CO1995 C22: AGRONOMY

THE EFFECTS OF S AND N ON THE YIELD AND QUALITY OF OILSEED RAPE IN THE U.K.

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ABSTRACT

Considerable variation occurred between site and seasons in yield and seed glucosinolate content of double-low cultivars of winter oilseed rape in response to sulphur. Sites were classified into three categories; non-responsive, marginally-responsive and responsive with respect to their response to applied sulphur. At responsive sites large increases in yield were observed from crops which had low total dry matter production and sulphur uptake. At marginally-responsive sites yield increases in the order of 10% were observed, and increases in seed glucosinolate content were generally greater than at responsive sites. The assignment of sites into categories could be predicted on the basis of initial leaf S levels, their response to sulphur application and in the levels of available sub-soil sulphate. The response of seed glucosinolate content to nitrogen application was modified by plant S status.

INTRODUCTION

The availability of sulphur to arable crops in many areas of the U.K. has diminished with the use of non S-containing fertilisers and reductions in the emissions of sulphur dioxide. Oilseed rape has been shown to respond well to applied fertiliser S due to its high demand for sulphur. Varying responses of oilseed rape to sulphur fertiliser in the U.K have been observed by Walker and Booth 1992, Zhao et al 1993 and Withers and O'Donnell 1994. The aim of this study was to look at the response of oilseed rape to sulphur fertiliser in the presence of different N levels at sites in the UK which from previous experience had produced seed of differing glucosinolate contents.

EXPERIMENTAL

Experiments were established at five sites; Cockle Park, Rothamsted, Woburn, and ADAS Bridgets in the 1990-91 and 1991-92 seasons, and at Flodden in the Scottish Borders in 1991-92. The treatments consisted of different combinations of N and S. At Cockle Park, Rothamsted and Flodden three rates of N (0 ,50 and 250 kg/ha) were used in combination with three rates of S (0, 50 and 100 kg/ha). At Woburn three rates of N (0, 180 and 230 kg/ha) were used in combination with four rates of S (0, 10, 20 and 40 kg/ha). At Bridgets extreme rates of N (0 and 250) and S (0 and 100 kg/ha) were combined. The double low variety Falcon was used in all experiments except at Woburn where Libravo was grown. Sulphur was applied as potassium sulphate at Cockle Park and at Flodden and as calcium sulphate at Rothamsted, Woburn and ADAS Bridgets. Leaf S concentrations were measured between stem extension and the start of floweing by X-ray fluoresence spectrometry (Schnug et al 1984). Seed glucosinolate contents were measured by XRF with correction for seed nitrogen (Zhao et al 1992). Nitrogen analysis was measured with a Carlo-Erba elemental analyser or by Kjeldahl analysis. Soil sulphate concentrations were measured by ICP following extraction with KH_2PO_4.

RESULTS and DISCUSSION

Sites could be classified into three groups non-responsive, marginally responsive and responsive with respect to their response to sulphur application (Table 1).

Non-responsive sites: Cockle Park and Rothamsted

At these sites yield and seed glucosinolate concentration were increased in response to spring N but not affected by sulphur application. At non-responsive sites dry matter production and seed yields were large (*c* 16 t DM/ha; >3.5 t seed/ha).

Marginally-responsive sites: Bridgets and Flodden

At these sites, dry matter production and seed yields were slightly smaller but more variable than at non-responsive sites (7-16 t DM/ha; 2.5-4.0 t seed/ha). Sites were characterised by low initial leaf sulphur values, and large increases in leaf S in response to applied sulphur. Large increases in seed glucosinolate content were obtained in both seasons in response to S.

Responsive sites: Woburn

Large increases in seed yield, dry matter production and sulphur uptake were observed at Woburn in response to S application (40kg/ha) in the 1990-91 and 1991-92 seasons respectively. The yield responses were only observed at high rates of N, and in the absence of spring N no yield response to sulphur application was observed. Plant leaf S levels were low at 4.02 and 2.46 mg/g in respective seasons and were increased by application of 40 kg S/ha to 4.79 and 5.42 mg/ g at high N. Application of S significantly increased seed glucosinolate content in both seasons at high N, and there was a significant N x S interaction. In the absence of sulphur, application of N decreased seed glucosinolate content from 17.9 to 15.3 μmoles and from 17.4 to 13.4 μmoles in respective seasons. Correspondingly in the presence of sulphur spring N increased seed glucosinolate content in 1990-91 from 19.5 to 22.1 (for the 180 kg N/ha treatment) and from 16.6 to 21.1 umoles in 1991-92. The Woburn site was characterised by very low dry matter production 6.2 and 2.3 t/ha in respective seasons at high N.

Beneficial effects of sulphur application on yield at responsive and marginally responsive sites were usually counteracted by deleterious effects on seed glucosinolate concentration, especially where the responses in yield were large. The effects of nitrogen application on seed glucosinolate concentration were modified by the sulphur supply to the crop. When sulphur was abundant as in non-responsive sites then application of nitrogen increased seed glucosinolate concentration. When sulphur was deficient then applied nitrogen decreased seed glucosinolate concentration at responsive sites and had little or no effect at marginally-responsive sites. These interactive effects are explained by the effects of the plant's nitrogen:sulphur balance on the balance between primary and secondary metabolism. When limited sulphur is available an increase in N supply diverts amino acids into primary metabolism and away from glucosinolate biosynthesis.

The assignment of sites into the three categories can be predicted from initial leaf S levels, their response to sulphur application and also in the levels of sulphate available in the subsoil. Previous experience has shown poor correlation between soil S levels and response to applied sulphur but this may be in part be due to the fact that soil analysis in the past has concentrated on the topsoil fraction. High levels of sulphate were available in the soil at Cockle Park and Rothamsted in the autumn and spring, especially at depth. Intermediate concentrations were available in the soil at Flodden and Bridgets, and very low concentrations at Woburn. Soil sulphate concentrations in the summer remained low at Woburn even after an application of 40 kg S/ha but at the other four sites they were increased by sulphur application. Atmospheric sulphur deposition ranged from 12 kg/ha in the Scottish borders to 17 kg/ha at Rothamsted. These small differences in atmospheric deposition are unlikely to be a major cause of the between-site variation in the responses of oilseed rape to applied sulphur.

ACKNOWLEDGEMENTS

This research was jointly funded by the Ministry of Agriculture, Fisheries and Food and the Home-Grown Cereals Authority.

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Table 1. Crop dry matter, leaf sulphur, seed yield and glucosinolate (GLS) content of oilseed rape crops grown without applied sulphur at five sites in 1990/91 and 1991/92, and their responses to applied sulphur

	NON-RESPONSIVE SITES COCKLE PARK		NON-RESPONSIVE SITES ROTHAMSTED		MARGINALLY-RESPONSIVE SITES ADAS BRIDGETS		MARGINALLY-RESPONSIVE SITES FLODDEN	RESPONSIVE SITE WOBURN	
	1990/91	**1991/92**	**1990/91**	**1991/92**	**1990/91**	**1991/92**	**1991/92**	**1990/91**	**1991/92**
Without applied S:									
Crop DM, t/ha	17.0	13.4	16.4	-	7.4	-	15.5	2.3	2.3
Seed yield, t/ha	4.77	4.43	3.97	3.61	3.41	3.17	2.72	1.12	1.03
Seed GLS, µmol/g	18.1	14.8	13.5	12.2	8.9	10.3	7.5	15.3	1.34
Leaf S, mg/g	3.65	8.07	5.47	4.68	3.13	4.03	3.23	4.02	2.46
Crop uptake, kg S/ha	133	129	108	-	20	-	124	22	5
% Response to applied S:									
Yield	108	102	93	103	101	107	111	243	165
Seed GLS	92	101	96	143	131	275	415	120	158
Leaf S	124	113	103	206	132	225	267	119	220