

Foliar Boron Enhances Fruit Set, Volume and Yield of Hot Pepper (*Capsicum annuum* L. cv. Demir F1) under Greenhouse Conditions

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Abstract: Boron is the micronutrient of reproduction. Pollen will not germinate properly without it, pollen tubes will not grow, and sugar will not move to the fruit. A shortage costs yield long before anything shows on the leaf, which is what makes it dangerous. Weekly sprays of a boric acid solution at 1 g L^{-1} were compared against a distilled-water control on hot pepper cv. Demir F1 under glass at Idlib in the 2024–2025 season, six pots per treatment in randomized complete blocks. The plants themselves changed little. Height moved from 62.00 to 65.83 cm, which is the smallest vegetative response in the whole trial, though leaf area rose from 15.63 to 21.64 cm^2 and branching stayed at four. The crop was transformed. Fruit number went from 16 to 26 per plant and yield from 66.72 to 118.73 g, up 78%. Fruits gained volume, 7.00 against 5.85 cm^3 , and width, 1.25 against 1.08 cm, while length hardly moved. Almost the entire yield gain came from fruits that set rather than from plants that grew. That is the signature of a fertility nutrient, and it is the reason boron deserves a place in the programme on calcareous ground, where it is least available and least visible when missing.

Keywords: *Capsicum annuum*, foliar boron, fruit set, pollen, fruit volume, greenhouse, hot pepper, micronutrient.

1. Introduction

Boron occupies an odd position among the nutrients of a pepper crop. The plant needs only traces of it, and those traces decide the harvest. Pollen germination and pollen-tube growth depend on boron. So does the integrity of the cell wall, through the cross-links boron forms with pectin, and so does the movement of sugars into a developing organ [1],[2]. A plant short of boron can flower normally and set almost nothing [3].

The calcareous and sandy soils common in Mediterranean horticulture either bind boron or let it leach away, so what is in the ground is a poor guide to what the plant will get. A spray avoids the question. Small amounts placed on the leaf reach the flower and the young fruit at the point when they need it [4]. Foliar boron has been shown to raise fruit number and quality in pepper by improving pollination and the flow of assimilate to the fruit [5], and boron supply is now treated as a lever for sustainable production rather than an afterthought [3].

This trial isolated the boron effect. Plants of cv. Demir F1 received weekly foliar boron at 1 g L^{-1} or plain water, and growth, fruit shape and yield were measured on otherwise identical plants.

a) Objectives of the study

1. To evaluate the effect of weekly foliar B (1 g L^{-1}) on the vegetative growth of hot pepper cv. Demir F1;
2. To assess fruit morphological responses (weight, volume, length, diameter, peduncle) to boron;
3. To quantify the effect of boron on fruit number and total yield per plant.

2. Materials and Methods

a) Site and plant material

The work was done in the 2024–2025 season at the Faculty of Agricultural Engineering, University of Idlib. The house is a gable glasshouse of 8 × 5 m with a 4 m ridge. It takes direct sun from mid-morning until the end of the day, keeps out wind, rain and insects, and takes the edge off the winter cold. Hot pepper cv. Demir F1 was grown throughout [6]. This is a Dutch hybrid. Its fruits are long and thin, they are strongly pungent, and they turn deep red at full maturity.

b) Experimental design and treatments

Seeds were sown in cork propagation trays filled with sphagnum peat. The trays were covered with black polyethylene for four days to bring the seed up faster, then watered every second day until the seedlings were ready to move. Seedlings of even size were picked and transplanted into 5.0-L plastic pots filled with clean growing medium. Each pot counted as one replicate and six pots made up a treatment, laid out in randomized complete blocks. With the control that comes to twelve plants. The spray was made up on the morning it was used, by dissolving 1 g of boric acid in one litre of distilled water. Where yeast was involved, the suspension stood for an hour with the sugar so the cells woke up before it went on the plant. Control plants received distilled water and nothing else. Agral was added to every solution, the control included, so that the droplets would sit on the leaf instead of rolling off. Spraying was done early in the morning to the point of run-off, about one litre for six plants, and it was repeated every week for the length of the season [4].

One point should be stated plainly. The treatment reported in this paper was one of several foliar products grown side by side in the same glasshouse during the same season, against one shared water control. Each product raises a separate question and is reported separately. The consequence is that the control figures quoted here, and the description of the site and the design, are common to the companion papers from this trial.

c) Measured traits

Plant height was taken with a graduated ruler and the main branches were counted by hand. Leaf area was computed in Image-J from five fully expanded leaves per replicate. The fruit measurements were made at harvest. Fruits were counted, then weighed on a balance reading to 0.001 g, from which mean fruit weight follows. Volume was read by displacement in a 500-mL graduated cylinder. Fruit length and peduncle length were measured against a ruler, and diameter with a digital vernier caliper. Yield per plant is the weight of all the fruit that plant carried.

d) Statistical analysis

Analysis of variance for the randomized complete block design was run in SigmaStat 10.0. Means were separated by Fisher's protected least significant difference at the 5% level, which is the usual threshold for field measurements of this kind.

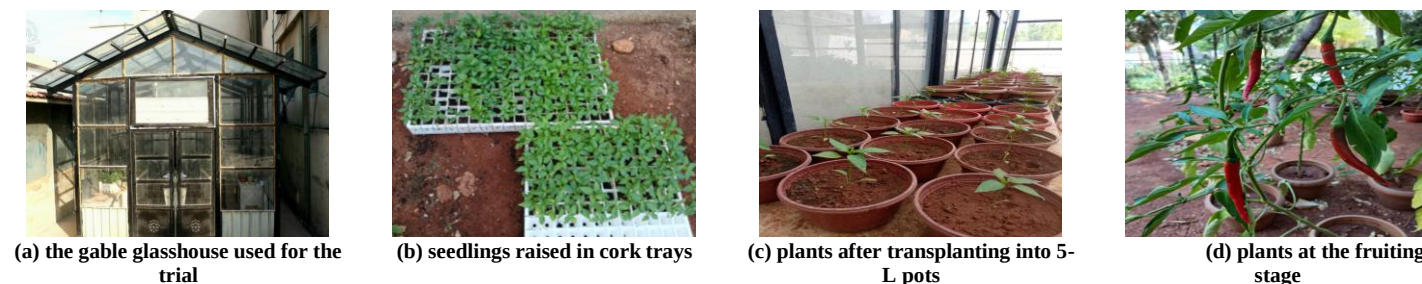


Figure 1: The experimental site and the successive stages of the hot pepper crop (*Capsicum annuum* L. cv. Demir F1)



(a) plant height



(b) leaf area



(c) fruit length on millimetre paper



(d) fruit diameter with a vernier caliper

Figure 2: Measurement of the vegetative and fruit traits recorded in the trial

3. Results and Discussion

a) Vegetative growth

Table 1: Effect of Boron foliar spray on the vegetative growth of hot pepper cv. Demir F1

Trait	Control	Boron	Change (%)	LSD	Significance
Plant height (cm)	62.00 ± 1.09	65.83 ± 1.09	+6.2	3.11	Significant
Number of main branches/plant	4.00 ± 0.02	4.00 ± 0.02	+0.0	0.050	n.s.
Leaf area (cm ²)	15.63 ± 1.00	21.64 ± 1.00	+38.5	2.87	Significant

Vegetative growth: Boron vs control

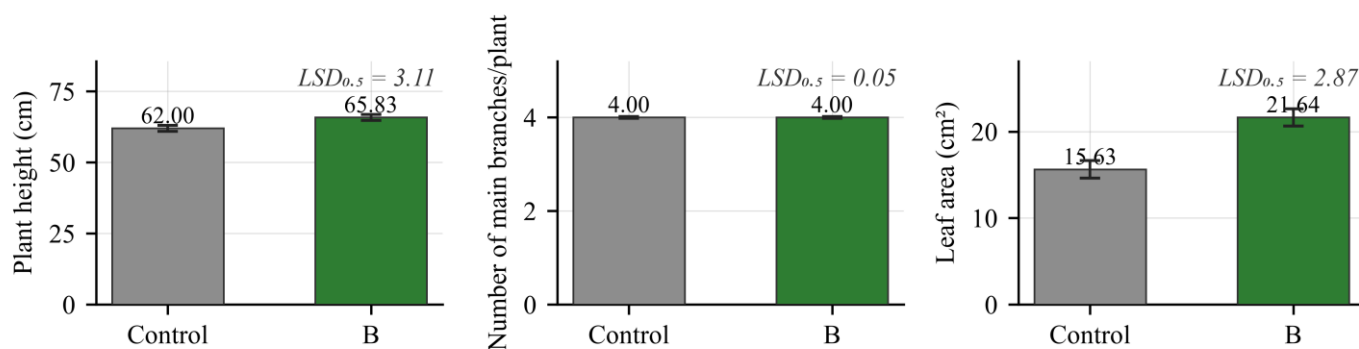


Figure 3: Effect of Boron foliar spray on the vegetative growth of hot pepper

Boron barely touched the size of the plant. Height went from 62.00 to 65.83 cm, a gain of under 4 cm and the smallest vegetative response recorded in this trial, and branch number did not move from four. Leaf area did rise, from 15.63 to 21.64 cm² (Table 1, Fig. 3). Boron builds cell wall and mobilises sugar, so a leaf can expand more completely, but boron is not a growth nutrient and this is what that looks like [2].

b) Fruit morphological traits

Table 2: Effect of Boron foliar spray on the morphological traits of hot pepper fruits

Trait	Control	Boron	Change (%)	LSD	Significance
Average fruit weight (g)	4.17 ± 0.05	4.57 ± 0.05	+9.6	0.15	Significant
Fruit volume (cm ³)	5.85 ± 0.10	7.00 ± 0.10	+19.7	0.30	Significant
Fruit length (cm)	13.30 ± 0.10	14.16 ± 0.10	+6.5	0.30	Significant
Fruit diameter (cm)	1.08 ± 0.02	1.25 ± 0.02	+15.7	0.050	Significant
Peduncle length (cm)	2.63 ± 0.03	3.10 ± 0.03	+17.9	0.10	Significant

Fruit morphology: Boron vs control

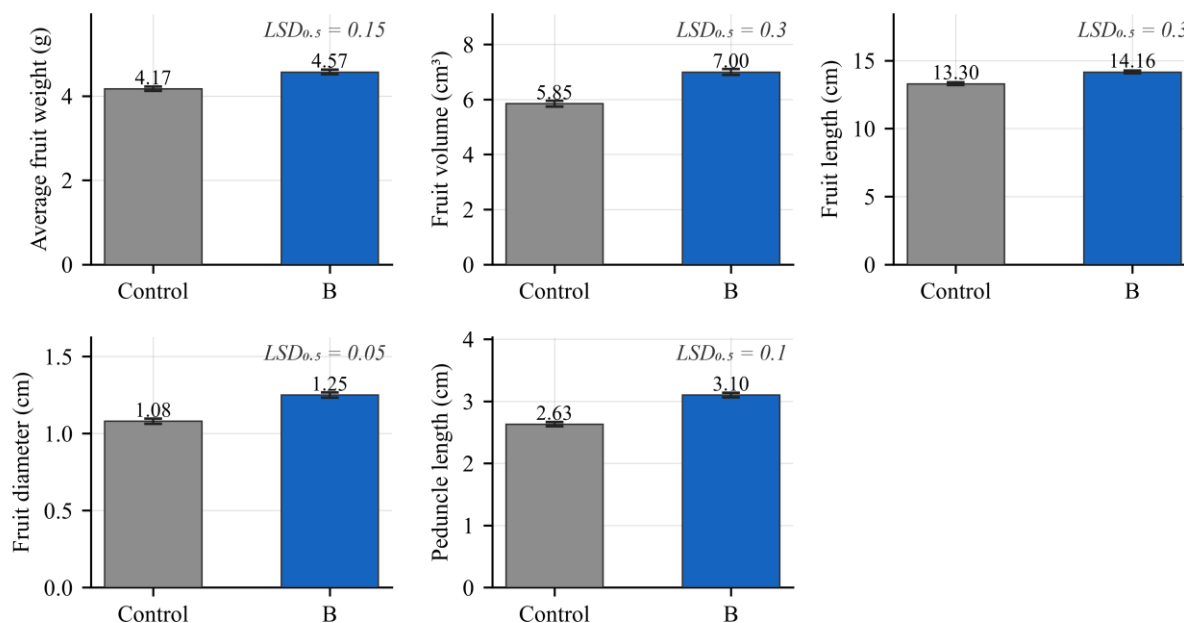


Figure 4: Effect of Boron foliar spray on the morphology of hot pepper fruits

The fruit filled out sideways. Volume rose from 5.85 to 7.00 cm³, diameter from 1.08 to 1.25 cm and mean weight from 4.17 to 4.57 g, while length stayed near where it started, 14.16 against 13.30 cm, and the peduncle went from 2.63 to 3.10 cm (Table 2, Fig. 4). Cross-linked pectin gives the wall its strength, and a steady flow of sugar keeps filling the cells behind it, so the fruit gains girth and weight without gaining length [1],[7].

c) Yield components

Table 3: Effect of Boron foliar spray on the yield components of hot pepper

Trait	Control	Boron	Change (%)	LSD	Significance
Number of fruits/plant	16.00 ± 0.88	26.00 ± 0.88	+62.5	2.50	Significant
Total fruit yield/plant (g)	66.72 ± 2.10	118.73 ± 2.10	+78.0	6.00	Significant

Yield components: Boron vs control

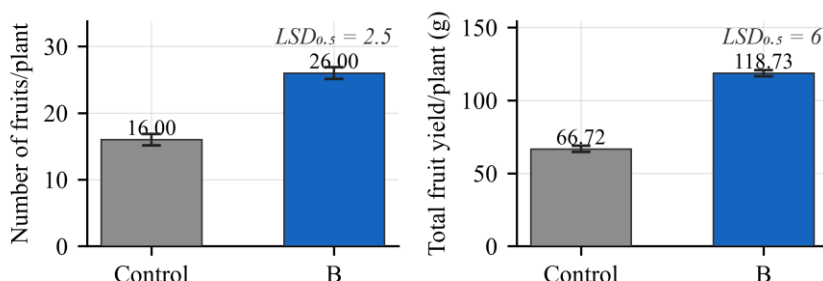


Figure 5: Effect of Boron foliar spray on the yield components of hot pepper

The harvest is the reason for this paper. Boron plants set 26 fruits against 16, and yield rose from 66.72 to 118.73 g per plant, up 78% (Table 3, Fig. 5). Note where that came from. Mean fruit weight increased by only 0.40 g, less than a tenth, so nearly all of the gain sits in the ten extra fruits. This is reproductive success and nothing else: with boron available, pollen germinates, tubes grow, and a far larger share of flowers turns into fruit [3],[1]. A plant only 4 cm taller than the control carried almost twice the crop. Earlier foliar-boron trials on pepper found the same thing [5].

4. Conclusion

Weekly foliar boron at 1 g L⁻¹ raised fruit number in cv. Demir F1 by 62% and yield by 78%, from 66.72 to 118.73 g per plant, with fruits of greater volume and diameter. The plants themselves grew barely at all.

That split is the finding. Boron works on fertilisation, not on growth, and the crop it delivers comes from flowers that became fruit rather than from a larger plant. Since deficiency is common on calcareous soils and gives almost no warning before the harvest is already lost, a weekly spray is cheap insurance for greenhouse pepper.

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