EFFECT OF FOLIAR BORON FERTILIZATION ON YIELD AND QUALITY OF WINTER RAPE

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INTRODUCTION

In the north-eastern region of Poland (14.000 ha), a high-erucic winter rape has been grown, mainly for oil. The climatic /510 mm precipitation/ and soil conditions assure obtaining the seed yield as high as 25-30 dt/ha. However, the potential productivity of the rape is much higher and the yield may be 50-60 dt/ha /Finck 1979/. This depends, in a great extent, on the supply to the crop of the essential nutrients (N,P,K,Ca,Mg,B). To produce 30 dt seeds and 90 dt/ha straw, the rape takes up 197 kg N, 36 kg P, 207 kg K, 98 kg Ca, 37 kg Mg, and 168 g B per ha (Szukalski et al. 1987). The rape has been found to require 170-260 g boron per ha (Bergman 1973). The availability of B is, however, often reduced. Soils containing 20-25% silt and clay, 1.6 % humus and having pH 6.5-7.0 are mostly characterized by deficient amounts of available B; Gupta 1968; Gupta and Macleod 1977). The uptake of B also depends on soil moisture and light intensity in particular stages of plant growth. Both those factors, when occur at good levels, have been found to promote the uptake of B (Gupta 1979) and increase the need for the element, particularly at the stage of bud formation throughout the complete silique setting (Szukalski et al. 1989). Szukalski and Sikora (1981) reported that the rape plants before flowering should contain 35 ppm B, the amount necessary for good yields. B as a pollen constituent is responsible for the process of pollination and silique formation. It also takes part in the metabolism of nitrogen compounds and synthesis of fats (Gupta 1976; Bobrzecka et al. 1973).

The need for boron fertilization of the rape is unquestionable. However, there is still the problem of the dose height and the date and method od application. This is associated with the limited tolerrance of plants to B concentrations in the soil.

The objectives of this experiment were: (a) to find the best dose of B for foliar application to the winter rape, and (b) to determine the offect of that method of application on yield and quality of seeds as well as the content and composition of oil.

MATERIALS AND METHODS

In 1987, 1988, and 1989, a field experiment was conducted with a high-erucic winter rape, cv. Skrzeszowicki, in the Agricultural Experiment Station at Bałcyny (Poland). Rape crops followed each year a leguminous mixture grown on the soils characterized in Table 1. Rape was seeded on August 15 at the rate of 8 kg/ha at row spacing 20 cm. After harvest of the forecrop, the soli was limed with calcium carbonate at the rate of 2 tons per hectare to supply the element of calcium and to raise the soil pH.

Before seeding, 180 kg K_2O/ha as 60 % KCL, 100 kg P_2O_5 as superphosphate, and 40 kg N/ha in the form of urea were applied to the soil. In the following spring supplemental N was added at 120 kg N/ha in the form of ammonium nitrate as a split application: 60 kg N in mid-March and 60 kg N two weeks later.

The following treatments were applied to single plots (10 m^2 each) and replicated four times in a randomized-block design: 0.2; 0.4; and 0.8 kg B per hectare. B was applied as aqueous solution of boric acid at concentrations 0.2; 0.4; and 0.8 % at full bud formation (first single flowers). No injuries to the plants were observwed due to treatments. After 5 days, samples of whole plants (without roots) were taken for chemical analysis. Before experiment and after harvest, soil samples were collected for physico-chemical analysis. Harvest was made at technical stage. the crop from each plot was weighed and analyzed separately for the content of dry matter, N, P, K, Mg, Ca, and B. Seeds from the 1989 harvest were analyzed for the contend of fat and ceratain fatty acids. Total N was determined by the Kjeldahl method and K, Mg, and Ca were determined using atomic absorption. Boron analyses were made by the method with curcumine. Oil content was determined by the distilatory method of Soxhlet. Methyl esters of fatty acids were determined using a gas chromatograph Pye Unicam series 104 with aflame-ionizing detector as described by Zadernowski and Sosulski (1979). The percentage share of fatty acids was calculated to all acids.

The date were analyzed statistically employing an analysis of variance.

DISCUSSION OF RESULTS

1. Yield

The yield of rape seeds obtained was a result of the effects of favourable weather (Fig. 1) and soil (Table 1) conditions. The most favourable year was 1987 when the yield of seeds amounted to 6.67 t/ha indicating the potentiality of genetic properties of that plant (Finck 1979). There were signiticant yield increases due to boron sprays of rape plants at budding that amounted to 0.4-0.65 tons of seeds per hectare (Table 2). The most effective dose of boron was 0.2 kg B/ha (0.2% solution).
These results are in accordance with the results obtained by Szukalski and Sikora (1985) who used solobur and borax.

In the next two years, the response of the rape to foliar boron nutrition was like in 1987. The soil on which the rape crop was grown in 1988 was heavier (40 % of silt and clay; Table 1), but poorer in the available nutrients and with a low boron content (0.12 ppm B in H_2O). Weather conditions during the growth period were also unfavourable (Fig. 1). A low precipitation in April no doubt was a limiting factor and seed yield in 1988 was by 30 % lower than that in 1987, which is in agreement with the results obtained by others Szukalski al. (1989). In a relatively dry year of 1988, the most effective dose appeared 0.4 kg B/ha wihich increased seed yield by 0.46 t/ha while the dose of 0.8 kg B/ha increased yield by 0.67 t/ha as compared with control.

In 1989, the effectiveness of the B doses was similar to that in previous years. In general, the seed yield in this particular year was higher than in 1988 and approximated that of 1987. This was due to more favourable weather conditions (Fig. 1) and to the optimal amounts of available P, K, and Mg (Table 1) in the soil (Kosek 1987).

The mass of 1000 seeds varied from year to year. The highest mass was noted in 1987 under boron treatments of 0.2 and 0.4 kg B/ha. In the next two years thore was a tendency for boron treatments to increase the mass of 1000 seeds.

2. Mineral content

The analyses of plants at budding and seeds showed that the N, P, K, Ca, Mg, and B content depended on soil fertility and the height of yield (Table 3). The highest variation was in potassium content, both in fresh plants (budding stage) and in the seeds. In 1987, the seeds were characterized by the highest content of phosphorus and potassium as well as of nitrogen. Boron-treated plants contained by 40 % more B in the tissue as compared with control. Boron application to the crop markedly incressed the seed boron content but not above the sefficient range, which is in accordance with the results obtained by Szukalski et.al. (1977). The magnesium and calcium content of the rape plants at budding and seeds was at the optimum range in all the years studied.

3. Content of fat and fatty acids

Foliar application of boron to the rape plants at the dose of 0.4 kg B/ha increased the seed fat content by 0.64 % (Table 4). There was an increase in the content of fatty acids C_{16} and $C_{18:1,2}$ and a decrease in the content of $C_{22:1}$. The highest decrease in the content of erucic acid was observed at the highest dose of boron (0.8 kg B/ha). Such a tendency was also found in the earlier studies (Bobrzecka et.al. 1973) when boron was applied to the soil.

4. Removal of nutrients in crop

The removal of nutrients in the crop (Table 5) indicates how high are the nutritional needs of the rape. This is in agreement with the results obtained by Sikora (1989). High levels of the available potassium, phosphorus, magnesium, and boron in the soil are greatly responsible for rape yields (Sikora 1989). In this study, it was found that foliar application of boron to the rape crop at budding stimulates the utilization of nitrogen, potassium, phosphorus and calcium and improves ionic balance between B and Mg and Ca in the plant.

In the soils on which the rape was grown, generally, the deficiency of available boron was observed (Krauze et.al. 1989) and there is need for supplemental application of the element. Foliar application appears the most effective method because thanks too slow translocation of B from lower parts of plants to growing points and generative organs, it assures rapid translocation of the element to cells. This way of supplying boron improved its level in the rape crop and increased the utilization of nitrogen, potassium, phosphorus, and calcium by that crop, which was decisive of obtaining high crop yields and high quality seeds (Tables 2, 3 and 4).

CONCLUSIONS

1. In the conditions of medium boron and magnesium levels and of high levels of potassium and phosphorus in the soil, the yield and quality of rape seeds were significantly increased under foliar boron treatments (at budding). Yields ranged from 4.4 to 6.67 t/ha depending on the kind of soil and season.

2. Boron doses of 0.2 and 0.4 kg B/ha appeared more effective with respect to yield than the dose of 0.8 kg B/ha. The reverse was true of the fat and fatty acids content that was higher under 0.8 kg B/ha.

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Table 1. Chemical composition of the soils (before treatments)

Study year	Org. matter	Silt and clay %	Texture	pH 1N KCl	mg/100 g soil Egner-Riehm P	Egner-Riehm K	$CaCl_2$ Mg	ppm H_2O B
1987	1.38	22.8	sandy loam	6.2	11.1	17.1	3.10	0.25
1988	1.61	40.3	medium heavy loam	6.5	4.6	11.2	2.10	0.12
1989	1.99	24.8	sandy loam	6.5	10.9	23.2	9.50	0.21

Table 2. Yield of high-erucic winter rape cv. Skrzeszowicki. grown in field under different levels of foliar-applied boron.

Study year	Item	Doses of B, in kg/ha Control No B	0.2	0.4	0.8	LSD 0.5
1987	seed yield t/ha	6.02	6.53	6.47	6.67	0.31
1988		4.40	4.71	4.86	5.00	0.15
1989		5.40	5.78	5.82	6.00	0.24
1987	Mass of 1000 seeds, g	4.73	5.05	4.93	4.65	
1988		4.64	4.89	4.61	4.89	
1989		4.01	3.94	4.15	4.15	

Table 4. Fat and fatty acids content of winter rappe seeds grown in field under different levels of foliar-appilied boron (1989)

Boron doses kg B/ha	Fat, % of dry weight	Fatty acids, in % $C_{16:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:1}$	$C_{22:1}$
1	2	3	4	5	6	7	8
No B	46.19	3.7	13.0	13.4	9.1	9.4	49.3
0.2	46.47	4.8	13.1	15.5	8.9	8.9	47.1
0.4	46.83	4.0	14.3	14.9	9.2	8.1	46.9
0.8	47.09	4.2	13.5	15.8	9.4	8.7	46.4
LSD P=0.05	0.52		0.71	0.65			0.61

Fig. 1.

Table 3. Mineral content of winter rape grown in field under different levels of foliar-applied boron

B doses kg/ha	Item	Study year	ppm B	% of dry weight N	P	K	Mg	Ca
Control (no B)	Fresh crop at budding	1987	11.5	3.47	0.65	4.07	0.15	1.37
		1988	15.4	2.78	0.43	2.72	0.20	1.30
		1989	17.9	2.88	0.48	3.02	0.24	1.55
	Seeds	1987	4.5	3.83	0.97	1.34	0.25	0.41
		1988	6.3	4.20	0.75	1.27	0.31	0.46
		1989	5.8	3.04	0.72	1.40	0.30	0.35
0.20	Fresh crop at budding	1987	16.5	8.36	0.61	4.20	0.16	1.35
		1988	16.5	2.58	0.43	2.72	0.18	1.18
		1989	21.2	2.86	0.44	3.12	0.23	1.42
	Seeds	1987	4.5	3.81	0.89	1.15	0.25	0.39
		1988	9.2	4.24	0.74	1.28	0.30	0.46
		1989	9.0	3.11	0.73	1.46	0.31	0.36
0.40	Fresh crop at budding	1987	16.6	3.64	0.63	4.20	0.19	1.32
		1988	16.6	2.83	0.44	2.79	0.18	1.15
		1989	20.5	2.98	0.52	3.05	0.22	1.46
	Seeds	1987	5.0	3.71	0.89	1.27	0.25	0.39
		1988	9.9	4.50	0.79	1.31	0.30	0.53
		1989	9.3	3.17	0.73	1.44	0.29	0.39
0.80	Fresh crop at budding	1987	23.0	3.53	0.65	4.25	0.20	1.31
		1988	20.2	2.52	0.43	2.78	0.19	1.30
		1989	21.4	2.64	0.51	3.01	0.23	1.45
	Seeds	1987	5.5	3.87	0.98	1.57	0.25	0.43
		1988	10.6	4.49	0.75	1.27	0.31	0.47
		1989	10.9	3.08	0.74	1.48	0.30	0.37

Table 5. Plant nutrients removed in rape crop (seeds+straw) as influenced by foliar boron fertilization Means of 1987 - 1989

Boron doses kg/ha	Nutrient removed in kg/ha N	P	K	Mg	Ca	B
No B	206.5	65.8	566.8	31.1	243.5	0.276
0.2	307.8	73.5	595.1	28.4	208.2	0.329
0.4	310.0	77.9	612.0	29.2	220.2	0.337
0.8	335.4	84.6	649.7	31.3	243.1	0.394

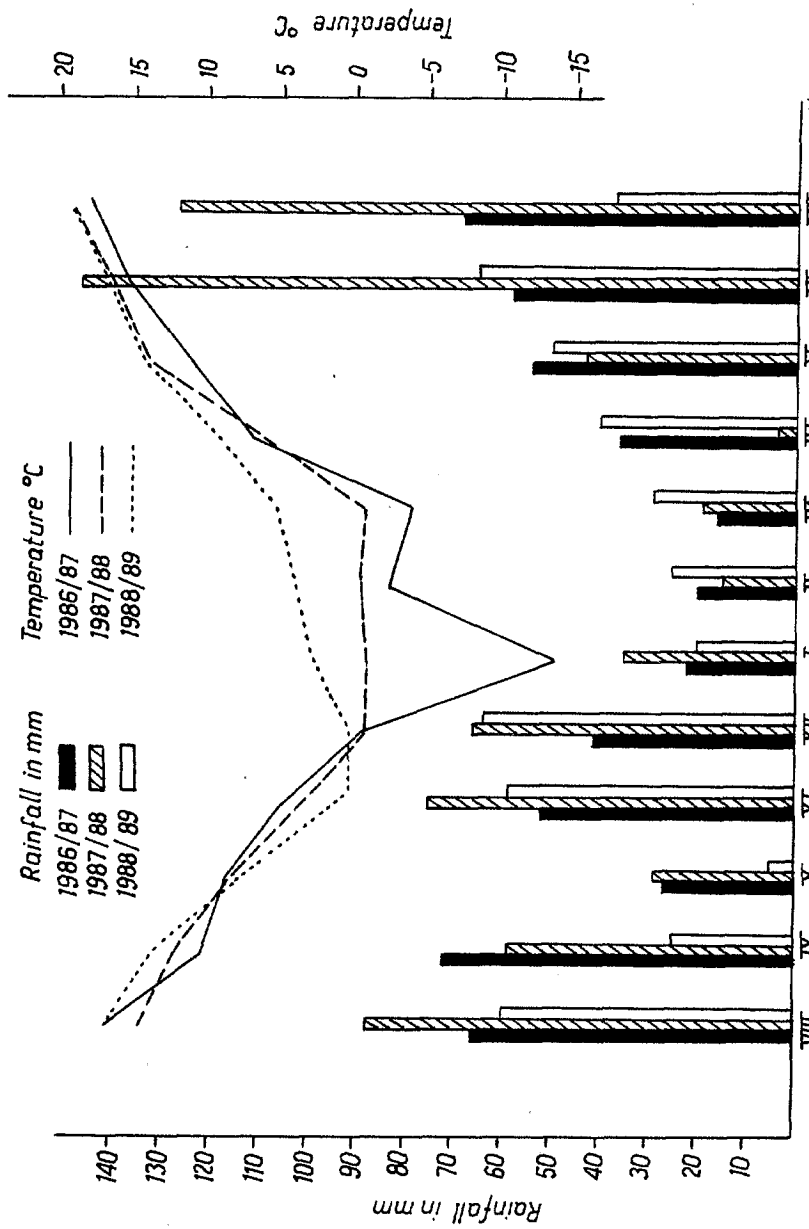

Fig.1 The distribution of monthly rainfall and temperature in winter rape vegetation time in 1986-1989 years