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Monitoring of the Sulfur Supply of Agricultural Crops in Northern Europe

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K e y w o r d s : Atmospheric deposition, oilseed rape, sulfur supply.

Summary

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The concentration of atmospheric sulfur deposition has fallen in recent years with the introduction of legislation to reduce sulfur dioxide emissions from power generating plants. This has caused a sharp decline in the sulfur status of oilseed rape crops in Northern Europe resulting in the increased incidence of sulfur deficiency symptoms and reduced seed yields.

Introduction

The sulfur requirements of high yielding agricultural crops have, until recently, been largely satisfied by atmospheric depositions of sulfur from the burning of fossil fuels. Since the beginning of the 1980's legislation to control the level of sulfur dioxide emissions from power generating plants has resulted in significant reductions in atmospheric depositions of sulfur. This diminishing supply of sulfur has several consequences both to the future efficiency of agricultural production systems and to the wider ecosystem. It has long been recognised that *Brassica* species have a high sulfur demand and with the widespread cultivation throughout Northern Europe of winter oilseed rape (*Brassica napus*) it has become possible to monitor the impact of reduced atmospheric deposition on the sulfur status of this crop. This contribution describes the results of a survey of the sulfur status of rapeseed and discusses the wider implications of

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a continued decline in atmospheric sulfur emissions.

Materials and Methods

Leaf samples were collected over several seasons from commercial crops of winter oilseed rape in Northern Germany, Scotland and Denmark. Sampling was restricted to young fully differentiated leaves on the upper third of the rapeseed plant just prior to flowering. Fields were selected where no sulfur fertilisation had been carried out. Samples were dried and the sulfur content determined by the X-RF method described by SCHNUG & HANEKLAUS 1988.

Results and Discussion

The results of the continuous monitoring of rapeseed crops in Schleswig-Holstein from 1980 to 1991 is presented in Figure 1. The decline in sulfur status of the rapeseed crop in this region of Germany has been accompanied by a marked increase in the appearance of sulfur deficiency symptoms described by HANEKLAUS & SCHNUG 1992. Accompanying measurements of soil sulfur status failed to identify those crops receiving suboptimal supply of sulfur. The critical level of leaf sulfur concentration necessary for maximum yield was found to be 6.5 mg g^{-1} for both single and double low varieties. Visible symptoms can be expected when the total sulfur concentration remains below 3.5 mg g^{-1} of leaf dry weight for the recently introduced low glucosinolate cultivars. In 1980 the sulfur status of the majority of crops in Schleswig-Holstein was adequate for the attainment of satisfactory yields. This contrasts markedly with the position in 1991 when only 1 % of all the surveyed fields gave leaf S concentrations higher than the critical value, while nearly 50 % of all crops showed sulfur deficiency during the vegetative period of growth. Such a dramatic change in the sulfur status of this crop in this region may be explained on the basis of the declining deposition of atmospheric sulfur. In the west coast regions of Schleswig-Holstein the annual atmospheric S input in 1956 was 80 kg S ha^{-1} (KURMIES 1957). Similar measurements by SCHNUG & HOLZ 1987 during the 1984/85 growing season found that the annual levels of sulfur deposition had fallen to only 20 kg S ha^{-1}. Using a similar sampling technique, PEDERSEN 1991 in Denmark, and EVANS & al. 1991 in the south of Scotland surveyed the sulfur status of commercial crops of oilseed rape (Fig. 2). Results from Denmark, during the 1989/90 growing season, showed a much wider range of leaf sulfur values than that recorded in the two other locations. While the majority of crops received adequate levels of sulfur, a small proportion of sampled crops gave sulfur values below the deficiency threshold. Leaf sulfur levels in the south of Scotland were similar to those recorded in Schleswig-Holstein. The large seasonal variation may, in part, be accounted for by low rainfall and poor growing conditions during 1990/91. Crop growth during the autumn and early winter was generally poor due to low temperatures and rainfall, while the spring and early summer were characterised by low rainfall. Such a weather pattern resulted in poor root development resulting in an inability by the

crop to exploit fully the ground water sulfur supplies. In conclusion, as a consequence of this reduction in atmospheric supplies oilseed rape grown without additions of fertilizer sulfur are unlikely to achieve their full yield potential over large areas of Northern Europe. Worthwhile yield responses to applied sulfur have been frequently recorded in recent years, while crops showing strong sulfur deficiency symptoms may fail to produce any seed. Since 1979 cereal crops have also responded well to sulfur fertilisation in Schleswig-Holstein (SCHNUG 1982), whilst sulfur deficiency symptoms are becoming increasingly common in both Britain and Denmark.

While sulfur excessive fertilisation may lead to an increase in seed yield, amounts will lower rapeseed quality by increasing its total glucosinolate level. In breadmaking wheat, however, the sulfur nutritional status is positively correlated both with yield and baking quality, especially loaf volume (SCHNUG & al. 1992).

Glucosinolates are S-containing compounds in cruciferous plants which form an important part of the plant's resistance against pests and diseases. An insufficient sulfur supply increases the plant's susceptibility to diseases such as phoma and light leaf spot (SCHNUG & CEYNOWA 1991). Applications of sulfur may therefore be regarded as an effective crop protection measure without generating harmful environmental effects. Recent interest in organic farming methods have yet to recognise the importance of supplementing organic manures with sulfur products to maintain a satisfactory N:S ratio. Since both nitrogen and sulfur are involved in protein biosynthesis, a shortage in the sulfur supply of crops lowers the utilisation of the available soil nitrogen thereby increasing nitrogen leaching.

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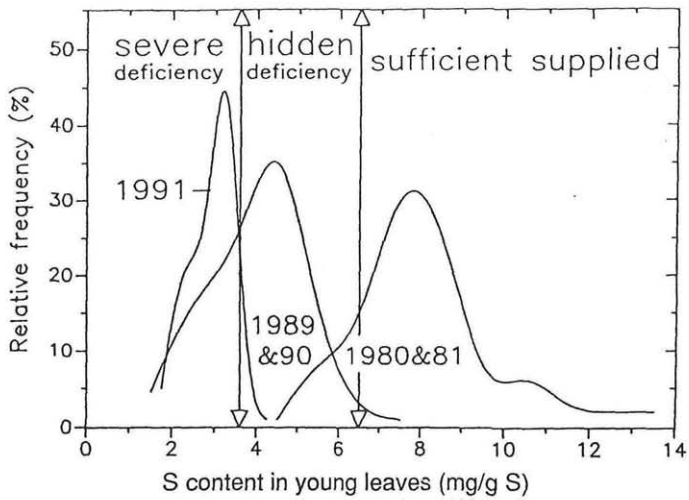

Fig. 1. Relative frequency of total sulfur concentrations in younger, fully differentiated leaves of the upper third of elongated rapeseed plants grown on fields without sulfur fertilisation in Schleswig-Holstein in 1980/81 (n = 203), 1989/90 (n = 227), and 1991.

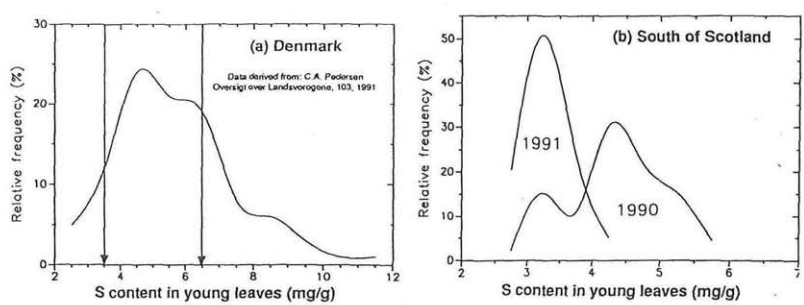

Fig. 2. Sulfur concentration of fully differentiated leaves of oilseed rape (a) Denmark, (b) South of Scotland in 1990 and 1991.