

IBTA and NBMA Influences Tomato Fruit Yield

submitted to:

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Introduction

Plant metabolism regulators are novel bioactive compounds that when applied to plants in bioregulatory amounts enhance plant development, increase total biomass, and increase plant quality (Yokoyama and Gausman, 1996). Plant metabolism regulators (PMRs) come from a family of amino ethers including IBTA (2-[diethylaminoethyl]-2-methylpropylether) and NBMA (2-[N-Methylbenzylaminoethyl]-4-methylbenzylether). These compounds and many other bioactive compounds were developed by Henry Yokoyama and Harold W. Gausman of the USDA Agricultural Research Service (U.S. Patent 5,710,099, 20 Jan 1998).

EcoLyst[®] (PT-807 [Diethyl-2-(4-methylbenzyloxy) ethylamine Hydrochloloride], Valent U.S.A. Corp.) is also from this unique group of plant growth regulators or PMRs that has been shown to increase and advance sugar (*Brix*) accumulation in oranges, resulting in more soluble solids per acre (Anonymous, 2001). Orange growers also benefit from an increase in harvest management flexibility allowing harvest to start earlier. According to the label provided by Valent U.S.A. Corp., EcoLyst[®] alters the growth of plants, blossoms, or fruits. It may accelerate or retard growth. It acts at a cellular level to control production of hormones, auxins, and other biological processes. Some of the theories on the mode of action EcoLyst[®] is that the amino ethers play a role in the photosynthetic pathway in green plants and that applications during early stages of growth manipulate the genetic expression of the plant so as to tap unused biological potential plant bioregulatory effects (Anonymous, 2001).

The Valent USA label for EcoLyst[®] recommends that it be applied during active cell division stages of plant development (Anonymous, 2001). Application during active cell division is critical for transmittal of the bioinduced regulatory gene expression information from one cell to another. Activity will be reduced if applied after active cell division has ceased. The label includes vine crops, tree fruits, and floral plants applied at rates ranging from 0.001-0.01 mg a.i. per seed (0.01-10

mg a.i./L⁻¹ diluent for 3-8 hours) as a seed soak, 0.1-10 mg a.i./L⁻¹ for 5-30 minutes as a root soak, and foliar applications at the 2-4 leaf stage using 0.001-0.1 mg a.i. per plant or 0.0125-10 mg a.i./L⁻¹ to drip.

Greenhouse Studies

Greenhouse studies completed at Colorado State University used garden tomato cultivars, Better Boy, Bush Better Boy, Fourth of July and Sweet 100. Foliar sprays to drip of IBTA at 0, 2, and 10 mg a.i. L⁻¹ and NBMA at 0, 0.5, and 1 mg a.i./L⁻¹ were applied at the 2-3 true leaf stage and at first fruit color. IBTA at 0, 2, and 10 mg a.i. L⁻¹ and NBMA at 0, 0.5, and 1 mg were also applied as an 8-hour seed soak prior to planting. All plants were pruned to four clusters, and three fruit per cluster. Otherwise, plants were grown with standard greenhouse protocols. Fruit were harvest when fully ripe and weighed. Fruit size was measured with calipers at two dimensions, at the widest point perpendicular to that point, and averaged. Selected fruit were used for lycopene analyses. Prior to lyophilization, Brix was determined. Lycopene and other similar pigments were then extracted from lyophilized tomato tissue with acetone and measured spectrophotometrically at 503 nm. All statistical analyses were using the SAS General Linear Model procedure (see Appendix).

Results and Discussion

Fruit Weight:

The influence of IBTA on individual fruit weight was not consistent among the four tomato cultivars trialed. Better Boy fruit harvested from plants treated with 10 mg/iter⁻¹ IBTA at the two to three leaf stage were smaller than the control plants (Fig. 1). Fruit harvested from plants treated with 10 mg/iter⁻¹ IBTA as a seed soak were larger than the control and those treated with 2 mg/iter⁻¹. Bush Better Boy fruit treated with 2 mg/iter⁻¹ IBTA at the two to three leaf stage and at first fruit color were larger than those harvested from the control plants and those treated with 10 mg/iter⁻¹ (Fig. 2). Bush Better Boy fruit was incrementally larger with increasing levels of IBTA applied as a seed soak. Fourth of July fruit treated with IBTA at the two to three leaf stage was incrementally larger with increasing levels of IBTA (Fig. 3). IBTA applied at first color did not influence fruit weight of Fourth of July fruit. Fourth of July fruit was larger than those harvested from control plants when IBTA applied as a seed soak at 2 mg/iter⁻¹. Sweet 100 fruit was larger when harvested from plants treated at first color with 10 mg/iter⁻¹ IBTA (Fig. 4). Sweet 100 fruit harvested from plants treated with 10 mg/iter⁻¹ IBTA over several days were larger over the harvest duration compared to those not treated with IBTA (App. Pages 78-79).

As with IBTA, NBMA did not consistently influence fruit weight among the four tomato cultivars trialed. Larger Better Boy tomato fruit were harvested from plants treated at first color and as a seed soak with 1 mg/iter⁻¹ NBMA (Fig. 5). Larger Bush Better Boy fruit were harvested from those plants treated with 0.5 and 1 mg/iter⁻¹ NBMA as a seed soak. Larger Fourth of July fruit were harvested from those plants treated with 1 mg/iter⁻¹ NBMA at all three application times (Fig. 7).

Sweet 100 fruit was larger when harvested from plants treated with 1 mg/iter^{-1} NBMA at the two to three leaf stage only (Fig. 8). As with Sweet 100 fruit treated with IBTA, NBMA treated plants yielded larger fruit size over several days of the harvest period compared to those not treated with NBMA (App. Pages 87-88).

Total fruit yield for the beefsteak cultivars was compiled and is illustrated in Figs. 9-11 and 13-15, however, since fruit clusters were thinned, these data are not very representative of the potential harvest. Yet, some larger fruit were harvested from Bush Better Boy and Fourth of July plants treated with IBTA and NBMA (Figs. 10, 11, 14, and 15). Total yield for Sweet 100, a cherry type, can be analyzed effectively for total yield (Fig. 12 and 16). Fruit yield harvested from Sweet 100 plants treated at first fruit color with 10 mg/iter^{-1} IBTA was greater than the control plants and from those treated with 2 mg/iter^{-1} IBTA as a seed soak (Fig. 12). Fruit yield was greater from Sweet 100 plants treated with 1 mg/iter^{-1} NBMA at the two to three leaf stage compared to the control plants and those plants treated with 0.5 mg/iter^{-1} NBMA (Fig. 16).

Daily harvest data was collected with few differences among the IBTA and NBMA treatments on any cultivar (Figs. 17-24). One trend, however, was observed. When IBTA was applied at 2 mg/iter^{-1} at the two to three leaf stage, more fruit were harvested from about 90-120 days after transplanting compared to later in the harvest period for Better Boy and Sweet 100 (Figs. 17 and 20). Otherwise, no earlier harvest due to IBTA or NBMA was observed as reported for citrus.

Brix and Lycopene:

Fruit harvested from Better Boy had greater Brix when treated with IBTA and NBMA at the two to three leaf stage and as a seed soak (Fig. 25). Greater Brix was not observed for fruit harvested from Bush Better Boy (Fig. 26). Fruit harvested from Fourth of July plants had greater Brix from plants treated with IBTA as a seed soak and NBMA at first fruit color and as a seed soak (Fig. 27). Sweet 100 plants yielded fruit with greater Brix when treated with 10 mg/iter^{-1} IBTA as a seed soak and 0.5 mg/iter^{-1} NBMA applied at first fruit color.

Lycopene levels from Better Boy fruit were greater when plants were treated at the two to three leaf stage with 10 mg/iter^{-1} IBTA and as a seed soak with 2 mg/iter^{-1} IBTA (Fig. 29). Lycopene levels were greatest from fruit harvested from Better Boy plants treated with 1 mg/iter^{-1} NBMA as a seed soak. Lycopene from Bush Better Boy fruit was greatest when harvested from plants treated with 10 mg/iter^{-1} IBTA and 0.5 mg/iter^{-1} NBMA as a seed soak (Fig. 30). Lycopene was greatest from fruit harvested from Fourth of July plants treated with 10 mg/iter^{-1} IBTA at first fruit color and 0.5 mg/iter^{-1} NBMA as a seed soak (Fig. 31). Lycopene levels of Sweet 100 fruit were incrementally greater with increasing levels of IBTA applied at the two to three leaf stage (Fig. 32). Lycopene levels of fruit harvested from Sweet 100 plants treated with 0.5 mg/iter^{-1} NBMA was greater than fruit harvested from the control or the 1 mg/iter^{-1} NBMA treated plants.

Conclusions

This study was conducted under less than optimal conditions. Greenhouse spacing was too tight and root volumes were too small. However, some trends can be detected and it is obvious that there is plant metabolism regulation effects occurring in response to IBTA and NBMA. The most consistent results are for the applications at the two to three leaf stage and as a seed soak prior to germination. This hold true with the literature, which implies that active cell division is required for a regulatory response. Responses at the first fruit color application period were most pronounced for the Sweet 100 cultivar, which is a cherry tomato. Many fruit were still under development at the time of application. These products merit further research and development.

Literature Cited

Anonymous. 2001. EcoLyst[®]. Valent U.S.A. Corp., Walnut Creek, CA.

Yokoyama, H and H Gausman. 1996. Plant biochemical regulators and agricultural crops, in: Biotechnology for improved foods and flavors, p. 206-213. American Chemical Society, Washington, DC.

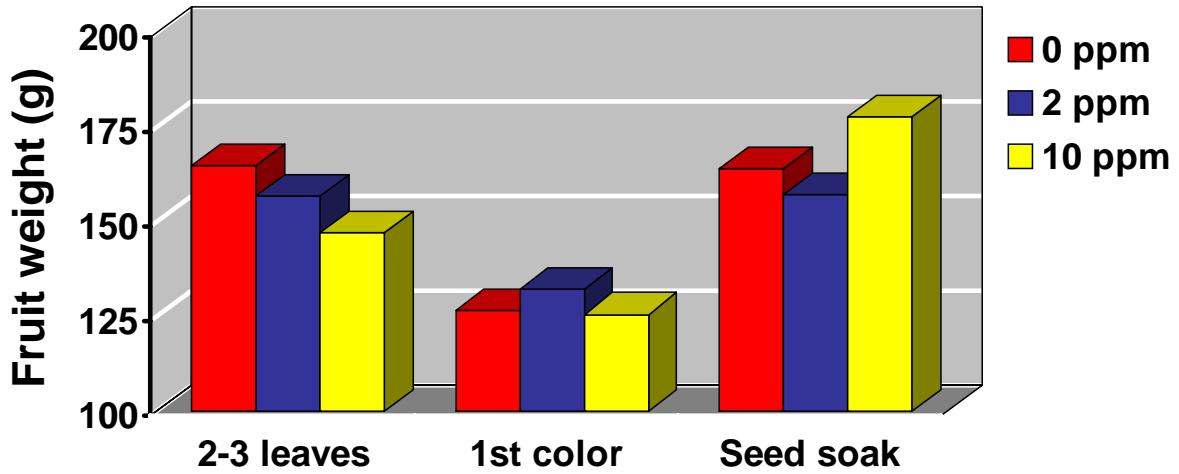


Fig. 1. Influence of IBTA on weight of Better Boy tomato fruit when applied at the two to three leaf stage, when the fruit was at showing first color, and as a 12 hour seed soak prior to germination.

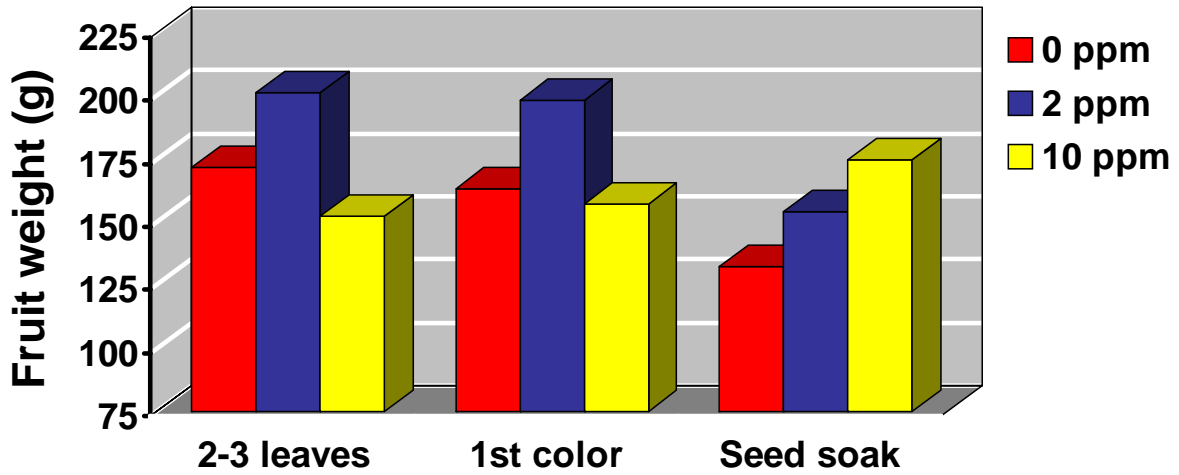


Fig. 2. Influence of IBTA on weight of Bush Better Boy tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

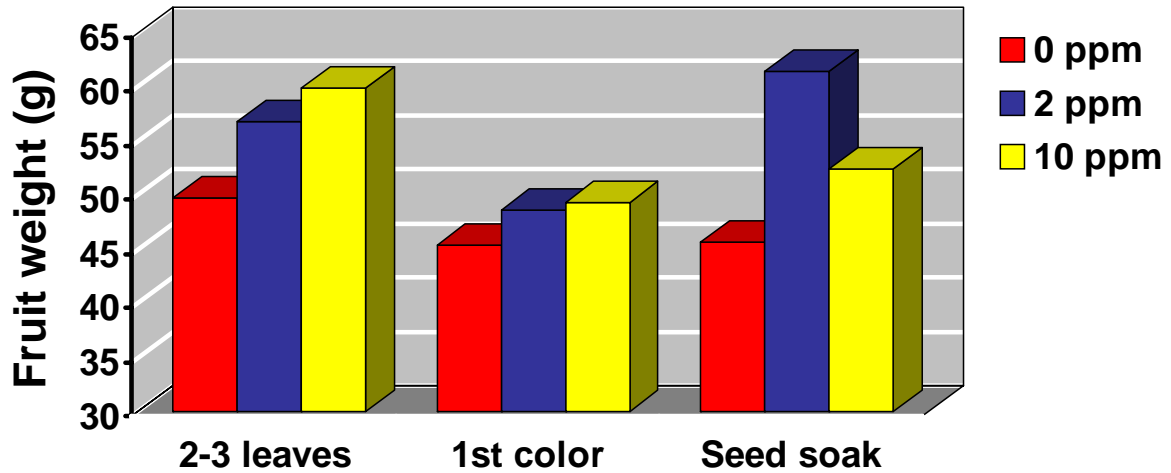


Fig. 3. Influence of IBTA on weight of Fourth of July tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

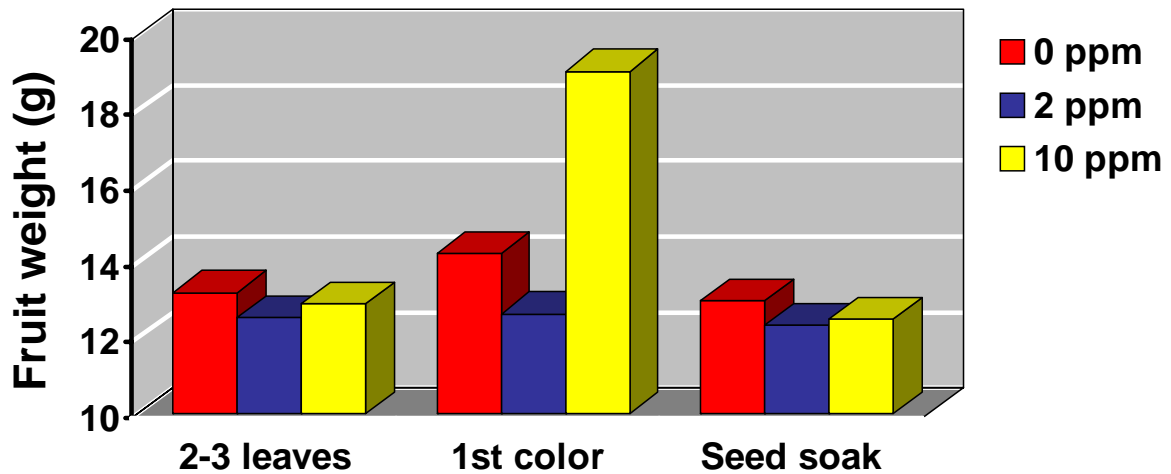


Fig. 4. Influence of IBTA on weight of Sweet 100 tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

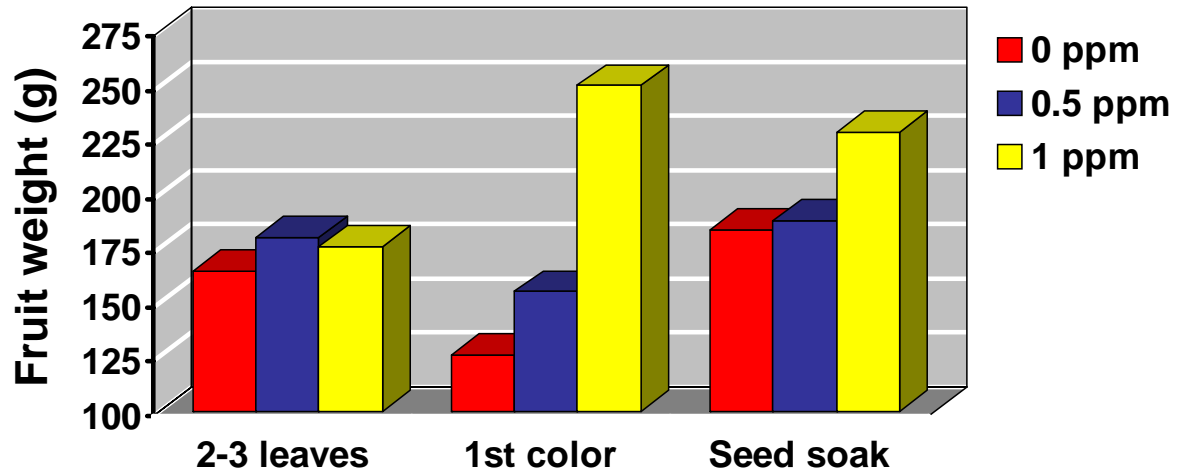


Fig. 5. Influence of NBMA on weight of Better Boy tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

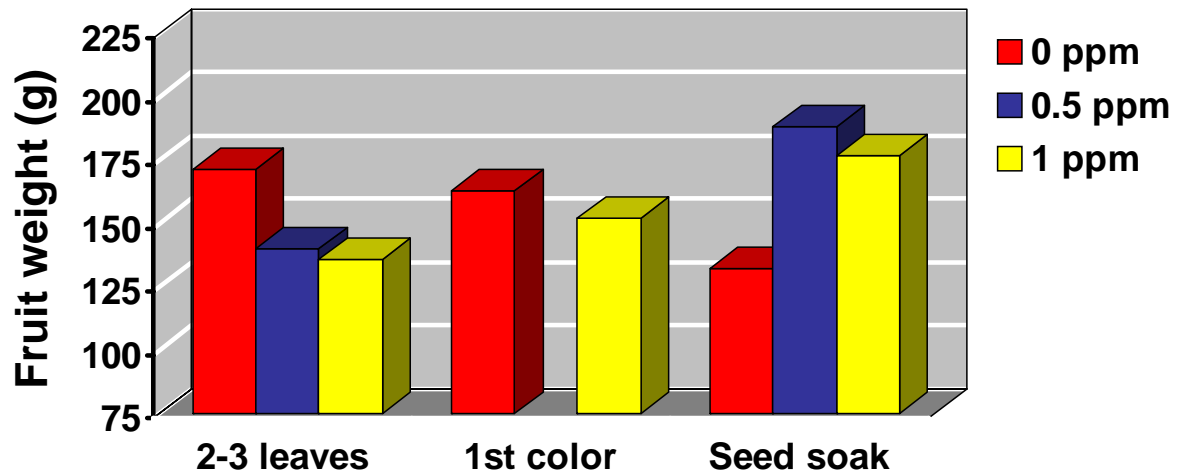


Fig. 6. Influence of NBMA on weight of Bush Better Boy tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

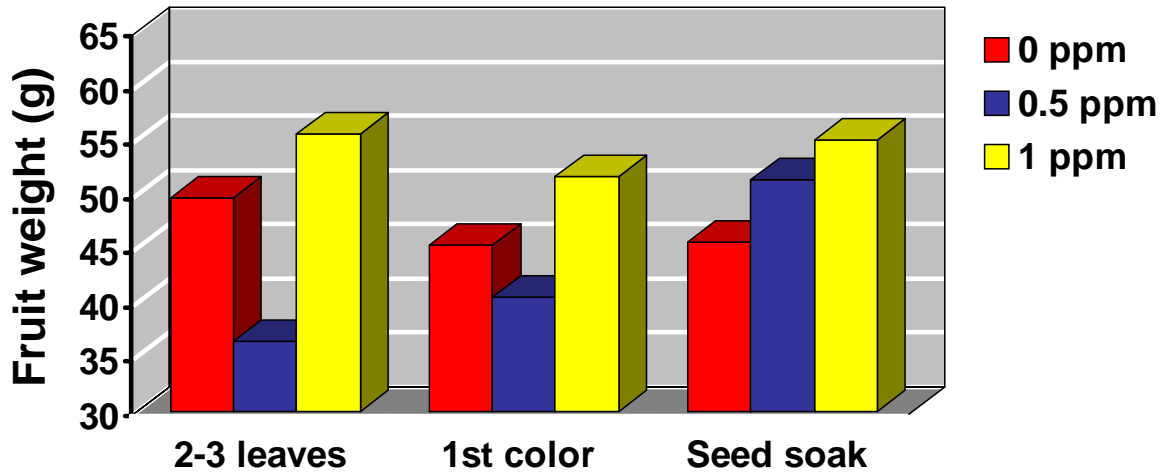


Fig. 7. Influence of NBMA on weight of Fourth of July tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

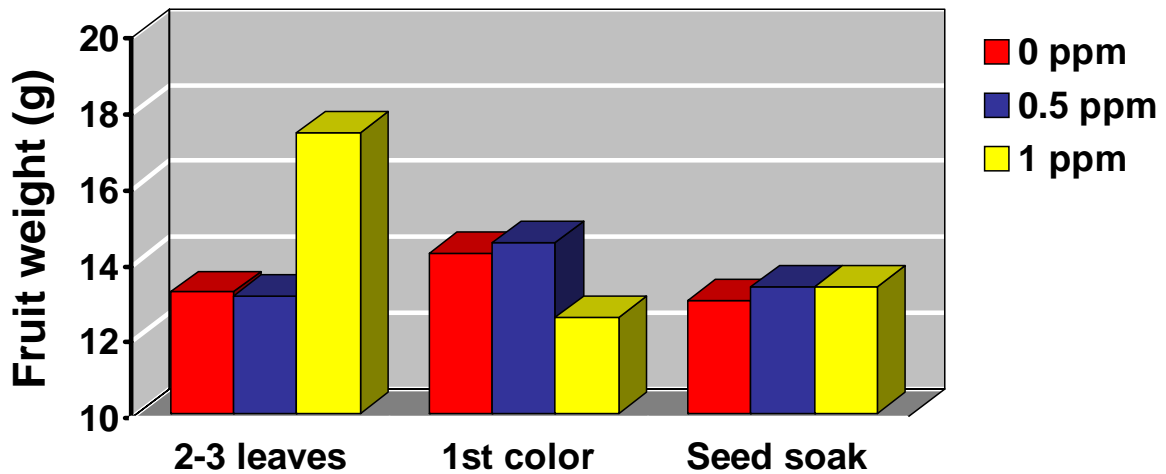


Fig. 8. Influence of NBMA on weight of Sweet 100 tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

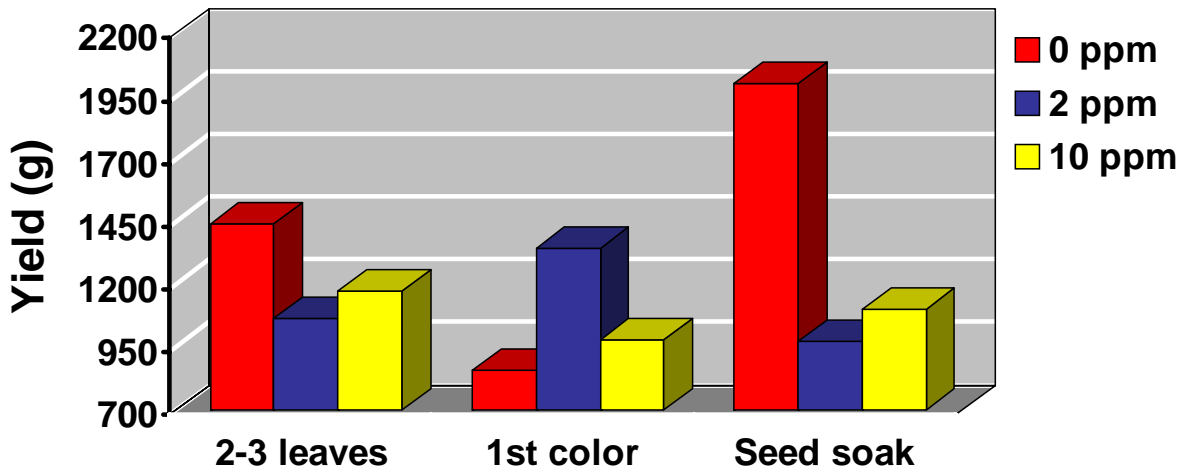


Fig. 9. Influence of IBTA on total yield of Better Boy tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

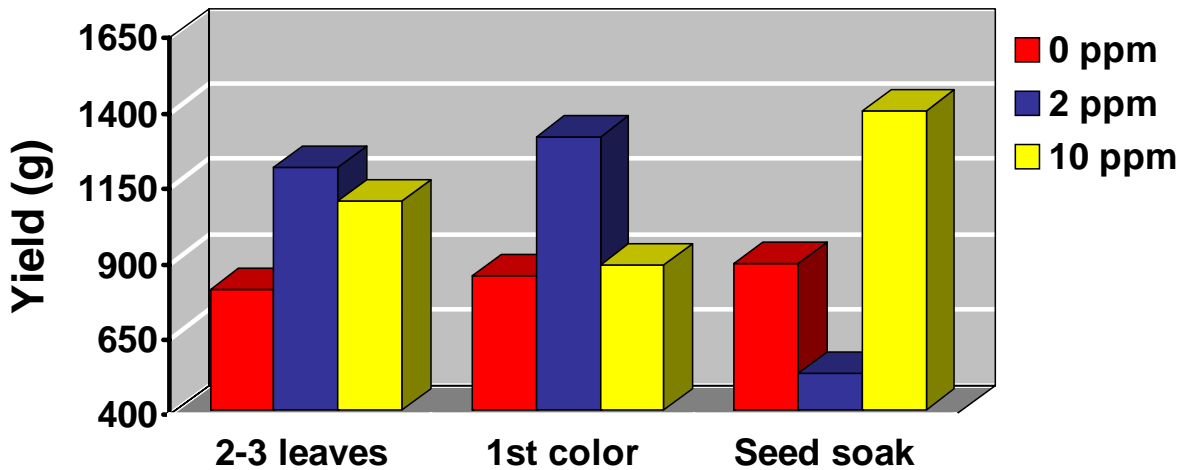


Fig. 10. Influence of IBTA on total yield of Bush Better Boy tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

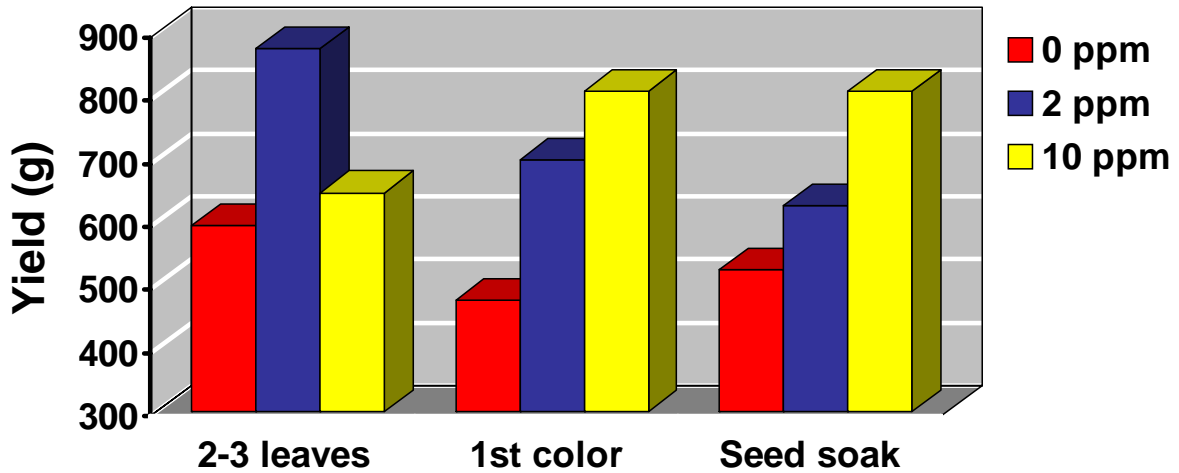


Fig. 11. Influence of IBTA on total yield of Fourth of July tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

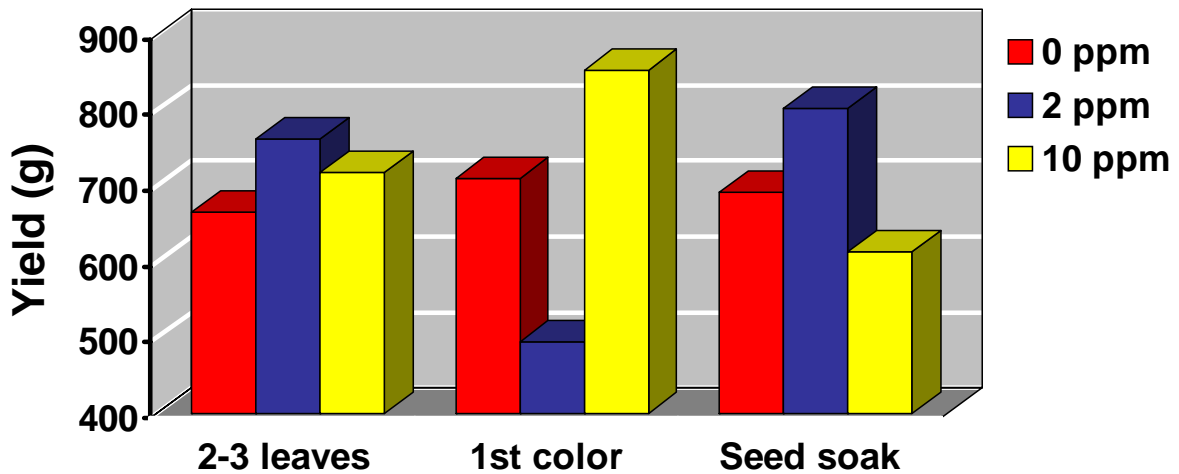


Fig. 12. Influence of IBTA on total yield of Sweet 100 tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

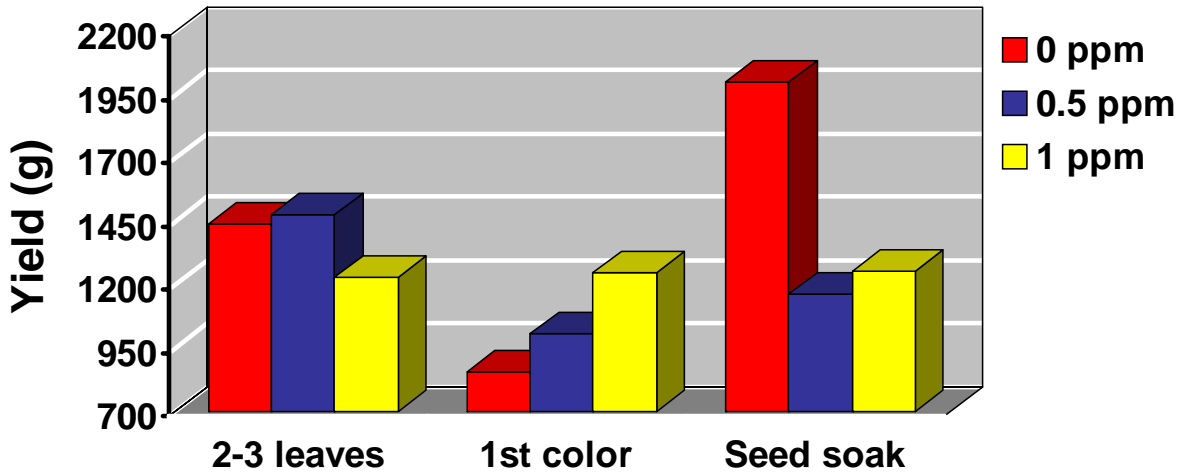


Fig. 13. Influence of NBMA on total yield of Better Boy tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

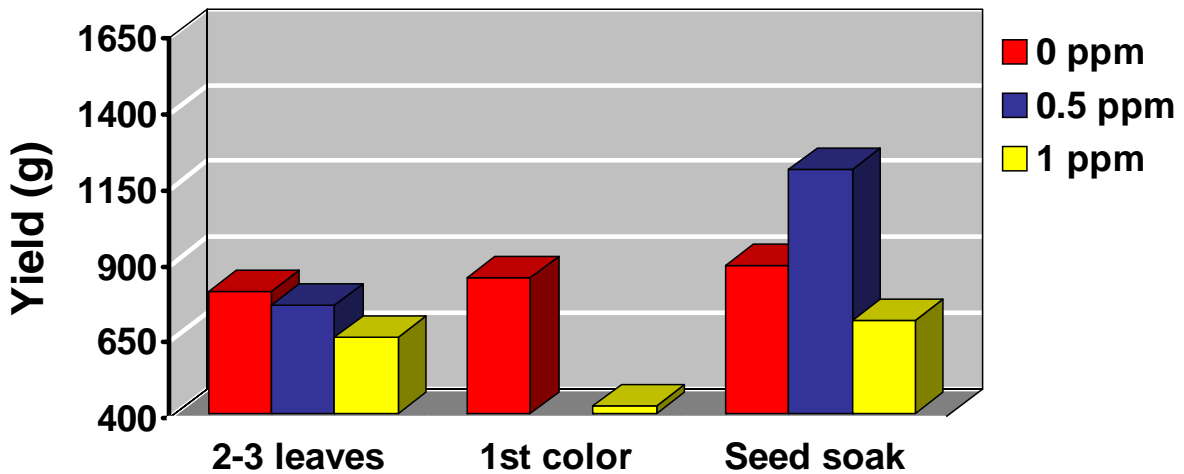


Fig. 14. Influence of NBMA on total yield of Bush Better Boy tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

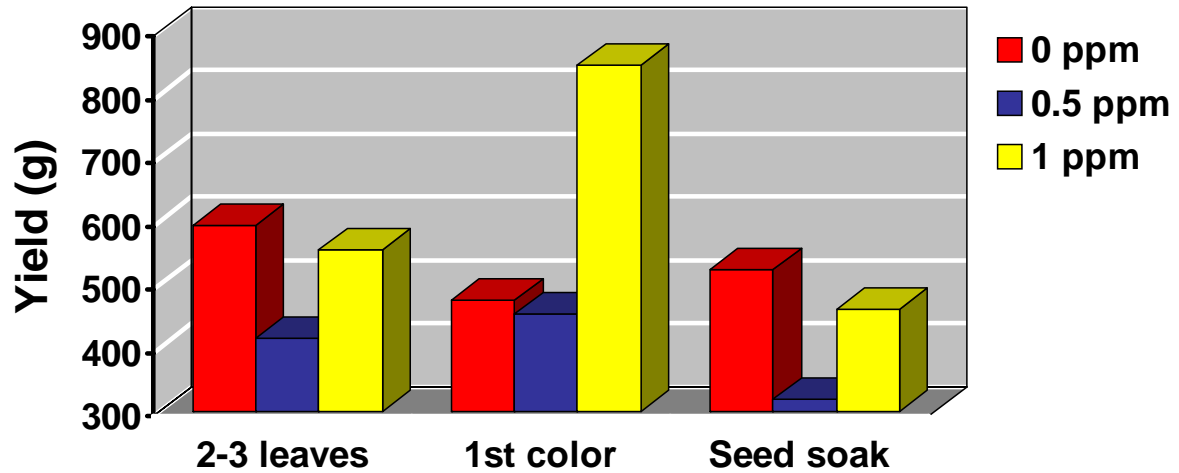


Fig. 15. Influence of NBMA on total yield of Fourth of July tomato fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

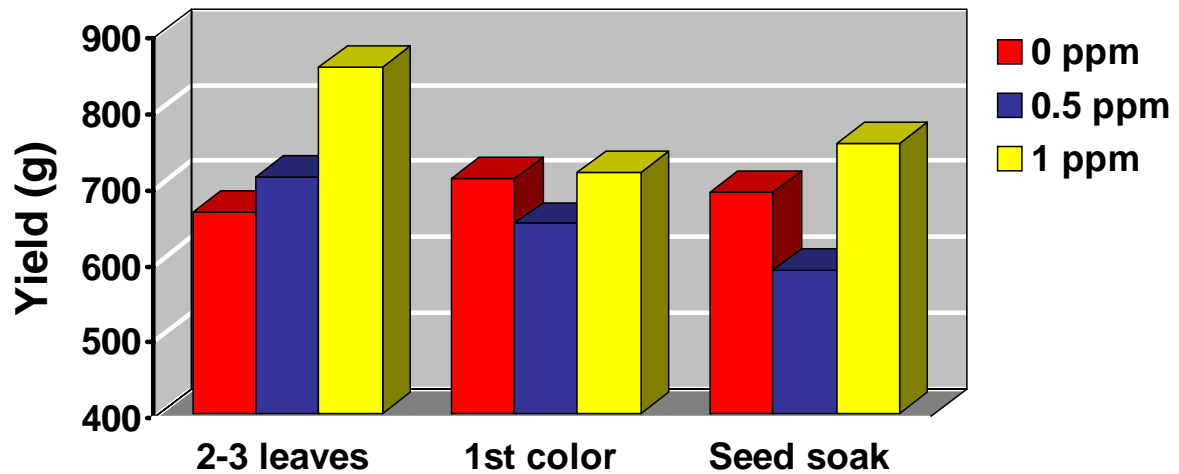


Fig. 16. Influence of NBMA on total yield of Sweet 100 fruit when applied at the two to three leaf stage, when the fruit was showing first color, and as a 12 hour seed soak prior to germination.

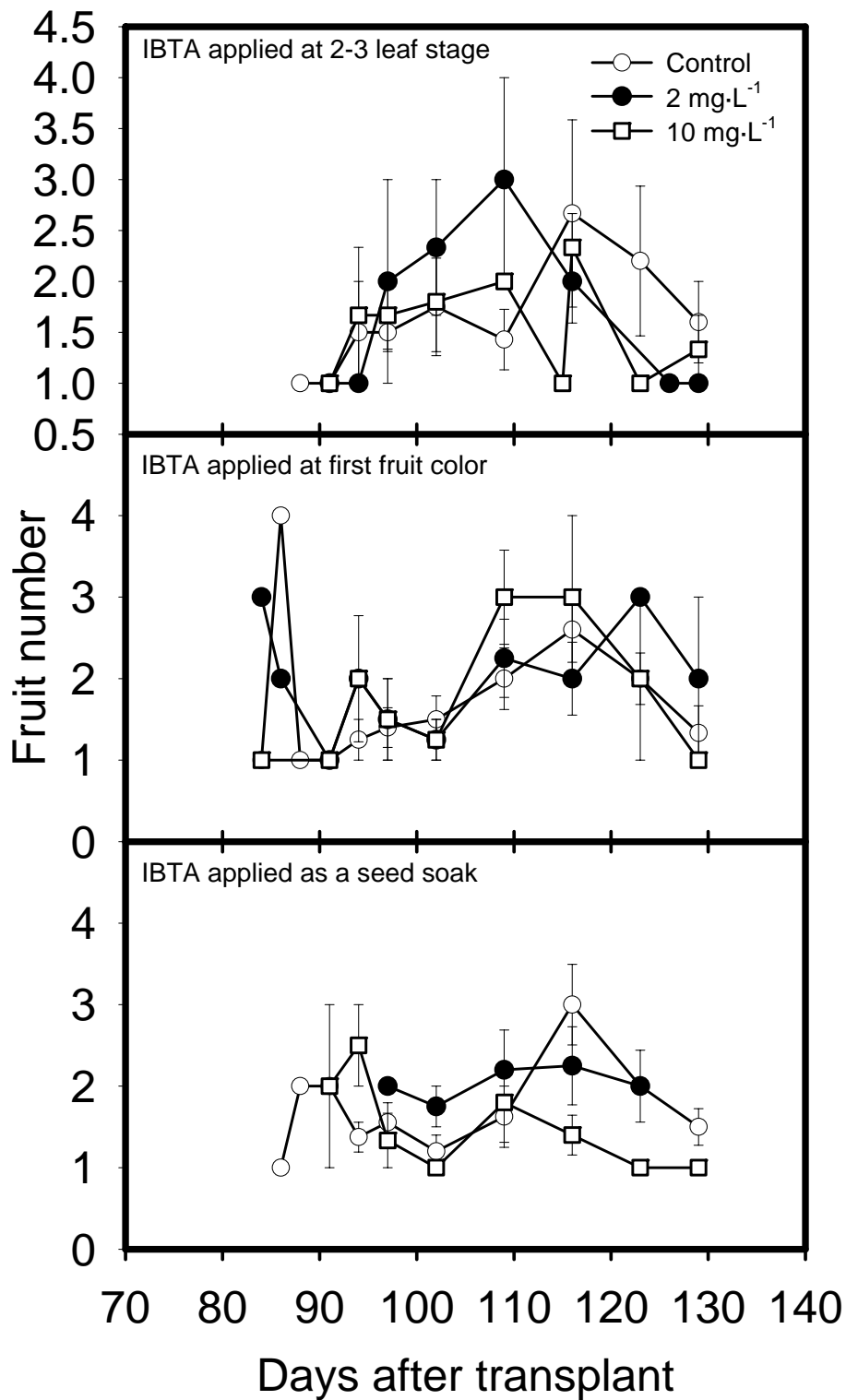


Fig. 17. Influence of IBTA on weekly Better Boy tomato fruit harvest when applied as the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

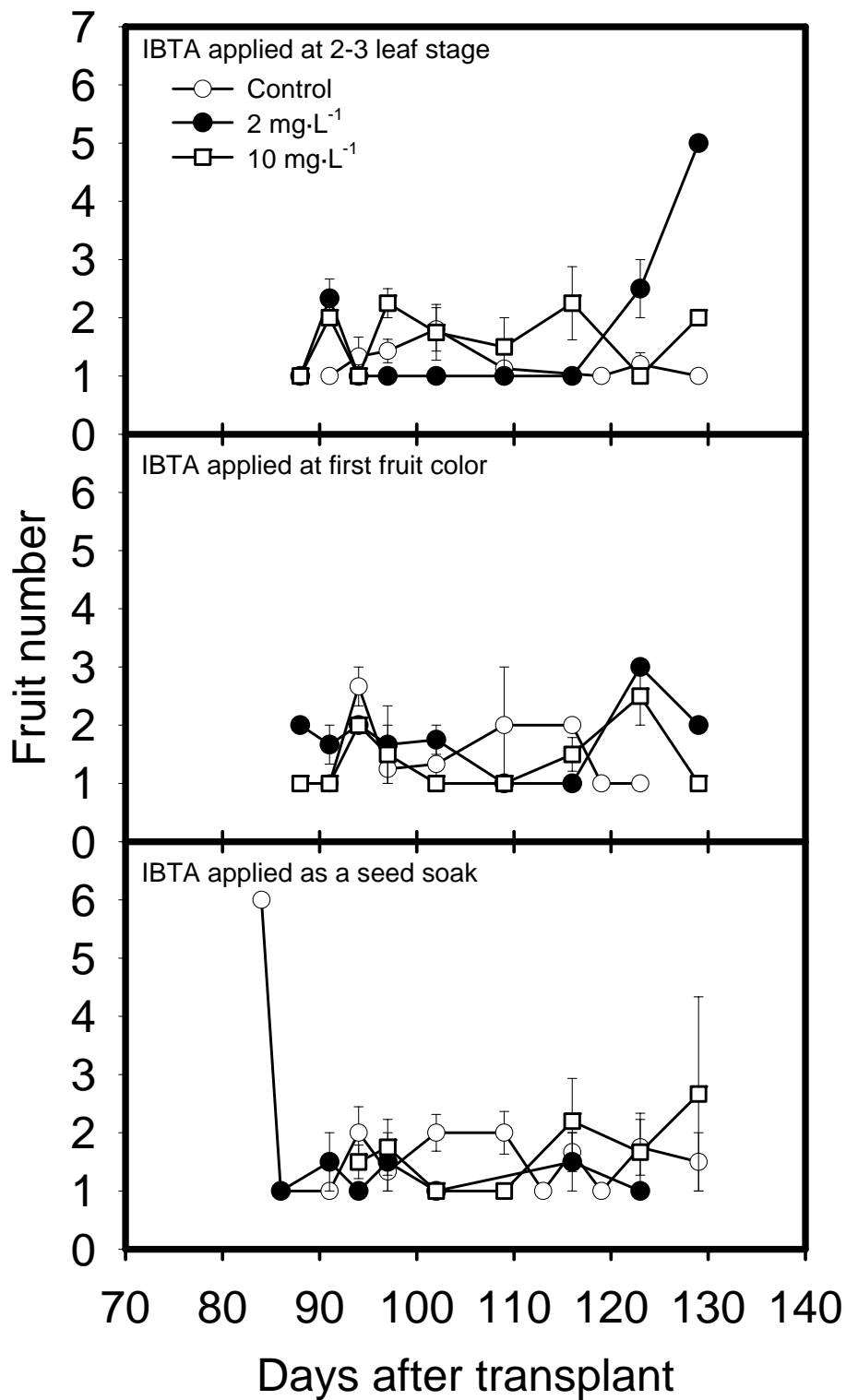


Fig. 18. Influence of IBTA on weekly Bush Better Boy tomato fruit harvest when applied at the two to three leaf stage, at first fruit color, and as a seed soak prior to germination. Vertical bars represent the standard error of the mean.

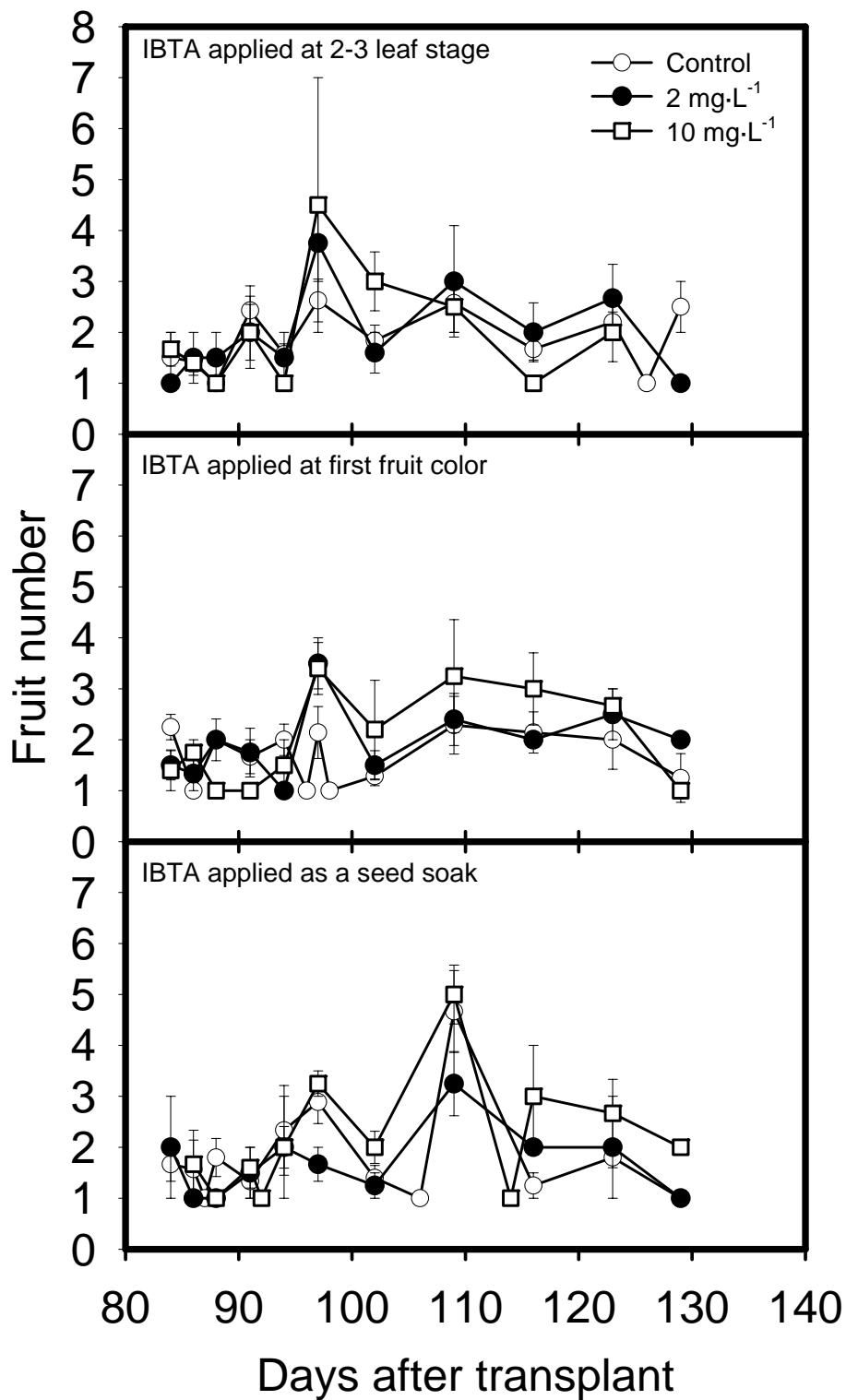


Fig. 19. Influence of IBTA on weekly Fourth of July tomato fruit harvest when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak. Vertical bars represent the standard error of the mean.

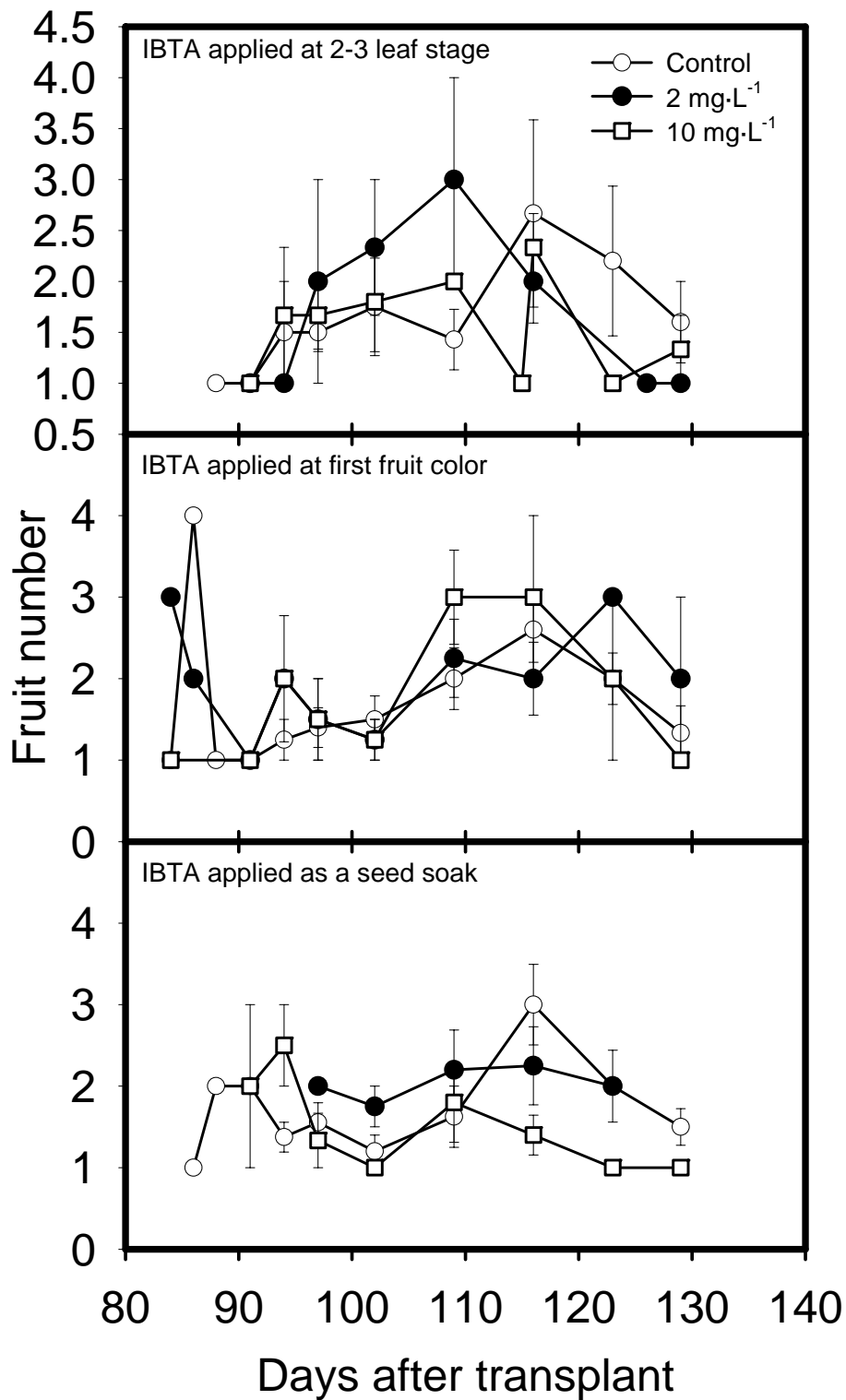


Fig. 20. Influence of IBTA on weekly Sweet 100 tomato fruit harvest when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

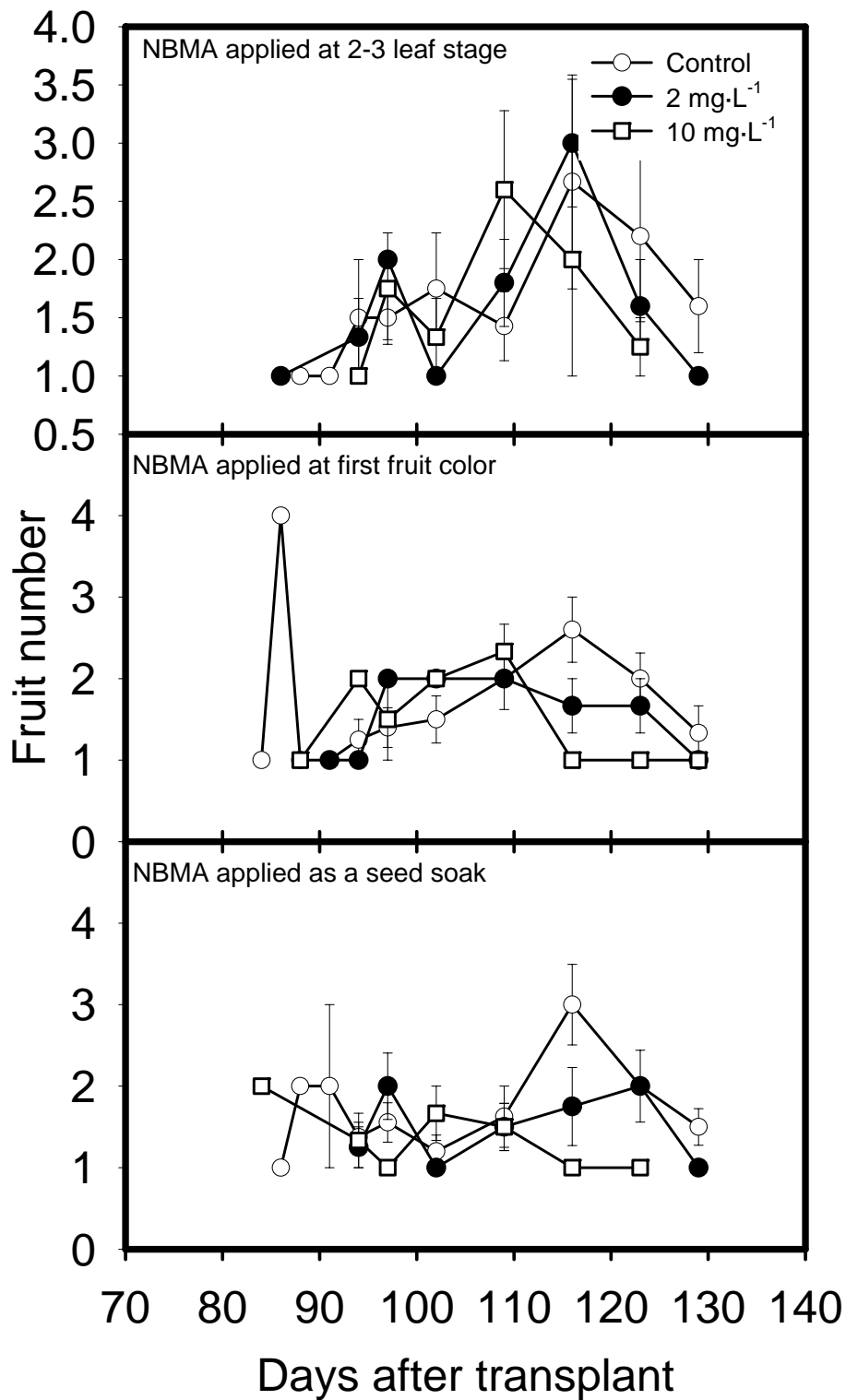


Fig. 21. Influence of NBMA on weekly Better Boy tomato fruit harvest when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

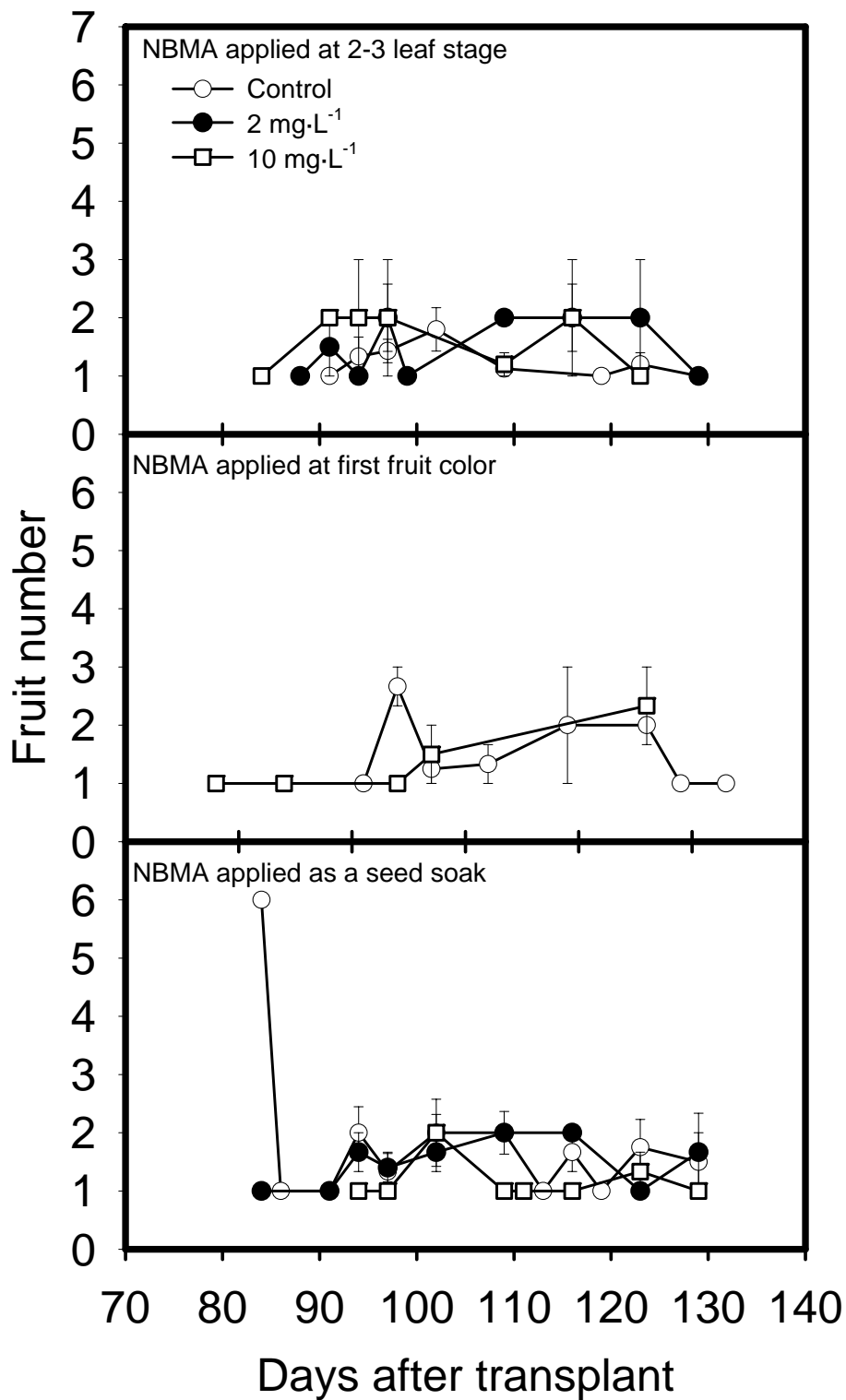


Fig. 22. Influence of NBMA on weekly Bush Better Boy tomato fruit harvest when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

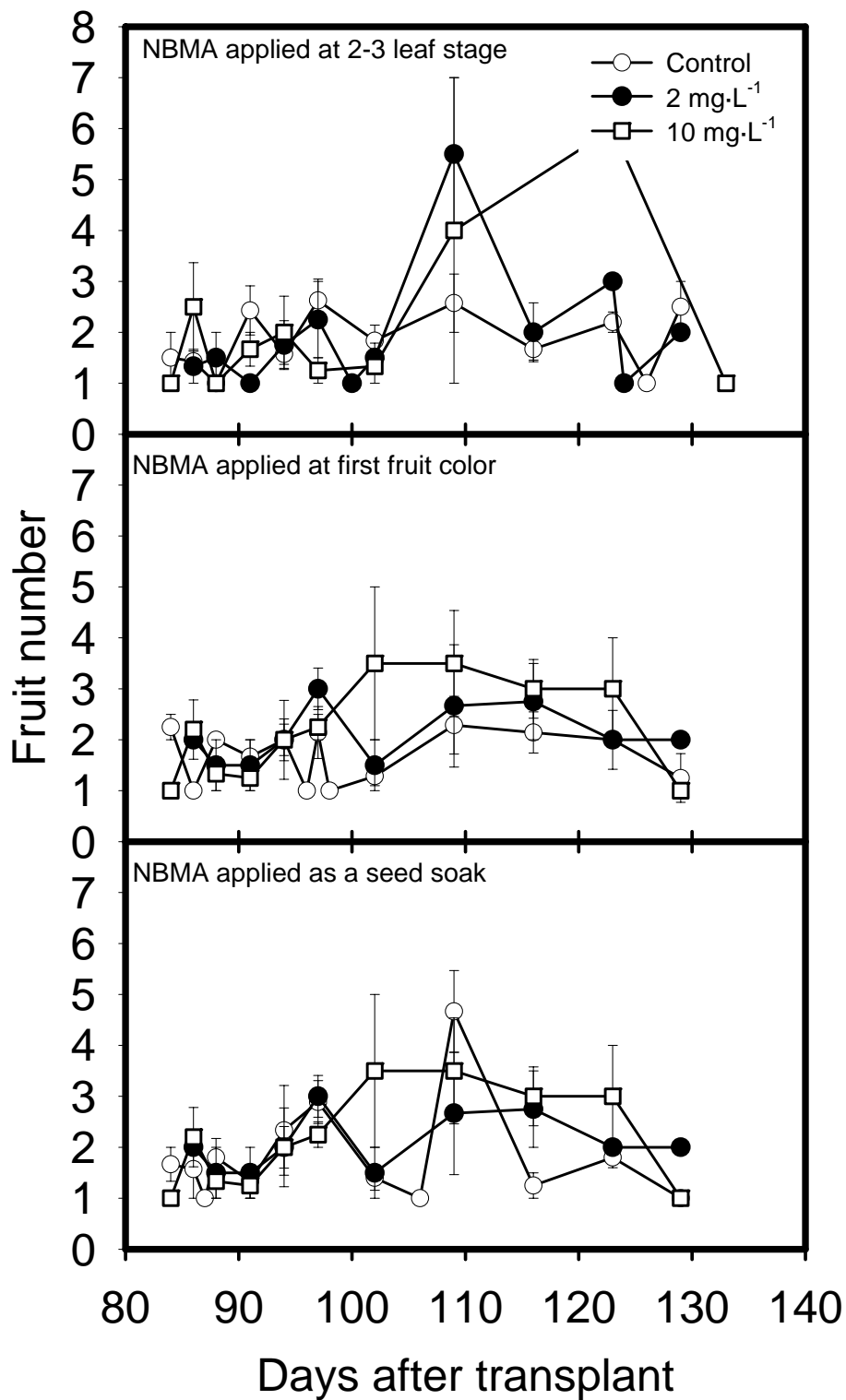


Fig. 23. Influence of NBMA on weekly Fourth of July tomato fruit harvest when applied at the two to three week stage, at first fruit color, and as a 12 seed soak prior to germination. Vertical bars represent the standard error of the mean.

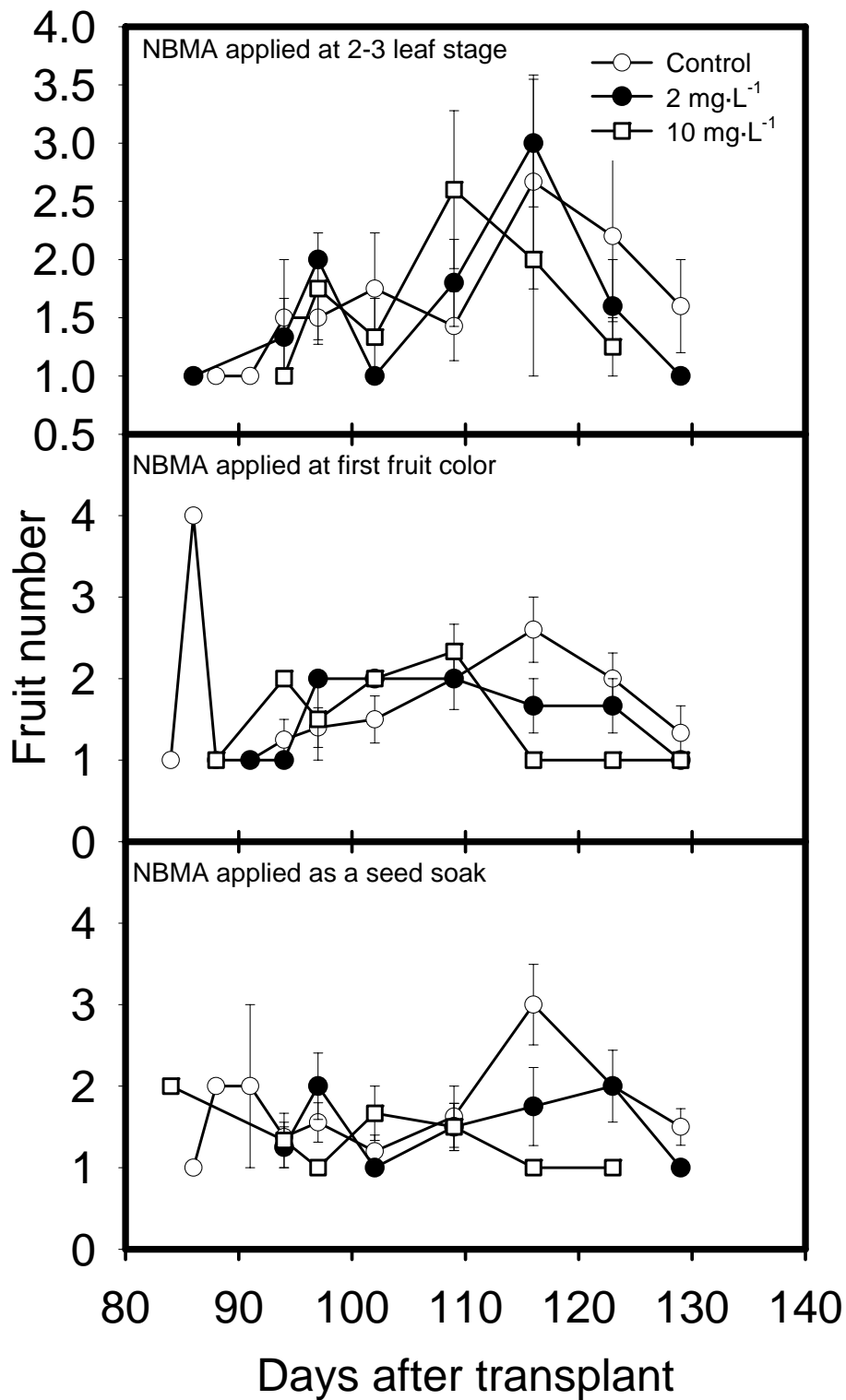


Fig. 24. Influence of NBMA on weekly Sweet 100 tomato fruit harvest when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

'Better Boy'

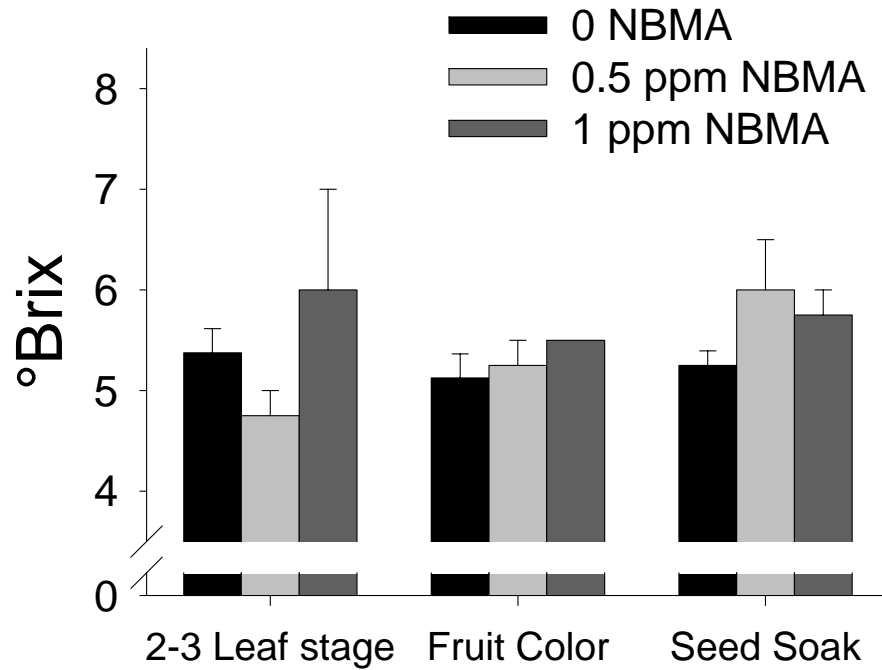
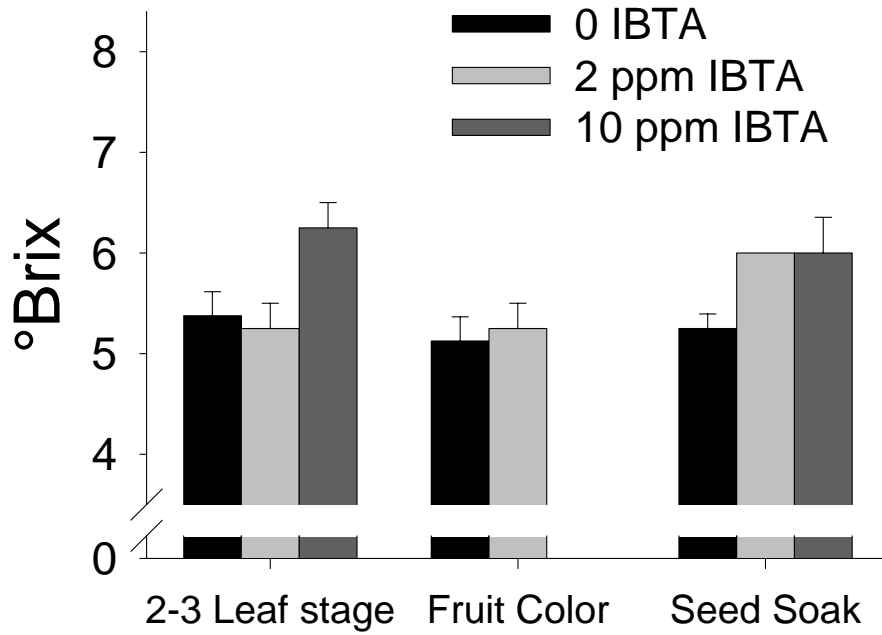


Fig. 25. Influence of IBTA and NBMA on $\sqrt{\text{Brix}}$ of Better Boy tomato fruit when applied at the two to three leaf stage, at first fruit color, and as a seed soak 12 hours prior to germination. Vertical bars represent the standard error of the mean.

'Bush Better Boy'

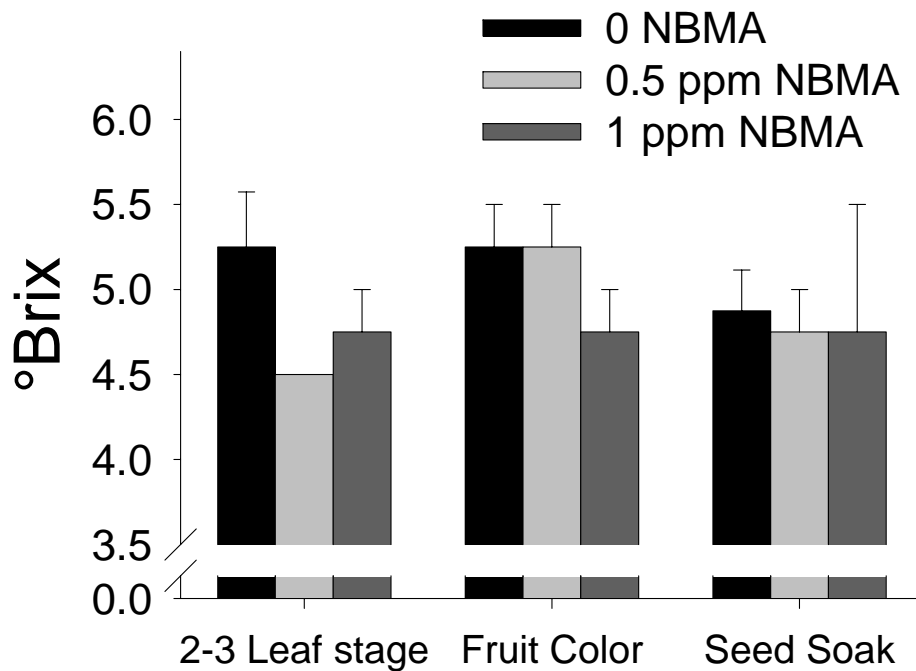
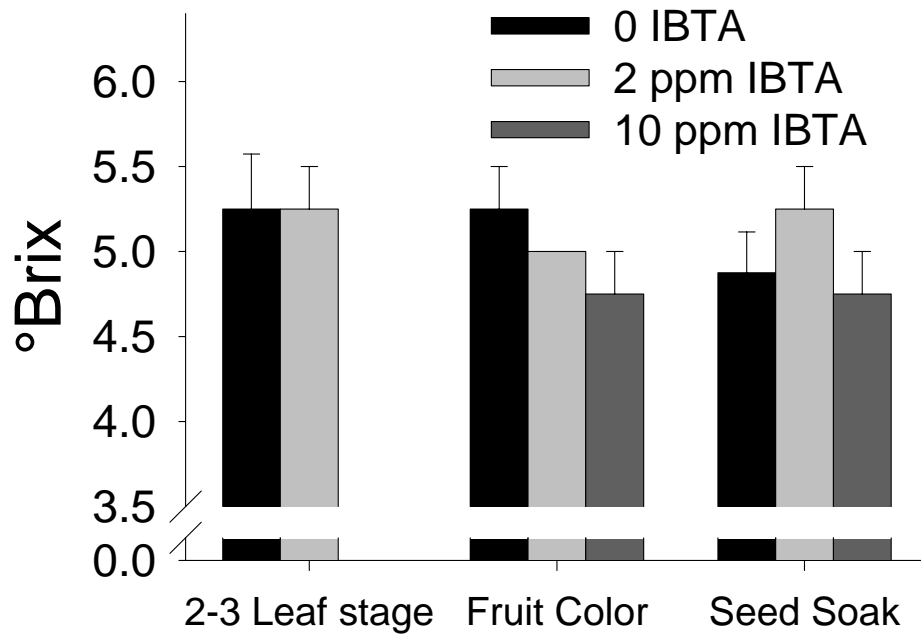


Fig. 26. Influence of IBTA and NBMA on $\sqrt{\text{Brix}}$ of Bush Better Boy tomato fruit when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

'Fourth of July'

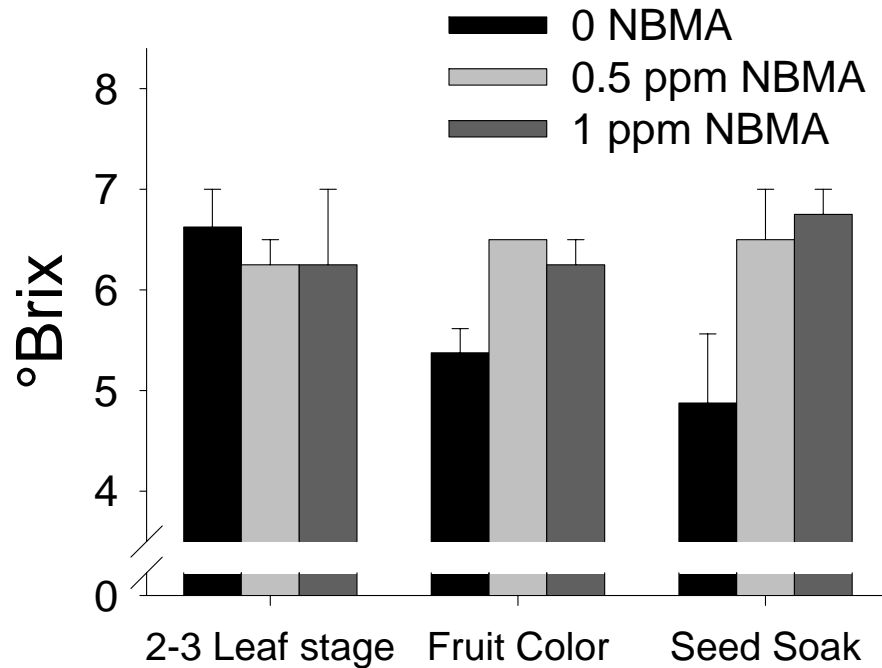
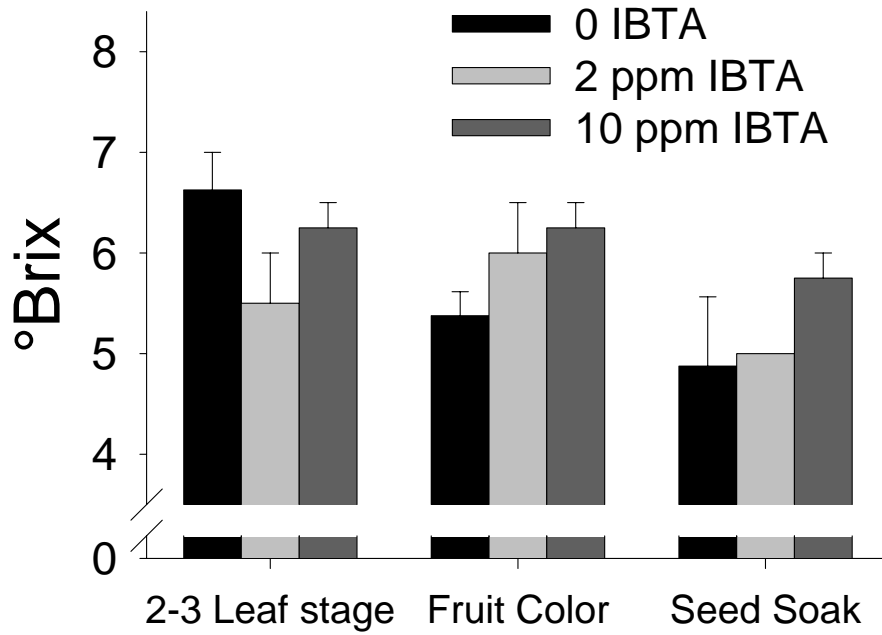


Fig. 27. Influence of IBTA and NBMA on \bar{B} rix of Fourth of July tomato fruit when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

'Sweet 100'

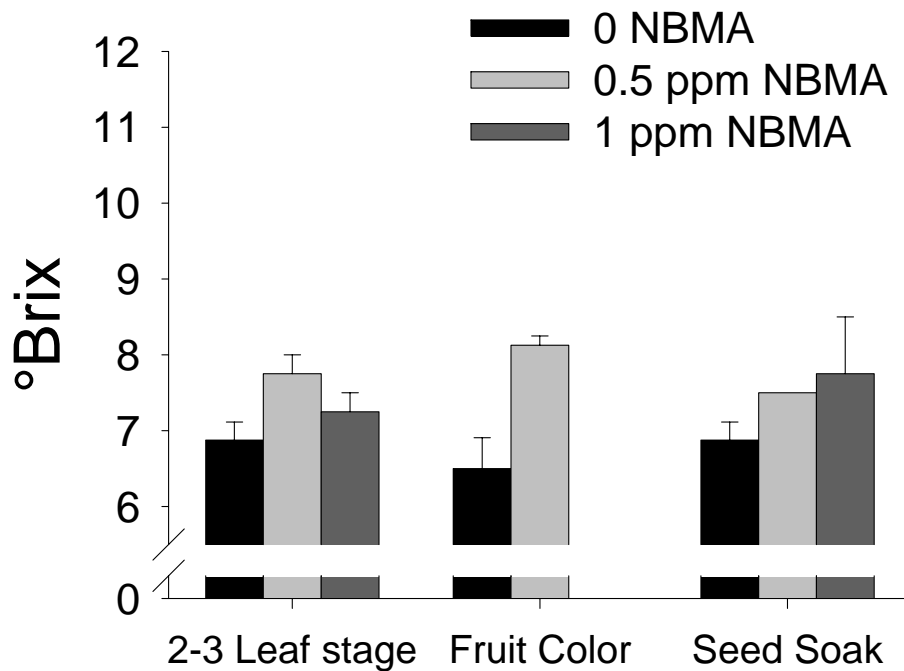
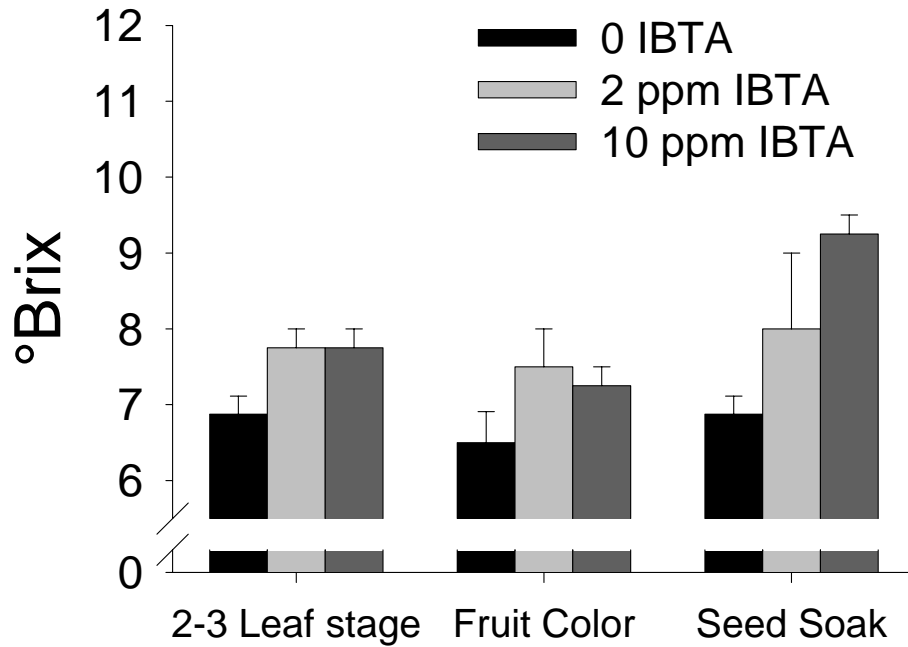


Fig. 28. Influence of IBTA and NBMA on $\sqrt{\text{Brix}}$ of Sweet 100 tomato fruit when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

'Better Boy'

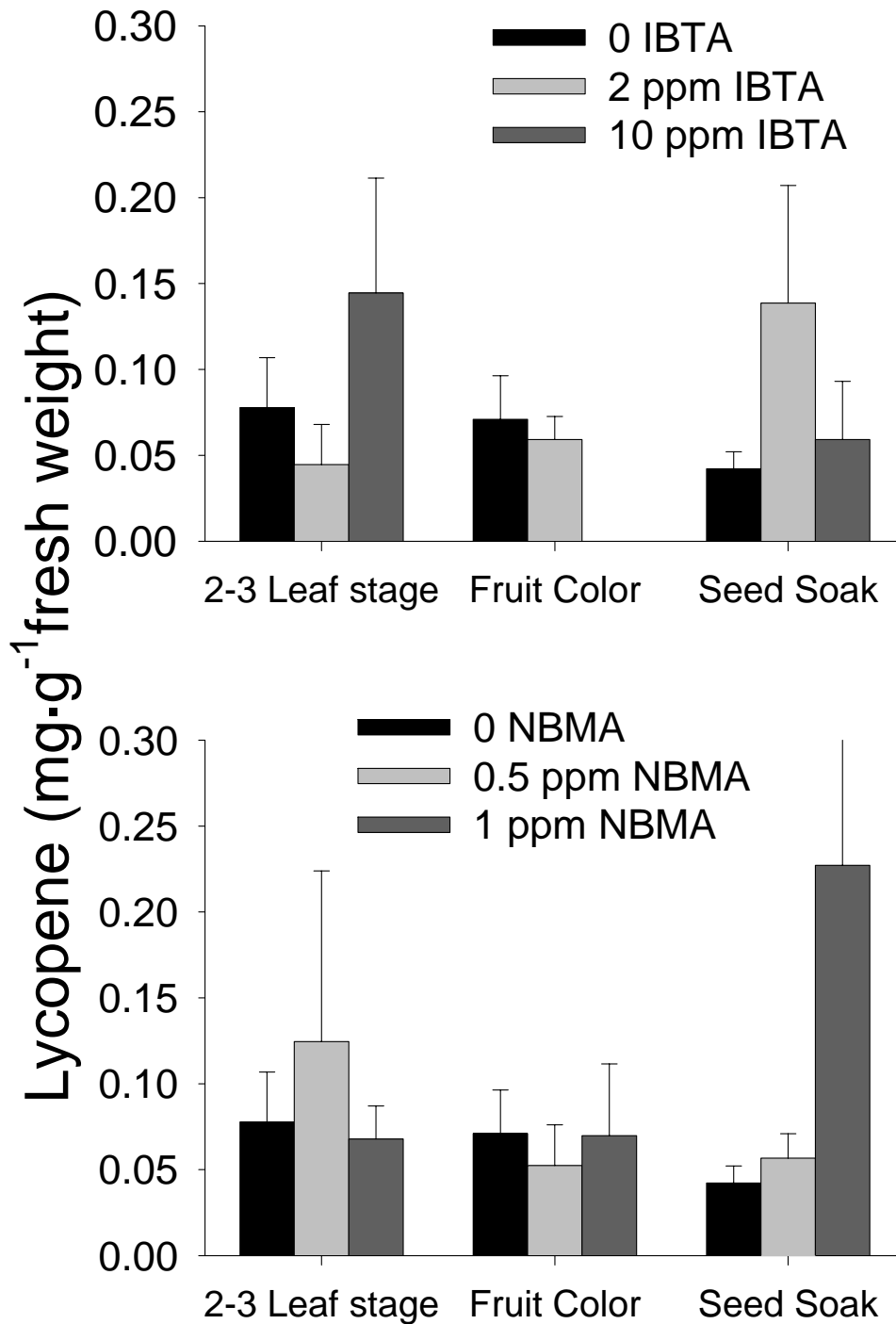


Fig. 29. Influence of IBTA and NBMA on lycopene levels in Better Boy tomato fruit when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

'Bush Better Boy'

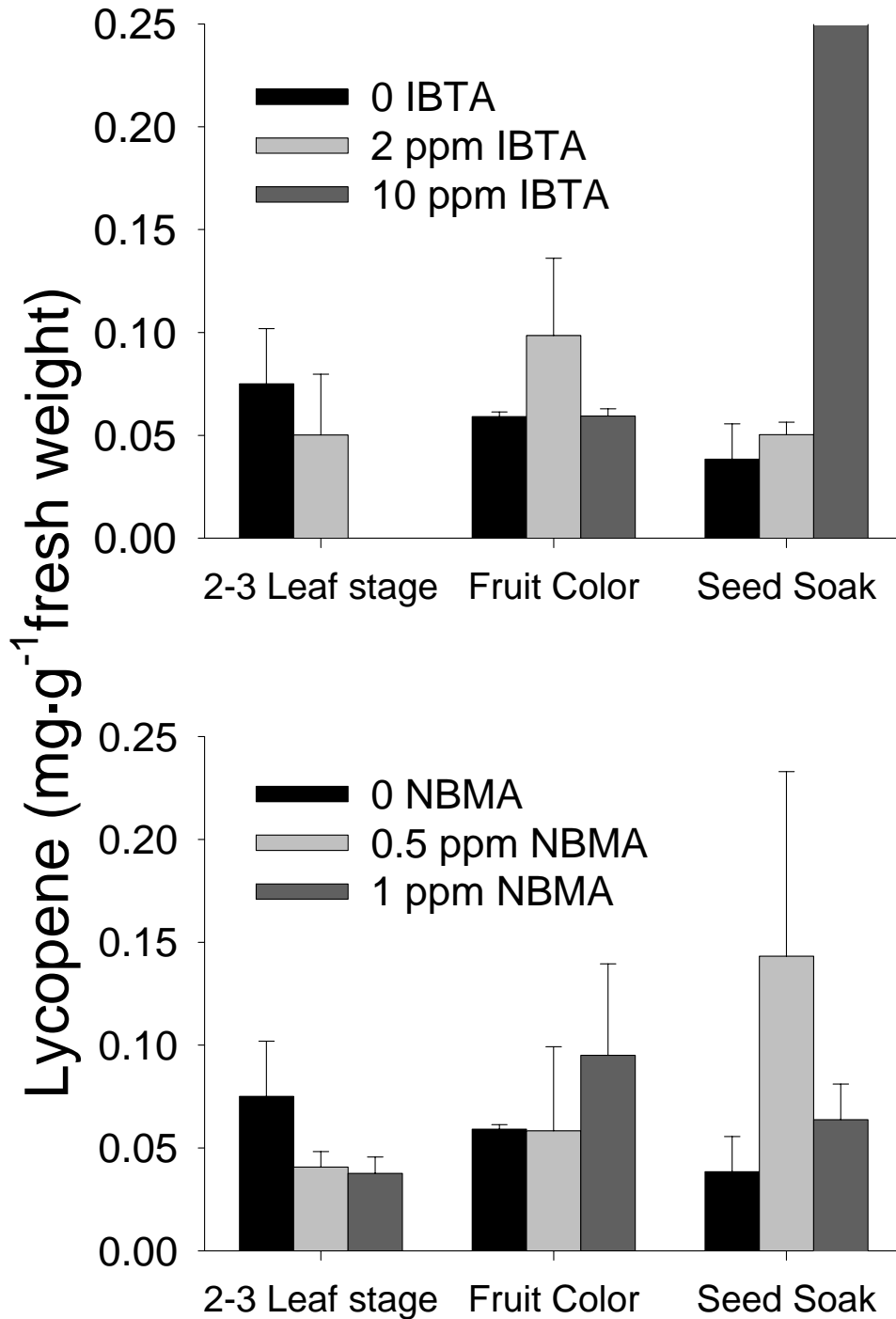


Fig. 30. Influence of IBTA and NBMA on lycopene levels in Bush Better Boy tomato fruit when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak. Vertical bars represent the standard error of the mean.

'Fourth of July'

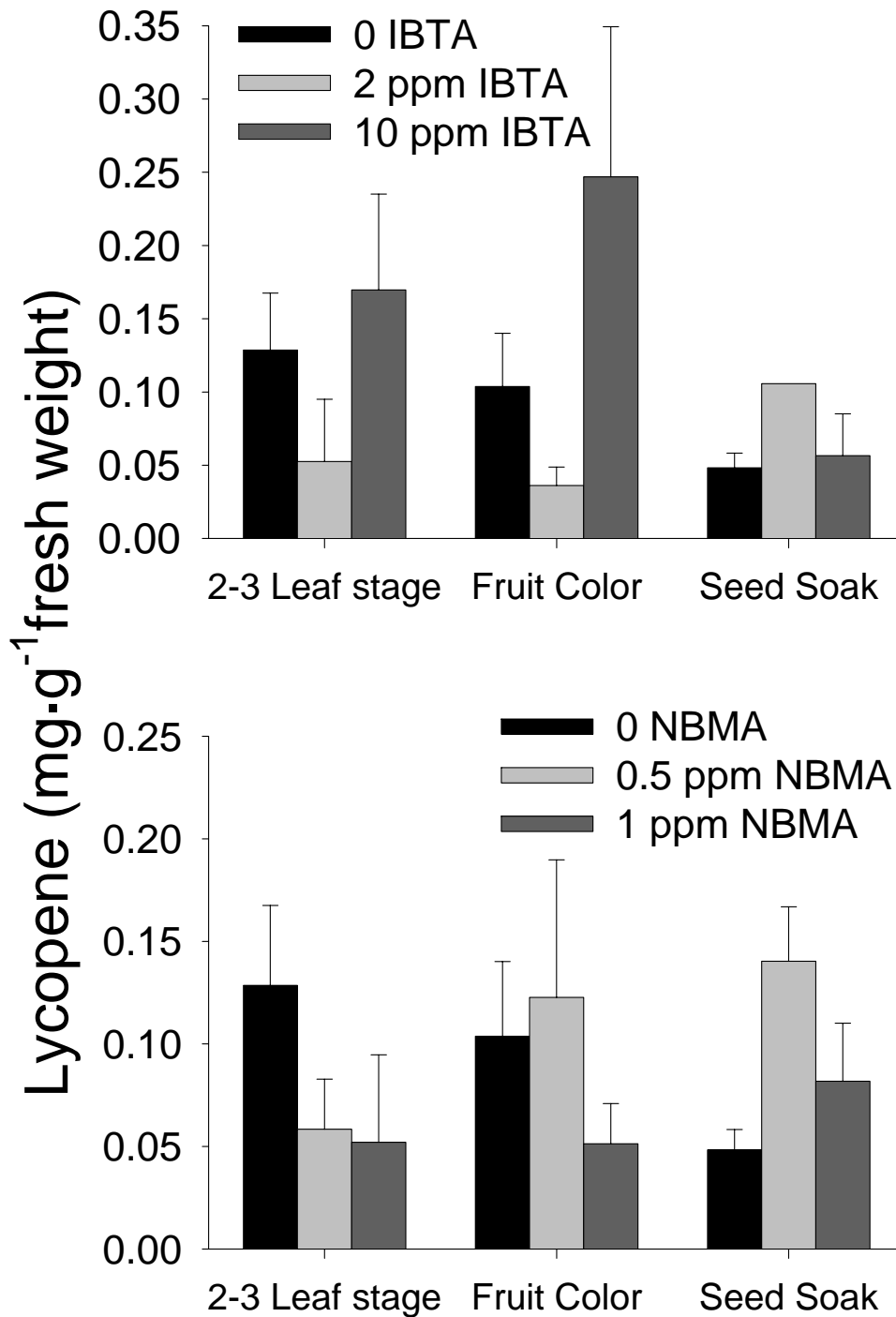


Fig. 31. Influence of IBTA and NBMA on lycopene levels in Fourth of July tomato fruit when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak prior to germination. Vertical bars represent the standard error of the mean.

'Sweet 100'

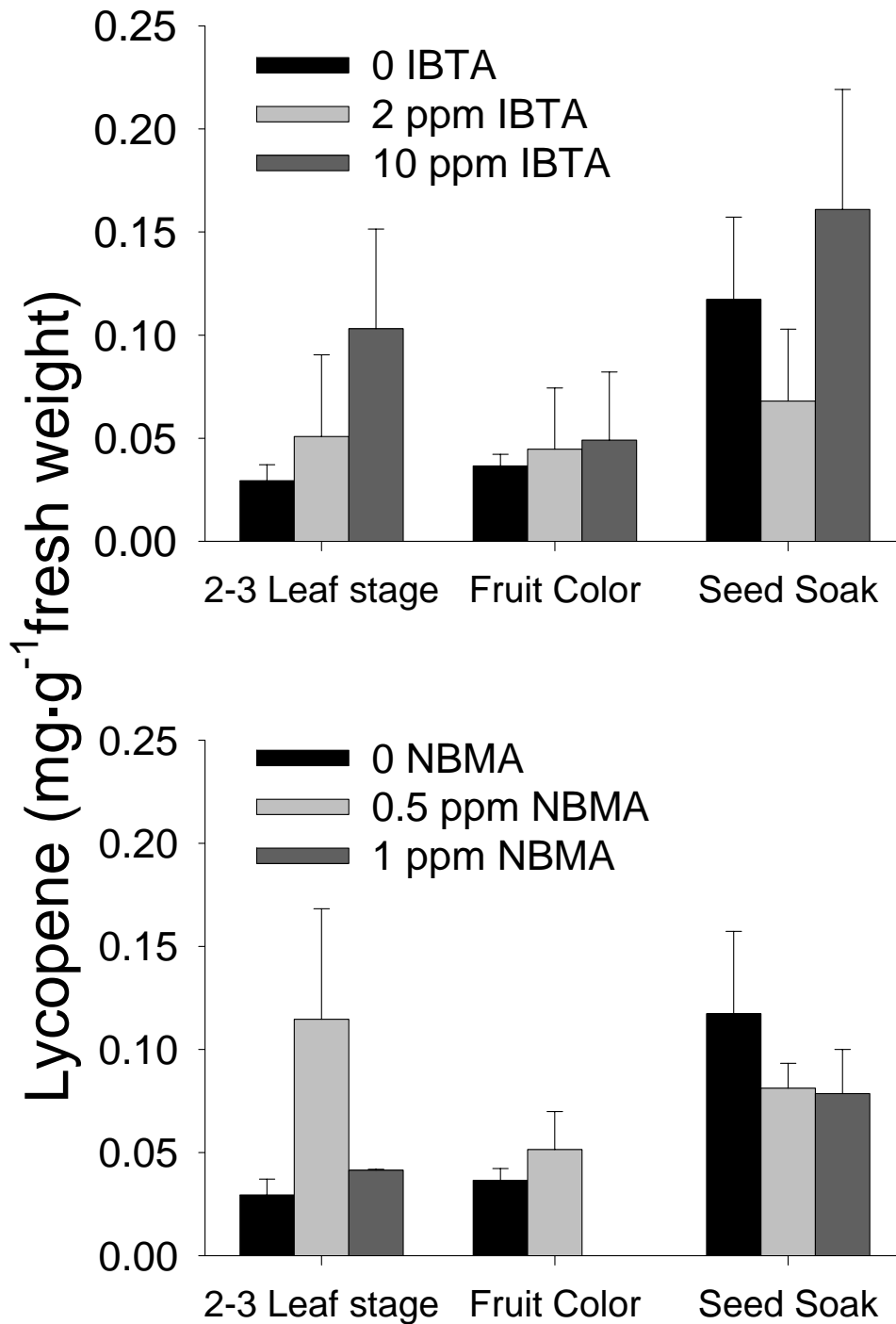


Fig. 32. Influence of IBTA and NBMA on lycopene levels in Sweet 100 tomato fruit when applied at the two to three leaf stage, at first fruit color, and as a 12 hour seed soak. Vertical bars represent the standard error of the mean.

Appendix