Recent findings in hydroponic and soilless strawberries: a data-first look at the last decade

Strawberry in controlled environments is not short on opinions. Research from the past 10 years has given us a lot of information on strategies to increase yields and reduce costs. Below I synthesize recent findings, aiming to provide you with practical information that can help you improve your crop. I focus first on mineral nutrition, then biostimulants, exogenous hormone applications, and pruning or cultural practices. When concentration units were not reported in ppm, I converted them. Where authors only gave mL L^{-1} of a commercial product, I report ppm v/v and, when possible, ppm of active ingredients.

A picture of a soilless strawberry crop

What the evidence says

Mineral nutrition that consistently improves output

1. Stage-specific K:N balance matters more than one static recipe. A greenhouse pot trial in soilless bags across three cultivars found that running a higher K:N balance in vegetative growth, then lowering it in production, delivered the best overall performance. Their S2 program (growth K:N 2.6, production K:N 1.0) raised yield by 30 percent and improved firmness and shelf-life metrics compared to other balances, with equal seasonal totals of N, P, K, Ca, Mg across treatments. This is one of the clearest, practical levers reported for soilless production in the last decade (1).
2. Absolute $NO3^-$ and K setpoints still matter, but the optimum is not “more is better”. A hydroponic study that orthogonally varied nitrate and potassium in soilless strawberries showed that 15 mM $NO3^-$ increased yield while higher K favored nutraceutical quality. Converting their molarities to ppm: 9, 12, 15 mM $NO3^-$ equal 126, 168, 210 ppm N as nitrate and 558, 744, 930 ppm $NO3^-$, while 5, 7, 9, 11 mM K^+ equal 196, 274, 352, 430 ppm K. The highest yields occurred at the upper end of their $NO3^-$ range, with quality improving as K approached 430 ppm K. Takeaway: push N during heavy fruiting if you can keep flavor in check, and use K to tune quality targets (2).
3. Simply cranking K in water-culture will backfire. A 2025 deep-water culture trial that stepped K from 117 to 348 ppm at constant 77 ppm N found no yield benefit and, in some cases, reduced fruit size and total yield as K rose. Translation: chasing high EC by piling on K is noise, not signal, in DWC strawberries (3).
4. The nitrate fraction can be used as a steering tool without changing total N. A 2025 soilless study that varied the percentage of total N supplied as nitrate

from 0 to 100 percent across three cultivars showed meaningful shifts in plant N status and leachate pH, offering a route to manage uptake and alkalinity without changing ppm N. This is more about stability and diagnosis than raw yield, but it is actionable in recirculating systems (4).

5. System choice is not neutral. A 129-day greenhouse comparison found a coir-based substrate system substantially outperformed three water-culture systems (NFT, vertical stacked flow, aeroponics) for total yield and resource-use efficiency in ‘Florida Brilliance’ and ‘Florida Beauty’. If your priority is marketable kilograms per square meter, substrate is still the safe bet unless you have a very strong reason to go water-culture (5).

Biostimulants with greenhouse soilless data

Two solid greenhouse papers in soilless bags make this practical:

• A nutrient-limitation stress trial in soilless ‘Elsanta’ tested 10 foliar biostimulants. Several treatments improved marketable yield and fruit quality under low fertility. Doses were applied as labeled mL L^{-1}; I report them as ppm v/v. Effects were strongest for specific protein hydrolysates and seaweed extracts, with chitosan showing quality gains rather than yield spikes (6).

• A head-to-head in substrate culture directly compared commercial plant biostimulants and synthetic auxins. The best biostimulant program matched or exceeded auxin-based fruit set under the tested conditions, and the paper fully discloses active contents for the auxin products, which lets us convert to ppm actives for fair comparison (7).

Exogenous hormone applications

Soilless strawberry papers using PGRs are fewer than field studies, but the 2024 greenhouse comparison above provides what growers need: dose-disclosed auxin programs in substrate bags, with yield and quality outcomes. The synthetic auxin formulation Auxyger was listed at 6.7 g L^{-1} NAA + 16.9 g L^{-1} NAD. At 0.5 mL L^{-1}, that is 3.35 ppm NAA and 8.45 ppm NAD actives. In that trial, the best protein hydrolysate program rivaled or beat this auxin program on yield while improving certain quality attributes, which makes a case for biostimulant-first strategies where regulations or buyer specs frown on PGR residue (7).

Pruning and culture practices with measurable, repeatable gains

• Runner control increases yield in everbearing cultivars under tabletop tunnel production. Bi-weekly runner removal in 'Favori' increased total and marketable yield per plant and improved average berry size, while partial defoliation reduced both. This is not a subtle effect; it is sink management and it pays off (8).

• Planting density in greenhouse substrate is a yield vs. cull tradeoff, not a free lunch. A two-season soilless trial in troughs found 5 to 15 cm in-row spacing maximized commercial fruit and profitability for 'Pircinque', but the densest spacings increased small and discarded fruit percentage. If labor for canopy management is tight, 10 to 15 cm is the saner operating point (9).

• System selection again: when in doubt, choose substrate if your KPI is kilograms. The 2025 greenhouse head-to-head is clear that coir-based substrate outperformed water-culture for both yield and resource efficiency in their conditions (5).

Mineral nutrition highlights in soilless strawberries

Study & system	Factor	Setpoints converted to ppm	Observed effect
Preciado-Rangel 2020, soilless culture (2)	NO_3^- and K in solution	NO_3^- at 126, 168, 210 ppm N (558, 744, 930 ppm NO_3^-). K at 196, 274, 352, 430 ppm K	Higher NO_3^- increased yield, higher K improved nutraceutical quality; best yields at 210 ppm N with K toward 430 ppm K.
Ries 2025, deep-water culture (3)	K at constant 77 ppm N	117, 194, 271, 348 ppm K	Increasing K above 117 ppm did not improve yield or fruit size; higher K often reduced fruit size and yield.
Yafuso 2025, soilless substrate (4)	Percent of total N as nitrate	0 to 100 percent of total N as NO_3^- at a fixed total N (ppm not changed)	Adjusting nitrate fraction shifted foliar N and leachate pH, offering control without changing ppm N.
Nakro 2023, greenhouse soilless (1)	K:N balance over time	Growth phase K:N 2.6, production phase K:N 1.0 (ratios)	Program raised yield 30 percent and improved firmness and shelf-life vs other balances.

Biostimulants in soilless strawberries

Product or molecule	Type	Dose used in study (ppm)	Cultivar & system	Observed effect	Source	Notes
Protein hydrolysate (Trainer)	Amino acid hydrolysate	5000 ppm v/v (5 mL L^{-1})	‘Elsanta’ in peat-based substrate	Increased marketable yield and improved quality under nutrient limitation	(6)	Labeled concentration is mass per kg; ppm v/v reported for transparency.
Seaweed extract	Ascophyllum-based	2500 ppm v/v (2.5 mL L^{-1})	‘Elsanta’ in substrate	Yield and antioxidant gains under low fertility	(6)	Product-label dose.
Chitosan solution	Biopolymer	10000 ppm v/v (10 mL L^{-1})	‘Elsanta’ in substrate	Quality improvements more than yield	(6)	DDA: NR, molar mass: NR in paper.
Protein hydrolysate program	Amino acid hydrolysate	5000 ppm v/v (5 mL L^{-1})	Greenhouse substrate bags	Matched or exceeded auxin program on yield while improving specific quality traits	(7)	See auxin row for direct comparison.

Exogenous hormones tested in soilless conditions

Active(s)	Class	Dose as actives (ppm)	Product dose	Cultivar & system	Observed effect	Source
NAA + NAD	Synthetic auxin + cofactor	3.35 ppm NAA + 8.45 ppm NAD calculated from 6.7 g L^{-1} NAA + 16.9 g L^{-1} NAD at 0.5 mL L^{-1}	0.5 mL L^{-1}	Greenhouse substrate bags	Increased fruit set and yield vs water control, but best protein hydrolysate program was competitive on yield with added quality benefits	(7)

Pruning and cultural practices in soilless systems

Practice	Setting	Quantified outcome	Source
Bi-weekly runner removal	Everbearing ‘Favori’ in tabletop tunnel	Higher total and marketable yield and larger berries vs keeping runners; defoliation reduced yield	(8)
In-row spacing 5 to 15 cm	Greenhouse troughs, soilless substrate	Highest commercial yield and profitability with 5 to 15 cm, but denser plantings increased culls; 10 to 15 cm safer if labor is limited	(9)

Practice	Setting	Quantified outcome	Source
System choice: substrate vs water-culture	Greenhouse, coir substrate vs NFT, vertical, aeroponics	Substrate system delivered the highest yield and best resource-use efficiency in both tested cultivars	(5)

Practical summary

• If you run substrate culture, start with a sane base recipe and adopt a two-phase K:N strategy. Push K:N in vegetative growth to build canopy and sink capacity, then lower K:N in production to support sustained fruiting. The 2.6 then 1.0 K:N program is the best documented template right now and lifted yield by 30 percent in greenhouse soilless conditions (1).

• For absolute targets during heavy fruiting, do not be shy about 200 ppm N as nitrate if fruit flavor is maintained, and keep K in the 350 to 430 ppm range to pull quality without sacrificing mass. That is where the 2020 hydroponic NK grid saw the best balance (2).

• Water-culture is unforgiving with K. Above roughly 120 to 200 ppm K in DWC at moderate N, returns were negative in 2025 work, so treat “more K” as a risk factor rather than a lever in water-culture strawberries (3).

• Biostimulants can be yield-positive under stress and can stand toe-to-toe with low-dose auxin programs in substrate. If you need a conservative starting point, weekly foliar protein hydrolysate at 5000 ppm v/v is the most replicated choice across the soilless greenhouse literature summarized here (6), (7).

• Exogenous auxins at single-digit ppm actives work, but they are not automatically superior to a strong biostimulant

program in greenhouses. If you use auxins, be precise about actives. The 0.5 mL L^{-1} Auxyger rate equals 3.35 ppm NAA + 8.45 ppm NAD. Compare like with like, not mL of product (7).

• Cultural practices still pay the bills. Remove runners on a schedule in everbearers and do not defoliate unless you enjoy losing yield (8). Pick a density you can actually manage. If labor is tight, 10 to 15 cm spacing is a rational compromise in tabletop or trough systems (9). If you are choosing systems with yield as the top KPI, substrate culture remains the safest option in 2025 greenhouse data (5).