UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Vegetable Views

Stanislaus County

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2026 Biostimulant Trial Update on Cilantro and Bok Choy

A plethora of studies demonstrated that nitrogen-fixing bacterial crop biostimulants can enhance the availability and uptake of nitrogen in major vegetables (e.g., tomato, potato, pepper), benefiting vegetative growth, leaf expansion, greenness, and marketable yield. Besides those major vegetables, we want to understand if the benefits also apply to minor vegetables and herbs. The 2026 field trials were carried out in the northern San Joaquin Valley to understand the impact of biostimulant application rate on bok choy and cilantro production and their nitrogen (N) dynamics.

I. Cilantro Trial

Trial setup: The cilantro trial was seeded on May 4, 2026, near Tracy, CA (Figure 1). Treatments included three application rates (50, 100, and 150 g/acre) for an N-fixing bacterial biostimulant plus a non-treated control with three replications. The active ingredients of the biostimulant are beneficial N-fixing bacteria such as *Azospirillum, Azotobacter,* and *Bacillus sp*. Soil samples



Figure 1. Cilantro trial site 25 days after emergence.

were collected at 14, 25, 31, and 39 days after sowing (DAS); canopy readings (NDVI) were taken at 18, 25, 31, and 39 DAS; and plant aboveground biomass samples were collected at 28, 37, and 42 DAS. Three biostimulant applications were made via foliar spray with a backpack sprayer in the early mornings to avoid rapid dryness and increase plant absorption. Specifically, the first application (25 DAS) involved mixing 3.5 g of biostimulant into 4 gal of water and applied to the 50, 100, and 150 g/acre treatment plots. The second application (31 DAS) used 2.3 g mixed into 2.5 gal of water and covered the 100 and 150 g/acre plots. The third application (39 DAS) used 1.2 g mixed into 1.5 gal of water and was only applied to 150 g/acre plots. The trial was harvested on June 22, 2026 (49 DAS).

Results

Yield and canopy cover: Increasing biostimulant application rate contributed to cilantro yield increase except for the 150g/acre treatment (Figure 2). The treatment of 100 g/acre produced the highest yield (3.2 tons/acre), followed by 50 g/acre and 150 g/acre (2.4-2.5 tons/acre each). At 18 DAS, each treatment had a similar canopy development (16-17%), but as the season moved on and after the first application, we saw significant differences in canopy growth among treatments (Figure 3). By 39 DAS, the 100 g/acre treatment reached the highest canopy cover (55%), while

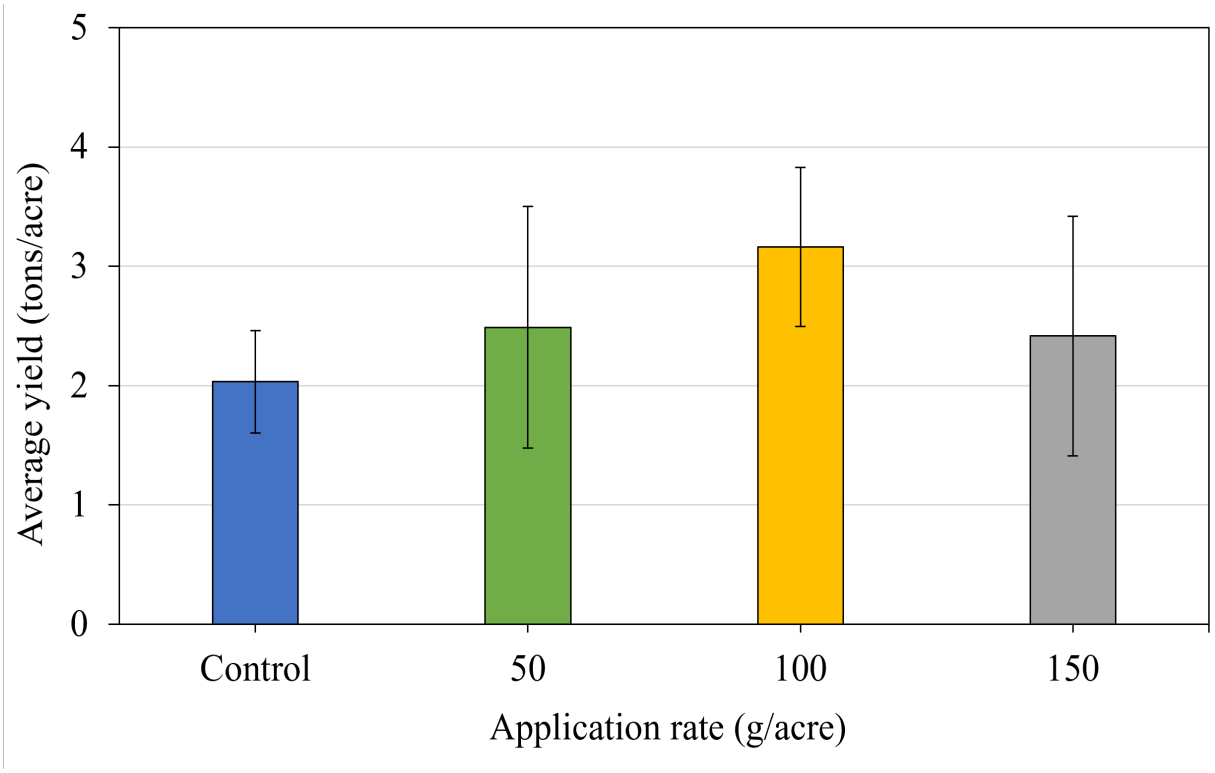


Figure 2. Average cilantro yield (tons/acre) for each application rate.

the control remained lowest (42%). This pattern matches the yield trend, demonstrating the stimulatory effects of biostimulant on crop vegetative growth and yield.

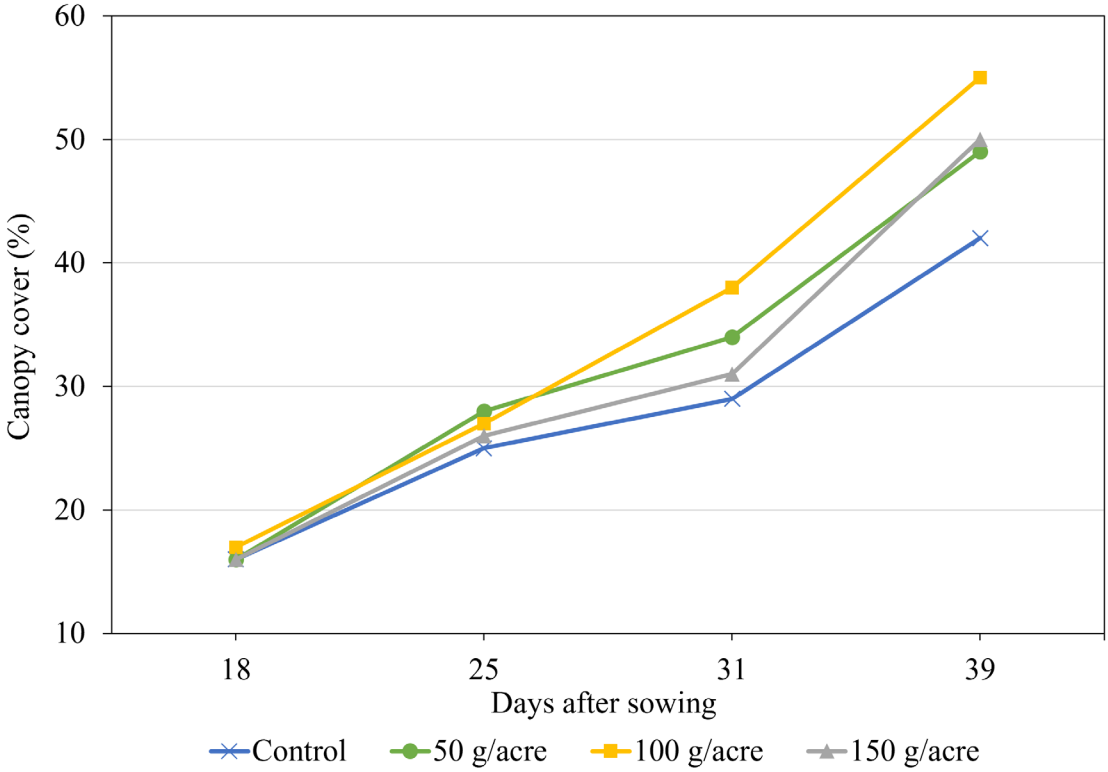


Figure 3. Canopy coverage for cilantro at each application rate.

Plant N uptake, accumulative aboveground biomass N, and soil available N: At 28 DAS, the 100 and 150 g/acre treatments had the highest N uptake (5.0-5.1 g N per 100 g DW), while the 50 g/acre treatment was the lowest (4.1 g N per 100 g DW), with the control being intermediate (4.5 g N per 100 g DW). However, there was almost no difference in N uptake for each biostimulant application rate at 49 DAS (at harvest) (Figure 4). Without knowing the total N fertilizer application from the grower, it is difficult to interpret the impacts of biostimulants on crop N uptake at each measuring date. However, accumulative N in aboveground biomass echoed the trends of yield and canopy coverage at 49 DAS. Specifically, all treatments accumulated N slowly through 42 DAS without distinct differences (Figure 5). From 42 to 49 DAS, plants accumulated an average of 20-25 lb N/acre for each treatment, which was 2.5 times the accumulation between 28 and 42 DAS (Figure 5). Similar to the yield and canopy coverage trends, the treatment of 100 g/acre reached the highest accumulated aboveground N (35 lb/acre), followed by 150 g/acre and 50 g/acre (28-29 lb/acre), while the control remained the lowest (24

lb/acre). Also, without knowing the fertilization schedule, soil NO_3-N fluctuated across the season without a consistent treatment effect (Figure 6).

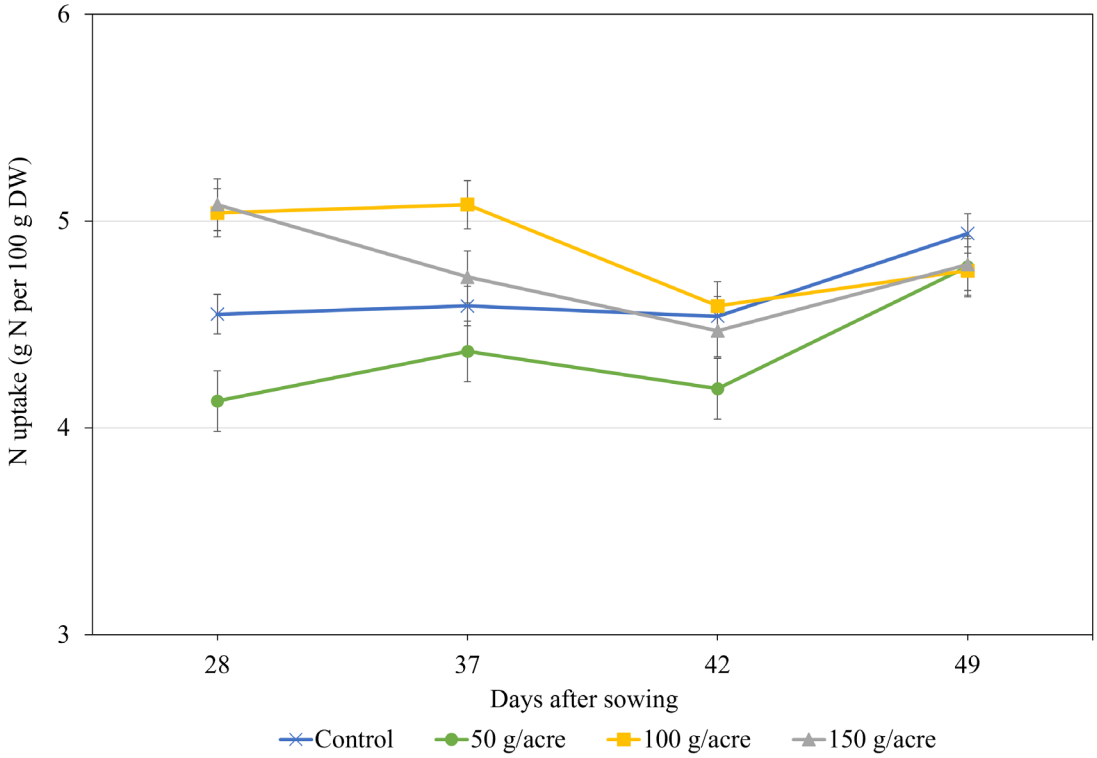


Figure 4. Seasonal nitrogen uptake (g N per 100 g dry weight) in cilantro biomass for each application rate.

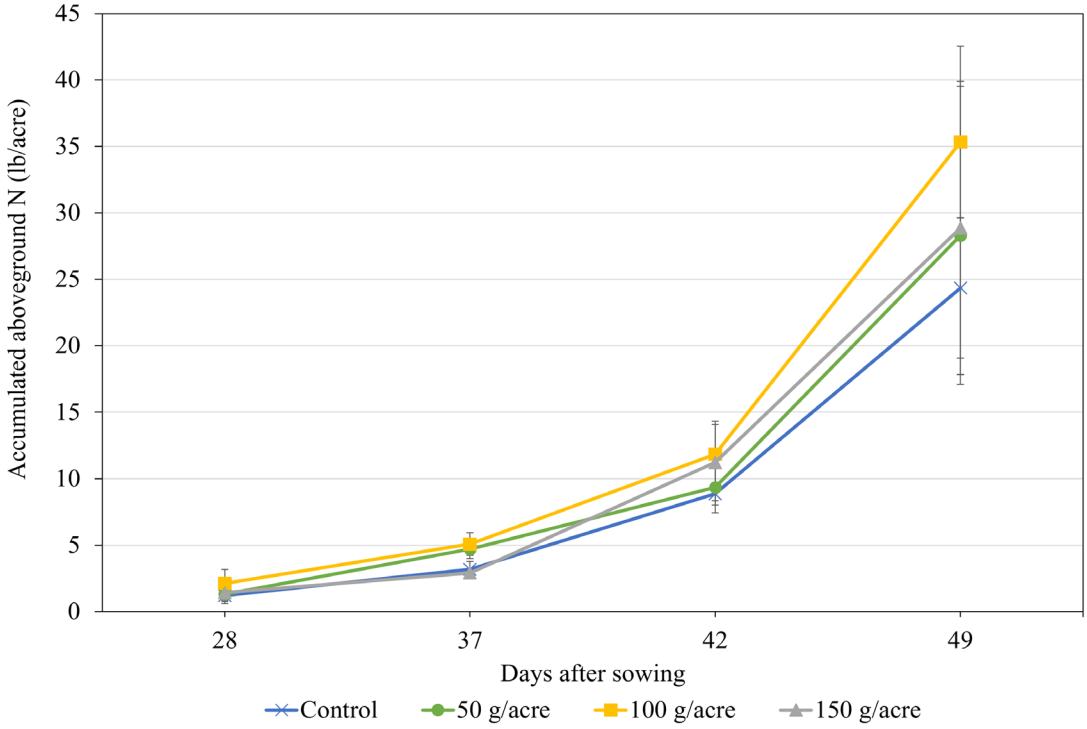


Figure 5. Accumulative nitrogen (lb/acre) in cilantro aboveground biomass for each application rate.

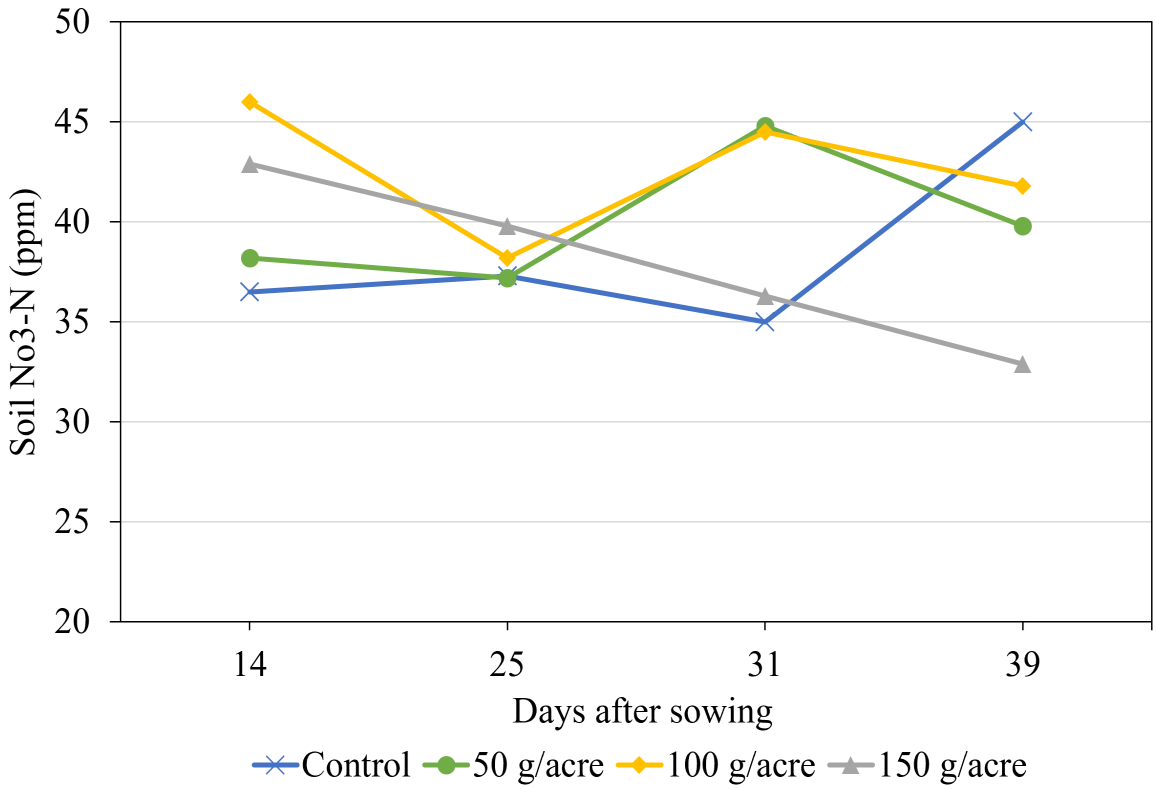


Figure 6. Soil NO_3-N (ppm) in the cilantro field at each measuring date across application rates.

Discussion

We realize that the cilantro yield in this trial was much lower than the average level according to UC ANR records. Meanwhile, the top-performing treatment (100 g/acre) only accumulated 35 lb/acre N at harvest, which is also lower than cilantro produced in cooler areas (~70 lb/acre N), though it may align with the low yield. However, it is noteworthy that the field was seeded in May and harvested in late June, which is the period cilantro production in the Central Valley usually skips due to high temperatures. As the daily high temperature consistently reaches over 80 ºF, cilantro leaf growth slows down and accelerates the bolting process, thereby shortening the growth cycle and facilitating early maturity. To slow down bolting and sustain normal maturity days, growers usually use more sprinkler irrigation to reduce leaf temperature, leading to field flooding and possibly nitrate leaching. As all treatments from the trial were under identical environmental conditions, the biostimulant advantages in productivity and nitrogen accumulation from a non-traditional cilantro production period remain meaningful.

II. Bok choy Trial

Trial setup: The bok choy field was seeded on April 16 near Modesto, CA, and all plots received the same standard fertility program independent of biostimulant treatment: UAN-32 at 2 days after sowing (DAS) (10 gal/acre), followed by CAN-17 at 43 DAS (15 gal/acre) and again at 51 DAS (23 gal/acre). The trial consisted of five treatments with application rates of 0 (control), 25, 50, 100, and 150 g/acre of biostimulants, replicated four times across twenty-four 50 ft beds (Figure 7). Rather than being applied all at once, treatments with higher rates were built up by repeated applications at a 50 g/acre increment (Table 1). The first foliar application was applied at 32 DAS during the early vegetative stage. For the T2 plots (25 g/acre), a total of 0.4 g of product was mixed with 1.5 gal of water; for the T3-T5 plots (50, 100, and 150 g/acre), a separate 2.4 g was mixed with 4.5 gal of water. The second application was made at 40 DAS by mixing 1.6 g of product into 3 gal of water, covering the T4 and T5 plots, while the third application was made in the pre-harvest stage (46 DAS) with 0.8 g of product mixed into 1.5 gal of water, covering only the T5 plots.



Figure 7. Bok choy trial site containing different application treatment plots.

Table 1. Application timing of biostimulants for each rate (g/acre) for bok choy.

Treatment	1st Application (32 DAS)	2nd Application (40 DAS)	3rd Application (46 DAS)	Total Applied (g/acre)
T1	-	-	-	0 (Control)
T2	25 g	-	-	25 g
T3	50 g	-	-	50 g
T4	50 g	50 g	-	100 g
T5	50 g	50 g	50 g	150 g

Results

Yield and canopy cover: Overall, higher application rates did not warrant an obvious yield advantage (Figure 8). Bok choy inoculated at the rate of 50 g/acre and higher produced almost the same yield though all were slightly higher than the control and the lowest rate (Figure 8). We did not observe any differences in the NDVI among treatments. The canopy reached the maximum coverage at 46 DAS and was well sustained until three days before harvest (57 DAS,

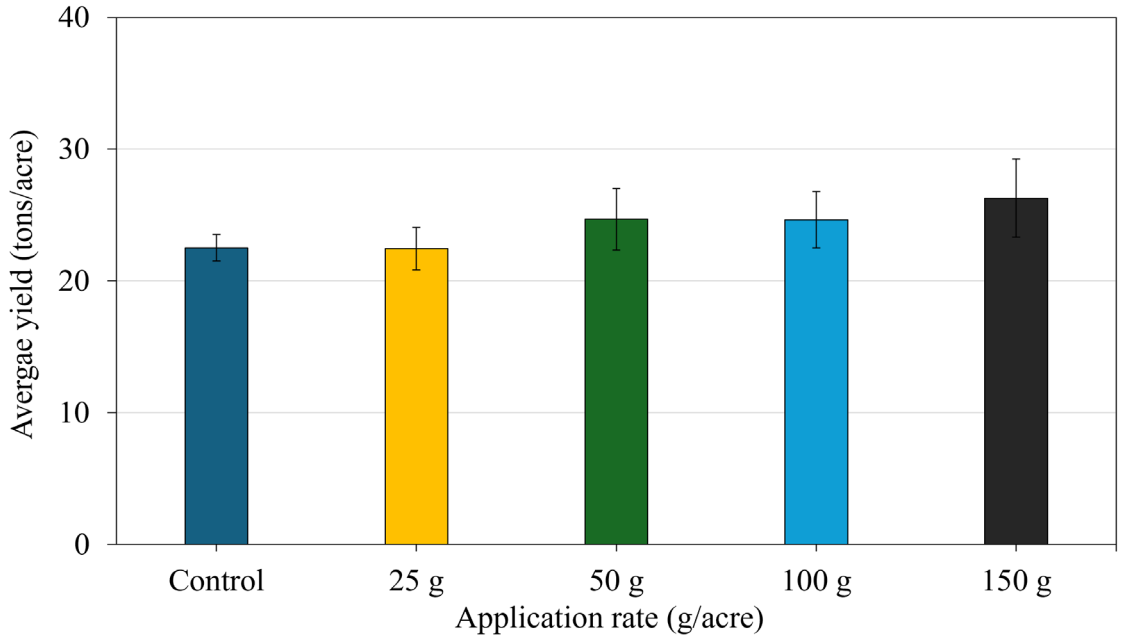


Figure 8. Average bok choy yield (tons/acre) across biostimulant application rates.

Table 2. Bok choy canopy coverage/NDVI (%) for each application rate (g/acre).

Treatment	May 6 (20 DAS)	May 22 (36 DAS)	June 1 (46 DAS)	June 12 (57 DAS)
T1 (0)	21	56	87	83
T2 (25)	17	54	87	82
T3 (50)	20	56	85	87
T4 (100)	20	54	88	78
T5 (150)	18	57	87	83

Nitrogen uptake and aboveground N accumulation: Nitrogen uptake for all treatments started near 5.4-5.8 g N/100 g dry weight (DW) at 32 DAS, dropped through the 40 and/or 46 DAS sampling points, and recovered by harvest (Figure 9). It is noteworthy that compared to the inoculated treatments (4.7-4.9 g N/100 g DW), nitrogen uptake in the control plots dropped much lower to below 4 g N/100 g DW at 40 DAS (Figure 9). This may indicate that biostimulant applications, especially at a higher rate, might have provided additional nitrogen for plant uptake at mid-season, which is an important stage for leaf growth and the final yield. For N accumulation in aboveground biomass, all treatments followed a similar nitrogen accumulation

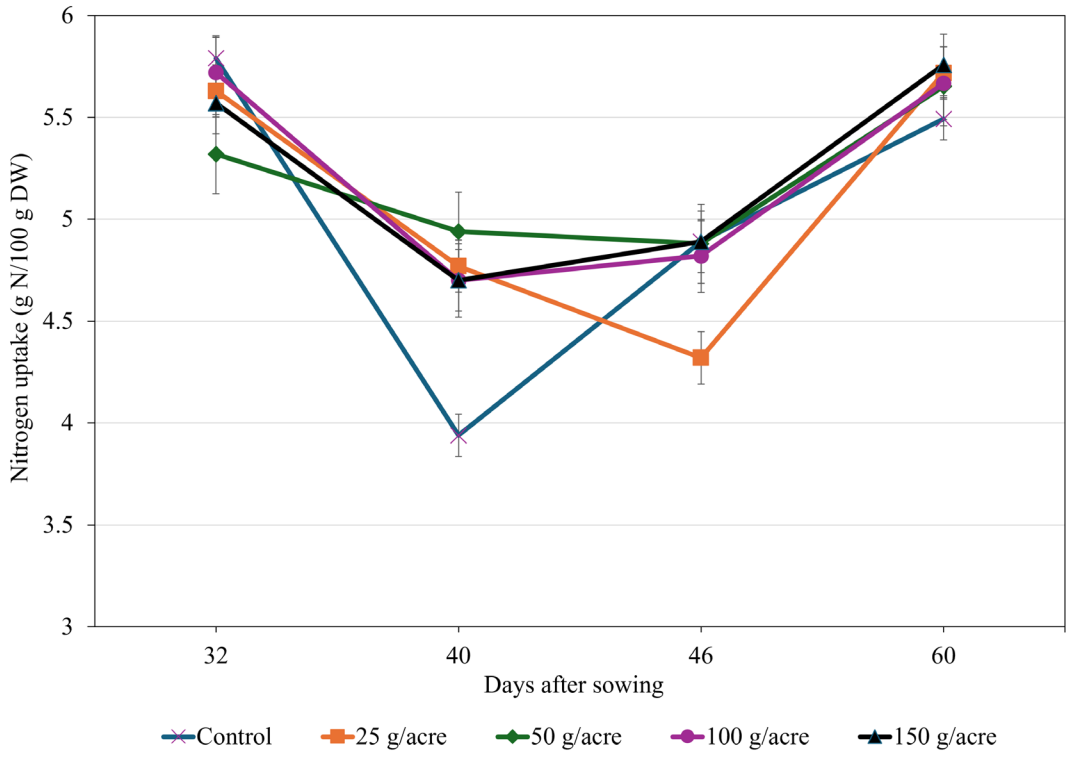


Figure 9. Nitrogen uptake (g N per 100 g dry weight) in bok choy biomass for each application rate.

pattern throughout the season, climbing from roughly 8 lb/acre at 32 DAS to over 120 lb/acre by

harvest at 60 DAS except for the control plot (Figure 10). Despite a 15 to 20 lb/acre advantage in N accumulation compared to the non-treated control, increasing the inoculation rate barely elevated plant N accumulation (Figure 10). This observation could inform growers that adding biostimulants containing N-fixing microbes at an appropriate rate may enhance crop N accumulation.

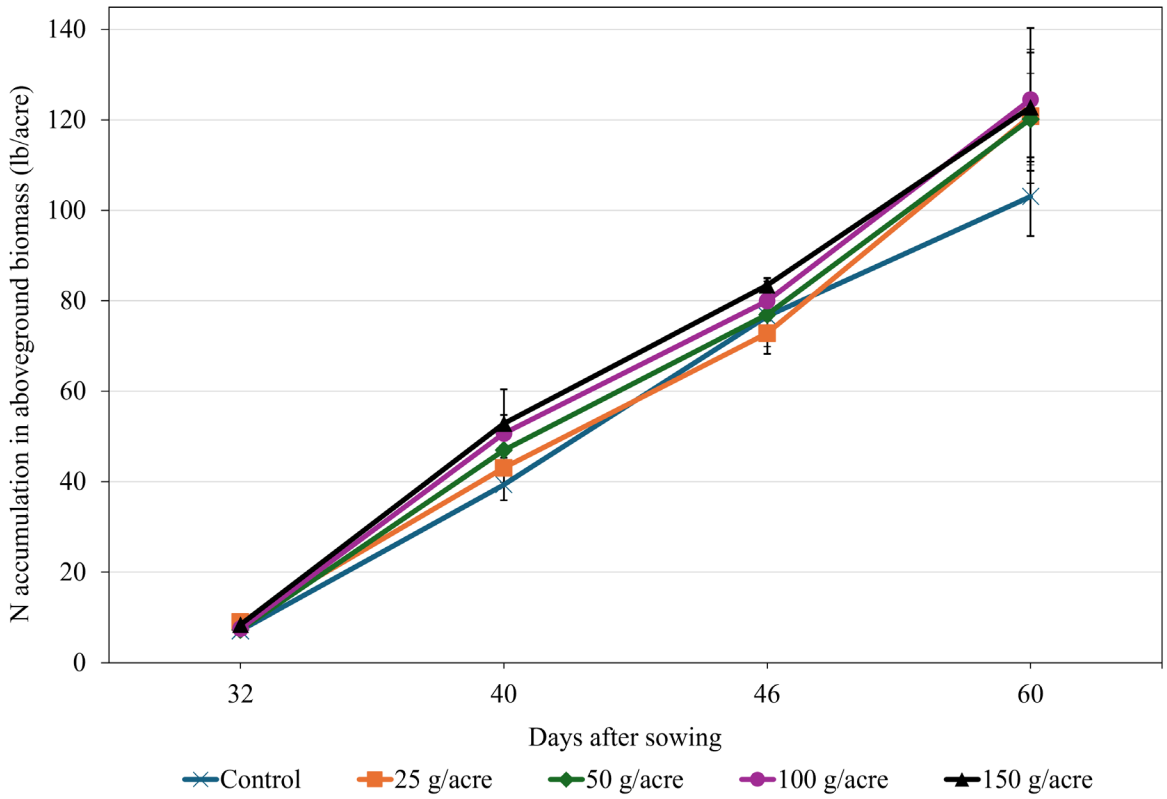


Figure 10. Accumulative nitrogen (lb/acre) in bok choy aboveground biomass for each application rate.

Available N and applied N fertilizer: Three fertilizations were made in the early and mid-late seasons, contributing to a total of 115 lb N/acre (Table 3). The first soil samples were taken at 4 DAS (2 days after the application of UAN-32) prior to seed emergence. An average of 28.6 ppm of nitrate-N from 1-foot cores translates to roughly 114 lb/acre of early-season total available N in the 0-12" profile (Table 3). Soil samples were taken again at 28 DAS (pre-biostimulant) and post-biostimulant at 40 and 46 DAS for the real-time nitrate-N. Soil nitrate-N rose sharply from the 4 DAS baseline to a peak of roughly 47-53 ppm at 28 DAS with the contribution of full release of UAN-32 and then declined steadily across all treatments through 40 and 46 DAS when the crop was within the peak N demand (Figure 11). Still, soil nitrate-N from inoculated plots (50 and 150 g/acre) at 40 and 46 DAS was slightly higher than other treatments. A third fertilizer

application, at 51 DAS, occurred after the final soil sample and is not reflected in this balance. The aboveground N accumulation data (Figure 10) showed that bok choy accumulated 75-84 lb

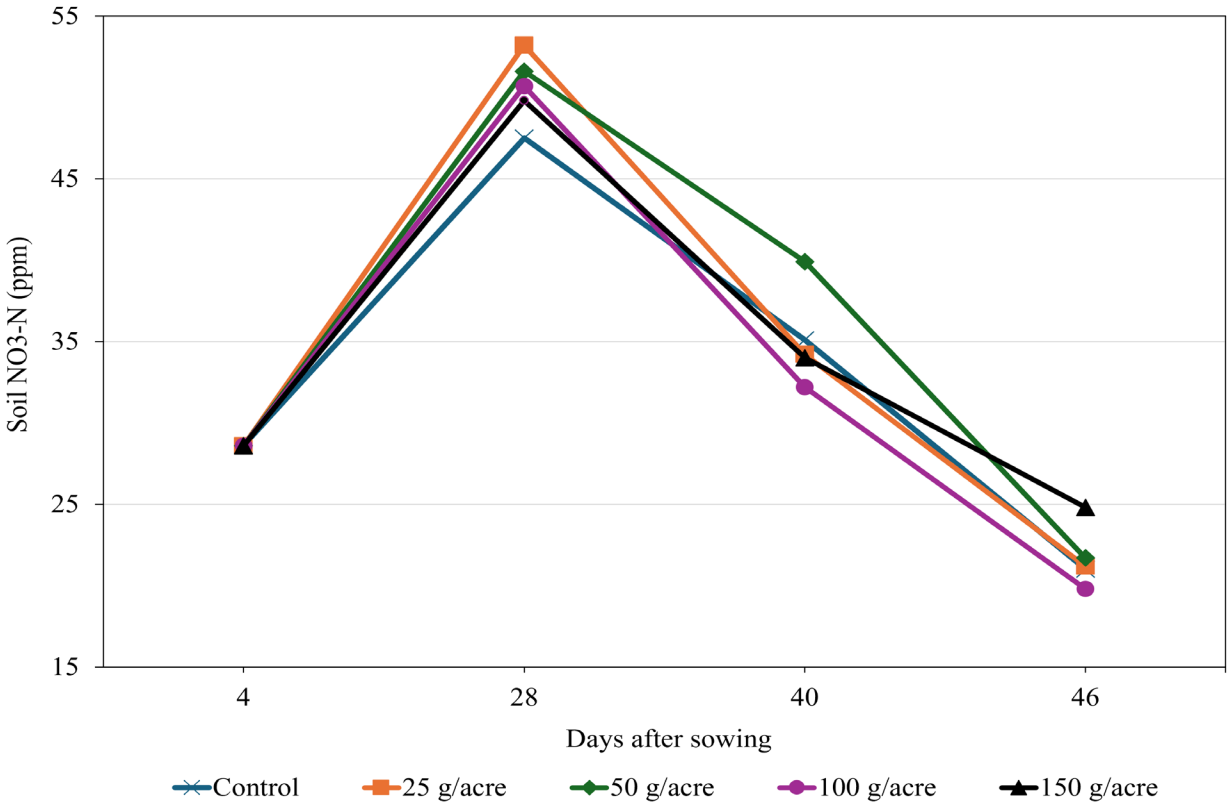


Figure 11. Soil NO_3-N (ppm) for bok choy field at each measuring date across application rates.

N/acre by 46 DAS, compared to a total of roughly 175 lb N/acre supplied from soil residues and the first two fertilizer applications, which aligns well with the remaining ~80-100 lb N/acre in the soil at 46 DAS (Figure 11).

Table 3. Soil N supplies throughout the growing season.

N source	Timing	N content
First soil samples	4 DAS	28.6 ppm = 114 lb N/acre
UAN 32 fertilizer	2 DAS	10 gal/acre = 35 lb N/acre
CAN 17 fertilizer	43 DAS	15 gal/acre = 32 lb N/acre
CAN 17 fertilizer	51 DAS	23 gal/acre = 48 lb N/acre
Total applied N		115 lb N/acre

Discussion

Overall, adding N-fixing microbial inoculants slightly increased bok choy yield and total nitrogen accumulation and left a higher level of remaining soil N, especially with the higher inoculation rate. Notably, the field received the same amount of N fertilizer across all treatments,

which differed from other studies where inoculated plants typically received a reduction in N application. This may explain the limited increase in productivity and nitrogen uptake after bok choy was treated. Application rate is another frequently asked question. At least in this study, the maximum rate did not translate into a superior yield over the others, raising questions about the balance between crop performance and budget. However, we should take the short growing cycle of bok choy into consideration and reasonably expect different outcomes for longer season commodities, such as tomato and cucurbits. The first year's outcomes should be considered more as a trend showing positive impacts of biostimulants.