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B DEFICIENCY SYMPTOMS EVALUATION
THE MOST ACCURATE METHOD TO DECIDE SUNFLOWER B FERTILIZATION.

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SUMMARY

Marked yield responses of about 20% were obtained on sunflower (Helianthus annuus L) to the foliar applications of boron in the humid pampa region of Argentina. Soil boron analysis before sowing was found to be an acceptable yet inaccurate method of predicting boron requirements. The boron content of leaves at flowering (TML), was not correlated with the boron responses. B content in the young seedlings up to 30 days after emergence showed a close correlation (R = -0.743) with the yield increase obtained following foliar application of B which is not in agreement with international literature. As a result of the studies carried out on 11 commercial hybrids and on 4 genetic lines from 1986 to 1989, it is concluded that the recognition and quantification of boron deficiency symptoms provides the most accurate method available for predicting B requirements. When this is carried out on seedlings it is possible to make decisions for the crop presently under cultivation.

INTRODUCTION

More than 90% of the sunflower production in Argentina, comes from the humid pampas (covering the provinces of Buenos Aires and parts of Santa Fe, Cordoba and La Pampa), where 2.4 million hectares are sown annually. The cropping systems includes the utilization of commercial hybrids, standard soil cultivation, herbicides and insecticides and the use of the natural soil fertility (chemical fertilizers unused). With this system, 1400-1700 kg/ha/year average yield are obtained.
Four soil textural types predominate, ranging from sandy to clay loams. More than 80 commercial hybrids are available each year to farmers. This study analyses the efficiency of the available methods of B status analysis to predict grain yield increases. All the experiments were carried out in the field, using standard methods of cultivation, a heterogeneous genetic population, different soil types and climatic conditions.
Boron is known to be a limiting factor in this area, (Diggs,et al.1988) and this was confirmed by the frequency and intensity of boron deficiency symptoms and the magnitude of responses to boron application.

MATERIAL AND METHODS

The effects of foliar application of boron were measured in the field during 1986-1988 on 11 commercial hybrids and 4 genetic lines growing on sandy, sandy loam, clay loam, and soils with high content of organic matter.
The plot areas on which foliar applications were to be carried out, were determined on the basis of the uniformity of the seedling stand, at 30 days after emergence. The average area of the seedlings was 12% of the total surface of the plot. A high soluble sodium borate (15.5% B) was used, at 1.8-16.1% w/v supplying 1.1-1.4 kg/B/ha/crop, in 22-44 lts/ha by aerial and 100-200 lts/ha by ground applications.

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Boron was first sprayed when the crop was between 40-50cm high, and a second spray given between the maximum flower boton elongation to flowering (stages R3-R4).
Samples were taken from soils (0-20 and 20-40cm depth) at V (within 30 days after emergence), R5, and of top-most mature leaves (TML) at R5. B deficiency symptoms were recognised and quantified at V and R5. Variables analysed were compared with yield increases; the correlation coefficients (r) calculated in Table 1 relate to the association between column 1 and the relevant column 4 to 7. Only female lines were harvested. For this reason symptomology observed in males is not considered.
$CaCl_2$ 0.02M at boiling point was used for B soil extractions. Tissues were digested with HNO_3 at 90°C. Colorimetric measurements were done with Azomethine H (Ratto de Miguez.S. et al. 1985). 325 sample stations (ss) were established, with an average area of 0.78 ha/ss. The average number of combined samples was 2.48/ha for soils, 0.44/ha for seedlings and 0.77/ha for leaves (TML).

RESULTS

Table 1. Effects of Foliar B Applications on 11 Hybrids and 4 Female Lines

Location	Hybrid or Female	Seed Prod. (kg/ha) Test	+B	(1)	(2)	Symptoms Frequency in: T	L	S	C	(3)	B (ppm) Content in: Soils (4)	(5)	Leaves (6)	(7)	T
1 25Myo	S405	1906 -	2331	22.3	10.4	A	M	A	A	SL	0.51	0.41	71	98	27
2 Past.	GI700	2148 -	2548	18.6	8.5	na	A	B	A	S	0.54	0.32	173	198	na
3 Balc.	G100	2574 -	3044	18.3	11.0	A	M	M	A	OM	0.98	1.04	64	82	27
4 M.Ter.	P6440			18.0	na	na	M	A	B	SL	0.68	0.61	137	176	na
5 Past.	GI600	2437 -	2787	14.4	10.0	M	M	A	B	SL	0.41	0.35	133	138	35
6 25Myo.	SB254	1214 -	1496	13.9	9.0	na	M	M	B	SL	na	na	na	na	na
7 G.Pin.	S380	1896 -	1870	10.5	13.0	M	M	M	B	L	0.47	0.52	110	129	31
8 D.Alv.		1810 -	1930	6.7	6.1	M	M	A	B	SL	0.78	0.56	172	166	40
10 G.Pin.	M701	2437 -	2550	4.6	8.0	B	B	-	-	SL	0.52	0.40	127	193	42
14 D.Alv.		1970 -	1978	0.4	6.6	B	B	-	-	SL	0.82	0.58	125	143	42
17 Huang.	S400	3113 -	2924	-6.0	10.8	B	B	-	-	CL	0.94	0.94	136	167	46
19 G.Pin.	Do854	717 -	1040	45.0	9.5	A	A	B	A	S	0.33	0.36	96	97	31
20 D.Alv.	CAo	390 -	500	28.2	7.0	M	M	-	M	S	0.82	0.39	116	154	27
21 Linc.	Dox854	901 -	1107	22.9	9.5	A	A	-	M	S	0.45	0.37	110	129	31
22 D.Alv.	DAo	491 -	600	22.2	7.0	M	M	B	M	S	0.82	0.39	116	144	27
23 Arias	CA5	380 -	447	17.6	9.9	B	M	B	A	L	0.76	0.66	81	124	25
24 G.Pin.	Do854	1189 -	1305	9.8	9.0	B	M	B	A	L	0.42	0.28	93	120	36
										n:	16	16	16	16	14
										X:	0.64	0.51	116	141	33
										SD:	0.21	0.22	31	34	7
										r:	.368	.386	.350	.435	.74
										5%:	.497	.497	.497	.497	.53
										1%:	.623	.623	.623	.623	.67
										S:	ns	ns	ns	ns	1%

(1) % yield increase. (2) % grain moisture. (3) Type of soils: S sandy, SL sandy-loam, L loam, Cl clay loam, OM soils with organic matter >4%. (4) Control soils 0-20 depth samples. (5) Control soils 20-40cm depth samples. (6) Control leaves. (7) Treated leaves.
T seedlings. L leaves. S stem. C capitulum. A high frequency >50%. M medium frequency 30-40%. B low frequency 10-20%. - no symptoms detected. na non available. SD standard deviation. r correlation coef. S significance.

SYMPTOMS. At each sample station, 10 plants were evaluated for symptoms, and soil and tissue sub-samples taken.

Table 4. Rating of Frequency B deficiency symptoms in untreated plots and yield increases

Experiment	Yield increase (%)	Rating of symptoms in: Seedlings	Leaves 1	Stems 2	Capitulums 3	X 1+2+3
1	22.3	7.5	3.5	7.5	7.5	6.17
2	18.6	na	7.5	1.5	7.5	5.50
3	18.3	7.5	3.5	3.5	7.5	4.80
4	18.0	na	3.5	7.5	1.5	4.17
5	14.4	3.5	3.5	7.5	1.5	4.17
6	13.9	na	3.5	3.5	1.5	2.80
7	10.5	3.5	3.5	3.5	1.5	2.80
8	6.7	3.5	3.5	7.5	1.5	4.17
10	4.6	1.5	1.5	0	0	0.50
14	0.4	1.5	1.5	0	0	0.50
17	-6.0	1.5	1.5	0	0	0.50
19	45.0	7.5	7.5	1.5	7.5	5.50
20	28.2	3.5	3.5	0	3.5	2.30
21	22.9	7.5	7.5	0	3.5	3.70
22	22.2	3.5	3.5	1.5	3.5	2.80
23	17.6	1.5	3.5	1.5	7.5	4.17
24	9.8	1.5	3.5	1.5	7.5	4.17
n		14	17	17	17	17
r		0.691	0.716	0.045	0.605	0.640
5%		0.532	0.482	0.482	0.482	0.482
1%		0.671	0.606	0.606	0.606	0.606
S		1%	1%	ns	1%	1%

na non available r correlation coef. S significance ns non significant
Frequency: Nil 0, Low 1.5, Medium 3.5, High 7.5.

The stem break, is produced by a hollowing in the stem or by a weakness in its upper third, without hollowing. Also in this case, the fracture is produced because the tissues can not bear the weight of the heads. As a consequence, the stem break can take place from the flowering stage (R5) to the beginning of its ripening. The earlier the break the bigger its detrimental influence on the yield. The virtual absence of these symptoms in the treated plots, is a clear sign that they are produced by deficiencies of this nutrient.

Symptom recognition at flowering, gives us the greatest and most accurate information about the yield increases that could be expected in that soil and on that genetic material. From a practical point of view, a soil B fertilization is virtually impossible to be carried out, based on symptoms, owing to the advanced development of the crop. Foliar applications can be done, although the maximum yield increases will not be obtained, as the determined structural and physiological changes caused by the deficiency during the early crop development can not be rectified.

This method will be of greatest value if sunflower is sown again in the same field. The recognition and quantification of symptoms in seedlings of up to 30 days post emergence is an efficient and practical predictive method. It does not have the accuracy of the recognition at flowering, but it does have the extraordinary advantage of allowing the taking of decisions on foliar or soil fertilization, on the crop under observation. High (A) and medium (M) frequency symptoms in seedlings, are associated with yield increases equal or higher than 10%. No yield increase should be expected when there are no symptoms. Seedlings with low symptom frequency, can originate yield increases from nil to 15%. At this stage, the chemical analysis of the seedlings, correlates well with the obtained yield increases (Table 1). The regression curve is $Y=61.8 - 1.389 X$, Y being the yield increase to be obtained and X the B content of seedlings. The correlation coefficient ($r = -0.743$) is significant to 0.01 ($n = 14$).

This would indicate, that the genetic heterogeneity of the analysed material, is manifested in later growing stages. The hybrids and lines analysed in this early stage, do not manifest their different capacities to absorb, translocate, process and use the available B in the soil.

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