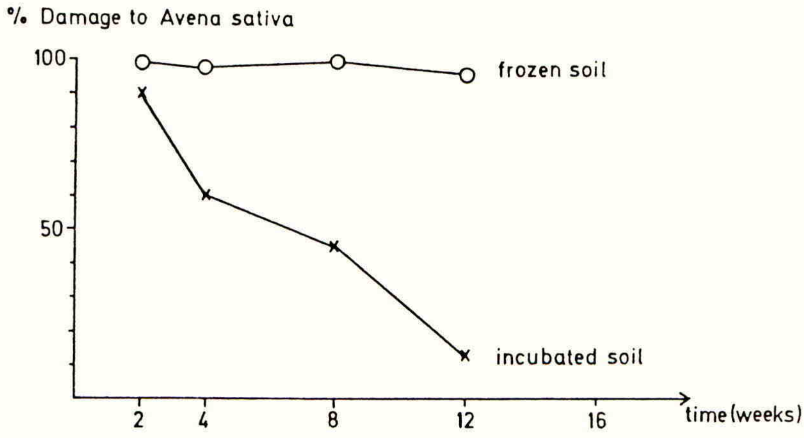


Fig. 3. The loss of activity of BAS 517 H in loam soil

2—11

BAS 517 H is being developed as a post-emergence herbicide. However, the compound itself does show pre-emergence activity (Fig.4), which can increase its efficacy under certain conditions.

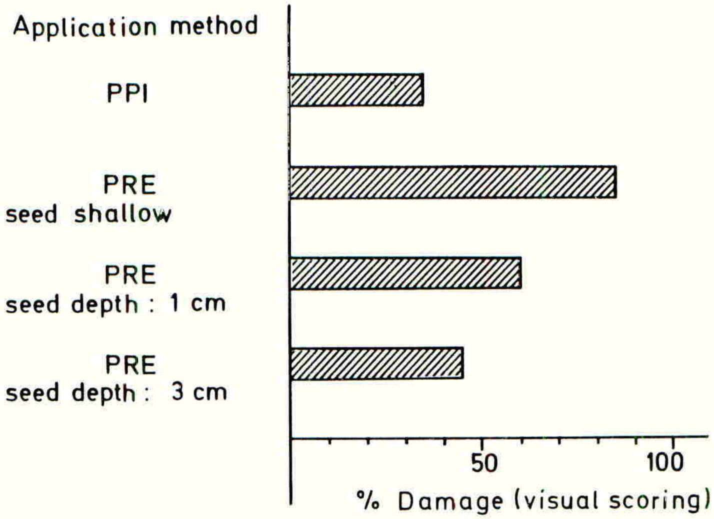


Fig. 4. The pre-emergence activity of BAS 517 H on oats assessed 4 weeks after treatment

REFERENCES

BASF (1984) APE/EH, BAS 517 01 H, Technisches Merkblatt.

BASF (1985) APE/RZ, BAS 517 H, Toxicological Data, (unpublished).

GERBER, H. R.: EBNER, L.; FREI, P.: BIERINGER, H. (1975). Biotestmethode zur Prüfung des Abbauverhaltens eines Bodenherbizides unter standardisierten Laborbedingungen. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, Sonderheft VII, 169-175.

HAMM, R.T. (1985) Lab Report 2112, Uptake and Transport of BAS 517 H, BASF APE/R, (unpublished).

HUBER, R. (1985) BASF APE/R. (unpublished results).

AKOBAYASHI, Y.; MANDSLEY, D.V. (1974). Biological application of liquid scintillation counting, Academic Press, New York.

YONG-ZHENG, C.; CHING-BORE, W.; PENNER, D. (1983). Plant metabolism of sethoxydim. Abstracts, Meeting of the Weed Science Society of America, 82.

ZWICK, W.; MENCK, B.-H.; NUYKEN, W. (1985). Cycloxydim (BAS 517 H) - A new post-emergence herbicide to control grasses in broadleaved crops, experience from field trials. Proceedings British Crop Protection Conference-Weeds, (in press).

AC 263,499: A NEW BROAD-SPECTRUM HERBICIDE FOR USE IN SOYBEANS AND OTHER LEGUMES

T. R. PEOPLES, T. WANG, R. R. FINE, P. L. ORWICK, S. E. GRAHAM, AND K. KIRKLAND

American Cyanamid Company, Princeton, New Jersey, U.S.A.

ABSTRACT

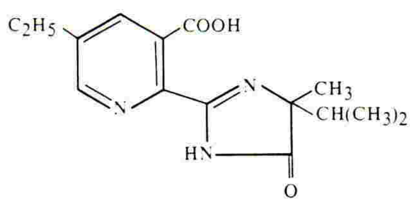
A new broad-spectrum herbicide, (±)-5-ethyl-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid, is being developed by American Cyanamid Company under the code number AC 263,499. The compound has provided excellent control of many major annual and perennial grass and broad-leaved weeds in soybeans and in other leguminous crops such as Phaseolus beans, peas, spring broad beans, chickpeas, and seedling and established lucerne (alfalfa). AC 263,499 may be applied pre-plant incorporated, pre-emergence, at cracking, or post-emergence.

INTRODUCTION

A new broad-spectrum herbicide, (±)-5-ethyl-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid, was discovered at American Cyanamid Company's Agricultural Research Centre in Princeton, New Jersey, U.S.A. The compound, coded AC 263,499, is currently under field evaluation in soybeans and other leguminous crops worldwide (American Cyanamid Company, 1985).

Chemical name and physical properties

The chemical name for AC 263,499 is (±)-5-ethyl-2-(4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid. The structural formula is:



The molecular formula for AC 263,499 is $C_{15}H_{19}N_3O_3$ and its molecular weight is 289.3.

AC 263,499 is an odourless white to off-white crystalline solid with a melting point of 172 to 175 °C and a water solubility of 1415 ppm at 25 °C.

Formulations tested

AC 263,499 is formulated as aqueous solutions containing various concentrations of acid equivalent (ae).

Mode of action

AC 263,499 is absorbed by the roots and foliage of plants and translocated in the xylem and phloem, with accumulation in the meristematic regions. With foliar application, susceptible weeds stop growing soon after treatment and die within two to four weeks depending upon species and size. With soil application, some susceptible weeds may emerge from the treated soil and remain as stunted plants before they die.

As with other imidazolinone herbicides, AC 263,499 acts by reducing the levels of three branched-chain aliphatic amino acids, valine, leucine, and isoleucine, through the inhibition of acetohydroxyacid synthase (AHAS), an enzyme common to the biosynthetic pathway of these amino acids. This inhibition causes a disruption of protein synthesis, which, in turn, leads to an interference in DNA synthesis and cell growth (Shaner et al., 1984a & b). The biosynthesis of these three amino acids and the site of inhibition do not occur in animals, which partially explains the low mammalian toxicity of AC 263,499 herbicide.

Differential metabolism of AC 263,499 in plants is important in determining species susceptibility in that tolerant species metabolise the herbicide more rapidly than susceptible ones. The half-life of AC 263,499 in soybeans is 1.6 days.

Toxicology

The acute toxicity of AC 263,499 technical is summarised in Table 1. The product is considered to be practically non-toxic by ingestion of a single dose and no more than slightly toxic by single skin application.

TABLE 1

Acute mammalian toxicity of AC 263,499 technical

Test Species & sex	LD_{50} (mg/kg body weight) or result
Oral	
Rat, male & female	>5000
Mouse, female	>5000
Dermal	
Rabbit, male & female	>2000
Eye Irritation	
Rabbit, male	Reversible[1]
Skin Irritation	
Rabbit, male	Mild

[1]Complete recovery in three days.

In a 28-day dietary study with rats, the no-effect level of AC 263,499 technical was 10,000 ppm in the diet, the highest dose level tested.

Mutagenicity

AC 263,499 is non-mutagenic as determined in the Ames test (Ames et al., 1975).

Rat metabolism

When ^{14}C-labelled AC 263,499 technical was fed to rats, 92% of the total radioactivity was excreted in the urine and 5% in the faeces within 24 hours. At 48 hours after dosing, residue levels in blood and in liver, kidney, muscle, and fat tissues were <0.01 ppm.

MATERIALS AND METHODS

Unless otherwise stated, results reviewed and presented are from replicated small-plot trials laid out in farmers' fields. Herbicide applications were made with various types of plot sprayers delivering from 200 to 500 l/ha at pressures ranging from 1500 to 2250 mm Hg. Doses tested in selectivity trials ranged from 50 to 450 g ae/ha and from 35 to 300 g ae/ha in efficacy trials. AC 263,499 treatments were applied pre-plant incorporated, pre-emergence, at cracking (between the cracking of the soil surface and the emergence of the soybean cotyledons), or post-emergence to the crop. All post-emergence treatments included 0.25% (wt/wt ai) of a non-ionic surfactant. Randomised block designs with three or four replications were used. Various methods indicated in the relevant tables were used to assess weed control.

RESULTS

Crop tolerance

In general, members of the Leguminosae were tolerant of AC 263,499 applications at doses required for weed control. Field trials showed excellent crop safety for soybeans, *Phaseolus* beans, peas, spring broad beans, chickpeas, and seedling and established lucerne.

Soybeans

In Brazil, Canada, France, Italy, and the United States, both determinate and indeterminate cultivars of soybeans showed tolerance to AC 263,499 applied pre-plant incorporated, pre-emergence, at cracking, or post-emergence at doses ranging from 35 to 300 g ae/ha. Occasionally, temporary leaf crinkling, slightly shortened internodes, and interveinal chlorosis were observed with applications of 250 g ae/ha or more at the unifoliate to the first trifoliate stage of the soybean.

In field trials in France and Italy, temporary dwarfing of the treated soybeans occurred; this effect was less severe with pre-emergence or cracking treatments than with post-emergence treatments. In Italy, temporary dwarfing of the soybeans was observed when AC 263,499 was applied post-emergence at 100 or 200 g ae/ha or pre-emergence at 300 g ae/ha. The plants completely recovered by approximately 30 days after treatment.

These symptoms are transitory and have no effect on yields as demonstrated in field trials in Brazil. In these trials, soybeans treated pre-emergence or post-emergence with AC 263,499 at 50 to 150 g ae/ha produced yields comparable to the hand-weeded controls and equal to or greater than the standard herbicide treatments (Table 2). Superior yields were also obtained with pre-plant incorporated treatments of AC 263,499 at 100 g ae/ha.

Other leguminous crops

Results from trials in Italy indicate that garden peas and broad beans were tolerant of AC 263,499 at a dose of 450 g ae/ha applied pre-emergence or at cracking and a dose of 300 g ae/ha applied post-emergence (Table 3). *Phaseolus* beans showed tolerance to pre-emergence applications of AC 263,499 at 450 g ae/ha and to cracking and post-emergence treatments at lower doses (250 and 300 g ae/ha, respectively). Chickpea was the most sensitive crop tested, with the maximum safe dose for pre-emergence, cracking and post-emergence treatments being 200, 300, and 100 g ae/ha of AC 263,499, respectively.

Limited field testing with lucerne (alfalfa) was conducted in the United States. Post-emergence treatments were selective in seedling, established, and dormant lucerne, while pre-plant incorporated and pre-emergence treatments caused a reduction in stand and vigour. Both seedling and established lucerne were tolerant of AC 263,499 at a maximum dosage of 280 g ae/ha.

TABLE 2

Average yield of soybeans treated with AC 263,499 (Brazil, 1985)

Compound	Dose (g ae or ai/ha)	Avg. yield (kg/ha) at various application timings[1] PPI[2]	PRE	POST
AC 263,499	50	2446 (8)	2532 (9)	2587 (10)
AC 263,499	100	2589 (8)	2510 (9)	2645 (10)
AC 263,499	150	-	2603 (9)	2638 (10)
Trifluralin + metribuzin	757+350	2485 (9)	-	-
Metribuzin + metolachlor	360+2520	-	2448 (5)	-
Acifluorfen	336	-	-	2576 (4)
Hand-weeded controls	-	2600 (8)	2600 (8)	2547 (6)

[1]Average of yields from number of trials indicated in parentheses.
[2]PPI = Pre-plant incorporated; PRE = Pre-emergence; POST = Post-emergence.

TABLE 3

Maximum safe dose of AC 263,499 for various leguminous crops (Italy, 1985)

Application timing	Maximum safe dose of AC 263,499 (g ae/ha)[1] Garden pea	Chickpea	Broad bean	Phaseolus bean
Pre-emergence	450	200	450	450
Cracking	450	300	450	250
Post-emergence	300	100	300	300

[1]Average of trial results from two locations. Tolerance determined as $\leq$ 15% crop phytotoxicity.

Effect on following crops

In the United States, no signs of phytotoxicity was observed in wheat and barley planted following harvest of soybeans treated with AC 263,499. Maize planted following soybeans treated with the recommended doses of 35 to 140 g ae/ha of AC 263,499 was not adversely affected. However, preliminary data from 1984 indicate that some following crops were affected, namely cotton, sorghum, potatoes, rapeseed, sugar beets, and rice.

Weed control

Soybeans

In 22 states in the United States, AC 263,499 was evaluated for weed control in soybeans from 1982 to 1985. Pre-plant incorporated, pre-emergence, and post-emergence treatments with AC 263,499 at the recommended doses of 35 to 140 g ae/ha provided excellent control of several grass and broadleaved weeds (Table 4). Setaria faberi, Abutilon theophrasti, Amaranthus retroflexus, and Datura stramonium were highly susceptible to low doses of AC 263,499 at several application timings.

Sorghum halepense (rhizome and seedling), Panicum miliaceum, and Cyperus esculentus were also susceptible to AC 263,499, but treatment doses have not yet been determined because of limited field tests on these species.

TABLE 4

Lowest effective doses (g ae/ha) of AC 263,499 for weed control in soybeans (United States, 1982-1985)

Scientific name	Application timings[1]				
	PPI	PRE	E. POST	POST	L. POST
Brachiaria platyphylla	140	NA	NA	140	NA
Digitaria sanguinalis	35	70	105	NA	NA
Echinochloa crus-galli	105	140	105	NA	NA
Eleusine indica	140	280	>280	NA	NA
Panicum dichotomiflorum	70	105	70	140	70
Setaria faberi	70	70	35	105	70
S. glauca	NA	70	140	NA	NA
S. viridis	140	70	140	140	NA
Abutilon theophrasti	35	105	70	105	35
Amaranthus retroflexus	35	35	35	35	35
Ambrosia artemisiifolia	70	105	105	140	105
Chenopodium album	70	70	140	280	280
Datura stramonium	35	35	70	NA	NA
Ipomoea hederacea	>280	>280	105	>280	NA
I. lacunosa	>280	>280	105	>280	NA
I. purpurea	105	105	105	105	NA
Polygonum pensylvanicum	70	105	70	70	140
P. persicaria	140	70	NA	70	NA
Sida spinosa	105	NA	140	NA	NA
Solanum ptycanthum	35	35	NA	35	NA
Xanthium strumarium	140	>280	70	70	70

[1]PPI = Pre-plant incorporated; PRE = Pre-emergence; E. POST = Early post-emergence (weeds 2.5 to 5 cm tall); POST = Post-emergence (weeds 5 to 12.5 cm tall); L. POST = Late post-emergence (weeds >12.5 cm tall).

NA = Not available; not enough data available to determine lowest effective dose. Control considered ≥85% kill.

In Italy, trials were established in soybeans to evaluate AC 263,499 at various doses and application timings. Results from these trials are summarised in Table 5. Excellent control of Digitaria sanguinalis, Echinochloa crus-galli, and Amaranthus retroflexus was obtained with AC 263,499 at 100 g ae/ha applied pre-plant incorporated, pre-emergence, or post-emergence.

Control of Chenopodium album and Polygonum aviculare was obtained with pre-plant incorporated and pre-emergence treatments of AC 263,499 at 100 g ae/ha, while post-emergence applications up to 200 g ae/ha failed to provide control. Seedling Sorghum halepense was very susceptible to post-emergence treatments of AC 263,499 at 100 g ae/ha; however, a dose of at least 200 g ae/ha was required for acceptable pre-plant incorporated and pre-emergence control.

TABLE 5

Control of six weed species in soybeans treated with AC 263,499 (Italy, 1985)

Application timing	Dose (g ae/ha)	Weed control (%)[1] DIGSA[2]	ECHCG	SORHA	AMARE	CHEAL	POLAV
Pre-plant incorporated	100	100	99.5	78.0	99.8	100	99.8
	200	100	99.6	91.4	99.9	100	100
Pre-emergence	100	100	99.6	78.9	99.8	97.3	87.0
	200	100	99.4	88.9	99.9	99.8	99.8
	300	100	99.5	97.3	99.9	99.9	99.5
Post-emergence	100	98.5	99.4	95.6	99.9	62.5	70.0
	200	98.5	99.9	99.2	99.9	78.1	65.0

[1]Average of results from five trials.

[2]DIGSA = Digitaria sanguinalis
ECHCG = Echinochloa crus-galli
SORHA = Sorghum halepense (seedling)
AMARE = Amaranthus retroflexus
CHEAL = Chenopodium album
POLAV = Polygonum aviculare

Other leguminous crops

In France, AC 263,499 at 100 g ae/ha applied to spring broad beans at cracking provided excellent control of Sinapis arvensis, Aethusa cynapium and C. album (Table 6). Post-emergence application at 100 g ae/ha gave similar results except for unacceptable control of C. album. A dose of 200 g ae/ha was required to achieve excellent pre-emergence control of all three species.

TABLE 6

Control of three weed species in spring broad beans treated with AC 263,499 (France, 1985)

Compound	Application timing	Dose (g ae or ai/ha)	Weed control (%)[1] SINAR[2]	AETCY	CHEAL
AC 263,499	Pre-emergence	50	51	37	38
		100	73	75	82
		200	97	97	98
	Cracking	100	97	99	95
		200	100	100	100
	Post-emergence	100	99	96	16
		200	100	98	58
Pendimethalin + neburon	Pre-emergence	400+1480	100	2	82

[1]Control evaluated at 77 days after treatment (DAT) for pre-emergence application, 56 DAT for cracking, and 18 DAT for post-emergence application.

[2]SINAR = Sinapis arvensis
AETCY = Aethusa cynapium
CHEAL = Chenopodium album

CONCLUSION

AC 263,499 is a promising new systemic herbicide with soil and foliar activity on a wide range of annual and perennial grass and broad-leaved weeds. Applications can be made pre-plant incorporated, pre-emergence, at cracking, or post-emergence, with excellent selectivity in soybeans and many other important leguminous crops, including Phaseolus beans, peas, spring broad beans, chickpeas, and seedling and established lucerne.

Favourable results have been reported from tests completed to date to investigate the toxicology, mutagenicity, and metabolism of AC 263,499.

ACKNOWLEDGEMENTS

The authors wish to thank the Cyanamid field teams in Brazil, Canada, France Italy, and the United States, who carried out the trial work reported in this paper.

The authors also wish to thank Mrs. Elsa Nadal, American Cyanamid Company, for her invaluable editorial assistance in summarising background information on AC 263,499 herbicide.

REFERENCES

American Cyanamid Company (1985) Technical information report: AC 263,499 experimental herbicide. Agricultural Research Division, Princeton, New Jersey, U.S.A., 16 pages.

2—12

Ames, B. N.; McCann, J.; Yamasaki, C. (1975) Methods for detecting carcinogens and mutagens with the Salmonella/mammalian microsome mutagenicity test. Mutation Research 21, 347-364.

Shaner, D. L.; Anderson, P. C; Stidham, M. A. (1984a) Imidazolinone herbicides are inhibitors of acetohydroxyacid synthase. Program and abstract of papers for the Annual Meeting of the American Society of Plant Physiologists, Davis, California, U.S.A., 12-16 August. In: Plant Physiology Supplement 75, 50 (Abstract 282).

Shaner, D. L.; Anderson, P. C.; Stidham, M. A. (1984b) Imidazolinones - potent inhibitors of acetohydroxyacid synthase. Plant Physiology 76, 545-546.

A NEW SAFENER FOR EPTC IN CORN

J. NAGY, K. BALOGH

Északmagyarországi Vegyimüvek, Sajóbábony, Hungary

ABSTRACT

A new safener, N,N^2-diallyl-N^2-dichloroacetylglycinamide is being developed by Északmagyarországi Vegyimüvek (ÉMV), under the code number DKA-24. It is effective in protecting corn from thiocarbamate and chloroacetanilide herbicides. In our experiments DKA-24 and other derivatives proved to be good safeners for several corn cultivars against EPTC. DKA-24 at rates of 0.11 to 1.76 kg a.i./ ha mixed with 5.6 kg a.i./ha EPTC showed good selectivity in corn in controlled environment room tests. SH-376 a mixture containing 72 % EPTC + 8 % DKA-24 formulated as an 80 % e.c. showed excellent selectivity and herbicide activity in controlled environment room experiments at temperatures from 17.7-28.3 ^oC.

INTRODUCTION

The first herbicide safeners were discovered in the late 1940's (Hoffman 1978) since when a large number of compounds with safening action have been found. Both R-25788 (N,N-diallyl-2,2-dichloroacetamide) as well as AD-67 (N-dichloroacetyl-1-oxa-4-aza-spiro-4,5-decane) have proved to be useful in agricultural practice (Görög et al. 1982). The mixtures of R-25788 with EPTC, butylate and vernolate are marketed. AD-67 is commercialized in mixtures with EPTC for weed control in corn by ÉMV and Nitrokémia Co.. 1,8-naphthalic anhydride is also a seed treating agent applicable against thiocarbamates in corn introduced into the market by Gulf Oil. A recent review on herbicide safeners has been made by Hatzios (1983).

MATERIALS AND METHODS

Strategy

The compound family DKA was developed at ÉMV using a research strategy started in 1982. We aimed at finding a new safener for EPTC in corn, which would act reliably in extreme temperature -, rainfall-, soil- and cultural conditions, and can be formulated as a mixture with herbicide without lowering its weed control effect.

Synthesis

N^2-dichloroacetyl-N,N^2-disubstituted glycinamides were produced in a two-step reaction. Ethylchloroacetate, the starting material was transformed to N-alkylglycinamide derivative by an excess of primary amine. After removing the excess of amine and alcohol formed during the reaction, the residue was reacted with dichloroacetylchloride. As acid-binding agent sodium hydroxide, as solvent a mixture of water-dichloromethane was used. The identification of compounds was carried out by means of i.r., n.m.r. and elemental analysis.

Chemical and physical properties

Code number: DKA-24

Chemical name: N,N^2-diallyl-N^2-dichloroacetylglycinamide

Molecular formula: $C_{10}H_{14}N_2O_2Cl_2$

2—13

Structural formula

```
                                  O
                                  ‖
H2C = CH - CH2 - N - C - CH2 - N - CH2 - CH = CH2
                 |               |
                 H               C = O
                                 |
                                 CHCl2
```

Molecular weight: 265

Physical state: pale yellow liquid

Solubility: Soluble in dichloromethane, chloroform and halogenated aromatic solvents.

Toxicological properties of technical material

LD_{50} oral (rat): 2500 mg/kg

LD_{50} oral (mice): 1010 mg/kg

LD_{50} dermal (rat): > 5000 mg/kg

LC_{50} inhalation (rat): ≈ 3000 mg/kg

Primary irritation: No dermal or eye irritation

Additional toxicology studies are in progress.

Screening

Plants were grown in pots containing sandy loam soil with low organic matter (1.4 %) and an acidic pH (5.1). The more important corn cultivars were used, namely Pioneer 3978, NKPX 20, BEKE TC 370, JX 97 SC, MVSC 484 and as a weed *Sorghum halepense*. The pots contained 4 seeds of each of the corn cultivars and 20 seeds of weed. The seeds were covered with a thin layer of soil. EPTC and DKA (e.c. formulations) were applied alone or as a mixture by spraying on the surface of the soil. Additional soil was then used to cover the herbicide and safeners.

The experiments were conducted under controlled environment room conditions with 16 hr photoperiod with 11,000 lux light intensity at 25 $^{o}C \pm 2$ and 8 hr dark period at 20 ^{o}C. The last series of experiments in pots was conducted in inhomogeneously programmed chamber which was designed to produce a continuous linear temperature gradient (17.7-18.7-19.9-21.2-22.7-23.7-24.3-25.5-26.8-28.3 ^{o}C) with various herbicide treatments (EPTC, EPTC + DKA-24) at right angles to each other.

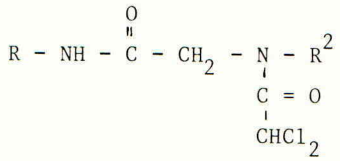
Two weeks after sowing the plants were harvested. Shoot length, fresh weight and visual damage symptoms were used as parameters in assessing herbicide effect.

RESULTS

Approximately 100 DKA compounds were tested for their safening effect against EPTC in corn. Compounds were ranked according to the results of the biotests. Table 1 shows the chemical structure of those having the best effect. The best safening effect was found if R and R_2 were identical, the decreasing order of activity being allyl > propyl > ethyl > methyl. Compounds with two different substituents showed a weaker protecting effect.

TABLE 1

Ranking of the effectiveness of DKA compounds in safening EPTC on corn



	R	R^2
1. DKA-24	allyl	allyl
2. DKA-43	propyl	propyl
3. DKA-42	ethyl	ethyl
4. DKA-41	methyl	methyl
5. DKA-59	allyl	propyl
6. DKA-60	allyl	ethyl

Further biotests were made with the compound coded DKA-24 which was found to be the most effective. The corn seedlings were damaged by 5.6 kg/ha of EPTC (Table 2). The damaged plants were stunted, twisted, brittle, and dark green. When DKA-24 was used at the rates of 0.06-0.11-0.22-0.44-0.88--1.76 kg/ha in combination with EPTC, no damage was seen on corn. When the dose of DKA-24 was increased to 3.52 kg/ha + EPTC shoot length and fresh weight of corn decreased significantly.

TABLE 2

The effect of increasing doses of DKA-24 as a safener for EPTC in corn

Dosage		% untreated		
EPTC kg/ha	DKA-24 kg/ha	shoot length	fresh weight	damage[x]
5.6	0.00	52	56	4
5.6	+ 0.03	76	81	2
5.6	+ 0.06	87 a	95 a	1
5.6	+ 0.11	96 a	102 a	1
5.6	+ 0.22	94 a	95 a	1
5.6	+ 0.44	91 a	93 a	1
5.6	+ 0.88	92 a	93 a	1
5.6	+ 1.76	90 a	88 a	1
5.6	+ 3.52	78	83	1
	LSD %	16	14	

"a" not significantly different from the untreated control at 5 % level.

ˣDamage assessmant: 4 plants dead
3 moderate distortion plants
2 slight reduction in growth
1 no symptoms

The rates of 4-8-16-32 kg/ha of EPTC were toxic to corn, giving significant reductions in shoot length (Table 3). SH-376 80 EC (72 % EPTC + 8 % DKA-24) was highly selective applied from 2 to 8 kg/ha but less effective at higher doses of EPTC. The weed control effect of the mixture was excellent in all cases. Experiments carried out at different temperatures showed that EPTC phytotoxicity developed at 22-23 ^{o}C or more with worse damage at higher temperatures.

TABLE 3

Comparison of the effect of EPTC and SH-376 80 EC on the shoot lenght of corn

Dose of EPTC kg a.i./ha	SH-376 80 EC d_1	EPTC d_2	Difference d_1-d_2
2	102	89	+ 13
4	99	55	+ 44
8	87	22	+ 65
16	85	18	+ 67
32	72	14	+ 58

LSD 14 % between any two values in each column at 5 % level

TABLE 4

The phytotoxicity of EPTC (16 a.i./ha) and SH-376 80 EC on corn grown between 17.7-28.3 ^{o}C

Temperature ^{o}C	Shoot length % untreated SH-376 80 EC d_1	EPTC d_2	Difference d_1-d_2
17.7	100	100	0
18.7	100	100	0
19.9	106	113	- 7
21.2	100	105	- 5
22.7	100	77	+23
23.7	93	83	+10
24.3	97	66	+31
25.5	89	47	+42
26.8	86	47	+39
28.3	84	32	+52

LSD 13 % between any two values in each column at 5 % level

The mixture SH-376 80 EC protected the corn from EPTC above this critical temperature. No relation between the weed control effect and the change of temperature could be detected (Table 4).

DISCUSSION

The experiments carried out in controlled environment rooms showed that it was advantageous to substitute N^2-dichloroacetylglycinamide by two allyl groups. N,N^2-diallyl-N^2-dichloroacetylglycinamide (DKA-24) is very effective in enhancing the selectivity of EPTC in corn. The SH-376 80 EC did not damage the corn cultivars Pioneer SC 3978, NKPX 20, BEKE TC 370, JX 97 SC, MVSC 484 either in extreme temperature conditions or at very high doses. SH-376 80 EC is now giving promising results in field and registration experiments.

REFERENCES

Görög, K.; Muschinek, Gy.; Mustárdy, L. A.; Faludi-Dániel, A. (1982) Comparative studies of safeners for the prevention of EPTC injury in maize. Weed Research 22, 27-33.

Hatzios, K.K. (1983) Herbicides antidotes: development, chemistry and mode of action. Advances in agronomy 36, 265-316.

Hoffman, O.L. (1978) Herbicide antidotes: from concept to practice. Chemistry and action of herbicide antidotes,F. M. Pallos and J. E. Casida, Ed., New York, Academic Press, 1-13.

THE USE OF RSW 0411 AS A GROWTH REGULATOR IN DIFFERENT CROPS UNDER DIFFERENT CONDITIONS

H. HACK, H. LEMBRICH

Bayer AG, GB Pflanzenschutz, D-5090 Leverkusen, West-Germany

D.B. MORRIS

Bayer U.K. Limited, Agrochem Division, Bury St. Edmunds, Suffolk, IP32 7AH

ABSTRACT

RSW 0411 is an azole compound with plant growth regulator properties. It inhibits elongation growth of plant shoots and affects other physiological processes in the plant e.g. CO_2-fixation and water balance. RSW 0411 can have also a fungicidal effect, if application time coincides with infections. The soil persistence is relatively short. This allows usage in important agricultural crops like rape, rice and legumes at rates of 300-750 g a.i./ha.

The main benefit to the farmer using RSW 0411 is easier harvesting and significantly reduced yield losses and yield increases.

INTRODUCTION

RSW 0411 (proposed common name triapenthenol) is an azole compound with plant growth regulator activity. Its chemical structure, physical, chemical and toxicological properties, and physiological activity in the plant, have been reported by Luerssen et al. (1985).

Lodging is a problem in many crops because it greatly influences the time of harvest and reduces yield. In legumes and in some other field crops tests were carried out to see if reduction of the vegetative phase is possible by application of RSW 0411.

MATERIALS AND METHODS

Field trials reported here were carried out in Canada, Europe, Japan and the USA. All trials were of randomised block design using 2-4 replicates. Plot size ranged from 5 to 100 m². Applications were made with various types of plot sprayers at a spray volume of 200 to 500 l/ha, or with granule applicators. RSW 0411 was formulated as a 70 w.p., 5 w.p., a 70% water dispersable granule, a 1 % extruded granule (Japan) and as a 1% coated granule with sand as carrier for rice in Europe.

To assess growth reduction in rice and rape, the height of the crop plants was measured and expressed as % untreated control. Numbers of side branches in rape were also measured. The percentage lodging was estimated visually on the whole trial plot. Rape and legume yield was recorded. The number of pods and beans per plant were also counted.

In some rape trials the oil content and the various fatty acids were assessed to see if RSW 0411 has an influence.

RESULTS

Results obtained in oilseed rape, rice, field beans, broad beans, are summarised below.

Oilseed rape

The effect of different application timings on the growth of the main stem in an experiment in the U.K. in 1984 is shown in Figure 1. Similar effects were recorded from trials carried out on the same farm over a 3 year period (Table 1). Maximum reduction in final crop height was obtained from applications made just prior to the exponential phase of stem growth usually around the middle of March. The prime effect of treatment was a shortening of stem internodes which with early applications resulted in a reduction in the length of stem below the lowest fertile branch. Other trials carried out throughout the U.K. produced similar findings although the degree of effect was not always so marked; the overall effect found was a reduction in crop height of 10 % in 1984 (mean of 10 trials) and 14 % in 1985 (mean of 11 trials).

TABLE 1

Effect of RSW 0411 applied at 500 g a.i./ha in oilseed rape on the final length of the main stem (ground to tip of terminal raceme) and the vegetative stem (ground to lowest fertile branch) in oilseed rape when applied in different seasons and at different application dates in Suffolk, U.K.

Trial year	1983	1984	1985
Cultivar	Jet Neuf	Bienvenu	Bienvenu
Date sown	18 August	17 August	3 September
		Length (% untreated)	
Application: Date		20. February	8. March
Main stem length (cm)		(3.0)	(4.4)
Main stem length		78	67
Vegetative stem length		33	41
Application: Date	11. March	20. March	22. March
Main stem length (cm)	(10.0)	(8.0)	(5.6)
Main stem length	75	76	63
Vegetative stem length	46	46	37
Application: Date	15. April	17. April	10. April
Main stem length (cm)	(65)	(40)	(32)
Main stem length	90	96	85
Vegetative stem length	98	94	74
UNTREATED			
Main stem (length in cm)	100 (147)	100 (123)	100 (148)
Vegetative stem (length in cm)	100 (48)	100 (55)	100 (69)

In two trials in Germany, numbers of sidebranches and pods were counted (Table 2). Compared with untreated plants RSW 0411 resulted in an overall reduction in plant size and especially stem length together with an significantly increased number of side branches and seed pods larger than 4 cm per plant.

TABLE 2

Crop height cm (H) and No. of sidebranches (S) and seedpods >4 cm (P) of untreated plants and plants treated with RSW 0411 at 525 g a.i./ha at plant height of 40 cm. Date of assessments 3 weeks before harvest. Values based on 20 plants.

Location	Mettmann 2			Soest		
Cultivar	Jet Neuf			Carina		
Assessment	H	S	P	H	S	P
RSW 0411	86	8*	115*	114	9*	159*
Control	96	5	78	126	7	111
LSD%		1.8	22		1.3	28

* Significantly different from control at 5 % level

Considerable yield increases observed in the cultivars Jet Neuf, Belinda, Korina, Miranda, Quinta, Garant and Doral (see Fig. 2) are however not only due to reduced harvest losses. Increased pod numbers per plant probably also contribute to yield increases. In the U.K. lodging has not been such a problem and although there were good yield increases from applications of RSW 0411 in 1983 they were small overall in 1984. In a trial in 1985 on a range of cultivars including Bienvenu, Jet Neuf, Darmor, Korina, Rafal and Fiona, all cultivars responded giving overall 7.9% additional yield.

Rice

For lodging prevention in rice 98 trials with RSW 0411 (1% granule) were carried out from 1982 to 1984 in Japan.Consistent effects were obtained 12-15 days before heading with applications of 300-500 g a.i./ha. These trials lead to an average yield response of 0.23 t/ha compared with untreated, and reduced lodging in 80% of the trials. In Table 3 results are shown from 14 trials in 1983 in a total of 6 locations. In 3 trials, rice did not lodge even in untreated plots. In a trial conducted in Yuki, RSW 0411 was not so clearly effective as to be seen in the others. In this test, severe lodging was caused by an unusually long autumn rain which resulted in little difference in lodging between treated and untreated plots at harvest. In the remaining 10 trials RSW 0411 was very effective in preventing lodging resulting in higher yield compared to untreated.

In 1984 yield-trials in combination with increased fertilizer use were conducted in Spain. They proved that, in spite of the increased fertilization lodging could be prevented by RSW 0411. In comparison to the normally fertilized untreated plots, the yield was significantly increased by RSW 0411 treatment - by 17% with 0.5 kg a.i./ha and by 20% with 0.75 kg a.i./ha. Increased fertilizer alone caused a yield increase of 10 % (Table 4).

2—14

TABLE 3

The effect of RSW 0411 (1 % granule) on lodging, culm length and yield of transplanted rice, Japan 1983

Location	cv	Applica-tiontime (DBH*)	Dosage Rate kg a.i./ha	Lodging (%)	Culm Length (cm)	Yield (t/ha)
Izumi	Sasanishiki	12	0.3	0	78.0	6.15
			0.5	0	73.1	6.41
			-	0	82.3	6.24
Sendai	Sasanishiki	15	0.5	0	72.4	5.95
			-	0	80.2	6.15
Sendai	Sasanishiki	10	0.5	0	74.0	6.44
			-	0	80.2	6.15
Soma	Sasanishiki	8	0.3	0	83.8	6.66
			0.5	0	83.2	7.33
			-	60	87.5	6.75
Toyoda	Koshihikari	12	0.5	0	74.7	4.38
			-	50	84.9	4.12
Yuki	Koshihikari	11	0.3	60	83.6	5.86
			0.5	60	83.3	5.74
			-	80	87.6	5.36
Nangoku	Koshihikari	15	0.3	30	77.0	5.83
			0.5	0	73.5	5.54
			-	60	77.8	5.22
Nangoku	Koshihikari	14	0.5	30	71.2	6.12
			-	70	77.5	5.94
Nangoku	Koshihikari	14	0.5	30	76.1	6.48
			-	70	83.0	6.59
Nangoku	Koshihikari	13	0.3	30	73.4	6.59
			0.5	0	65.6	6.23
			-	50	78.6	6.62
Nangoku	Koshihikari	15	0.5	30	76.3	5.94
			-	100	87.5	5.58
Nangoku	Fujihikari	9	0.5	0	70.9	5.69
			-	50	75.9	5.47
Nangoku	Koshihikari	14	0.5	10	70.6	6.01
			-	70	81.0	6.12
Nangoku	Koshihikari	9	0.3	35	70.0	6.55
			0.5	0	64.0	6.70
			-	60	72.8	6.23

* DBH = Days before heading

These trials were conducted by NIHON TOKUSHU NOYAKU SEIZO K.K.

TABLE 4

Effect of RSW 0411 (1% granule) applied at about 2 node stage of rice in Spain 1984; (a) standard fertilizer, 720 kg/ha $(NH_4)_2SO_4$ before sowing (b) addional fertilizer, 252 kg/ha $(NH_4)_2SO_4$ one day before treatment

Treatment	kg a.i./ha	Crop height (cm)	Lodging %	Yield t/ha
(a) Control		101	0	6.91
(b) Control		102	33	7.61
RSW 0411	0.5	100	0	8.08**
RSW 0411	0.75	93	0	8.31**
LSD 5%				0.72
LSD 1%				1.09

plot size 800 m^2
** significantly different from control standard fertilization at 1% level

This trial was conducted jointly with the CRIDA-Institute, Valencia.

Field beans and broad beans

Applications of RSW 0411 at 0.5 kg a.i./ha to field beans at 40 cm crop height (*Vicia faba minor*) resulted in a significantly higher yield compared with the untreated control. Crop height was also reduced markedly (Table 5). RSW 0411 at 05.-1.0 kg a.i./ha applied at the beginning of flowering (crop height 36 cm) of broad beans (*Vicia faba major*) resulted in a significantly higher number of pods and beans and in a higher weight of beans (Table 6).

TABLE 5

Effect of RSW 0411 applied at 0.5 kg a.i./ha at crop height 40 cm on the height and yield of field beans (1984 trial).

Treatment	cv Kristall		cv Alfred	
	Crop height (cm)	Yield	Crop height (cm)	Yield
RSW 0411	86	61.9**	147	67.9**
Control	94	46.3	173	57.4
LSD 5%		5.2		4.9
LSD 1%		11.9		9.4

** Significantly different from control at 1% level.

TABLE 6

Effect of RSW 0411 applied to broad beans at crop height of 36 cm at the beginning of flowering, assessed on 25 July 1985. Values based on a total of 60 plants

Treatment	kg a.i./ha	% untreated control Crop height (cm)	No. of pods	No. of beans	Weight of beans (g)
RSW 0411	0.53	83	122	108	102
RSW 0411	0.70	77	139**	127*	125*
RSW 0411	1.05	74	146**	131*	117
Control		100	100	100	100
		(117 cm)	(223)	(829)	(1273.8 g)
LSD 5%		-	26	25	22
LSD 1%		-	37	34	31

* ,** Significantly different from control at 5% and 1% level resp.

Soil persistence

The relatively short soil persistence of RSW 0411 became obvious in the first field trials. Crops like Persian clover, oilseed rape and lupin were sown 5 months after application of 0.5 - 2.0 kg a.i./ha, without any resulting damage. Even higher rates in the range of 5.0 kg a.i./ha were tolerated by sugar beet sown 10 months after application. Persistence following applications of RSW 0411 at 0.5 kg a.i./ha in rice crops was intensively investigated in Japan.

The crops listed below were not affected when sown at the number of days after treatment indicated: Broad bean (88 DAT), Spinach (71), Two row barley (71), Winter wheat (80), Strawberry (71), Radish (241), Corn (276), Carrots (241), Kidney beans (241), Soybean (241), Cucumber (262), Chinese yam (250) and Lettuce (227).

DISCUSSION

In rape, rice and legumes RSW 0411 gave the most consistent results. In these crops RSW 0411 is most advanced in terms of development and registration. Registration is being applied for in several countries and is expected from 1986/87 onwards. Other crops in which RSW 0411 is currently being tested include herbage seed crops, potatoes, lawns, shrubs, top fruit and ornamentals under glass results will be reported elsewhere.

In oilseed rape RSW 0411 will be of considerable interest in Europe and Canada (Lembrich et al., 1984). Due to the waxy cuticle of rape, the main uptake of RSW 0411 is via the roots and this is enhanced by rainfall after treatment. Optimum results were obtained with rates of 0.5 kg a.i./ha applied in spring from rosette stage to bud formation (20-40 cm plant height). Reduction in height and stronger stems led to more compact plants and improved standing power which in the majority of the trials prevented lodging completely, or at least, reduced it considerably. In untreated areas in Germany, where lodging was very bad in 1984, a considerable number of secondary shoots developed leading to uneven ripening whereas ripening was more even in plots treated with RSW 0411. Prevention or reduction of lodging in rape means easier harvesting, reduced harvest losses and lower moisture content of seed.

Yield response to RSW 0411 may also be affected by its influence on the plant water balance and CO_2-fixation (Lürssen et al., 1985) and some diseases. It is very effective against light leaf spot (Pyrenopeziza brassicae) and also shows some effect on canker (Phoma lingam) if application time coincides with infections. RSW 0411 did not change the raw fat content of seeds and did not affect the relative proportions of the various fatty acids (Höfner et al., 1984, unpublished report).

RSW 0411 was also applied in rape in combination with liquid urea; the growth regulatory effect was very uniform but more trials are required before this combined use can be recommended.

Lodging in rice is a problem which has concerned farmers for many years in Japan. Yield decrease of 70 % can occur, if rice lodges during early maturity. It is especially the high quality cultivars such as Koshihikari and Sasanishiki that suffer as they are tall and easily lodged by strong winds with heavy rain in the ripening season.

Growth inhibition of RSW 0411 in rice, being a monocotyledonous plant, only occurs via the roots (Luerssen et al., 1985). As moisture is always plentiful, timing can be well defined and is aimed at 12-15 days before heading. Consistent effects were obtained with applications of 300-500 g a.i./ha as a 1 % granule formulation. Application as a granule has advantages; more a.i. reaches the soil compared with application as a spray which can be partly retained by the plant foliage.

The flowering and growth of field beans (Vicia faba minor) and broad beans (Vicia faba major) is indeterminate and often there is considerable vegetative growth after flowering. This late growth does not affect yields but increases the risk of lodging and consequent difficulties in harvesting. RSW 0411 applied at 0.5 - 1.0 kg a.i./ha at the beginning of flowering resulted in a significant yield increase.

In rape, rice and beans RSW 0411 has its greatest value in terms of safeguarding yields. In this context we are investigating the effect of fertilizer-timing, in relation to the use of RSW 0411. There are indications that specially timed fertilizer applications will have specific effects on yields.

The relatively short persistence of RSW 0411 in soil allows its use in crops grown in close rotation.

REFERENCES

Lembrich, H., Dengel, H.-J., Luerssen, K. and Reiser, R. (1984) RSW 0411, ein Wachstumsregulator zur Verbesserung der Standfestigkeit im Winterraps sowie im Grassamenvermehrungsbau. 44. Deutsche Pflanzenschutztagung Heft 223

Luerssen, K. and Reiser, W. (1985) Chemistry and physiological properties of the new plant growth regulator RSW 0411. Proceedings 1985 British Crop Protection Conference-Weeds.

2—14

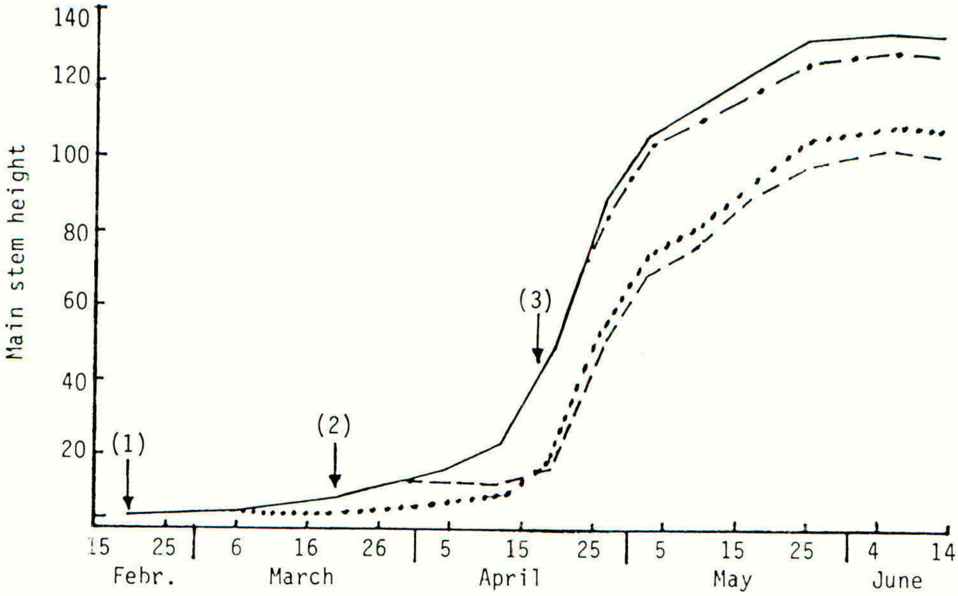


Fig. 1. Growth curves based on main stem height (ground to tip of terminal raceme) for winter oilseed rape, comparing Untreated contol (———) with RSW 0411 500 g a.i./ha applied at three different timings: (1) 20 February 1984 (……), (2) 20 March 1984 (— — —) and (3) 17 April 1984 (-·-·-).

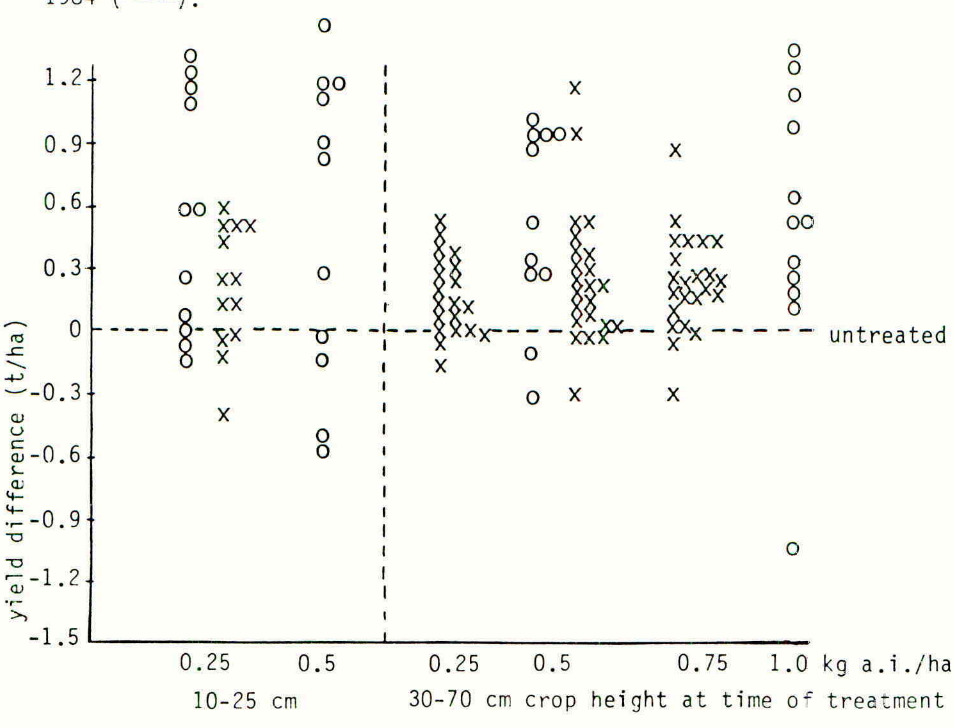


Fig. 2. Yield differences in winter oilseed rape treated with RSW 0411 compared with untreated; Open circles: o trials in 1983 ; x trials in 1984

CHEMISTRY AND PHYSIOLOGICAL PROPERTIES OF THE NEW PLANT GROWTH REGULATOR RSW 0411

K. LÜRSSEN, W. REISER

Bayer AG, Pflanzenschutz, D 5090 Leverkusen

ABSTRACT

RSW 0411 is a new triazole plant growth regulator. It inhibits extension growth of plant shoots without affecting number of leaves or root growth. It's primary mode of action is the inhibition of gibberellin biosynthesis. However, an interference with sterol biosynthesis has also been shown. Apart from the growth inhibition, the compound can increase the CO_2-fixation of whole plants after an initial drop in assimilation. RSW 0411 changes water relations in plants. Treated plants have a higher water content than control plants. Water consumption of treated plants is reduced. The magnitude of these effects varies in different plant species. Transpiration expressed as water loss per leaf unit area is reduced in barley. In rape the reduction in water consumption is only temporary. At the end of an experiment even a slight increase in transpiration was calculated for this species. The nitrogen content of treated plants is increased when calculated in % of dry matter and it is unchanged when calculated per plant. We assume that the positive effects of this compound on yield observed in field trials (Hack et al. 1985) are partly due to these changes in plant metabolism.

INTRODUCTION

Plant growth regulator usage is small compared with that of herbicides. There are only a few products with a major sales volume. This situation is the result of 1) the difficulty of regulating plant growth for physiological and biochemical reasons, 2) the more complex screening and development of PGRs compared with pesticides, 3) the use of PGRs which is often limited to one crop in relation to the increasing costs of development of new agricultural chemicals. We present in this paper a new PGR of the triazole chemical group which is useful in several crops. It's primary action upon plants is growth inhibition. However, the physiology of plants is altered in many different ways by this compound, therefore the beneficial effects on crops are not limited to growth inhibition.

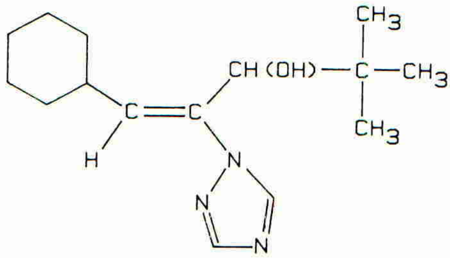
CHEMICAL AND PHYSICAL DATA

chemical name: (E)-(RS)-1-cyclohexyl-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl)pent-1-en-3-ol

molecular formula: $C_{15}H_{25}N_3O$ molecular weight: 263.4

2—15

structural formula:



appearance: colourless crystals   melting point: 135.5 °C

solubility: 38 mg / 1000 ml water   43.3 g / 100 ml methanol

15.0 g / 100 ml acetone

vapor pressure (20 °C): 4.4 x 10^{-8} mbar

formulations: 70 % water dispersable granules;   1 % granule

TOXICOLOGY

LD_{50} rat: acute oral > 5000 mg / kg; acute dermal > 5000 mg / kg

MODE OF ACTION

In all plant species tested extension growth was inhibited by RSW 0411. Treated plants generally have a darker green colour than untreated ones. The number of leaves is not negatively affected by the treatment. Root growth is not inhibited. Examples of growth inhibition are given in Fig. 1. Plants were grown in soil in the greenhouse and were sprayed to runoff with a solution containing 0.05 % RSW 0411. The data in Fig. 1 are mean values of 20 independent experiments. The growth inhibition of all plant species treated with RSW 0411 and it´s compensation by simultaneous application of gibberellic acid suggested that RSW 0411 interfered with gibberellin metabolism. It was found that treated plants had a lower content of gibberellins (Weiler, personal communication) and that the compound specifically inhibited the oxidation steps from ent-kaurene to ent-kaurenoic acid in the pathway of gibberellin biosynthesis (Graebe, personal communication).

It has been suggested that the height of untreated plants and of plants treated with a growth inhibitor should become equal when increasing amounts of a growth substance are applied to both groups of plants if the mode of action of the growth inhibitor is only to limit the availability of this growth substance (Lockhart 1962). In a study of the compensation of RSW 0411-induced growth inhibition by GA_3 barley seedlings were grown in vermiculite / water in 5 x 5 x 7 cm pots containing 8 seedlings. Both compounds were applied in mixture by pouring 100 ml solution to each pot. No compensation of growth inhibition by gibberellic acid was detected. Instead of meeting, the two curves run parallel (Fig. 2). It was concluded that besides the inhibition of gibberellin biosynthesis there must be a second target for RSW 0411 in plants. This target has been identified as sterol biosynthesis. Further details of the mode of action will be published elsewhere.

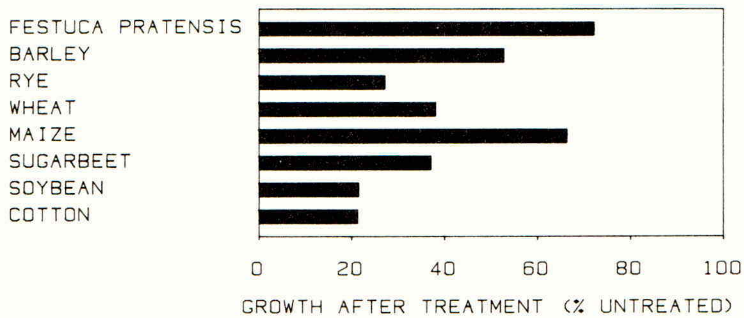


Fig. 1. Inhibition of extension growth of different plant species 21 days after treatment with 0.05 % RSW 0411.

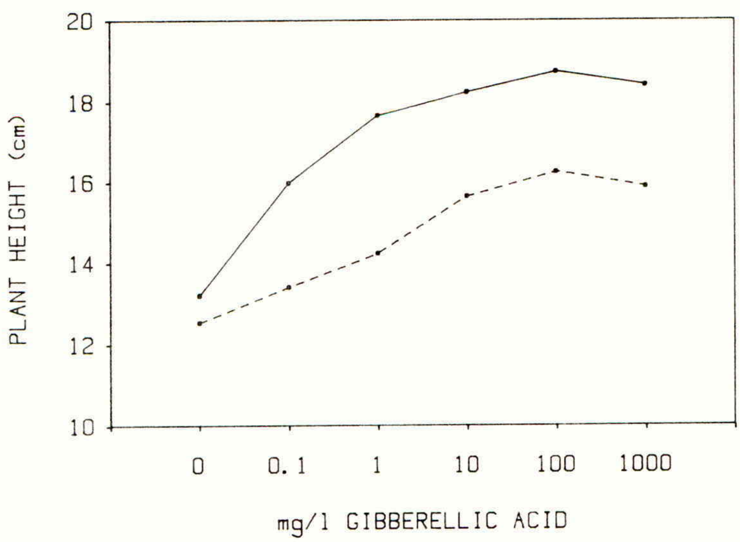


Fig. 2. Compensation of growth inhibition of RSW 0411-treated barley seedlings with gibberellic acid 6 days after treatment. —— untreated; ----- 2 mg/l RSW 0411.

2—15

SITE OF UPTAKE AND GROWTH INHIBITION

Plants were grown in the greenhouse in 10 x 10 x 10 cm pots. Barley, rye and wheat with 15 plants per pot were treated at the two leaf stage. Soybeans (1 per pot) were treated, when the first true leaf was developed. For foliar treatment, the plant shoots were dipped for 1 minute into a 0.05 % RSW 0411 preparation. Care was taken that no solution could drip on the soil during drying. For soil treatment 30 ml of the 0.05 % RSW 0411 preparation was poured on the soil without wetting the plant shoots. The cereal crop plants responded much more to a soil treatment than to a foliar treatment, while soybean responded equally well to both treatments (Fig. 3). However, the response of dicotyledons to foliar treatment may vary. In rape for example, foliar treatment is less effective than soil treatment.

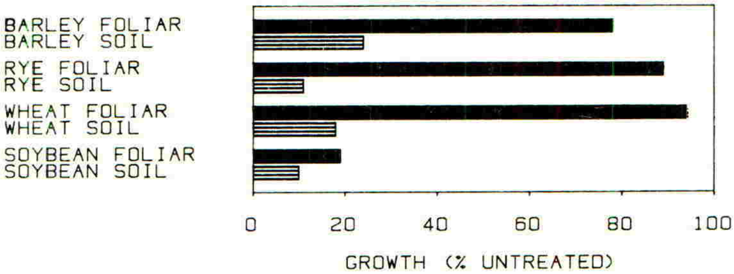


Fig. 3. Effect of the application site of RSW 0411 on growth inhibition in different crops.

Studies on uptake and transport of other triazole compounds have shown a mainly acropetal transport of these materials but no fundamental difference in uptake between monocotyledons and dicotyledons (Führ et al. 1978; Brandes et al. 1978). The reduced effectiveness of foliar application in cereals may be due to the protection of meristem from spray by the leaf sheaths and the direction of translocation of RSW 0411.

WATER RELATIONS

Plants were grown in soil in 10 x 10 x 10 cm pots in the greenhouse. Barley with 10 plants per pot was treated at the 2-leaf stage with 1 kg / ha RSW 0411, rape with 1 plant per pot was treated in the 5-leaf stage with 0.5 kg / ha. The treatment was carried out in a spraying cabinet with a moving nozzle and a calculated spray volume of 500 l / ha. At the beginning of the experiment the soil moisture was set at 80 % soil water capacity. The weight of each pot was measured and the pots were weighed and watered daily to this initial weight in an automatic system. All values for water use were corrected for evaporation which was measured similarly, using pots with soil but without plants. Three weeks after treatment plant height, fresh weight, dry weight, and leaf area were measured. Transpiration was calculated using the leaf area and the water consumption of the last day of the experiment.

Fig. 4 shows the daily water consumption of the plants. In the treated barley, water use was less troughout the experiment. In rape there was a reduction in water use during the first 2 weeks but in the 3rd week water use was similar for treated and untreated plants. In Table 1 the water relations of the plants are summarized. The % growth inhibition approximately equals the % dry weight reduction in treated plants. The reduction in fresh weight is smaller than the reduction in dry weight. This is just a tendency in barley but treated rape plants have nearly the same fresh weight as untreated ones. The transpiration 3 weeks after treatment is influenced differently in barley and rape. In barley a reduction of the transpiration per leaf unit area of more than 25 % results from the RSW 0411 treatment in spite of a reduction in leaf area. By contrast, in rape there was a 15 % increase in transpiration which resulted from the decrease in leaf area rather than from an increased water use. The water content in relation to dry matter is raised in RSW 0411 treated plants. The magnitude of this increase depends on the plant species.

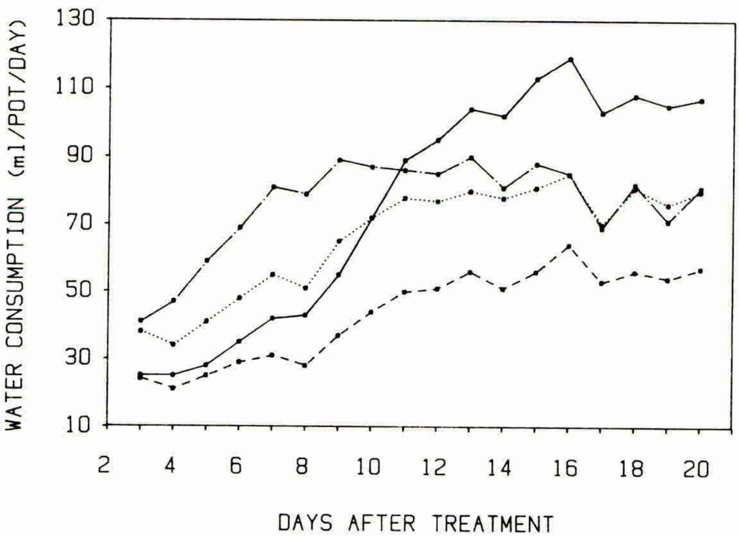


Fig. 4. Water consumption of barley and rape with 1.0 and 0.5 kg RSW 0411 / ha. (Barley —— untreated, --- treated 1 kg/ha; rape -·- untreated, ········ treated 0.5 kg/ha)

INFLUENCE UPON NITROGEN CONTENT

The shoots of the wheat and barley plants from the experiments reported in Fig. 1 were harvested, dried at 80 °C, ground to powder in a coffee mill and analysed for total

TABLE 1: Water relations in barley and rape

	BARLEY			RAPE		
	control	1 kg/ha		control	0.5 kg/ha	
plant height (cm)	51	28	***	36	26	***
fresh weight (g/pot)	43.9	28.1	**	51.0	48.4	n.s.
dry weight (g/pot)	4.6	2.6	***	7.3	4.8	***
% dry matter	10.5	9.3		14.3	9.9	
leaf area / pot (cm^2)	1273	929	**	992	844	*
water consumption (ml/ pot, last day only)	81.8	31.2	**	56.2	54.8	n.s.
transpiration ($\mu l/cm^2/day$)	84.1	61.4		81.7	94.8	

The t-test was used for statistical analysis of the measured data. Levels of significance: *** = $p < 0.001$; ** = $p < 0.01$; * = $p < 0.05$; n.s. = not significantly different;

nitrogen content with a Heraeus CHN Rapid Analyser. Calculated as % of dry matter the nitrogen content was increased by the RSW 0411 treatment in wheat and barley by about 25 % (Fig. 5). Calculated as nitrogen content per plant there was no significant difference between treated and untreated plants. Assuming that the nitrogen was present mainly as proteins we concluded that in RSW 0411-treated plants the protein content of the dry matter was increased over other plant constituents.

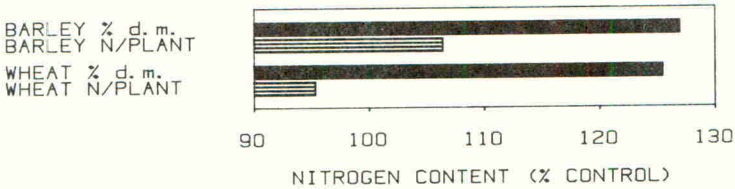


Fig. 5. Nitrogen content of barley and wheat plants treated with 0.05 % RSW 0411.

INFLUENCE UPON CO_2-FIXATION

Rape plants were grown and treated as described in the section "Water Relations". CO_2-fixation was measured on whole plants using an infrared gas analyser. The light intensity during measurements was 26000 Lux. RSW 0411 caused an initial drop in CO_2-fixation (Fig. 6). However, one week after treatment the CO_2-fixation of treated plants equaled that of untreated ones, and in the third week treated plants show a higher CO_2-

fixation than control plants. It is interesting to note that the smaller treated rape plants with a reduced leaf area are able to fix more CO_2 than the bigger control plants. An increase in CO_2-fixation was also found in barley.

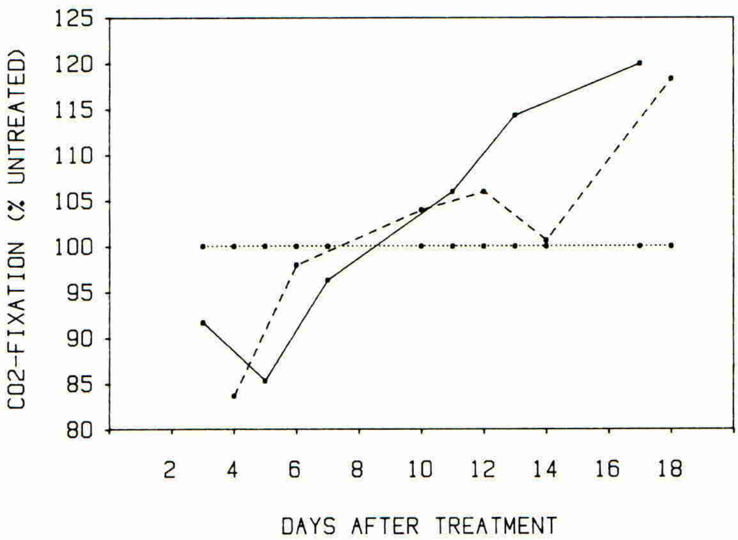


Fig. 6. Carbon dioxide fixation of RSW 0411-treated rape plants in % of untreated plants. (---- 0.5 kg/ha; ——— 1.0 kg/ha, ... untreated)

DISCUSSION

RSW 0411 inhibited the extension growth of all plant species investigated. This characteristic makes the compound suitable for many uses in agriculture and horticulture (Hack et al. 1985). More detailed investigations into the mode of action and the influence upon plant metabolism and physiology have shown that this new PGR can influence plants in many ways. Apart from growth inhibition with the expected result of increased side shoot development or increased tillering, two aspects may be especially important for the effects of this compound upon yields in field crops (Hack et al. 1985). The observed increase in CO_2-assimilation could be useful for increasing yields. The correct time of application in relation to plant development and physiological status of the plant would be very important for a successful treatment. The reduced water consumption of RSW 0411-treated plants may also contribute to a yield increase under conditions when water supply to the plants is limited. The increased nitrogen content in relation to dry weight and the increased water content of the vegetative plant organs indicate an intensified metabolism which may result in a yield increase of the treated plants.

The compound has also a strong fungicidal effect on several plant diseases. This effect is related to the inhibition of sterol biosynthesis in fungi. We believe that this new PGR will give the opportunity for an improved management in a variety of crops in the near future.

ACKNOWLEDGEMENT

We thank Dr. H. Strang for help in the preparation of the manuscript.

REFERENCES

Brandes, W.; Steffens, W.; Führ, F.; Scheinpflug, H. (1978). Weitere Untersuchungen zur Translokation von (^{14}C)Triadimefon in Gurkenpflanzen. Pflanzenschutz-Nachrichten Bayer 31, 132-144.

Führ, F.; Paul, V.; Steffens, W.; Scheinpflug, H. (1978). Translokation von (^{14}C)Triadimefon nach Applikation auf Sommergerste und seine Wirkung gegen Erysiphe graminis var. hordei. Pflanzenschutz-Nachrichten Bayer 31, 116-131.

Hack, H.; Lembrich, H.; Morris, D. (1985). The use of RSW 0411 as a growth regulator in different crops under different conditions. Proceedings 1985 British Crop Protection Conference - Weeds. (in press)

Lockhart, J. A. (1962). Kinetic studies of certain antigibberellins. Plant Physiology 37, 759-764.