

Drench Applications in Citrus Trees: Soil–Plant Boron Dynamics and Fertilizer Recovery

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Abstract

Aims To improve our understanding of B dynamics in the soil–plant system and identify strategies to increase the efficiency of B fertilization in citrus orchards, we evaluated how B sources and rates applied via drench affected soil B availability, plant B status, B accumulation, recovery of fertilizer-derived ^{10}B , and physiological parameters in young citrus trees.

Methods Two experiments were conducted in a newly established ‘Valencia’ sweet orange orchard. In the first experiment, boric acid and zinc borate were applied at four B rates. In the second, boric acid, zinc borate, and B-monoethanolamine enriched with ^{10}B were applied to determine fertilizer-derived B recovery.

Results Increasing B rates increased soil and leaf B concentrations without affecting plant growth. On average, 6.7% of B accumulated in plants was derived from the fertilizer, corresponding to a mean fertilizer recovery efficiency of 2.2%, with no differences among B sources. Leaf B concentration increased linearly with B rate, by 12.6 mg kg^{-1} for every 100 mg B applied. The $900 \text{ mg B plant}^{-1}$ rate provided the greatest increase in plant B status without phytotoxicity.

Conclusion Localized B application via drench effectively increased soil and plant B availability without affecting growth. The $900 \text{ mg B plant}^{-1}$ rate was the most promising for B supply during citrus orchard establishment.

HIGHLIGHTS

- Boron drench increased soil B availability and leaf B concentration
- B sources showed similar fertilizer recovery in young citrus trees
- B responses were driven mainly by fertilizer rate rather than B source
- Applying $900 \text{ mg B plant}^{-1}$ increased leaf B without phytotoxicity

INTRODUCTION

Boron (B) is a micronutrient involved in cell wall structure, membrane integrity, cell division, meristematic tissue growth, and reproductive development (Landi et al., 2019; Brown et al., 2002). In citrus, adequate B supply supports vegetative growth, fruit set, and yield, whereas B deficiency impairs plant development and production quality (Yang et al., 2021). Boron deficiency is among the most common micronutrient disorders in citrus orchards established on highly weathered tropical soils (Boaretto et al., 2020), mainly due to the low B content of the soil parent material and the high mobility of B in the soil, which favors leaching losses (Mattos-Jr. et al., 2017; Ferreira et al., 2020).

Micronutrient application in citrus production is usually carried out together with other agricultural operations, given the difficulty of applying small amounts of nutrients in a localized manner. Accordingly, foliar application in combination with insecticide management has been recommended to prevent

nutritional disorders (Mattos-Jr. et al., 2020). However, considering the limited mobility of B in the phloem and its low efficiency of foliar absorption and redistribution (Brown & Shelp, 1997; Boaretto et al., 2008, 2011), current recommendations for Brazilian citrus production indicate that B should be supplied to the soil in two or three split applications, at rates of 2–3 kg B ha⁻¹, as boric acid (BA) mixed with a contact herbicide spray mixture (Quaggio et al., 2022). However, applying B through a herbicide spray mixture distributes it over an area extending up to 1.5 m from the trunk, potentially increasing B leaching losses, particularly in young orchards with less-developed root systems.

Recently, Huanglongbing (HLB) management practices have led to the adoption of drench applications of systemic neonicotinoid insecticides during orchard establishment, complementing foliar sprays (Vieira et al., 2023; Boina & Bloomquist, 2015; Bassanezi et al., 2020). Adopting this practice creates an opportunity to use the same operation for localized nutrient supply, reducing operational costs and positioning the fertilizer directly in the region with the highest root concentration (Umar et al., 2022). However, information on the efficiency of this strategy for B fertilization, as well as on the most appropriate B rates and sources for young citrus trees, remains scarce.

Differences among B sources may influence B availability in the soil and plant uptake (Mattos-Jr., 2017). Among the B sources most used in Brazilian citrus orchards, boric acid (H₃BO₃; BA) and B-monoethanolamine (BA dissolved in monoethanolamine, see below; B-MEA) are widely used due to the high solubility of BA and the liquid formulation of B-MEA, which allows easy homogenization in herbicide solutions. More recently, less soluble sources, such as zinc borate (ZnB), have also been considered as alternatives for B supply in citrus (Macedo et al., 2020). In this context, the use of the stable isotope ¹⁰B allows fertilizer-derived B to be distinguished from B already present in the soil or previously accumulated by plants, providing a useful tool to quantify nutrient recovery and fertilizer recovery efficiency under different fertilization strategies (Brown et al., 1992; Boaretto et al., 2008, 2011, 2026). Therefore, this study tested the hypothesis that B supply via drench would increase soil B availability and improve the nutritional status and growth of citrus trees. The objective of this study was to evaluate the effects of different B rates and sources applied via drench on soil B availability, B uptake, and the nutritional status of young citrus trees, as well as to compare the performance of fertilizers with different solubilities when applied locally during orchard establishment.

MATERIALS AND METHODS

Plant material, experimental site and growing conditions

Two experiments were conducted concurrently at the Sylvio Moreira Citrus Research Center, located in Cordeirópolis, São Paulo, Brazil (22° 27' 32.17" S, 47° 24' 18.33" W), in a 'Valencia' sweet orange [*Citrus sinensis* (L.) Osbeck] orchard grafted onto Swingle citrumelo [*C. paradisi* Macf. × *Poncirus trifoliata* (L.) Raf.]. The orchard was established in January 2024 at a spacing of 6.0 m × 2.0 m (833 plants ha⁻¹). The soil had a clayey texture (> 500 g kg⁻¹ clay), with the following initial characteristics in the 0–20 cm soil layer: pHCaCl₂ = 4.6, P = 179 mg dm⁻³, K = 3 mmolc dm⁻³, Ca = 27 mmolc dm⁻³, Mg = 11.7 mmolc dm⁻³, B

= 0.4 mg dm⁻³, and base saturation (V%) = 46. In the 20–40 cm layer, the soil characteristics were: pHCaCl₂ = 4.5, P = 157 mg dm⁻³, K = 3.1 mmolc dm⁻³, Ca = 24 mmolc dm⁻³, Mg = 10.7 mmolc dm⁻³, and B = 0.3 mg dm⁻³, according to the soil analysis method described by van Raij et al. (2001). During the experiments, maintenance fertilization was performed according to the recommendations of Quaggio et al. (2022), except for B fertilization, which was applied according to the treatments described for each experiment.

Experimental design and boron application

Experiment 1 used a 2 × 4 factorial design with two B sources, BA and ZnB in concentrated suspension, applied at four rates (0, 100, 300, and 900 mg B plant⁻¹ year⁻¹). Experiment 2 consisted of three ¹⁰B-enriched B sources: BA, ZnB in concentrated suspension, and B-MEA, all applied at a rate of 300 mg B plant⁻¹ year⁻¹. The sources of experiment 2 were prepared using ¹⁰B-enriched BA, for B-MEA, BA was dissolved in deionized water and mixed with monoethanolamine at an approximate 2,5:1 B:MEA molar ratio, based on the composition of monoethanolamine borate formulations containing water-soluble B as a BA ester with monoethanolamine (Boaretto et al., 2026). ZnB was prepared by mixing ¹⁰B-enriched BA with zinc oxide (ZnO) in hot water (> 65°C) (Schubert et al., 2003). After the reaction, the resulting ZnB was formulated as a concentrated suspension by adding surfactant and wetting agents to improve particle dispersion and suspension stability. Both experiments were conducted in a randomized complete block design with four replicates and three plants per experimental plot, and the mean of the three plants was used for each evaluation. The total B rate was split into three applications, performed in August 2024 and at 90 and 180 days after the first application. The treatments were applied by drenching 200 mL of the treatment solution onto the soil within an approximately 20-cm radius of the trunk, together with the insecticide Actara® 250 WG.

Experiment 1: Soil nutrient availability, leaf nutrient concentration and plant growth

At 160 days after the last treatment application, soil and leaf samples were collected, and plant growth measurements were performed. Soil samples were collected at depths of 0–20 and 20–40 cm and at distances of 20 and 40 cm from the trunk, representing the wetted and non-wetted zones of the drench application, respectively. Nutrient availability, soil organic matter, pH, sum of bases, base saturation, and potential acidity were determined (Raij et al., 2001).

The concentrations of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), B, copper (Cu), iron (Fe), manganese (Mn), and zinc (Zn) in plant tissues were determined according to the method proposed by Bataglia et al. (1983). The third and fourth leaves from a shoot approximately six months old were collected to compose the new-leaf sample, whereas the central leaves of the second flush were collected to determine nutrient concentrations in old leaves.

Plant height and canopy diameters along and across the planting row were measured using a measuring tape. Canopy volume was calculated from these measurements according to Eq. 1 (Sutton & Vashisth, 2025):

$$V = 4/3 \cdot \pi \cdot (D1/2) \cdot (D2/2) \cdot (H/2)$$

where:

V = canopy volume;

D1 = canopy diameter along the planting row;

D2 = canopy diameter across the planting row;

H = canopy height.

Experiment 2: Soil nutrient availability, B accumulation and isotopic determination

At 160 days after the last treatment application, soil samples were collected, and plants were destructively harvested to determine dry matter and ^{10}B isotope abundance. Soil samples were collected at depths of 0–20 and 20–40 cm to determine nutrient availability, soil organic matter, pH, sum of bases, base saturation, and potential acidity, following the method proposed by van Raij et al. (2001). Soil sampling was performed only at 20 cm from the trunk.

After destructive sampling, the plants were separated into flowers, new shoots (including shoots and leaves developed after treatment application), old leaves (developed before treatment application), trunk, and roots. The samples were washed in a 10% detergent solution, followed by two rinses with distilled water. The samples were then dried in a forced-air oven at 65°C for 72 h. Dry matter was determined using an analytical balance.

After dry matter determination, the samples were ground and digested for B concentration determination by inductively coupled plasma mass spectrometry (ICP-MS). Boron accumulation in each plant organ was calculated by multiplying B concentration by the corresponding dry matter. The $^{10}\text{B}/^{11}\text{B}$ isotope ratio was determined by ICP-MS (Agilent 7500ce), as described by Brown et al. (1992). Samples (0.2 g) of dried and ground plant material were ashed in a muffle furnace at 550°C for 5 h and 30 min and subsequently digested with 10 mL of 0.1 N HCl (Brown et al., 1992). For ICP-MS analysis, a 500-μL aliquot of each sample was diluted with 4.5 mL of 5% nitric acid. The natural abundance of ^{10}B in the plant samples was 18.46%.

The fraction of B derived from fertilizer (%Bdff) was calculated based on the ^{10}B enrichment in plant tissues, according to Eq. 2:

$$\%Bdff = [(\%^{10}B \text{ sample} - \%^{10}B \text{ natural})/(\%^{10}B \text{ fertilizer} - \%^{10}B \text{ natural})] \times 100$$

The amount of fertilizer-derived B (Bdff) in the plants was calculated by multiplying %Bdff by the total B accumulated in each plant part, according to Eq. 3:

$$Bdff \text{ (mg plant part}^{-1}\text{)} = (\%Bdff \times \text{Amount of B in plant parts})/100$$

Fertilizer recovery efficiency (FRE) was estimated as the ratio between the amount of fertilizer-derived B recovered in the whole plant and the total amount of B applied to the soil, according to Eq. 4:

$$FRE = (Bdff / B \text{ applied to the soil}) \times 100$$

Statistical analysis

The data were tested for residual normality and homogeneity of variances. Subsequently, analysis of variance (ANOVA) was performed, and when significant, treatment effects were evaluated by regression analysis for the quantitative factor in Experiment 1 or by Tukey's test for mean comparison ($p \leq 0.05$). Statistical analyses were performed using R software (R Core Team, Vienna, Austria using the ExpDes.pt package). Graphs were prepared using OriginPro 2024 (OriginLab Corp., Northampton, MA, USA).

RESULTS

Experiment 1: Responses to boric acid and zinc borate rates

B rates increased soil B availability at 20 cm from the trunk in both the 0–20 and 20–40 cm soil layers, whereas no effects were observed at 40 cm from the trunk (Fig. 1). In the 0–20 cm layer, the application of 900 mg B as BA and ZnB increased soil B availability by 2.8 and 1.4 mg dm⁻³, respectively, compared with the control, which had a mean soil B availability of 0.9 mg dm⁻³ (Fig. 1A). Although the simple-effect analysis showed no significant differences between B sources for soil B availability, at the 900 mg B rate, BA increased soil B availability by 61% compared with ZnB in the 0–20 cm layer (Fig. 1A). In the 20–40 cm layer, at 20 cm from the trunk, the application of 900 mg B as BA or ZnB increased soil B availability by 2.7 and 1.7 mg dm⁻³, respectively, compared with the control, which had a mean soil B availability of 0.9 mg dm⁻³ (Fig. 1C). At 40 cm from the trunk, soil B availability was not affected by B rates or sources in either the surface or subsurface layer (Figs. 1B and D). The treatments did not affect other fertility-related soil chemical properties, including pH, availability of other nutrients, soil organic matter, sum of bases, base saturation, and potential acidity (data not shown).

B concentration in the leaves responded differently between new and old leaves (Fig. 2). In new leaves, B rates and sources applied via drench did not affect B concentration (Fig. 2A). In contrast, B concentration in old leaves increased linearly with the applied rate for both BA and ZnB (Fig. 2B). The application of 900 mg B as BA and ZnB increased B concentration in old leaves by 124 and 103 mg kg⁻¹,

respectively, compared with the control, which had a B concentration of 82 mg kg⁻¹. No differences between B sources were observed for B concentration in old leaves. The treatments did not affect the concentrations of other nutrients in either new or old leaves (data not shown).

The treatments did not affect the biometric variables evaluated, including plant height, canopy diameter within the row, canopy diameter between rows, and canopy volume.

Experiment 2: Responses to different ¹⁰B sources

The availability of nutrients and other soil variables evaluated were not affected by the B sources applied via drench (data not shown). However, drench-applied B sources affected B concentration in different plant tissues (Table 1). Roots of orange trees fertilized with ZnB had higher B concentrations (approximately 23 mg kg⁻¹), whereas roots of plants fertilized with BA or B-MEA had B concentrations of approximately 20 and 18 mg kg⁻¹, respectively (Table 1). In flowers, the highest B concentration was observed in plants receiving BA (67 mg kg⁻¹), compared with those receiving B-MEA (61 mg kg⁻¹) and ZnB (54 mg kg⁻¹) (Table 1). The treatments did not affect B concentration in the trunk, old leaves, or new branches (Table 1).

Table 1

Boron (B) concentration, accumulation, percentage of B derived from fertilizer (%Bdff), and fertilizer-derived B accumulation (Bdff, mg plant⁻¹) in roots, trunk, old leaves, new branches, flowers, and whole plants of 'Valencia' sweet orange [*Citrus sinensis* (L.) Osbeck] grafted onto Swingle citrumelo [*C. paradisi* Macf. × *Poncirus trifoliata* (L.) Raf.] under different boron fertilization sources applied via drench.

Source	Root	Trunk	Old leaves	New Branches	Flower	Whole plant
B concentration (mg kg⁻¹)						
ZnB	23a	23	91	62	54b	-
B-MEA	18b	28	96	66	61ab	-
BA	20b	20	96	65	67a	-
B acumulation (mg)						
ZnB	42a	17	35	9.3	0.5	104
B-MEA	33b	20	45	13.6	1.0	112
BA	37b	12	26	9.0	0.6	84
%Bdff						
ZnB	8.9	6.2	4.1	4.7	4.9	6.5
B-MEA	6.0	7.7	6.4	5.9	6.6	6.3
BA	6.6	9.4	7.6	7.7	7.3	7.4
Bdff acumulation (mg)						
ZnB	3.8	1.1	1.5	0.4	0.0	6.8
B-MEA	2.0	1.4	2.7	0.7	0.1	6.8
BA	2.4	1.1	1.9	0.7	0.1	6.2

Values represent the means of four replicates (n = 4). Means followed by different lowercase letters within a column differ according to Tukey's test ($P \leq 0.05$). ZnB = zinc borate; B-MEA = boron monoethanolamine; BA = boric acid; Bdff = boron derived from fertilizer.

Plants treated with ZnB had higher B accumulation in the roots (approximately 42 mg) than those receiving BA or B-MEA (37 and 33 mg, respectively; Table 1). B accumulation in the trunk, old leaves, new branches, flowers, and whole plant did not differ among B sources (Table 1). Mean B accumulation in the whole plant across the three sources was approximately 99.9 mg plant⁻¹.

The percentage of B derived from fertilizer (%Bdff) was not affected by B sources in any of the plant parts evaluated (Table 1). In the whole plant, mean %Bdff was 6.7% (Table 1). Of the total Bdff recovered in the plants, approximately 41.4% was found in the roots, 30.7% in old leaves, 17.8% in the trunk, 9.5% in

new branches, and 0.6% in flowers (Fig. 3). The amount of Bdff was also not affected by B sources, averaging approximately 6.6 mg plant⁻¹ (Fig. 3; Table 1). Fertilizer recovery efficiency (FRE) did not differ among B sources and averaged 2.2%.

The treatments did not affect the dry mass of roots, trunk, old leaves, new branches, flowers, or the whole plant (data not shown).

DISCUSSION

This study demonstrated that B application via drench altered nutrient distribution within the soil–plant system in a young citrus orchard and may serve as a complementary strategy to conventional application via herbicide boom during orchard establishment. Localized drench application has been evaluated as an alternative approach for positioning micronutrients, including B, directly in the region of highest root activity (Zheng et al., 2019; Umar et al., 2022). Boron supply via drench increased soil B availability within the wetted zone (i.e., at 20 cm from the trunk) but did not affect B availability at 40 cm from the trunk, suggesting limited lateral movement of B in the soil during the evaluation period.

This is particularly relevant in young citrus orchards, where roots are predominantly concentrated in the upper soil layers near the trunk and explore a limited soil volume. Thus, the region of greater nutrient availability overlaps with the area of highest root density (Mattos-Jr et al., 2003; Kadyampakeni et al., 2014). This finding is relevant considering the high mobility of B in the soil and the risk of nutrient losses when it is applied over a larger soil area (Das & Purkait, 2020), as in conventional management using an herbicide boom.

The greater B availability observed in soils receiving BA at the highest rate may be attributed to the higher solubility of this source and its rapid release into the soil solution compared with ZnB, which dissolves more gradually (Schubert, 2019; Zheng et al., 2023). However, this difference was restricted to the surface layer, whereas in the subsurface layer, soil B availability was affected only by the applied rates. In addition, increased soil B availability resulted in a linear increase in B concentration in old orange leaves in response to the applied rates.

Boron concentration increased linearly in old leaves but remained unchanged in new leaves, which is consistent with the behavior of this nutrient within the plant. Previous studies in orange trees have shown that old leaves had B concentrations approximately twice those observed in newly formed, not-yet-fully-expanded leaves (Boaretto et al., 2011). The ¹⁰B isotopic results showed that more than 70% of the Bdff recovered in the plant was found in the roots and old leaves (Fig. 3). The high proportion of Bdff recovered in the roots may be related to their biomass and the retention of part of the B within the root compartment. In contrast, the proportion recovered in old leaves is consistent with B transport through the xylem and its accumulation in mature organs with higher transpiration rates (Brown & Shelp, 1997; Mattos-Jr. et al., 2017).

Although the B sources resulted in differences in B concentration and accumulation in the roots, these responses did not translate into differences in total B accumulation in the plant, the amount of Bdff, or fertilizer recovery. The ^{10}B recovery data indicate that differences in source solubility were not sufficient to alter B acquisition by the whole plant. In citrus, B sources with contrasting solubilities have also shown similar performance in soil and leaves, whereas plant responses to B varied according to nutrient demand (Mattos-Jr. et al., 2017). Thus, plant demand, B retention in the soil, the contribution of pre-existing B pools, and the time required to take up residual B may have attenuated differences among sources (Boaretto et al., 2008, 2011; Silva et al., 2018; Zheng et al., 2023).

Even though the ^{10}B data confirmed the uptake of fertilizer applied via drench, only 6.7% of the B accumulated in the plant was derived from the fertilizer, and 2.2% of the applied B was recovered in the biomass. These values indicate a predominance of pre-existing B pools in the soil and plant, which, in citrus, may contribute substantially to B supply to newly developed tissues and maintain a residual effect in subsequent growth cycles (Boaretto et al., 2008, 2011). Although FRE was approximately 2.2%, increasing B rates promoted an average increase of 12 mg kg^{-1} in B concentration in old leaves for every 100 mg of B applied. Considering that foliar B concentrations in the control treatment were already within the range considered adequate for citrus (Quaggio et al., 2022), the adequate initial B supply likely reduced plant responsiveness to the lower applied rates and contributed to the lack of response in growth parameters. The linear increase in B concentration in old leaves, without changes in growth variables, indicates that the application of $900 \text{ mg B plant}^{-1} \text{ year}^{-1}$ promoted foliar B enrichment beyond the level required to produce a measurable vegetative response during the evaluation period.

From a management perspective, B application via drench is a practical strategy for placing small amounts of micronutrient within the active root zone of young citrus plants and it can be integrated into operations during the early years of orchard establishment. The application of $900 \text{ mg B plant}^{-1}$ via drench resulted in the greatest increase in plant B nutritional status, with no evidence of phytotoxicity, making it the most suitable rate among those evaluated for B supply during citrus orchard establishment. In addition, combining B with other inputs may streamline field operations, reduce the need for additional applications, and improve operational efficiency and sustainability in citrus management.

CONCLUSION

Considering the impact of B deficiency in citrus orchards and this nutrient's susceptibility to leaching, strategies that improve the efficiency of B supply are needed. The results confirmed the hypothesis that B application via drench is an effective strategy for supplying B to young citrus plants, increasing its availability in the soil and improving plant B nutritional status. Responses of the soil-plant system were primarily determined by the applied B rate. In contrast, the different B sources showed similar performance in terms of soil B availability, nutrient uptake, and distribution within the plant. The ^{10}B isotopic tracer confirmed fertilizer uptake and its preferential accumulation in roots and old leaves. Under the conditions of this study, the application of $900 \text{ mg B plant}^{-1}$ via drench resulted in the greatest

increase in plant B nutritional status, with no evidence of phytotoxic effects, and may be used as a complementary strategy for B supply during citrus orchard establishment. Further studies should validate this strategy across different soil classes and growing conditions, refine the recommended rates, and evaluate its potential for the localized supply of other micronutrients during citrus orchard establishment.

Abbreviations

B	Boron
BA	Boric acid
ZnB	Zinc borate
B-MEA	B-monoetanolamina
¹⁰ B	Boron isotope
Bdff	B derived from fertilizer
FRE	Fertilizer recovery efficiency
HLB	Huanglongbing

Declarations

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author Contributions

All authors contributed to the initial conception of the project. The experimental study was conducted by R.Y.R. Souza, R.S. Teixeira, and M.F.B. Cordaz. Field data collection was performed by R.Y.R. Souza, R.S. Teixeira, M.F.B. Cordaz, R.M.L. Carvalho, G.A. Bortoloti, G.T. Devite, and W.P. Bernardo. Laboratory analyses and data processing were performed by R.Y.R. Souza, R.S. Teixeira, H. Abreu-Junior, and R.M.

Boaretto. The first draft of the manuscript was written by R.Y.R. Souza, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data Availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

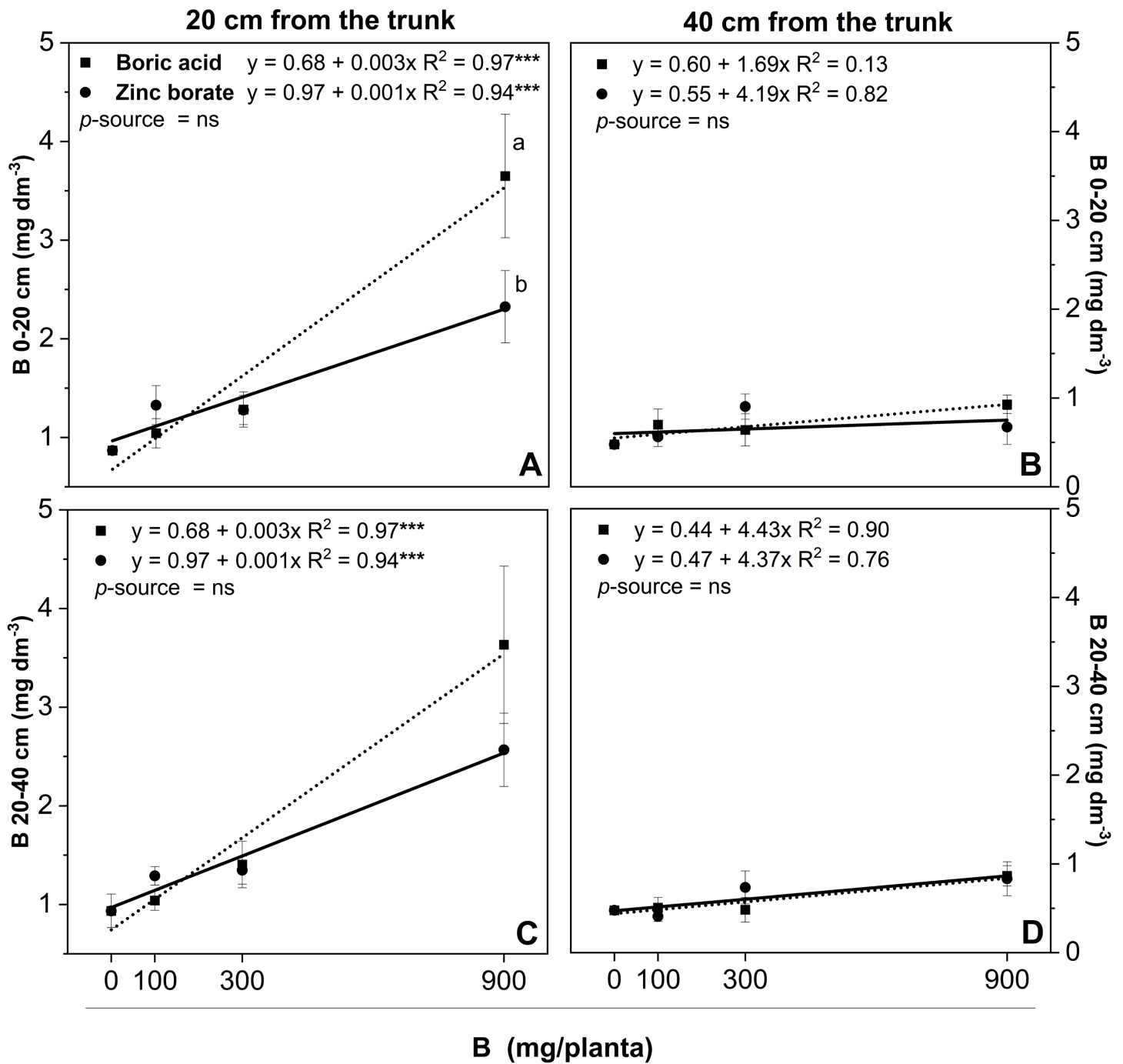


Figure 1

Soil boron (B) availability at depths of 0–20 cm (A and B) and 20–40 cm (C and D), sampled at 20 cm (wetted zone) and 40 cm (non-wetted zone) from the trunk, in a ‘Valencia’ sweet orange [*Citrus sinensis* (L.) Osbeck] orchard grafted onto Swingle citrumelo [*C. paradisi* Macf. × *Poncirus trifoliata* (L.) Raf.]. Points represent means ($n = 4$) ± standard error. Significant effects of the “rate” factor are indicated by *, **, and *** ($p \leq 0.05$, $p \leq 0.01$, and $p \leq 0.001$, respectively). Means followed by different letters differ between B sources within each rate according to Tukey’s test ($p < 0.05$).

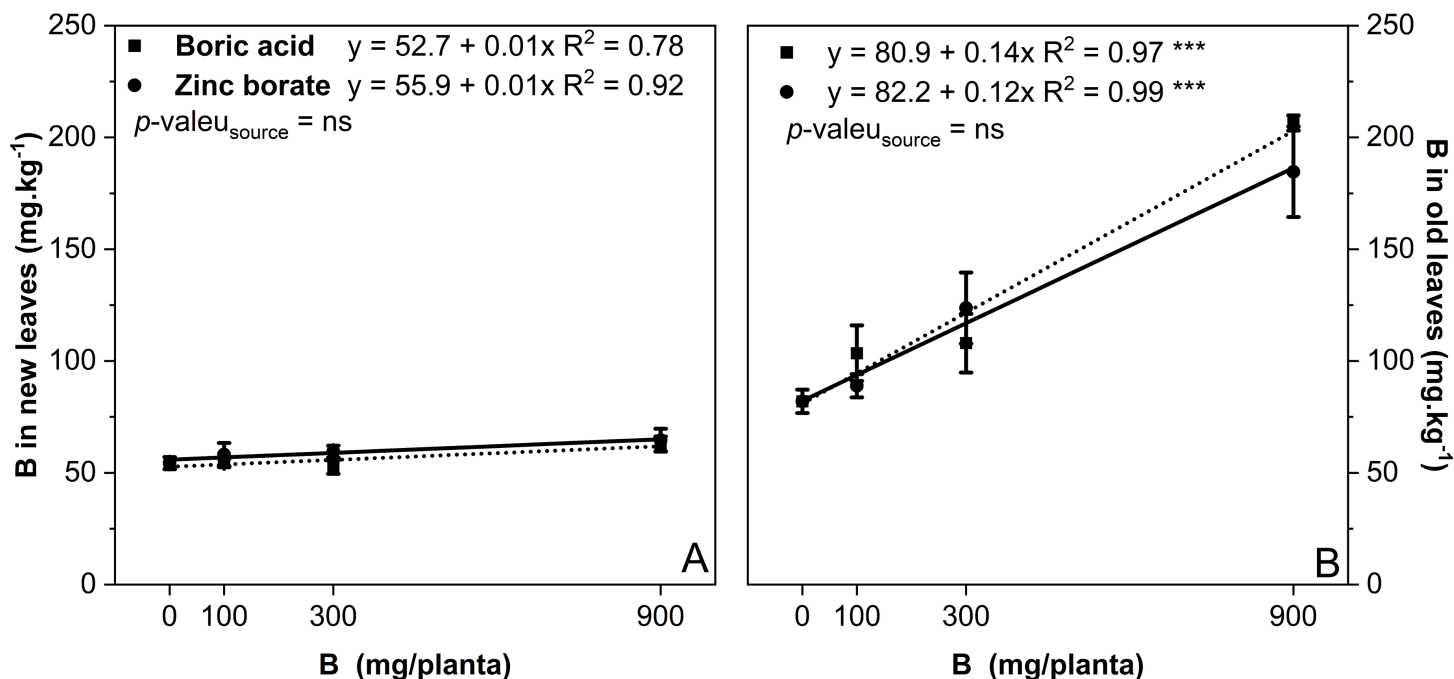


Figure 2

Boron (B) concentration in new leaves (A) and old leaves (B) of 'Valencia' sweet orange [*Citrus sinensis* (L.) Osbeck] grafted onto Swingle citrumelo [*C. paradisi* Macf. × *Poncirus trifoliata* (L.) Raf.] under different B fertilization rates. Points represent means ($n = 4$) ± standard error. Significant effects of the "rate" factor are indicated by *, **, and *** ($p \leq 0.05$, $p \leq 0.01$, and $p \leq 0.001$, respectively). Means followed by different letters differ between B sources within each rate according to Tukey's test ($p < 0.05$).

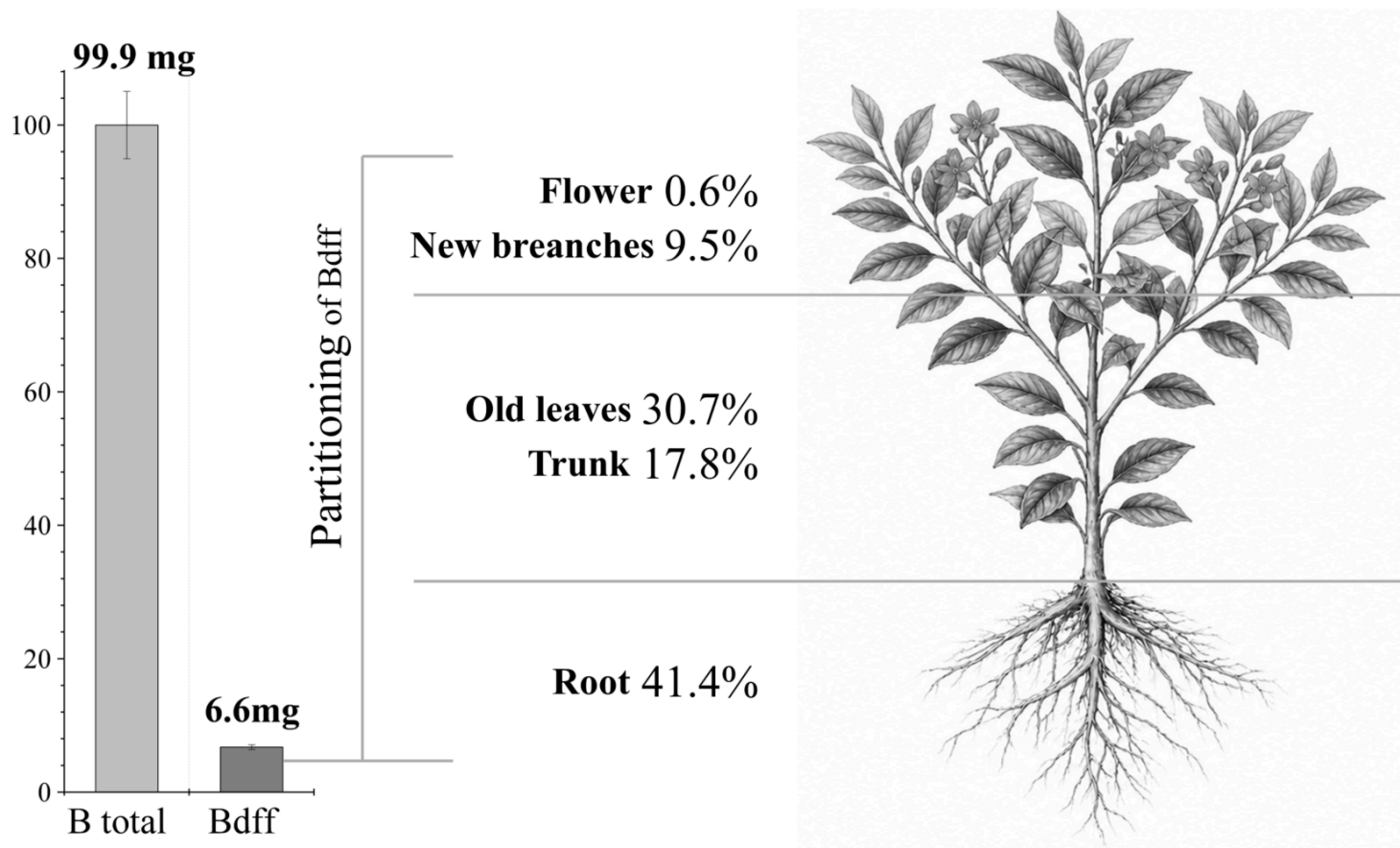


Figure 3

Total boron accumulation (B total), boron derived from fertilizer (Bdff), and partitioning of fertilizer-derived B among organs of young orange trees at the end of the experimental period. As treatments did not differ significantly, values represent the overall means of B total, Bdff, and the percentage of Bdff recovered in each organ.