Global Change : Implications for Crop Protection

D Atkinson
SAC
West Mains Road
Edinburgh EH9 3JG

SUMMARY

Information presented elsewhere on the probable implications of global change for crop protection is reviewed against the background of factors which are currently known to influence major practices within crop protection, i.e. chemical and non-chemical based control of weeds, pests and diseases. On the basis of this review, some questions of importance to the crop protection industry are defined and some suggestions as to major effects on crop protection practices are made.

INTRODUCTION

At any presentation on change, one of the major thoughts of the listener will be "how this will influence me". It is therefore important to assess the probable impact of global climatic change on the crop protection industry and the practice of crop protection. There are four lines of reasoning in relation to crop protection which can be followed. These are:

1. Climatic change will not occur and any changes it may bring about will be too small to be of practical significance.

2. All the effects of climatic change envisaged can be accounted for within the range of variation that we already need to allow for.

3. Climatic change will influence the interactions between organisms, between organisms and their physical environment, and between organisms and crop protection materials in ways which are quantitatively or qualitatively different from the current situation and so require "new" action.

4. Climatic change will influence the agricultural systems with which we work and require crop protection strategies to be replanned.

These various options will be discussed against the background of the other papers in this volume and the recent crop protection literature.

The Magnitude of Climatic Change

The probable magnitude of climatic change has been detailed by Tinker (1993) and Rowntree (1993). These effects can be summarised as follows:

a) The concentration of CO_2 has increased since 1750 from a mean level of 280ppm at that time to 350ppm currently. This is predicted to rise to around 600ppm by 2060.

b) This and the increase in other greenhouse gases, i.e. methane and NO_x should result in an increase in mean global temperature of 1.5 -4.5°C. This rise will not be uniform at all latitudes.

c) The 70ppm rise in CO_2 since the Industrial Revolution has been accompanied by an increase in temperature of 0.5°C. This is consistent with the temperature rises predicted above.

d) Ultimate temperature increases on land seem likely to be within the range 3-6° in winter and 2-4° in summer.

e) Precipitation is likely to change, increasing in winter north of 45°N and decreasing in middle latitudes. Changes are likely to be less than 0.5mm per day. Despite this soil moisture evaporation is predicted to increase, probably by around 0.25mm per day.

We thus need to ask if these changes are large enough to have an effect upon our crops and upon the working of crop protection materials. This question has been addressed by Parry and Rosenzweig 1993, who predict effects on crop yields which will differ between different crops. Similar predictions were made by Parry, *et al,* (1988).

Cooper (1973) reviewed the effect of root temperature on plant growth, root:shoot ratio, leaf development, flowering and fruiting. This review makes it clear that changes in temperature of 5°C can have significant effects, i.e. in soybean, increasing root temperature from 10°C to 15°C, increased growth from 0.8g to 1.7g. In addition, it is clear that not all species respond in the same manner, i.e. increasing root temperature from 17 to 22°C increased strawberry growth from 39 to 47g, whilst at the same time decreasing growth of bent grass from 105 to 70g.

In crop protection terms, changes in temperature have been found to influence factors such as the dormancy of *Echinochloa* seeds (Furuya and Kotoaka, 1993), the retention of growth regulators by cereal leaves (Hunt and Baker, 1983) and the activity of *difenzoquat* (Kowalczyk *et al* 1983). In a study of the effectiveness of AC 252, 214 Malefyt *et al* 1983, found decreased activity with increasing temperature in some species, e.g. soybean and the weed species *Abutilon theophrasti* but not in *Digitaria sanguinalis*. Temperature effects of the magnitude predicted are likely to be complex and biologically significant. Reviewing the effects of environmental factors on herbicide metabolism Cole (1983) concluded "Although much effort is expended in establishing the optimum environmental conditions for applying individual herbicides, little is known about the influence of specific factors upon herbicide metabolism. Hence, at the moment, few principles have arisen apart from the obvious importance of light in photochemical activation and in provision of substrate for glycosyl cojugate formation, the possible effect of temperature on detoxifying reactions and the importance of the soil micro flora with respect to soil applied herbicides. These are also factors which must be taken into account in residue studies conducted away from the field. Since soil micro flora seem potentially to be of great importance in determining residues of soil applied compounds within the plant, other factors such as soil type, pH and the application of fertilisers may be germane. It should particularly be recognised that it is the combination of external factors which is important in influencing herbicide performance".

It would thus seem unrealistic to conclude that the effects of global change are of no significance. Hence we must ask if they are significant compared to the effects of other factors which influence crop protection practice. The effects illustrated above, suggest that for individual chemicals, crop and weeds, the magnitude of temperature related effects would require a change in practice or usage of a particular compound.

Climate Change and Normal Variation

Chemical products are developed for world-wide markets (Beyer, 1991) and so are likely to work in a range of circumstances and on a varied spectrum of weed species. However, many modern materials are being developed for specific crops, which are usually grown in a specific type of environment and so whilst global change may not require the development of new crops able to cope with ranges of environmental variation outwith the current crop range, or with growing conditions which are outside the current range of conditions met elsewhere in the world, it may change the area needing to be treated with a particular product which will have a major impact on the usage of that product and particular manufacturers. For example, Beraud *et al* (1991) described the use of ICIA0051 for the control of a range of broad leafed weeds and grass in maize. If the area of maize grown is to be decreased as suggested by Parry and Rosenzweig (1993), then the value of this new material will be reduced. While some of the changed environmental conditions likely to result from global change can be predicted from models and sets of data from a particular geographic area, the testing of new herbicides on geographically distinct sites by most manufacturers would suggest that understanding of the effects of the range of climatic variants which occur at different sites is not yet sufficiently good for multi-site testing to be abandoned. From this it would seem logical to conclude that not all of the effects of climate change can easily be allowed for on the basis of current understanding of environmental effects.

Climate-Biota Interactions

The studies discussed above indicate that there are interactions between materials and environmental variates, between organisms and environmental variates and between these three groups of factors. As with all complex interactions, understanding their cause is difficult. It is improbable that there will not be major interactions between the climate of the future, weed and crop species and the activity (control of weed species/safety to crop species) of specific chemicals. At the least, these changes are likely to necessitate the rewriting of labels of guidance notes to users.

Climate Change and Agriculture

Interactions between climate change and agriculture have been discussed by Tinker (1993) and Parry and Rosenzweig (1993). It is clear from these studies that the distribution of individual crops change and in some areas in a major way. Parry and Rosenzweig (1993) estimate changes in wheat yields using the Goddard Institute for Space Studies Model (GISS) which vary from a decreased of 33% in Brazil to and increase of 27% in Canada. They also predict maize yields as being reduced most and protein crops like Soya least influenced. It is clear that climate change will modify the appearance of the countryside in any one place. The extent of the modification compared to the effects of factors such as technological drift, i.e. the advances due to plant breeding, etc, are hard to quantify.

The studies of Pregitzer (1993) indicate that soil processes will be changed by changes in CO_2 supply to crops as a consequence of modified carbon flows to plant roots and associated micro-organisms. In addition, there will be indirect effects of the influence of CO_2 on temperature. These changes are likely to cause alterations in the levels of soil organic matter, which in turn will have a major influence on the physical properties of soils and on the activities of crop protection materials (Cole, 1983). In that soil conditions are known to modify crop growth, the longer term changes in soil physical and chemical conditions which will occur due to modified soil biological activity resulting from changes in car flow to the soil-plant-microbial system may well be among the most crucial and influential effects of climatic change. This particular area of crop production is among the least well understood and so it is now important that there is a major increase of knowledge about processes in this subject area.

CONCLUSIONS

It is clear from the papers given in this volume that global climatic change is likely to have a major effect upon the way that crop protection is practised and the use of the materials which are currently the basis of crop protection practices.

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