**CROPS:** Canola (*Brassica napus*) cv. InVigor L233P

**PEST:** Clubroot (*Plasmodiophora brassicae* Woronin)

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**TITLE: GROWTH ROOM STUDY OF THE INTERACTION OF BORON AND LIME ON THE SEVERITY OF CLUBROOT IN CANOLA**

**MATERIALS:** HYDRATED LIME (calcium hydroxide), SOLUBOR (20.5% B, disodium octaborate tetrahydrate)

**METHODS**: A study was conducted to examine the interaction between lime and boron for management of clubroot in a growth room set at set to 24°/21°C day night cycle, a 17-hour photoperiod and 50% humidity. Two runs of the study were conducted. The trials were conducted as a three-way factorial study in a replicated complete block design with four replicates and 10 plants per experimental unit. The factors were boron x lime x inoculation. The treatments were as follows: boron (B) applied at a rate of 0 or 4 kg B/ha as SOLUBOR in run 1 and 0 and 12 kg B/ha as SOLUBOR in run 2; HYDATED LIME applied to achieve the targets of pH 7.0 and pH 7.5 plus a control at pH 6.4 and inoculated with resting spores of *P. brassicae* pathotype 2 vs. non-inoculated control.

To ensure that the pH of the soil was a stable and uniform as possible prior at the start of the study, all of the LA4 Sunshine Mix (Sungro; pH 5.6 in Run 1 and pH 5.3 in Run 2) required for each individual treatment was placed in a plastic bin, and a weighed amount of HYDRATED LIME was applied to reach the target pH of 7.0 and 7.5 (Run 1: pH 7.0 - 0.84 t/ha = 27.7 g/bin and pH 7.5 - 1.14 t/ha = 37.6 g/bin; Run 2: pH 7.0 – 1.15 t/ha = 37.6 g/bin and pH 7.5 – 1.3 t/ha = 43.51 g/bin). No lime was added for the pH 6.4 control. The lime was thoroughly incorporated into the soilless mix and 4 L of deionized water was incorporated into the soil. After one week, the pH of the soil was tested to ensure each target pH levels had been achieved. The mix was then placed into tall, narrow plastic pots (conetainer, Steuve & Sons, OR) and compressed firmly to provide a soil density conducive for clubroot. Boron was applied as a solution of SOLUBOR (10 mL of solution with 0.25 g SOLUBOR/L = 4 kg B/ha in Run 1 and 5 mL of solution with 1.5 g SOLUBOR/L = 12 kg/ha in Run 2) to the soil of each pot, one day before seeding with canola cv. L233P from BASF (two seeds). Three days after germination, the seedlings were thinned to one seedling per pot. Inoculum was extracted from clubbed canola roots collected from the Ontario Crops Research Centre-Bradford in 2018 using standard procedures. Seven and twelve days after seeding, each plant was inoculated with 5 ml of 1x106 resting spores/mL. Plants were top watered with water adjusted to pH 6.4, 7.0 and 7.5 with pH lowered with commercial vinegar or raised with sodium hydroxide. Plants were fertilizer twice a week with a 0.1% solution of 20-20-20 and magnesium sulfate.

Roots were assessed for clubroot symptoms at 6 weeks after inoculation using a 0 - 3 scale, where 0 = no clubbing, 1 = clubs on 1/3 of the root, 2 = clubs on 1/3 to 2/3 of the root and 3 = clubs on more than 2/3 of the root. A disease severity index (DSI) was calculated using the following equation:

$$DSI=\frac{Σ\left[(class no.\right)(no. plants in each class)]}{(total no. plants per sample)(no. class-1)} × 100$$

In addition, fresh and dry weight was measured on the above-ground portions of each experimental unit. Data was analyzed using ANOVA in PROC GLIMMIX and means were separated using Tukey’s test at *P* = 0.05 in SAS 9.4 (SAS Institute, Cary, IN). Data for clubroot severity and incidence were analyzed as a two-way factorial (boron x lime) while fresh and dry weights were analyzed as a three-way factorial (inoculation x boron x lime)

**RESULTS**: As seen in Table 1 and 2 and Figure 1 and 2

**CONCLUSIONS**: In both runs of the experiment there was no effect of boron and no interaction between lime and boron for clubroot incidence or severity. However, clubroot incidence and severity decreased as pH increased (Table 1 and 2). Inoculation reduced plant fresh and dry weight except in soil amended with lime (Figure 1 and 2). This growth room trial supports previous results that there is no interaction between boron and lime. Using lime to increase the soil pH is an effective management strategy to decrease clubroot severity. The use of boron for clubroot management requires further study.

**Table 1**: Effect of boron (applied as SOLUBOR) and lime (applied as HYDRATED LIME) on clubroot incidence and severity (disease severity index, DSI) on canola inoculated with *P. brassicae* pathotype 2 in Run 1

|  |  |  |
| --- | --- | --- |
| Treatment | Incidence (%) | Severity (DSI; %) |
| Lime (pH target) |  |  |
| pH 6.4 (control) | 100 a1 | 97 a |
| pH 7.0 | 79 b | 43 b |
| pH 7.5 | 14 c | 5 c |
| Boron (kg B/ha) |  |  |
| 0 (control) | 68 ns2 | 51 ns |
| 4 | 60  | 46  |

1 Means followed by the letter do not differ at P=0.05 based on Tukey’s Test

2ns = not significant

**Table 2:** Effect of boron (applied as SOLUBOR) and lime (applied as HYDRATED LIME) on clubroot incidence and severity (disease severity index, DSI) on canola inoculated with *P. brassicae* pathotype 2 in Run 2

|  |  |  |
| --- | --- | --- |
| Treatment | Incidence (%) | Severity (DSI; %) |
| Lime (pH target) |  |  |
| pH 6.4 (control) | 100 a1 | 85 a |
| pH 7.0 | 41 b | 18 b |
| pH 7.5 | 13 c | 5 c |
| Boron (kg B/ha) |  |  |
| 0 (control) | 54 ns2 | 38 ns |
| 12 | 48 | 34  |

1 Means followed by the letter do not differ at P=0.05 based on Tukey’s Test

2 ns = not significant

**A**

**B**

**Figure 1**. Effect of lime (applied as HYDRATED LIME), boron (applied as SOLUBOR at 0 and 4 kg B/ha) and inoculation with *Plasmodiophora brassicae* pathotype 2 (-/+) on fresh (A) and dry (B) weight of canola (10 plants per plot) in Run 1.

**A**

**B**

**Figure 2**. Effect of lime (applied as HYDRATED LIME), boron (applied as SOLUBOR at 0 and 12 kg B/ha) and inoculation with *Plasmodiophora brassicae* pathotype 2 (-/+) on fresh (A) and dry (B) weight of canola (10 plants per plot) in Run 2.