Broccoli growth and nutritional status as influenced by doses of nitrogen and boron


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Proper growth and development of broccoli may be affected by the application of N and B. Accordingly, the objective herein was to verify the effects of N and B application on growth and the nutritional status in the vegetative phase of broccoli. The experimental design was a completely random one in a factorial \((4 \times 2 +1)\) scheme, with four doses of B \((0.25, 0.50, 1.00, \text{ and } 2.00 \text{ mg dm}^{-3})\) and two doses of N \((200 \text{ and } 600 \text{ mg dm}^{-3})\), and the check treatment \((\text{no B and no N})\), with four repetitions. The green color index, the accumulation of N and B in the plant aerial part, leaf area, and the aerial part dry matter content were evaluated. The interaction between nitrogen and boron was not important for the green color index, N and B accumulation, leaf area and dry matter production of broccoli in the vegetative phase. However, the isolated effects of nitrogen fertilization and boron doses were beneficial for broccoli development.

**Key words:** Fertilization, *Brassica oleracea* var. italic, vegetative phase.

INTRODUCTION

Broccoli (*Brassica oleracea* var. *italica*) is one of the vegetable species most widely grown and consumed in the world (Pizetta et al., 2005), highlighted mainly for its nutritional value as a source of various compounds, such as vitamins, minerals, antioxidants (Umar et al., 2013a), as well as its anticancer properties (Yboldas et al., 2008). Among the cultural practices capable of increasing the productivity and the quality of broccolis, the equilibrated application of nutrients, especially N and B (Kojoi et al., 2009), is one of the most important. Nitrogen, the second most demanded nutrient by the crop, plays important role on the plant vegetative growth. Previous research has

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indicated that nutrients have important effects on broccolis productivity and quality (Belec et al., 2001; Moniruzzaman et al., 2007; Ambrosini et al., 2015).

Boron, needed by the plants in low quantities, is the most important micronutrient also due to its interaction with N (Campagnol et al., 2009). This interaction between N and B may result from non competitive inhibition (Malavolta et al., 1997). Thus, high doses of N may reduce the absorption of B, leading to physiological disturbances. The B deficiency may be induced by the plant rapid growth promoted by N (Figueira, 2003).

Research works with boron in broccoli is restricted to the reproductive phase, since its larger demand and importance since pollen grain germination up to the pollen tube growth reflecting on fecundation and growth of the flowers (Prado, 2008). During the vegetative phase, B demand is relatively low in comparison with the reproductive one. But little is known about the effects of boron specially when in association with N in excess.

The hypothesis that the plants submitted to the N in excess could reduce the amount of accumulated B without hampering dry matter production since the low demand of that micronutrient during the vegetative phase, and thus, the interaction between N and B is lowly probable as long as B is not deficient.

Having those facts in mind, the objective of this research work was to verify the effects of the application of N and B on the growth and nutritional status of broccoli plants during the vegetative phase of growth.

RESULTS AND DISCUSSION

N doses affected only the green color index and the accumulation of N, independently of the application of boron (Table 1). A similar result was reported by Ambrosini et al. (2015) in broccoli cultivation.

The highest dose of N promoted the largest increment in the green color index, independently of boron dose (Table 1). A similar response was reported by Dufault (1988) in broccolis plants growing in green house and by Arjona and Greig (1984) in broccoli cultivar Green Comet, with a detected increase in chlorophyll content. Ambrosini et al. (2015) also reported that for the broccoli cultivar BRO 68, nitrogen application stimulated the synthesis of chlorophyll in the leaves, resulting in improved nutritional quality.

This result may be justified by the role played by N in the constitution of the chlorophyll molecule (Malavolta et al., 1997), since there was a larger accumulation of N in the broccolis plants resulting from the increment in N doses (Table 1). Another hypothesis is that the presence of N in the leaves favored the assimilation of CO₂ in the photosynthesis process, promoting an increase in the net photosynthesis rate and consequently an increase in the chlorophyll content of the leaves (Li et al., 2013).

There was an effect of B doses on the accumulation of N and B in the plant (Table 1). The boron doses...
Table 1. Green color index (GCI), accumulation of nitrogen and boron, leaf area and dry matter of broccoli in the vegetative phase in nitrogen function and boron rates, Jaboticabal, SP, Brazil, 2013.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>GCI</th>
<th>N Accumulation</th>
<th>B Accumulation</th>
<th>Leaf area</th>
<th>Dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>g per plant</td>
<td>mg per plant</td>
<td>cm²</td>
<td>g per plant</td>
<td></td>
</tr>
<tr>
<td>Doses of nitrogen (N)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200 mg dm⁻³</td>
<td>35.75ᴮ</td>
<td>62.36ᴮ</td>
<td>0.11</td>
<td>470.57</td>
<td>3.59</td>
</tr>
<tr>
<td>600 mg dm⁻³</td>
<td>46.50ᴬ</td>
<td>89.37ᴬ</td>
<td>0.12</td>
<td>452.99</td>
<td>3.39</td>
</tr>
<tr>
<td>(N)</td>
<td>8.20**</td>
<td>8.22**</td>
<td>0.02ᴺˢ</td>
<td>0.71ᴺˢ</td>
<td>0.29ᴺˢ</td>
</tr>
<tr>
<td>Doses of boron (B)</td>
<td>3.01ᴺˢ</td>
<td>3.54*</td>
<td>2.83*</td>
<td>0.99ᴺˢ</td>
<td>1.0ᴺˢ</td>
</tr>
<tr>
<td>N × B</td>
<td>1.12ᴺˢ</td>
<td>0.54ᴺˢ</td>
<td>2.84ᴺˢ</td>
<td>2.4²ᴺˢ</td>
<td>2.25ᴺˢ</td>
</tr>
<tr>
<td>Factor × Control</td>
<td>14.12**</td>
<td>19.43**</td>
<td>20.74**</td>
<td>19.31**²</td>
<td>24.20**²</td>
</tr>
<tr>
<td>CV (%)</td>
<td>19.9</td>
<td>19.2</td>
<td>21.9</td>
<td>24.5</td>
<td>22.2</td>
</tr>
</tbody>
</table>

Means followed by the same capital letter in the column, does not differ from each other by the Tukey test at 5% probability. NS not significant and **, * significant at 1 and 5% probability by F test.

Figure 1. Accumulation of nitrogen (A) and boron (B) expressed in g per plant for broccoli in the vegetative phase in function of boron doses. *Significant at 1% probability by the F-test.

promoted a quadratic increase in the accumulation of foliar N, with a maximum value of 0.11 g per plant when the N dose reached 1.34 mg dm⁻³ (Figure 1A) and also in the accumulation of B, with a maximum value of 0.143 per plant when the dose was of 1.22 mg dm⁻³ (Figure 1B). The absence of interaction between B and N doses during the vegetative phase (Table 1), may be explained by the relation that exists between these two nutrients only in the reproductive phase due to the demand of B being higher during that phase as determined by the germination of the pollen grain and growth of the pollen tube and also to the fact that N accelerates plant growth thus inducing B deficiency (Shelp et al., 1995). Since during the vegetative phase flowering does not take place, the amount of B needed by the plant are low so that a deficiency of that nutrient is less likely as well as an interaction with nitrogen.

In relation to the interaction factorial × check treatment, an effect of the interaction for the studied variables was observed (Table 1). This result may be explained by the importance of the roles played by N and B in the plant life when both nutrients are at deficient levels and plants
growing without those nutrients (Malavolta et al., 1997).

Conclusion
The interaction between nitrogen and boron was not important for the green color index, N and B accumulation, leaf area and dry matter production of broccoli in the vegetative phase. However, the isolated effects of nitrogen fertilization and boron doses were beneficial for broccoli development.

Conflict of Interests
The authors have not declared any conflict of interests.

REFERENCES