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DIFFERENTIAL RESPONSE OF TWO SUNFLOWER CULTIVARS TO BORON FERTILIZATION.

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ABSTRACT

Sunflower cultivars have been shown to differ in their ability to absorb boron (B) from the soil. A two-year field trial was carried out to establish whether two cultivars of differing B-uptake ability differed in response to applied B (0 to 4 kg B/ha) at two lime levels (0 and 3,000 kg dolomitic lime/ha). The B concentration in the topmost mature leaf of PNR 40-S was significantly lower than that in SO 320, particularly where no B fertilizer had been applied. The concentrations of N, P, Ca, Mg, Fe, Mn, Cu and Zn in leaf tissue were not affected by B application. B fertilization significantly increased seed size and oil level in the seed but decreased seed protein level, the effects being more marked in the case of PNR 40-S than SO 320. Averaged over the two seasons, B fertilization significantly increased seed yields of SO 320 by 49% and that of PNR 40-S by 113%. Where adequate B had been applied, seed yields of the two cultivars were not significantly different being *c.* 2,400 kg/ha in both seasons. The differential response of the two cultivars to B fertilization appeared to be due to a difference in B-uptake ability and not to a difference in tissue requirement for B. Liming this acid soil (pH NKCl 4.3) had no significant effect on B-uptake nor on cultivar response to applied B.

INTRODUCTION

For many years, it has been recognized that plant species as well as cultivars within species may vary in response to soil nutrient levels (Brown, Ambler, Chaney and Foy, 1972). Two reasons for this variation have been proposed, *viz* variation in ability to absorb nutrients from the soil and variation in tissue requirement for a particular nutrient. Sunflower *(Helianthus annuus* L.) cultivars and inbred lines were shown to differ markedly in their ability to absorb nutrients from the soil (Blamey, Vermeulen and Chapman, 1980). Of particular importance was the variation between cultivars in their ability to absorb boron (B) from the soil. Although marked, the practical implication of this variation has not been evaluated.

Sunflower has long been recognized as having a relatively high B requirement (Schuster and Stephenson, 1940), and widespread B deficiency has been observed in field-grown sunflower in South Africa. The aim of the present study was to measure the response of two sunflower cultivars of differing B-uptake ability to B fertilization in order to assess the possible practical importance of this variation in B-uptake ability.

MATERIALS AND METHODS

Field trials were conducted on a Doveton fine sandy clay (MacVicar, de Villiers, Loxton, Verster, Lambrechts, Merryweather, le Roux, van Rooyen and Harmse, 1977) at Dundee Agricultural Research Station, South Africa during 1977/78 and 1978/79. Five rates of B fertilizer (0, 1, 2, 3 and 4 kg B/ha/annum) were broadcast and incorporated to a depth of 150 mm prior to planting on plots which had received the same B rates for the previous two seasons (Blamey, Mould and Chapman, 1979). Two dolomitic lime rates (0 and 3,000 kg/ha) were applied and disced into a depth of 150 mm prior to planting in 1977/78. Plots were split for two sunflower cultivars of differing B-uptake ability, *viz* PNR 40-S and SO 320. Leaves of SO 320 had been found to contain higher B concentrations than those of PNR 40-S (Blamey *et al.,* 1980). Treatments were arranged in a 5 x 2 split plot factorial design with four replications.

Sunflower seed was planted in 750 mm rows with an in-row spacing of 30 mm in early November in both seasons. One week after planting, soil samples were taken to a depth of 150 mm, air dried and ground to pass through a 2 mm sieve. Soil analyses subsequently carried out, using methods described by Blamey and Nathanson (1977), were pH (N KCl), H_2SO_4-extractable P, and exch. Ca, Mg, K and Al. Effective cation-exchange capacity (CEC) was calculated as the sum of exchangeable metal cations. One month after planting, seedlings were thinned to a population of 44,000 plants/ha. At flowering, i.e. Growth Stage 3.4 to 4.1 (Siddiqui, Brown and Allen, 1975), the blade of the topmost mature leaf was removed from 30 plants in each sub-plot, placed in a forced draft oven and dried to constant mass at 80°C. After milling, concentrations of N (by the Kjeldahl procedure), P (by the vanadate-molybdate procedure), K, Ca, Mg, Fe, Mn, Zn and Cu (by atomic absorption) and B (by the carmine procedure of Hatcher and Wilcox, (1950)) were determined. The heights of 20 plants in each sub-plot were measured at flowering in 1977/78.

Seed yields were recorded on an air-dry basis (*c.* 5% moisture). In addition to seed yield 100-seed mass, and oil and protein concentrations in the seed were determined.

RESULTS AND DISCUSSION

As expected, liming significantly increased soil pH (KCl) and exch. Ca and Mg levels in the soil and decreased the exch. Al level in the soil (Table 1). The exch. K level in the soil was not significantly affected by liming. The concentration of H_2SO_4-extractable P was slightly increased by liming, the effect only being significant in the second season. Boron fertilization had no significant effects on the soil analyses carried out.

Table 1. Liming effects on soil tests in two seasons.

Season	1977/78		1978/79		LSDs (0.05)	
Lime (kg/ha)	0	3,000	0	3,000	1977/78	1978/79
pH (KCl)	4.3	4.6	4.3	4.9	0.1	0.2
Exch. Ca (meq/100g)	5.15	5.70	5.00	5.90	0.23	0.27
Exch. Mg (meq/100g)	2.57	3.20	2.44	3.46	0.22	0.29
Exch. K (meq/100g)	0.46	0.44	0.56	0.54	NS	NS
Exch. Al (meq/100g)	0.10	0.03	0.10	0.02	0.02	0.02
CEC (meq/100g)	8.27	9.37	8.10	9.92	0.42	0.56
P test (μg/g)	28	29	25	28	NS	2

As with previous trials on this site (Blamey *et al.*, 1979) no marked treatment effects were evident until shortly before flowering. From this time onwards, however, B deficiency symptoms (Blamey, 1976) became progressively more severe at Bo, particularly in PNR 40-S. In fact, in this cultivar considerable leaf necrosis occurred in those plots which did not receive B fertilizer, resulting in senescence, a symptom resembling insect damage as the necrotic tissue disintegrated. In contrast with the detrimental effect of B deficiency on growth, vigorous plant growth was recorded following B fertilization, the improvement being particularly noticeable with PNR 40-S. Plant height of both cultivars was significantly increased by B fertilization. In PNR 40-S, plant height at flowering was increased from 1.34 m at Bo to an average of 1.44 m where B was applied, and in SO 320 from 1.68 m at Bo to an average of 1.76 m with B fertilization. Liming had no visible effect on plant growth nor on plant height, nor did liming appear to aggravate the B deficiency symptoms at Bo.

In the absence of B fertilization, B concentrations in the topmost mature leaf at flowering of both cultivars were markedly below the critical concentration of 34 μg/g established for two sunflower cultivars, Smena and SO 320 (Blamey *et al.*, 1979). With these low concentrations, particularly in the case of PNR 40-S, marked responses to B fertilization would be expected. In both seasons, B fertilization resulted in highly significant, curvilinear increases in the B concentration in the topmost mature leaf at flowering (Table 2). In 1977/78, the topmost mature leaves of PNR 40-S contained on average significantly less B than those of SO 320. A significant B x C interaction indicated that this effect was largely due to the difference in B concentration in the absence of B fertilization. In the second season, these effects were not as marked although similar tendencies were recorded. The differences between PNR 40-S and SO 320 in B-uptake ability confirmed the results of a previous study on this soil (Blamey *et al.*, 1980).

Liming had no significant effect on B concentration in the leaf in either of the cultivars. This confirmed results recorded with sunflower (Blamey and Chapman, 1979) and peanut (*Arachis hypogaea* L.) (Blamey, Chapman and Smith, 1981) but was in conflict with results recorded in many other studies (eg. Wear and Patterson, 1962; Gupta, 1972).

B fertilization had no significant effect on the concentrations of other nutrients in the leaf, a similar finding having been recorded in red raspberry (*Rubus idaeus* L.) (Chaplin and Martin, 1981). Liming, on the other hand, while having no effect on B-uptake slightly increased concentrations of Ca and Mg and decreased Mn concentrations in the topmost mature leaf of both cultivars.

As expected from the low B concentrations in the leaves and the observed B deficiency symptoms at Bo, B fertilization markedly increased the seed yields of both cultivars (Table 2). Along with the lower B levels in the leaf and the more severe B deficiency symptoms at Bo in PNR 40-S compared with SO 320, seed yields of the former cultivar were increased more by B fertilization than were those of the latter. Yields of PNR 40-S were increased by 116% and 110% and those of SO 320 by 46% and 51% in 1977/78 and 1978/79, respectively. It was interesting to note that the increased yield of SO-320 with B fertilization was similar to that recorded in the previous two seasons on this site (Blamey *et al.*, 1979). Other aspects of practical importance were the high maximum seed yields of *c.* 2,400 kg/ha recorded with adequate B fertilization and the finding that yields with an application of 1 kg b/ha/annum were >90 and >80% of the maximum in the two seasons, respectively.

From the data recorded, it was possible to plot the relationship between B concentration in the topmost mature leaf at flowering and seed yield for each cultivar (Bates, 1971). From these relationships it appeared that the differential response of the two cultivars to B fertilization was due to a difference in B-uptake ability rather than a difference in tissue requirement for B. Furthermore, the critical B concentration did not appear to be different from that previously established (viz 34μg/g) (Blamey *et al.*, 1979).

Table 2. Effects of B fertilization on B concentration in the leaf, seed yield and seed characteristics.

	Season	Cultivar	B applied (kg/ha) 0	1	2	3	4	LSDs* (0.05)
[B] in leaf (μg/g)	1977/78	PNR 40-S	11.9	34.5	41.2	44.6	49.2	3.9
		SO 320	19.4	38.1	43.4	45.3	47.1	
	1978/79	PNR 40-S	13.7	40.0	48.0	53.4	52.1	4.1
		SO 320	16.6	39.5	50.7	52.3	55.0	
Seed yield (kg/ha)	1977/78	PNR 40-S	1,163	2,333	2,291	2,517	2,418	258
		SO 320	1,854	2,452	2,520	2,704	2,583	
	1978/79	PNR 40-S	1,105	1,886	2,005	2,324	2,317	351
		SO 320	1,526	1,999	2,306	2,107	2,142	
100-seed mass (g)	1977/78	PNR 40-S	3.28	4.38	4.33	4.80	4.53	0.43
		SO 320	3.42	3.74	3.81	4.01	3.73	
	1978/79	PNR 40-S	3.82	4.48	4.47	4.95	4.67	0.62
		SO 320	3.71	4.22	4.41	4.11	4.15	
Oil %	1977/78	PNR 40-S	38.0	43.5	43.9	44.9	43.6	3.5
		SO 320	39.8	42.2	41.5	44.8	41.9	
	1978/79	PNR 40-S	40.1	42.6	43.3	43.9	42.9	1.3
		SO 320	41.4	42.9	43.9	42.5	43.3	
Protein (%)	1977/78	PNR 40-S	18.7	17.4	17.6	17.8	18.0	0.5
		SO 320	16.6	16.6	16.4	17.0	16.8	
	1978/79	PNR 40-S	21.2	20.7	20.4	20.1	20.5	0.6
		SO 320	20.6	20.5	20.1	20.4	20.5	

*LSDs presented are those for no levels of whole plot or sub plot factors in common.

In contrast with the beneficial effect of B fertilization on seed yield, liming this acid soil did not improve yields. Furthermore, liming did not affect the response of sunflower to B fertilization, a finding in keeping with the absence of any effect of liming on B-uptake.

Of further practical importance in this study was the finding that B fertilization markedly increased the oil percentage in the seed of both cultivars (Table 2). Once again, a significant B x C interaction in both seasons indicated that the effect was more marked in the case of PNR 40-S than S0 320. Concomitant with the increased oil level in the seed, protein percentage in PNR 40-S was significantly decreased by B fertilization (Table 2). The decrease in protein percentage was not as great as the increase in oil brought about by B fertilization. This may have been due, in part at least, to an increased seed size with B fertilization (Table 2) which presumably would have increased the kernel to hull ratio.

Although liming had no effect on oil concentration in the seed, in both seasons a slight though significant increase inprotein concentration (*c.* 0.3%) was brought about by liming.

CONCLUSIONS

In recent years considerable research has been conducted on the differences between plant species and cultivars within species in nutrient uptake ability. The results of the present study have illustrated one of the practical implications of such differences between sunflower cultivars which had been shown to vary considerably in leaf nutrient levels (Blamey *et al.*, 1980). PNR 40-S was shown to contain less B in the topmost mature leaf at flowering than SO 320 particularly in the absence of B fertilization. This difference resulted in yield increases of *c.* 1,200 kg/ha in PNR 40-S and *c.* 800 kg/ha in SO 320 with B fertilization. Furthermore, along with these yield increases, oil level in the seed was increased resulting in oil yield increases of the order of 600 kg/ha in PNR 40-S and 400 kg/ha in SO 320. In spite of a decreased protein concentration in the seed with B fertilization, protein yields were increased by *c.* 230 kg/ha in PNR 40-S and by *c.* 150 kg/ha in SO 320.

The magnitude of the differential response of the two cultivars to B fertilization has important practical implications for the farmer since in the absence of B fertilization a smaller yield decrease would be expected with SO 320 than with PNR 40-S. However, both cultivars required B fertilization in excess of 1 kg B/ha/annum to ensure maximum yields of more than 2,400 kg/ha. With the finding that the two cultivars differed in susceptability to B deficiency, largely through differences in B-uptake ability, further studies should be carried out to establish whether it would be possible to breed cultivars efficient in B-uptake ability.

LITERATURE CITED

BATES, T.E. 1971. Factors affecting critical nutrient concentrations in plants and their evaluation: A review. *Soil Science* 112, 116 — 130.

BLAMEY, F.P.C. 1976. Boron nutrition of sunflowers *(Helianthus annuus* L.*)* on an Avalon medium sandy loam. *Agrochemophysica* 8, 5 — 10.

BLAMEY, F.P.C. and CHAPMAN, J. 1979. Soil amelioration effects on boron uptake by sunflowers. *Communications in Soil Science and Plant Analysis* 10, 1057 — 1067.

BLAMEY, F.P.C., CHAPMAN, J. and SMITH, M.F. 1981. Boron fertilization and soil amelioration effects on the boron nutrition of Spanish groundnuts. *Crop Production* (In Press).

BLAMEY, F.P.C., MOULD, D.J. and CHAPMAN, J. 1979. Critical boron concentrations in plant tissues of two sunflower cultivars. *Agronomy Journal* 71, 243 — 247.

BLAMEY, F.P.C. and NATHANSON, K. 1977. Relationships between aluminium toxicity and sunflower yields on an Avalon medium sandy loam. *Agrochemophysica* 9, 59 — 66.

BLAMEY, F.P.C., VERMEULEN, W.J. and CHAPMAN, J. 1980. Variation within sunflower cultivars and breeding lines in leaf chemical composition. *Communications in Soil Science and Plant Analysis* 11, 1067 — 1075.

BROWN, J.C., AMBLER, J.E., CHANEY, R.L. and FOY, C.D. 1972. Differential response of plant genotypes to micronutrients. *In*: Mortvedt, J.J., Giordano, P.M. and Lindsay, W.L. (Eds). Micronutrients in Agriculture. Soil Science Society of America, Madison, Wisconsin pp. 389 — 418.

CHAPLIN, M.H. and MARTIN, L.M. 1981. The effect of nitrogen and boron fertilizer applications on leaf levels, yield and fruit size of red raspberry. *Communications in Soil Science and Plant Analysis* 11, 547 — 556.

GUPTA, U.C. 1972. Interaction effects of boron and lime on barley. *Soil Science Society of America Proceedings* 36, 332 — 334.

HATCHER, J.T. and WILCOX, L.V. 1950. Colorimetric determination of boron using carmine. *Analytical Chemistry* 22, 567 — 569.

MACVICAR, C.N., DE VILLIERS, J.M., LOXTON, R.F., VERSTER, E., LAMBRECHTS, J.J.N., MERRYWEATHER, F.R., LE ROUX, J., VAN ROOYEN, T.H. and HARMSE, H.J.V. 1977. Soil classification — a binomial system for South Africa. Department of Agricultural Technical Services, Pretoria, South Africa.

SCHUSTER, C.E. and STEPHENSON, R.E. 1940. Sunflower as an indicator plant of boron deficiency in soils. *Journal of the American Society of Agronomy* 32, 607 — 621.

SIDDIQUI, M.Q., BROWN, J.F. and ALLEN, S.J. 1975. Growth stages of sunflower and intensity indices for white blister and rust. *Plant Disease Reporter* 59, 7 — 11.

WEAR, J.I. AND PATTERSON, R.M. 1962. Effect of soil pH and texture on the availability of water-soluble boron in the soil. *Soil Science Society of America Proceedings* 26, 344 — 345.

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EFFECT OF PHOSPHORUS AND NITROGEN FERTILIZATION LEVELS ON THE YIELD AND OIL CONTENT OF SUNFLOWER (*HELIANTHUS ANNUUS* L.).

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ABSTRACT

The experiments were carried out during the summers of 1979/80 and 1980/81 at 3 sites near Coronel Pringles and Huanguelen in the south-west of the province of Buenos Aires, under field conditions. The hybrids used were Cargill S 400 and SPS 891 with three levels of phosphorus fertilization (0, 40 and 80 kg P_2O_5 ha^{-1}) and two levels of nitrogen (0 and 60 kg N ha^{-1}). There was a positive correlation between the pre-existing phosphorus level in the soil and the effect of the fertilizers. In the two years there was no response to nitrogen application in these soils. Taking into consideration the cost factor, the results indicate that the application of 46 kg ha^{-1} P_2O_5 may be recommended.

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