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SOIL APPLIED HERBICIDES IN A NORTHERN ENVIRONMENT

F.R. Stovell and M.G. Allen

Shell Chemicals U.K. Limited

In practice the activity of soil-applied herbicides is determined to a large extent by outside factors which by affecting soil conditions govern the availability of the herbicide. Temperature and moisture status will also determine whether the target plant or weed is in a receptive stage, and indirectly govern the selectivity of the treatment. The purpose of this paper is to examine these factors as they occur in a northern environment and to relate them to recommendations made for, and results obtained with, soil-applied herbicides under these conditions.

Dr. Gloyne has indicated that temperatures are not widely different and certainly the partly continental climate found in Kent with some snow being a regular feature would support this, yet nevertheless spring is unquestionably later as you progress northwards, there being 4-6 weeks difference occurring gradually from south to north. One example of this slower break of dormancy is seen in forestry where recommendations for chlorthiamid and dichlobenil which must be applied during dormancy, only permit application to the end of March in England, but to April in Scotland. A parallel situation arises in the treatment of strawberries where established fruiting beds may be treated with simazine no later than December in England but due to the longer dormant period in the north may be safely treated up till mid-March. A case not of dormancy but slow emergence is typified by the potato crop which, omitting the Ayrshire belt, emerge so slowly that applications of linuron tend to be insufficiently persistent when applied immediately post-planting, yet the indigenous weeds emerge long before the potatoes and show increasing resistance with age to any later applications of linuron. The obvious solution is adopted, namely to increase the post-emergence activity against weeds by the addition of dinoseb in oil, diquat, or where grassy weeds predominate paraquat.

Returning however to the true dormant situation: TCA has been shown by Bylterud to be most effective when applied to dormant couch in wet conditions and the acceptance of this treatment in Scotland is much greater than farther south where natural dormancy is shorter, and permits the effective use of leaf-absorbed herbicides which are relatively ineffective in Scotland. Moisture is an important factor in this treatment and soil moisture is certainly higher in the north despite similar rainfall amounts owing to reduced evaporation losses. It is ceratin that this high soil moisture has a considerable effect on the movement and adsorption of chemicals in the soil. Chlorthiamid and dichlobenil produce a highly soluble metabolite 2,6-dichlorobenzamide which under conditions of rapid transpiration will produce leaf margin chlorosis which is often regarded as a symptom of damage, though in fact no reductions in yield or growth increments accompany this phenomena. Under Scottish conditions this is extremely rare and indeed has not been seen in raspberries with triple dose rate 27 kg a.i./ha though it occurs in southern England particularly in dry autumns. In the same crop atrazine is applied in the south at 4 kg/ha and if this is exceeded, damage may result, yet in Scotland there is a firm recommendation for a dose of 4-6 kg/ha, the top rate of 6 kg/ha being applied for perennial grass control without damage to the crop.

The lack of effectiveness of EPTC though generally thought to be due to

lower soil temperatures reducing volatilisation and permeation of the soil, in view of Dr. Gloyne's comments, may be due merely to increased losses because of competition with the water for adsorption sites.

The presence of sufficient moisture to bring the soil nearly to field capacity is of great importance when considering the predictability of action of a soil-applied herbicide. The degree of adsorption will be less and with equivalent rainfall the material will readily move to root depth in the soil. However, as Dr. Batey commented, the amount of organic matter in the soil will be enough to buffer the effect on the crop as has been reflected by lack of damage on sandy soils by such mobile compounds as cyanazine on peas and pyrazon on sugar beet. The classic situations which occasionally occur in the south with high soil moisture and low humidity leading to rapid transpiration with consequent excessive uptake of pyrazon has never occurred in Scotland and the safe use of the compound on red beet late in the season confirms this. Indeed the uptake of pyrazon by the weeds is frequently so slow because of the low transpiration rate that a recommendation is made for the addition of propham as a booster to control the weeds before they become to large and "escape". The fact that even the sandy soils in Scotland have an organic matter content in excess of 3 per cent has increased the safety of this treatment.

The situation with cyanazine on onions and leeks is similar where again high organic content of the soil combined with a low transpiration rate make the application of 1.5 lb a.i. satisfactory on leeks and even on onions while in the south, except on fen soils, damage will occur. The swing to selectivity is excessive in the case of prometryne which works well on peas in southern mineral soils but occasionally has reduced weed control efficiency in Scotland due almost entirely to the high organic matter present. These effects on different triazines are further reflected by results with terbutryne plus terbuthylazine which does not give such good weed control as in the south while there does not appear to be so much difference with the trietazine plus simazine mixtures.

Finally of course, products have to deal not only with the vagaries of the climate but also those cultural practices which husbandry demands in such an environment. In an area where wet seed-beds are likely to be met and with weeds emerging ahead of the crop there is a distinct advantage to drilling root crops on a ridge to facilitate early side-hoeing and to dry the seed-bed. Such a practice is unknown further south where conservation of moisture for roots is frequently more essential and recommendations for beet are made with "drilling on the flat" in mind. Thus a recommendation to make an incorporated application of herbicide prior to drilling roots on the ridge can only result in an unexpected but nevertheless excessive dose beneath the ridge. This practice produced damage in beet pretreated with propham and subsequently drilled on the ridge due to the mechanical concentration of propham below the beet row produced by drawing up the ridges.

The foregoing catalogue of differences in herbicide activity, albeit small, and in some cases due to differing techniques, serves to underline the variations in plant growth which occur in 10 degrees of latitude so that the main causes of variation appear to be this difference in plant growth. Strawberries ripen only about three weeks later than in England, yet there is a 2½ month safety margin in the application of triazines and this can only be explained by a fundamental change in the pattern of producing feeding roots following a period of true dormancy. The effect of climate appears to be small except in so far as the generally higher moisture content gives a much greater degree of predictability. The question of lower clay contents

which are of illitic origin and intermediate in adsorptivity probably leads to less locking up of the herbicides in the soil, so the frequently large doses of herbicide which can be applied with safety must be explained otherwise. The difference in organic matter is a possibility but this tends to be small on Dr. Batey's evidence so that we might be looking for differences in adsorptive capacity between incompletely-rotted humus and that more completely broken down in the south, which would seem to be questionable. The most fruitful area for search may well be in the higher moisture status and lower transpiration rates providing a lower uptake of chemical. While this explanation is being sought it is essential to arrive at the correct recommendations by empirical methods and to check them thoroughly where they are to be used.

Within the context of the Symposium the "Northern Environment" has been taken to mean those predominantly arable areas lying north of the Humber, and including Northern Ireland; this paper has shown that regional recommendations are necessary and indicated the importance of local evaluation work. To take a single crop on which soil-applied herbicides are used, 34.5 per cent of the 1973 acreage of potatoes was grown in the area in question yet it would be fair to assume that a much smaller proportion of the total evaluation work expended on potato herbicides was carried out in this northern part of Britain. In order to ensure our material resources are used to best advantage the need for this regional work should be recognised.

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FOLIAR HERBICIDES

J D FORREST & M A MILLER

Bayer Agrochem Ltd, Eastern Way, Bury St Edmunds, Suffolk

From the title of this symposium the existence of a northern environment is acknowledged and for the purpose of this symposium it has been defined as a line 'north of the Humber'. Taking this line of latitude this would then include geographically the Scandinavian countries and perhaps parts of Canada. However, within this group there are some countries which have a maritime climate and others more of a Continental type - is it correct to group them together?

The aim of this paper is to discuss foliar-applied herbicides and the factors which affect their activity and whether these factors differ between north and south. There is obviously a strong Scottish bias at this symposium and, therefore, the subject matter of this paper will refer to Scottish experience. However, reference will be made to other countries, particularly Scandinavia. Other agro-chemical companies were consulted in order to obtain a balanced view and pose particular questions. This may help to provoke discussion and if no definite conclusions are arrived at then at least some further areas for investigation may be highlighted.

A review of the available literature gives the impression that most foliar acting compounds would appear to give efficient control when applied as per label instructions. Herbicide trials by agro-chemical companies usually refer to trials in the North of England and Scotland. These of course are often supplemented by the valuable work of ADAS in the North, the Scottish Colleges, the SHRI and research bodies. Whether this work is considered sufficient is discussed by Makepeace in the next paper in this Session. It should be remembered that trial applications can usually be timed accurately, but of course this is not always the case with commercial applications. Accordingly this paper shall draw upon experiences of farm usage rather than trial results.

A general concensus of opinion in the UK suggests that there are differences in the usage of foliar-acting herbicides in a northern environment but these are not sharp. In Scandinavian countries whilst recommendations are broadly similar, a number of important differences do occur (Anderson 1971). The reasons for these differences include:

(a) Different experiences regarding the effect on weeds and the crop probably related to climatic differences, cultivation and spraying techniques

(b) Different regulations governing the use of herbicides

(c) Commercial reasons - different commercial interests have resulted in different compounds or formulations being marketed. Also price differences can occur.

In the context of this paper two main categories of foliar herbicides are recognised - CONTACT and TRANSLOCATED. Emphasis is placed on those compounds which act through the leaf only; but mention is made of special cases such as mixtures of foliar and soil-acting materials.

The criteria influencing the effectiveness of the older materials such as the growth regulators and dinoseb are well documented. With some of the newer materials it is worth mentioning the more specific requirements, particularly in terms of application technique. It is not intended to discuss these in detail as the questions are: do foliar applied herbicides work less or more effectively in the northern environment; are there special factors which affect the choice or usage of a particular compound under northern conditions?

It is difficult to isolate the various factors involved as they can vary from one particular crop/weed situation to another. It would, therefore, be preferable to make comments on what are termed as botanical, agronomic, climatic and economic factors. The major crops are then considered in conjunction with a discussion of salient points with reference to particular compounds and weed situations.

Botanical Factors

In a paper this morning Scragg dealt with these aspects but it is perhaps useful to re-emphasise some of the points which may concern foliar acting herbicides.

(a) Differences in Flora

The outstanding weed which seems to be common to the northern environment is hempnettle (Galeopsis spp.) In the UK this is well illustrated by the survey carried out by Fisons and reported by O'Leary (1973) where the percentage acreage infested with hempnettle in spring cereals is as follows:

	% Acreage Infested
South & East England	15
South West England & Wales	20
Northern England	21
Northern Ireland	91
Scotland	82

In the West of Scotland Survey 1970 (Waterson et al 1972), redshank (Polygonum persicaria) was the most troublesome weed of wheat and barley followed by hempnettle, but in oat crops the order was reversed. In other countries e.g. Canada and Scandinavia, hempnettle is also common and perhaps it could be designated a northern weed. However, hempnettle can occur in more southerly areas of Europe e.g. the Fens, Northern France, Belgium and Holland. It is possible that one of the requirements of Galeopsis spp. is adequate water supplies for germination and the first six weeks of growth. In northern climates the evaporation rate at the beginning of the season is normally low. Could there also be a difference in the distribution of Galeopsis spp. for example in the Fen area Galeopsis speciosa is most common?

(b) Differences within species

Are there differences within species such as biotypes or clones which can be identified geographically and do they react differently to foliar-applied herbicides? Some 20 years ago it was fairly easy to kill redshank (Polygonum persicaria) in the West of Scotland with MCPA but results were poor in the south and 2,4-D was used before the introduction of dichlorprop. Has this situation changed? Were these differences due to different bio-types or was the weed in a 'soft' growing condition and more easily killed in the north? Could there also be cuticular differences?

Perennial weeds, particularly those which propagate vegetatively, have different clones. Perhaps these react differently to herbicides. This was one of the reasons suggested for differing results with aminotriazole on bracken between the West of Scotland and Norway. The WRO have collections of bracken, docks and couch grass and it would be interesting to know if any differences have been found with foliar herbicide treatments.

Climatic Factors

It is perhaps difficult to separate climatic from botanical and agronomic factors but there are two salient points:

(a) Effect of weather on growth of crop and/or weed

In Southern Britain, perhaps due to temperature, cereals can make considerable increases in growth compared to weeds. This could make cereals more able to compete with weeds, particularly if they were only moderately affected by a herbicide. Carpenter (1973) suggested that in Canada and Scandinavia, summers tend to be dry and hempnettle does not tend to be a serious competitor later in the season, whereas in Scotland and the Fens early control is necessary otherwise growth will proceed vigorously throughout the summer because adequate moisture is available.

(b) Effect of weather at spraying time

Weather at spraying time can affect a foliar-acting herbicide (a) directly by allowing the material to be absorbed or to be washed off and (b) indirectly by the ground being too wet to support a tractor - is field drainage less effective in the north than the south or is evaporation rate involved again?

Another factor which could be important is humidity, particularly with growth regulator type herbicides. Permin (1971) states that trials in Denmark have shown that spraying at high air humidities gives good control and spraying early in the morning has given better results than later in the day and indeed this method is recommended rather than increasing the dose by $\frac{1}{4}$ - $\frac{1}{3}$ as is sometimes done by farmers when spraying in dry conditions.

Before leaving climatic factors there could be some advantage in some northern environments as MCPA is approved for use in Finland in the autumn on frozen soil but is impossible to use during wet autumns.

Agronomic Factors

Does farming practice in the northern environment influence weed flora which could then affect the choice of herbicide? Lawson (1972) has already suggested that growers should plan ahead to avoid situations like a Brassica crop/weed problem. Another example is the build-up of weed species resistant to a herbicide being regularly used but is this different from elsewhere?

The selection of main crop cultivars is often made on the basis of their agronomic suitability to the north. Do they have any influence on weeds due to their power of competition or otherwise? Does growth play a part also? When oats were commonly grown in the north did they tend to smother weeds?

Economic Factors

Traditional systems of land tenure, though less stringent today, have a profound effect on farming practice. These systems were more concerned with good stewardship of the land than profitability. Thus in the northern environment we

find that rotational farming has survived the economic pressures of the past two decades. Indeed many farmers consider selling straw as a process of land impoverishment. Soil organic matter contents benefit accordingly.

Undersown grass/clover swards can be of much greater economic significance to the farmer than the nurse crop. The agronomist might argue that many fields should never be undersown until the problems of corn marigold, or wild oats, or couch grass have been controlled with herbicides.

Should a farmer with limited resources adopt a programme of uninterrupted silage making or should he utilise available spray days during the silage work to control weeds in his cereals? The decision is an economic one.

Is there a level of weed infestation below which weed control is not economic?

Are northern farmers more or less inclined to cut costs by using cheap herbicides or by applying less than the recommended rates? What is the real cost of such practices in terms of lost yield and quality?

These are a few of the economic aspects; many more can be cited. The economic structure of a farm and the farming industry is complex and the farmer has to make decisions within this context .... even in regard to the usage or abusage of foliar herbicides!

Foliar Acting Herbicides in Northern Crop/Weed Situations

Having discussed the main factors which can influence foliar acting herbicides one can look at the present situation in relation to the major crops.

Cereals

The most important northern crop in the UK is spring barley, providing a greater area sprayed with herbicides than any other crop.

(a) Broad-leaved weeds

The only published survey data on control of broad-leaved weeds in cereals is the West of Scotland Survey (Waterson *et al* 1972) where the acreage sprayed was barley 90% and oats and wheat 69%. Was the remaining acreage left unsprayed due to the lack of weeds or due to weather conditions? The most extensively used herbicide was MCPA, and it was recorded that this was surprising in an area where chickweed and redshank are widely distributed. It would be interesting to know whether MCPA was chosen because of price or because hempnettle was present. Also it would be interesting to know if the situation was similar in the other College areas. Are there less spraying days in the north than the south and as Joice (1973) suggests, less opportunity to spray under optimum conditions? Clearly there is a need for further survey work.

The use of ioxynil mixtures in Scotland tends to be related to the control of specific weeds, but they do not always fit into the necessary requirements for controlling the most commonly occuring weed associations. Their performance in the north tends to be poorer compared to the south possibly because of their reliance upon high light intensity (Allen *et al* 1974).

There is now a MCPA/cyanazine mixture which has been tailor-made for northern conditions and has been reported by Allen *et al* (1974) as giving good results in Scotland and Denmark and is effective at low temperatures. The new mixture of bromofenoxim/terbuthylazine may be useful under northern conditions as it can be sprayed over a longer period than the growth regulator herbicides.

(b) Wild Oats - (Avena fatua)

Wild oats are spreading fairly quickly and although some infestations are still rougeable, most require spraying. It was stated at the 6th Review of Herbicide Usage Symposium that barban was generally preferred to tri-allate as it is more effective under Scottish conditions. No reasons were given but perhaps the answer lies in the soil. Recently chlorfenprop-methyl was introduced to the market and this also performed well commercially in Scotland (Forrest et al 1972). It is possible that under northern conditions there is a more even flush of wild oats and thus better control because more have emerged and are at the correct stage for application.

(c) Couch (Agropyron repens)

Couch grass appears to be a serious weed in the north. At the 6th Herbicide Usage Symposium it was stated (Anon 1969) that many of the techniques discussed for the control of grass weeds did not take into account the special problems of the north where protracted harvests and difficult autumn conditions are more common than in the south. The earlier onset of winter conditions leaves little time for stubble cultivations to provide optimum conditions for couch herbicides to work. However, Atwood (1973) stated that for the past 3-4 years northern autumn conditions have been as easy as the south. This comment ties in with the use of dalapon (Allen 1973) where the latitude experienced by the Southern English farmers in the case of dalapon is not enjoyed by the Scots. Reduced effectiveness could be due to the fact that temperatures in Scotland fall rapidly in late autumn. There are indications that the new material glyphosate may be particularly useful in the northern environment. Hodkinson (1973) suggested that glyphosate translocates much better to underground parts in cooler more humid conditions. Trials have shown adequate performance but a much slower appearance of leaf symptoms, e.g. 30 days instead of the normal 10-14 days. There are also indications that a higher rate may be required in the north.

Potatoes

(a) Broad-leaved weed control

The most widely used herbicide on potatoes at present in Scotland is paraquat. Is this purely due to economic reasons i.e. a low cost herbicide, or is it because once the flush of weeds at time of spraying is controlled the aggressive vigorous haulm growth smothers any later germinating weeds? Metribuzin, which has contact and residual action, can also be applied after emergence to most maincrop cultivars and promises to be a useful material under northern conditions.

(b) Haulm desiccation

It would appear that sulphuric acid is the preferred material. Is this a reflection again of vigorous haulm growth and sulphuric acid giving a quicker and more effective control than diquat or dinoseb in oil?

Peas

Dinoseb amine is the preferred material at present in Scotland and although slower in action perhaps due to cooler conditions, the final result is similar or even better to that obtained in the south - as long as it is not washed off!! Soil-applied herbicides have not been as successful as in the south (Edwards 1973).

Brassicas

Soil-applied herbicides do not cover the complete spectrum but desmetryne can be used as a supplementary treatment. However, this has its limitations in not

controlling shepherd's purse (Capsella bursa pastoris) but does of course control chickweed (Stellaria media) (Lawson 1972).

Carrots

TVO is still widely used in Scotland for weed control in carrots. In the south it has been superceded by residual herbicides. There is some interest in metoxuron but there is still a need for a good post-emergence material because on sandy soils early pre-emergence treatment is not desirable on 'blowing sands'.

Root Crops

There is at present no foliar acting selective herbicide for turnip and swede crops - perhaps this is a useful gap which could be filled. Sugar beet is now a memory in Scotland but with beet crops (sugar or red) supplementary foliar sprays of phenmedipham may be required due to either poor performance of residuals or because of the particular weed spectrum. There is a tendency in Scandinavian countries to move away from residuals on sugar beet to a post-emergence treatment with phenmedipham.

Soft Fruit

(a) Strawberries

Residuals are widely used but occasionally there are failures due to dry conditions or perhaps high soil OM content and the introduction of phenmedipham for the strawberry crop may allow supplementary treatments to be carried out.

(b) Raspberries

In this very important Scottish crop foliar-acting herbicides are usually used only in emergency situations and paraquat is the usual material. In crops where no residual treatment has been applied weed growth can take place at an alarming rate in the spring probably due to crop microclimate plus soil fertility.

Bracken

As one of the authors was intimately involved with bracken control many years ago (Forrest 1958) the introduction of asulam is of great interest and the product looks very promising under Scottish conditions (Pink & Burman 1974). It is interesting to speculate whether asulam could have an effect on the northern environment economically and perhaps this is a case of a herbicide influencing the environment benefically rather than a herbicide being influenced by the environment.

Conclusion

In this subjective review of foliar acting herbicides in a northern environment it is difficult to provide a factual basis for possible differences although they do exist. In a northern climate it is more likely that a foliar-acting herbicide is helped less by the crop and hindered more by the weather, before, during and after application than in the south. Perhaps higher dose levels may be required to achieve the same degree of reliability in the north but would this be shown up in small scale controlled experiments? More monitoring or survey work of commercial applications is required to determine the factors or characteristics which influence foliar-acting herbicides in the northern environment. With such information it might then be possible to determine whether "the right horse was being chosen for the right course".

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