CO1995 C4: AGRONOMY

ASSESSING THE RISK OF SULPHUR DEFICIENCY IN OILSEED RAPE

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ABSTRACT: Sulphur deficiency has become a yield limiting factor for rapeseed production in many areas of the UK, as a result of decreased inputs of S from the atmosphere and fertilisers. Yields of winter oilseed rape were increased by 42-267% by application of 40 kg S/ha at Woburn Farm in three seasons during 1990-94. Leaf S concentration at early flowering was the best indicator to predict S deficiency and a critical value of 4 mg/g was obtained. A qualitative model predicted that about one third of the British land area was currently at high risk of S deficiency.

INTRODUCTION

Oilseed rape is the third major crop in the UK and currently occupying about 400,000 ha. Winter oilseed rape requires as much as 50-100 kg/ha of S in a growing season and is therefore particularly susceptible to S deficiency. In the past, S nutrition of arable crops in the UK has been largely ignored, as the inputs from the atmosphere were sufficient for most crops. However, emissions of sulphur dioxide (SO_2) in the UK have decreased by approximately 40% during the past two decades, and further large decreases are expected to occur as a result of the government policy on pollution control (Department of Environment, 1992). In addition, the use of S-containing fertilisers, such as ammonium sulphate and single superphosphate, has largely diminished. As a result, shortage of S has become a serious problem in some areas in the UK. As S inputs decrease, the S supply in the soil becomes a more critical component of the crop's demand. There has been a growing concern that the pool of available S in soil may have been depleted, particularly in light soils with little organic matter (Syers *et al.*, 1987), thus accentuating S deficiency. This paper evaluates the responses of winter oilseed rape to S fertiliser and discusses the use of tissue analysis and computer modelling in predicting the risk of S deficiency.

YIELD RESPONSES

The inputs of S from the atmosphere have been monitored continuously since the late 1960s at Woburn Farm, Bedfordshire. Total dry deposition was in the range of 60-80 kg S/ha before 1980 and has since decreased markedly to a current level of 5-10 kg S/ha. Yield responses of winter oilseed rape (cv. Libravo or Falcon) to the addition of S fertiliser, at three N application rates, were tested on a sandy loam at this site, in three growing seasons between 1990-94. Large and significant increases in seed yields, ranging from 0.7 to 1.6 t/ha or 42-267% on a relative scale, were obtained in response to the application of 40 kg S/ha applied as gypsum along with either 180 or 230 kg N/ha (McGrath and Zhao, in press). Such large yield benefits indicate that the use of S fertiliser was highly cost effective, with the ratio of value to cost greater than 10.

Increasing N application from 180 to 230 kg/ha decreased seed yield in 1993/94, when no S was applied (Fig. 1a). This shows that a larger input of N agravated the problem of S deficiency and emphasises the importance of a balanced supply of N and S in seed production. Significant responses have also been reported in Scotland and northern England, with yield increases typically in the range of 10 to 300% (Zhao *et al.*,1993; Walker and Booth, 1994; Withers and O'Donnell, 1994).

DIAGNOSIS OF SULPHUR DEFICIENCY

Total S concentrations and the N:S ratios of whole plants or individual vegetative tissues varied considerably at different growth stages. Sampling at a precise growth stage is therefore required if any of these indices is to be used. The concentration of S in leaves at early flowering was found to be the best index for the diagnosis of S deficiency in winter oilseed rape (Fig. 1b). Yield losses due to S deficiency were likely to occur when leaf S concentration was smaller than 4 mg/g. Variation of N rate between 180 and 230 kg/ha did not affect the relationship between this index and relative seed yield (Fig. 1b). In contrast, the N:S ratio was a much poorer predictor of S deficiency.

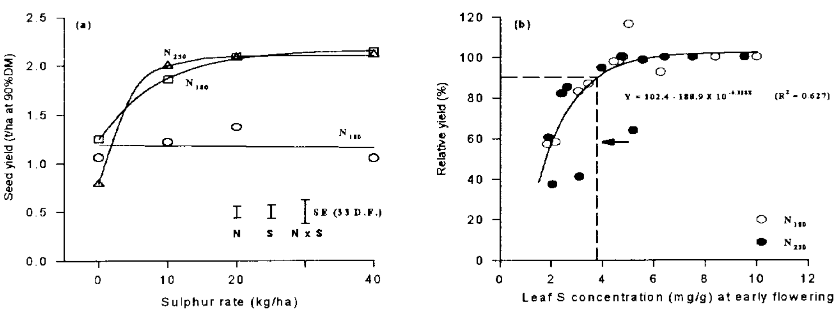

Fig. 1 Yield responses to S at three N rates (a) relationship between relative yields and leaf S concentrations (b).

PREDICTING SULPHUR DEFICIENCY USING A QUALITATIVE COMPUTER MODEL

Although tissue analysis offers a reliable tool in the diagnosis of S deficiency in oilseed rape, the results often come too late for the purpose of recommending fertiliser additions to the current crop. Additionally, soil testing has been shown to be much less reliable than tissue analysis, because the availability of S in soil is governed by the interactions between a number of factors, such as atmospheric deposition, mineralization of organic S and the potential leaching of sulphate from the soil. As an alternative, we have developed a qualitative model to assess the risk of S deficiency in oilseed rape crop by taking into account these factors. Approximately 6000 data points for soils in England and Wales were obtained from National Soil Inventory (McGrath and Loveland 1992), and 700 points for Scotland from Macaulay Land Use Research Institute. Data for the atmospheric S inputs, which include both wet and dry deposition and of marine-derived S, were obtained from Warren Spring Laboratory. Soil information (soil type, texture and pH) and rainfall data were used to assess the potential S losses due to leaching. The atmospheric S inputs, soil organic matter and leaching potential were then combined to give a risk index for S deficiency using a decision tree. The results were mapped and shown in Fig. 2. It is estimated that currently about 33% of the British land area is at high risk of S deficiency, and a further 20% at medium risk. The high risk areas are mainly located in eastern Scotland, northern England, East Anglia, Welsh Borders and South East England. These are also among the major arable areas in Britain. The results of model prediction agree very well with the reported incidence of S deficiency in oilseed rape (Zhao *et al.*, 1993; Walker and Booth, 1994; Withers and O'Donnell, 1994). If the target of future reduction in SO_2 emissions is met, according to the model the high risk area will increase to approximately 50% in 10 years time.

Fig. 2 Risk of sulphur deficiency in oilseed rape

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