INTRODUCTION

Cauliflower is particularly susceptible to boron deficiency, with the symptoms consisting of curd browning and hollow stem. Hollow stem disorder (HSD) can occur even if boron is applied or if there is a sufficient level in the soil (Shelp et al., 1995).

Most studies have shown an increase in HSD with nitrogen fertilization. With respect to boron, the results are contradictory. Some studies showed any significant result on yield and HSD (Gupta and Cutcliffe, 1973, 1975), but positive effects of boron were also observed on HSD and yield (Pizetta et al., 2005). Everaarts and Putter (2000) showed that N rates increase HSD while B (2 and 4 kg ha^{-1}) had no effect. In contrast, Batal et al. (1997) reported HSD reduction with 269 kg ha^{-1} N and 8.8 kg ha^{-1} B in clay (0.21 mg kg^{-1} B) and sand (0.07 mg kg^{-1} B) soils.

Considering the scarcity of information under tropical conditions, the aim was to evaluate yield and hollow stem in summer cauliflower cultivated in two soils with low levels of nitrogen and boron in Brazil.

MATERIAL AND METHODS

The experiments were carried out on two soils in the Sao Paulo state, Brazil, during November 2005 through February 2006. The cauliflower cultivar Sharon was chosen for its good commercial performance. The Hapludox soil (PVA) was located at the APTA experimental farm in Tietê (0.54 mg kg^{-1} B), and the Rhodic Kandiudox soil (NVef) was located in the ESALQ-Piracicaba area (0.84 mg kg^{-1}B).

The experiments were set up in a completely randomized factorial design (4 x 3 x 2) with 4 N rates (100, 150, 200, and 250 kg ha^{-1}), applied as ammonium nitrate, 3 B applications (0; 1.5 kg ha^{-1} planting and 1.5 kg ha^{-1} at curd initiation; 3 kg ha^{-1} at planting), using Boromol (8 % B and 0.8 % Mo), and 4 replicates. The N top dressing took place 15, 30 and 45 days after transplanting. 60 kg ha^{-1} of N (urea), 600 kg ha^{-1} of P_2O_5 (triple superphosphate) and 120 kg ha^{-1} of K_2O (KCl) were applied as basal dressings prior to planting.

Seedlings were planted with 1.0 m spacing between rows and 50 cm between plants. Each plot had 20 plants cultivated in four rows. Five diagnostic leaves were chosen at curd initiation (58 days after transplanting) in each plot to evaluate N (Malavolta et al. 1997) and boron status (Abreu et al., 1994). Ten plants of the two inner rows of each plot were picked, and curd mass, diameter and HSD were evaluated. The concentration of nitrogen and boron was also evaluated in inflorescences.

RESULTS AND DISCUSSION

Nitrogen application did not affect total and curd yield and HSD incidence on both soils in line with Scaife and Wur (1990) but not with Batal et al. (1997) who reported a linear increase in yield with N rates. The lack of N response could be due to a sufficient N supply of the soils or to the leaching of fertilizer nitrate due to heavy rains (700 mm). The latter is suggested by the N concentrations in leaves and curds (Table 1) which were below the sufficiency range suggested by Raji et al., (1997).

Boron fertilization did not influence total curd mass or total yield in either soil (Table 1), agreeing with Gupta and Cutcliffe (1973) and indicating that the B supply of the soils was sufficient to sustain growth of cauliflower. However, the soil boron levels were not sufficient to avoid HSD particularly on the PVA soil where HSD significantly reduced the commercial yield due to suboptimum B concentrations in leaves and curds (Table 1). But also on the NVef soil, HSD occurred with no effect on commercial yield in spite of B concentrations in leaves and curds (80 and 37, respectively) which are in the optimum range according to Raij et al. (1997).

Table 1. Curd mass, total and commercial yield, hollow stem percentage, nitrogen and boron concentrations in leaves and curd at planting cauliflower cultivar 'Sharon' in two soils. (Means over N fertilization rates).

B	Hollow stem		Commercial yield		N conc. leaves		B conc. leaves		N conc. curds		B conc. curds	
	PVA	NVef	PVA	NVef	PVA	NVef	PVA	NVef	PVA	NVef	PVA	NVef
	------%------		------t ha^{-1}---		-----g kg^{-1}-----		---mg kg^{-1}---		----g kg^{-1}----		---mg kg^{-1}---	
0	36.9a	22.1a	7.4 b	10.6a	30.0 b	38.3a	10.6c	79.4a	40.1a	37.2a	13.2b	32.9a
1.5	2.5b	8.2b	16.2a	11.6a	31.3ab	36.8a	28.9b	74.4a	38.6a	38.7a	30.3a	36.5a
3.0	7.5b	12.0b	15.9a	11.8a	33.2a	39.4a	45.1a	80.3a	38.9a	35.2a	30.4a	33.7a
D*	14.3	12.0	3.8	3.2	3.2	4.98	5.2	13.01	3.75	3.75	2.09	8.16

D = minimum significant difference. *Means followed by the same letter in the column do not differ at $p < 0.05$ (Tukey test).

These results for the NVef soil suggest that foliar analysis might not be the best parameter to diagnose HSD in cauliflower. Although boron is immobile in plants with low sorbitol production (Brown and Hu, 1984), such as cauliflower, we suggest that its mobility should be studied because it can be adequate in leaves but not in inflorescences.

However, on the PVA soil the boron concentrations in leaves and inflorescences were increased by B application in agreement with Scaife and Wurr (1990). There was a negative relationship between hollow stem (X) and B in leaves ($Y=-7.941X + 35.69$; $R^2 = 0.44^*$) and inflorescences ($Y= -49.164X + 29.371$; $R^2 = 0.58^*$). These results are in agreement with Batal et al.(1997) and Pizetta et al.(2005).

The results suggest that cauliflower grown on medium and low B soils in Brazil is prone to HSD especially in summer, due to fast growth and high nutrient absorption. Thus B needs to be applied. Application of 3 kg ha^{-1} B was suggested (Raij et al., 1997) without evaluating its soil levels and proved to be sufficient also in this study. However, more studies are needed to confirm this recommendation.

CONCLUSIONS

It is suggested to study boron mobility in cauliflower to increase fertilization efficiency and commercial yield, with the goal of reducing hollow stem disorder in cauliflower plants.

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