Hydroponic Nutrients

Guide 4 · Nutrients, pH & Precision

Masterblend · DIY · pH · Indoor

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Contents

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About this guide

Four tracks · one nutrient profile · the same pepper at the end

This is the longest reference in the Dragoon Mountains library, and it is deliberately structured as four parallel tracks that all converge on the same crop ppm targets. You can read it cover to cover, but most growers will live in one or two parts at a time.

Part	Track	When you read it
Part 1 — Masterblend	Purchased 3-part precision program	Daily use. The canonical recipe and feeding charts.
Part 2 — Locally-sourced DIY	Off-grid brews from Cochise County materials	Project mode. Replacing one or all three Masterblend parts with foraged equivalents.
Part 3 — pH adjustment	Acids and bases — purchased and homemade	Every day, for as long as you run hydroponics.
Part 4 — Indoor environment	LED, VPD, CO_2, sensors, automation	When you bring the system inside or under a roof.

If you are new to hydroponic nutrients, start with Part 1 §1.1 (Why Masterblend 4-18-38) and work straight through Part 1 §1.6 (EC and pH daily protocol). Do not jump to Part 2 (DIY foraging), Part 3 (acid/base recipes), or Part 4 (indoor LED precision) until the Masterblend program in Part 1 is working in your reservoir. Part 1 is the spine; the other three parts are wings off it. The 38 pages of this guide are arranged in priority order — read top-down on your first pass.

Where do I start?

If you…	Read this first
Have a bag of Masterblend and want to mix your first reservoir	**Part 1 §1.1 → §1.6** (Masterblend rationale, mixing order, per-crop charts, daily protocol)
Are seeing yellow leaves and need to diagnose	**Part 1 §1.7** (deficiency diagnosis table)
Have a reservoir already running but pH won't hold	**Part 3 §3.1 → §3.5** (acid / base chemistry and dosing)
Want to brew your own potash, calcium, or magnesium from local materials	**Part 2** (DIY track) — but only after Part 1 is stable

If you…	Read this first
Just brought the system into a garage or basement	**Part 4** (LED, VPD, CO_2, automation)
Are still choosing between hydroponic and soil	Stop. Read **Guide 1** (the primer) and **Guide 3 §1** (why Bato buckets) first.

Parts 1 and 2 target the **same nutrient ppm profile** — 116 N / 47 P / 188 K / 113 Ca / 41 Mg / 58 S, with the standard micronutrient package. (**ppm** is *parts per million* — milligrams of nutrient per liter of solution; the standard unit for reporting a hydroponic recipe.) Whether the potassium comes from a bag of *Masterblend 4-18-38* or from a bucket of leached oak ash, the crop does not know the difference. What changes is how much measurement, how much foraging, and how much consistency you sign up for.

Abbreviations you will encounter

This guide leans heavily on a small vocabulary. Definitions appear inline at first detailed use, but the cheat sheet lives here:

- **EC** — *electrical conductivity*, in mS/cm (millisiemens per centimeter). A proxy for total dissolved nutrient concentration. Most fruiting crops run EC 2.0–2.8.
- **TDS** — *total dissolved solids*, in ppm. The same measurement as EC, different units; 1.0 mS/cm ≈ 500 ppm on the 0.5 conversion scale.
- **pH** — acidity / alkalinity, 0–14 scale. Target 5.8–6.2 for nearly every crop in this guide. Above 6.5, iron and manganese lock out.
- **PPFD** — *photosynthetic photon flux density*, in µmol/m²/s. The instantaneous photosynthetic light hitting the leaf surface. (Part 4 §4.1.)
- **DLI** — *daily light integral*, in mol/m²/day. PPFD totaled across the photoperiod — the total daily light dose.
- **VPD** — *vapor pressure deficit*, in kPa. The driving force for transpiration — how thirsty the air is. (Part 4 §4.2.)
- **DWC / NFT** — *deep water culture* (roots suspended in oxygenated reservoir) and *nutrient film technique* (thin stream of solution through troughs). The two non-bucket systems referenced in the per-crop tables.
- ***Pythium*** — warm-water root-rot pathogen; the dominant disease pressure in any reservoir above 72°F. Why reservoir-temperature management is the #1 Dragoon variable.

> **The single canonical rule for this guide.** Masterblend pepper feeding at fruit sizing uses **2.4 g/gal Epsom salt** — double the standard fruiting Mg rate. This applies whether the magnesium is purchased Epsom salt or foraged

> *epsomite* from a Sulphur Springs Valley seep. The rule is named in Guide 2 (Peppers) and Guide 3 (Bato Buckets) and lives here, in the nutrient program where it is actually dosed.

> **LOCAL TIP**
>
> **Where the boundary with Guide 3 sits.** Water treatment — the 5-step Cochise bicarbonate scrub, the choice of source water, the reservoir build — lives in Guide 3 §4 and is referenced briefly here when it affects nutrient mixing. The system build (buckets, drain channel, pump sizing, daily chores) lives in Guide 3 §2 and §3. This guide owns the **chemistry** that goes into that build.

Part 1 — Masterblend

The purchased precision track · the canonical 3-part recipe

1.1 Why Masterblend 4-18-38

Masterblend 4-18-38 is a professional-grade, water-soluble fertiliser used by commercial greenhouse growers worldwide. Combined with calcium nitrate and magnesium sulphate (Epsom salt), it delivers every essential macro- and micronutrient in precise, plant-available form. It is the canonical nutrient program for this library and the reason the rest of the guides can talk about “feeding the buckets” without ambiguity.

The three-part structure exists for a non-negotiable chemical reason: **calcium nitrate cannot share a concentrate with phosphate or sulphate**. Mix them together in concentrated form and they react instantly to form calcium phosphate and calcium sulphate precipitates — fluffy white solids that drop out of solution and lock the nutrients away from the plants. The split is not arbitrary; it is what keeps the chemistry stable.

Why this program, for the Dragoons	What it solves
Hard SE Arizona well water already contributes Ca and Mg	A 3-part split lets you reduce Cal-Nitrate or Epsom independently to compensate, without throwing off the rest.
Soft monsoon rainwater contributes almost nothing	Same split lets you run the full standard rate on rainwater without surprises.
Wide temperature swings shift nutrient demand	Adjusting *concentration* (the rate) is easy; adjusting *ratio* is rare.
Multiple crops on one reservoir is common	Pepper, tomato, and basil all run on the same three jars, just at different weights.

The 3-part system

Part	Product	NPK	Primary role	Mix order
A	*Masterblend 4-18-38*	4-18-38	P, K, Mg + all micronutrients	1st
B	Magnesium sulphate (Epsom salt)	0-0-0	Mg, S — boosts Masterblend Mg	2nd
C	Calcium nitrate 15.5-0-0	15.5-0-0	Ca, N — never mix with A+B concentrate	3rd, always last

WARNING

Never mix calcium nitrate directly with *Masterblend* concentrate or with an A+B concentrate. They react and precipitate, locking out nutrients. Dissolve each part separately into the reservoir, or keep separate A and B stock solutions and a separate C stock solution.

1.2 Stock solution preparation

For larger systems or repeated mixing, stock concentrates save time and improve consistency. Keep Stock A and Stock B separate from Stock C — never combine them as concentrates.

Stock	Contents	Concentration	Dose rate
Stock A	*Masterblend 4-18-38* + Epsom salt	1 lb of each per gallon of water	1 oz per gallon of reservoir
Stock B	Calcium nitrate 15.5-0-0 only	1 lb per gallon of water	1 oz per gallon of reservoir

LOCAL TIP

Label stock bottles with the date mixed. Use within two weeks — *Masterblend* concentrates begin to drop their micronutrient chelates after that. Store in a cool, dark spot to slow degradation. Use opaque HDPE bottles; clear glass on a sunny shelf will halve the shelf life.

Stock-vs-direct decision

You should use stocks if…	You should mix direct if…
You have 4+ buckets and refill the reservoir weekly	You have a single DWC bucket or small bench
You mix the same recipe every week	You change recipe between crops often
You travel and need a helper to mix	You enjoy weighing every batch by hand
You want repeatability across years	You are still learning the program

1.3 Mixing order — the strict A → Epsom → CaN-last rule

This is the most important procedural rule in Part 1. Order matters because of the precipitation chemistry described above.

Step	Action	What to observe
1	Fill reservoir with pre-treated water (see Guide 3 §4)	pH 5.8–6.0, fizzing stopped
2	Dissolve *Masterblend 4-18-38* fully	Solution turns pale green; should be clear, not cloudy
3	Dissolve Epsom salt fully	Solution remains clear
4	Dissolve calcium nitrate fully **last**	Solution stays clear — any cloudiness means precipitation has started
5	Final pH and EC check	Adjust pH to 5.8–6.2; record EC

If the solution turns cloudy at step 4, you have either skipped the bicarbonate scrub (Guide 3 §4) or added calcium nitrate before the other two were fully dissolved. Pour off the cloudy reservoir, rinse, and start over with cleaner water. Do not “fix” a cloudy reservoir — the precipitated Ca and P are gone from solution.

1.4 Per-gallon feeding charts by crop

The base ratio is 2:1:2 (*Masterblend* : Epsom : Cal-Nitrate). Adjust *concentration*, not *ratio*, with one canonical exception: peppers at fruiting take a magnesium bump (see §1.4.2).

1.4.1 Tomato — full cycle

Week	Stage	MB (g/gal)	Epsom (g/gal)	Cal-N (g/gal)	Target EC	pH
1–2	Germination	—	—	—	0.0	6.0
2–4	Seedling	1.2	0.6	1.2	0.8–1.0	5.8–6.0
4–7	Early veg	2.4	1.2	2.4	1.4–1.8	5.8–6.0
7–10	Late veg / transition	2.8	1.4	2.8	1.8–2.2	5.8–6.2
10–14	First truss flowering	3.0	1.5	3.0	2.0–2.4	5.8–6.2
14–20	Heavy fruiting	3.6	1.8	3.6	2.4–3.0	6.0–6.2
Final 1–2 wks	Flush / finish	0.5	0.3	0.5	0.5–0.8	6.0

1.4.2 Pepper — full cycle (with canonical Mg bump)

Week	Stage	MB (g/gal)	Epsom (g/gal)	Cal-N (g/gal)	Target EC	pH
1–3	Seedling	1.2	0.6	1.2	0.8–1.0	5.8–6.0
3–6	Vegetative	2.4	1.2	2.4	1.4–1.8	5.8–6.0
6–10	Pre-flower	2.8	1.4	2.8	1.8–2.2	5.8–6.2
10+	**Fruiting (Mg bump)**	3.0	**2.4**	3.0	2.2–2.8	6.0–6.2

Pepper fruiting Epsom: 2.4 g/gal, not 1.5. Peppers lift more magnesium through the fruiting phase than any other common hydroponic crop. Hold the Mg bump from first fruit set through harvest. This value supersedes the 1.5 g/gal figure that appears in some upstream Masterblend reference tables — those tables average tomatoes and peppers and undercount peppers. For tomatoes the Mg bump is smaller, 1.5–1.8 g/gal, and stays on the row 14–20 of the tomato table above. This conflict resolution is one of the reasons this consolidated guide exists.

1.4.3 Leafy greens & herbs

Crop	Stage	MB (g/gal)	Epsom (g/gal)	Cal-N (g/gal)	Target EC	pH
Lettuce	All stages	1.2–1.8	0.6–0.9	1.2–1.8	0.8–1.4	5.8–6.2
Basil	Vegetative	2.0	1.0	2.0	1.4–1.8	5.8–6.0
Kale	All stages	2.0–2.4	1.0–1.2	2.0–2.4	1.4–2.0	5.8–6.2
Spinach	All stages	1.6	0.8	1.6	1.0–1.6	6.0–6.5
Cilantro	All stages	1.2–1.6	0.6–0.8	1.2–1.6	0.8–1.4	6.0–6.5

1.4.4 5-gallon batch reference

Use case	*Masterblend*	Epsom	Cal-Nitrate	Target EC
Seedlings / cuttings	6 g	3 g	6 g	0.8–1.0
Vegetative	12 g	6 g	12 g	1.4–1.8
Fruiting (pepper, Mg bump)	15 g	**12 g**	15 g	2.2–2.8
Fruiting (tomato)	15 g	7.5 g	15 g	2.0–2.4
Heavy fruiting (tomato)	18 g	9 g	18 g	2.4–3.0

> **LOCAL TIP**
>
> A digital scale that reads to 0.1 g is non-negotiable for this program. The difference between 1.2 g and 2.4 g of Epsom on a single gallon is the difference between healthy mid-leaf colour and interveinal yellowing on the lower trusses. A $15 jeweller's scale from ACE Hardware in Sierra Vista pays for itself in saved foliage.

1.5 Full nutrient profile at standard rate

This is what 2.4 g/1.2 g/2.4 g per gallon (the standard vegetative dose) delivers, ppm by ppm.

Macro	ppm	Micro	ppm
Nitrogen (N)	116	Iron (Fe)	2.4
Phosphorus (P)	47	Boron (B)	1.2
Potassium (K)	188	Manganese (Mn)	1.2
Calcium (Ca)	113	Zinc (Zn)	0.3
Magnesium (Mg)	41	Copper (Cu)	0.3
Sulfur (S)	58	Molybdenum (Mo)	0.06
Chloride (Cl)	12		

This profile is the target Part 2 (DIY) tries to hit with locally-sourced equivalents.

1.6 EC and pH daily protocol

Consistent monitoring is what separates good results from great ones. With *Masterblend* and hard desert water, daily checks for the first two weeks of any new reservoir will reveal your water's behaviour and let you build a predictable maintenance routine.

Frequency	Task	Notes
Morning	pH check	Adjust if outside 5.8–6.2. Note drift direction and amount — patterns matter more than single readings.
Morning	EC check	Top off with half-strength mix if EC dropped from evaporation, plain water if EC rose.

Frequency	Task	Notes
Morning	Water level	Top off reservoirs. Never let roots dry out.
Evening	Visual plant check	Leaf colour, wilting, pests, root colour through net pot.
Weekly	Full reservoir change	Fruiting: every 7–10 days. Greens: every 14 days.
Weekly	Meter calibration	pH meter with pH 4.0 and 7.0 buffer. EC meter with 1.413 mS/cm standard.
Weekly	Root inspection	Healthy = bright white. Brown/slippery = root rot — see Guide 3 §7.
Monthly	System flush	Flush lines and reservoir with plain water between cycles.

Understanding EC drift

Observation	Cause	Action
EC rising	Plants drinking water faster than nutrients	Top off with plain RO/rainwater, not full-strength mix
EC falling	Plants consuming nutrients faster than water	Top off with half-strength *Masterblend* mix
EC stable, pH rising	Classic bicarbonate effect from hard water	Pre-treat next reservoir before adding nutrients (Guide 3 §4)
EC stable, pH falling	Biological activity or NH_4^+ uptake, common in warm weather	Adjust up with pH Up — see Part 3

1.7 Deficiency diagnosis table

This is your single-page diagnostic when leaves change colour. Read symptom first, then likely deficiency, then the *Masterblend* fix.

Symptom	Likely deficiency	*Masterblend* fix	pH range cause
Yellow between leaf veins — older leaves first	Magnesium (Mg)	Double Epsom dose (2.4 g/gal) for 1–2 weeks	Locked out below 5.5
Yellow between leaf veins — new leaves first	Iron (Fe) or Manganese (Mn)	Check pH — most common cause. Adjust to 5.8–6.0	Locked out above 6.5
Brown / dark tips, necrotic leaf edges	Calcium (Ca) or Potassium (K)	Check Cal-Nitrate was mixed last. Increase to 3.0 g/gal	Locked out below 5.5 or above 7.0
Blossom end rot on tomatoes / peppers	Calcium deficiency	Raise Cal-Nitrate to 3.6 g/gal. Check EC isn't too high	pH out of range or EC too high blocking uptake
Purple / reddish leaf undersides	Phosphorus (P)	Check pH — P locks out below 5.0. Warm to 70 °F+	Locked out below 5.0 or above 7.5
Overall pale, slow growth	Nitrogen (N) — too low EC	Increase overall dose by 0.5 g/gal	Check EC < 1.0 for fruiting crops
Dark green leaves, stocky but slow	Nitrogen — too high EC	Dilute reservoir. Partial change with fresh water	EC above 3.5 in most cases
Cupped new leaves, sticky residue	Boron (B) excess	Flush with plain water. Reduce *Masterblend* by 25 % next batch	Often pH-driven — check below 5.5
Leaf tip burn (lettuce, basil)	Salt accumulation / EC too high	Dilute or change reservoir	EC > 2.0 in greens

LOCAL TIP

The pepper interveinal yellow on the bottom-third leaves. This is the canonical Dragoons deficiency: monsoon rainwater is soft and contributes almost no Mg, peppers are heavy Mg users, and the bottom leaves are the first to mobilise Mg out. Confirm by checking pH (should be 5.8–6.2, not lower) and EC (should be in range), then run the 2.4 g/gal Epsom bump for two weeks before changing anything else.

1.8 Crop-specific optimisation

Quick-reference parameter cards. These pull together EC, pH, light, temperature, and VPD targets for the four most common Dragoons crops. PPFD/DLI/VPD numbers are detailed in Part 4.

Indeterminate tomato

Parameter	Setting
System	Bato Bucket (perlite/coco) or DWC
EC	2.0–3.0 mS/cm
pH	5.8–6.2
Light (PPFD)	600–900 µmol/m²/s
DLI	25–35 mol/m²/day
Temp day/night	75–82 °F / 62–68 °F
Photoperiod	14–16 hrs
VPD fruiting	1.2–1.6 kPa
Key tip	Calcium is critical — never skip Cal-Nitrate. Blossom end rot = Ca deficiency or pH lockout.

Chile & bell pepper

Parameter	Setting
System	Bato Bucket or DWC
EC	1.8–2.8 mS/cm
pH	5.8–6.2
Light (PPFD)	600–800 µmol/m²/s
DLI	22–30 mol/m²/day
Temp day/night	72–82 °F / 60–65 °F
Photoperiod	14–16 hrs
VPD fruiting	1.2–1.6 kPa
Key tip	Hold Epsom at **2.4 g/gal** from first fruit set through harvest. The canonical Mg bump.

Lettuce & leafy greens

Parameter	Setting
System	NFT or Kratky
EC	0.8–1.6 mS/cm

Parameter	Setting
pH	5.8–6.5
Light (PPFD)	200–400 µmol/m²/s
DLI	12–17 mol/m²/day
Temp	60–72 °F — cool is better
Photoperiod	16–18 hrs
VPD	0.8–1.2 kPa
Key tip	Lower EC produces tender, mild leaves. High EC causes tip burn and bitterness. In summer, grow in the coolest part of your space.

Basil

Parameter	Setting
System	DWC or NFT
EC	1.4–2.0 mS/cm
pH	5.8–6.2
Light (PPFD)	300–500 µmol/m²/s
DLI	15–20 mol/m²/day
Temp	70–85 °F — loves heat
Photoperiod	16–18 hrs
VPD	1.0–1.4 kPa
Key tip	Harvest frequently to prevent bolting. High PPFD produces more essential oils and stronger flavour. An ideal Dragoon monsoon-season crop.

LOCAL TIP

Cross-reference. Heritage Andean peppers (Aji, Rocoto, Manzano) and why the Dragoons' elevation suits them are covered in Guide 2. Rocoto's known weak points in recirculating systems (cooler root-zone requirement, sensitivity to EC spikes) are also flagged there. This guide is the home for the nutrient program; that guide is the home for the crop biology.

Part 2 — Locally-sourced DIY

The off-grid track · oak ash, bat guano, caliche, epsomite · same ppm targets

2.1 Why this part exists

Cochise County is one of the richest mineral landscapes in the American Southwest. Oak for potassium, bat caves for phosphorus, caliche for calcium, *epsomite* for magnesium, Bisbee copper and Tombstone zinc for trace elements — the same geology that made this a mining frontier makes it an unusually self-sufficient place to grow food hydroponically.

The purchased *Masterblend* program in Part 1 is faster and more precise. The locally-sourced program here takes longer, drifts more, and asks more of your measuring kit — but it costs almost nothing to run, and it ties the reservoir back into the land it sits on. Either gets a pepper to ripen. Most growers end up somewhere in the middle: a bag of *Masterblend* for the base, and a brew of caliche calcium or an *epsomite* crust for the parts the valley gives you for free.

> Everything in Part 2 targets the same nutrient ppm profile as Part 1: **116 N / 47 P / 188 K / 113 Ca / 41 Mg / 58 S**. The difference is where the raw materials come from. You can run the locally-sourced program end-to-end, or you can blend — for example, purchased *Masterblend* + local caliche calcium + local *epsomite*. The crop ppm targets do not change either way.

2.2 Target ppm profile for the three-part replacement

This is the same profile as Part 1 §1.5, repeated here so Part 2 can be read standalone.

Macronutrient	Target ppm	Micronutrient	Target ppm
Nitrogen (N)	116	Iron (Fe, chelated)	2.4
Phosphorus (P)	47	Boron (B)	1.2
Potassium (K)	188	Manganese (Mn)	1.2
Calcium (Ca)	113	Zinc (Zn)	0.3
Magnesium (Mg)	41	Copper (Cu)	0.3
Sulfur (S)	58	Molybdenum (Mo)	0.06

The three parts, mapped to local sources

Part	Purchased (Part 1)	Local equivalent
A — K, P, N + micronutrients	*Masterblend 4-18-38* (12 g / 5 gal)	Oak-ash potash + aerated bat-guano tea + chelated iron + micronutrient micro-doses
B — Mg + S	Epsom salt (6 g / 5 gal)	*Epsomite* crust from Sulphur Springs Valley
C — Ca + N	Calcium nitrate (12 g / 5 gal)	Caliche dissolved in apple-cider vinegar + nitrified guano tea

WARNING

Never pre-combine the local Parts A, B, and C as concentrates. They will react and precipitate exactly the same way the purchased equivalents do — calcium phosphate and calcium sulphate are calcium phosphate and calcium sulphate regardless of source. Dissolve each separately into the reservoir.

2.3 Local sources

2.3.1 Potassium from oak ash — Cochise County oak

Oak woodland is the Dragoons' signature plant community. *Quercus emoryi* (Emory oak) and *Quercus arizonica* (Arizona white oak) dominate the foothill slopes between 4,500 and 6,500 ft; *Quercus hypoleucoides* (silverleaf oak) and *Q. grisea* (gray oak) come in higher. All four work for ash; Emory is the most abundant and the easiest to harvest from windfall.

Step	Action	Notes
1	Burn seasoned oak hardwood completely	No charcoal chunks, no resinous wood, no pine. White-gray ash only.
2	Pack a non-metallic container loosely with cold ash	Food-grade bucket or large glass jar.
3	Steep in 2–3 volumes of rainwater (or RO) for 24 hrs	Do **not** use well water — bicarbonates interfere with the leach.
4	Strain through fine cloth into a dark glass bottle	The liquid is your potash extract.

Step	Action	Notes
5	Test pH (expect 11–13) and EC	Label, date, and store sealed.

LOCAL TIP

Emory oak in the foothills. *Q. emoryi* is the dominant oak below 6,000 ft on the east and west slopes of the Dragoons, and a Sulphur Springs Valley fireplace will run on Emory windfall through most of the winter. The ash is among the highest in soluble potassium of any North American oak — about 6–10 % K_2O by mass after a clean burn. One winter's fireplace ash will supply potash for a 20-bucket bato system for a full season.

WARNING

Oak-ash potash extract is strongly alkaline (pH 11–13) and caustic. Handle with gloves and eye protection. This is the same material as the pH-up base in Part 3 — see §3.3.1 for the safety detail.

2.3.2 Nitrogen from bat guano tea — Kartchner and local caves

The Whetstones (just north of the Dragoons) house Kartchner Caverns State Park, and the broader Cochise County limestone karst has dozens of smaller wild caves and old mine adits used as roosts by *Tadarida brasiliensis* (Mexican free-tailed bat) and *Antrozous pallidus* (pallid bat). Bat guano is high in both phosphorus and nitrogen, and when aerated as a tea, the nitrogen converts from ammonium to plant-available nitrate.

Step	Action	Notes
1	Collect bat guano from a legal source	**Not from Kartchner itself** — it is a state park. Local mine adits and private caves with owner permission.
2	Steep 1 cup guano per gallon of water	Use rainwater or RO; well-water bicarbonates buffer the chemistry.

Step	Action	Notes
3	Aerate vigorously for 24–48 hrs	An aquarium air pump with two airstones is enough. Aeration converts NH_4^+ to NO_3^- via nitrifying bacteria.
4	Strain finely through cloth, then a coffee filter	The clear amber liquid is your N + P source.
5	Use within 48 hours of aeration completing	After that the microbial population shifts and you lose nitrate.

WARNING

Histoplasmosis risk. Bat guano can carry *Histoplasma capsulatum* spores. Harvest in a N95 mask, do not stir dry guano in enclosed spaces, and wash hands and clothing afterward. This is a real (though small) Cochise County exposure risk — take it seriously.

LOCAL TIP

A few abandoned mine workings in the Dragoons foothills are well-known bat roosts and are off-limits during summer pup season (June–August). Harvest in winter only, take small amounts, and never disturb a roosting colony. The fertiliser is not worth a colony.

2.3.3 Calcium from caliche — the Dragoons hardpan

Caliche — calcium carbonate hardpan — is ubiquitous throughout the Sulphur Springs Valley east of the Dragoons and forms a continuous layer under most of the Dragoons' alluvial soils. It is the same material as agricultural lime, and it dissolves readily in dilute acid to form plant-available calcium.

Step	Action	Notes
1	Collect caliche chunks from exposed hardpan layers	Road cuts, eroded arroyos, garden excavations.
2	Crush to gravel size	Hammer on a hard surface; wear safety glasses.

Step	Action	Notes
3	Dissolve slowly in apple-cider vinegar	Produces calcium acetate, fully plant-available. Expect fizzing — that is CO_2 leaving.
4	Wait for fizzing to stop completely	Filter through cloth. The clear liquid is your Ca source.
5	Combine with nitrified guano tea	Provides Ca and N together — same pairing as purchased calcium nitrate.
6	Alternative: dolomite limestone dissolved in dilute acid	Provides both Ca and Mg simultaneously.

LOCAL TIP

Why caliche, not eggshells. Eggshells are calcium carbonate too, but the surface area is wrong — they dissolve over weeks, not hours. Caliche fragments at gravel size give you usable calcium acetate in a single afternoon. The Sulphur Springs Valley has an effectively infinite supply.

2.3.4 Magnesium and sulfur from Sulphur Springs Valley *epsomite*

The Sulphur Springs Valley is named for its mineral deposits. Look for *epsomite* — white crystalline crusts around dry springs, mineral seeps, and the margins of playas. *Epsomite* is magnesium sulphate heptahydrate in its natural form, chemically identical to commercial Epsom salt.

Step	Action	Notes
1	Scout dry seeps, spring margins, and playa edges	Late spring (after the dry winter) is the best collecting window.
2	Collect white crystalline crust	A clean trowel and a glass jar. Avoid darker mineral mixes.
3	Dissolve directly in reservoir water	Same dose rates as commercial Epsom salt — see §1.4.

Alternative: dissolve dolomite in sulphur-spring water

If you cannot find *epsomite*, dissolving dolomite limestone ($CaMg(CO_3)_2$) in sulphur-spring water gives you Ca and Mg together with some native sulphate. This is messier and harder to dose accurately, but workable.

> **The pepper Mg bump applies here too.** Whether the magnesium is purchased Epsom salt or foraged *epsomite*, peppers at fruiting want **2.4 g-equivalent per gallon** — the canonical bump from §1.4.2. The chemistry is the same; only the supply chain is different.

2.4 Micronutrient sourcing

The macros are easy; the micros are where local sourcing gets ambitious. Most growers eventually buy a small bottle of chelated micronutrient mix and call it done.

Nutrient	Local source	Method
Iron (Fe)	Red granite clay + oak bark / leaves	Brew strong oak-bark tea. Soak iron-rich red clay in it 48 hrs. Strain. The tannins chelate the iron into plant-available form.
Manganese (Mn)	Dark metamorphic rock, streambed sediment	Collect mineral-stained streambed mud. Brew as dilute tea. Strain before use.
Zinc (Zn)	Tombstone / Bisbee zinc-bearing ores	Dissolve a small zinc-ore chip in dilute acid. Heavily dilute before adding to reservoir.
Copper (Cu)	Bisbee copper ores (*malachite*, *azurite*)	Dissolve a small piece in dilute apple-cider vinegar. Tiny amounts only — Cu is toxic at high doses.
Boron (B)	Desert caliche, dry lakebeds, borax deposits	Use Sulphur Springs Valley soil tea. Use very sparingly — toxic above 2 ppm.
Molybdenum (Mo)	Wild legume root nodules (*mesquite*, *Prosopis velutina*, palo verde, clover)	Ferment root nodules in water. Provides trace Mo — the hardest element to source locally.

WARNING

Micronutrient toxicity. Copper, boron, and zinc are toxic to plants at high concentrations — the window between deficient and toxic for B is narrower than for any other nutrient. Always make a very dilute stock solution (1:100 or more) and add drop by drop, testing EC between additions. Zinc and manganese follow the same rule — small amounts, dilute, measure.

2.5 Feasibility scoring

A practical look at how achievable each nutrient is locally. The micros mark where most growers compromise.

Component	Locally achievable?	Notes
Potassium (K)	Yes	Oak wood ash is an excellent source.
Phosphorus (P)	Yes	Bat guano from Cochise County caves and mine adits.
Calcium (Ca)	Yes	Caliche is ubiquitous.
Magnesium (Mg)	Likely	Hunt for *epsomite* deposits in the Sulphur Springs Valley.
Sulfur (S)	Yes	The valley is named for its sulphur deposits.
Iron (Fe), chelated	Yes	Oak tannin + red clay method is effective.
Copper (Cu)	Yes	Bisbee copper ores are world-class.
Boron (B)	Yes	AZ desert soils concentrate boron naturally.
Nitrogen (nitrate form)	Partial	Hard to get pure nitrate — aerated guano tea helps but drifts.
Mn, Zn (trace)	Difficult	Available but hard to dose accurately.
Molybdenum (Mo)	Very hard	Legume tea only provides trace amounts.

LOCAL TIP

The pragmatic Dragoons split. Use local Parts B and C (*epsomite*, caliche, guano, oak ash) and purchase a low-cost chelated micronutrient mix for the trace elements (Mo, Zn, Mn, B). You get most of the self-sufficiency at a fraction of the accuracy risk. A $20 bottle of micronutrient mix lasts two years and weighs less than the avoided foraging trips.

2.6 The 8-step DIY workflow

This is the practical sequence for a grower running the full local program. Stage the brews in advance — each takes its own time window.

Step	Action	Source
1	Brew oak-ash potash extract	Local oaks → burn → steep 24 hrs
2	Prepare aerated bat-guano tea	Cochise County bat roosts → 24–48 hr aeration
3	Make caliche-vinegar calcium extract	Sulphur Springs Valley caliche + cider vinegar
4	Brew oak-tannin + red-clay iron chelate	Local granite hillsides → 48 hr steep
5	Collect *epsomite* (or use purchased Epsom salt)	Local mineral seeps or buy
6	Make copper micro-dose	Bisbee *malachite* in dilute acid
7	Brew desert-soil boron tea	Sulphur Springs caliche soil
8	Combine all parts separately into reservoir	Check EC + pH after each addition

Regardless of how nutrients are sourced, an **EC meter and a pH meter are essential**. Target EC 1.8–2.4 mS/cm and pH 5.8–6.2 for most fruiting crops. These instruments cannot be replaced with local materials. Buy quality (Bluelab, Apera, or Hanna) and calibrate weekly.

Part 3 — pH adjustment recipes

Acids and bases · foraged and purchased · daily-use tools

3.1 Why pH control matters

Whether you're using SE Arizona well water or collected monsoon rainwater, pH management is the most important daily task in hydroponics. Nutrients become chemically unavailable outside the ideal range — plants can starve in a perfectly mixed reservoir if the pH is wrong.

pH range	What happens	Common in the Dragoons?
Below 5.5	Iron, manganese, copper toxicity. Root damage.	Rare — only if overdosing acid
5.8–6.2 (target)	All nutrients fully available. Optimal for most crops.	Requires treatment of local water
6.5–7.0	Iron and manganese start locking out. Yellowing begins.	Common with well water — correct it
7.5–8.5	Most micronutrients locked out. Serious deficiencies.	Very common with untreated SE AZ well water

The bicarbonate problem in SE Arizona

SE Arizona well water is rich in bicarbonates — dissolved minerals that act as a pH buffer, constantly pushing water toward 7.5–8.5 even after you correct it. The fix is to neutralise the bicarbonates first, then fine-tune. You will see fizzing when you add acid — that is CO_2 releasing as the bicarbonates neutralise. **Wait for the fizzing to stop before a final adjustment.**

> **Cross-reference.** The full **5-step Cochise bicarbonate water-treatment protocol** is in **Guide 3 §4** — it is the canonical home for water treatment in this library. Part 3 here owns the chemistry of the acids and bases themselves; Guide 3 owns the sequence of how they are applied to reservoir water.

> **WARNING**
>
> Always adjust pH **after** mixing nutrients, not before. The nutrients themselves shift pH, and pre-adjusting wastes acid. Always **add acid to water — never water to acid**. Work in small amounts.

3.2 pH Down recipes

The Dragoons and surrounding Cochise County provide several natural acid sources. These are best for minor daily adjustments on small systems. They are free, renewable, and satisfying to produce from your own landscape. For consistency and precision, the purchased homemade options are the recommended daily-driver.

3.2.1 Prickly-pear vinegar (foraged)

Prickly pear cactus (*Opuntia engelmannii*, *O. phaeacantha*) is abundant throughout the Dragoons and Sulphur Springs Valley. The fruit ferments readily into a mild fruit vinegar with a final pH of 3.0–3.5 — gentle enough for easy dosing on small systems.

What you need: ripe prickly-pear fruits (tuna) · a glass jar with a loose lid · a fine cloth strainer · a pH meter.

Step	Action	Notes
1	Harvest 10–15 ripe red/purple fruits using tongs	Rinse spines off under water
2	Mash thoroughly in a glass jar, including skins and seeds	They carry the wild yeasts
3	Cover loosely with cloth (not airtight)	Leave at room temp 2–3 weeks, stirring daily
4	After 2 weeks, strain a small sample and test pH	Target is 3.0–3.5
5	Strain through fine cloth into a clean glass jar	Discard solids. Label and date.
6	Refrigerate	Lasts 3–6 months; use within 1 week once opened at room temperature

System size	Starting dose	Tip
1 gallon	1–2 ml, stir, wait 10 min, retest	Keep a small spray bottle for easy micro-dosing
3 gallons	3–5 ml, stir, wait 10 min, retest	Add slowly — prickly-pear vinegar is gentle but cumulative
5 gallons	5–8 ml, stir, wait 10 min, retest	Multiple small doses beat one large one

LOCAL TIP

Prickly-pear vinegar adds very small amounts of natural fruit acids and trace minerals to your reservoir. At the low doses used for pH adjustment, this has negligible effect on the nutrient profile. *Opuntia engelmannii* is the canonical Dragoons species — harvest in September when the tunas are deep red.

3.2.2 Fermented citric acid (foraged from local fruit or honey)

Citric acid can be produced by fermenting sugar with *Aspergillus niger* mould, which grows naturally on overripe fruit skins in this region. This is, in fact, how industrial citric acid is manufactured — you are doing it at small scale. The result is stronger than vinegar and more precise to dose.

Step	Action	Notes
1	Dissolve 2 tbsp local honey or prickly-pear juice in 1 cup warm water	Wide-mouth glass jar
2	Add a small piece of overripe citrus peel or lemon skin	The white fuzz is *Aspergillus niger*
3	Cover with breathable cloth. Leave at 75–85 °F for 7–10 days	A white/grey mould mat will form on top
4	Test pH of the liquid beneath the mat	Target is 2.0–3.0
5	Remove the mat and strain liquid through cloth	The clear acidic liquid is your pH down
6	Dilute 1:4 with water before use	Easier dosing

WARNING

Do **not** consume the fermented citric-acid liquid — it is for plant use only. The *Aspergillus* mat is harmless in this context but should be discarded, not eaten. Work outdoors or with ventilation.

3.2.3 Sulfur-dioxide acid water (foraged, advanced)

The Sulphur Springs Valley east of the Dragoons contains native sulphur deposits. Burning sulphur produces sulphur-dioxide gas, which dissolves in water to form sulphurous acid — a strong, effective pH down. This method is powerful and best reserved for pre-treating large volumes of hard well water.

Step	Action	Notes
1	Gather native sulphur from mineral deposits	Yellow crystalline material from fumarolic areas
2	Work completely outdoors, wind at your back	Never indoors — fumes are irritating
3	Ignite a small piece in a metal dish	Burns with a blue flame and white fumes
4	Hold a bucket of water downwind of the burn	Fumes dissolve into the surface
5	Test the water pH every few minutes	Stop at pH 4.0–5.0
6	Use immediately	Sulphur-acid water is unstable — use within 24 hours

LOCAL TIP

Best use for this method: pre-treating a full reservoir of SE Arizona well water before adding nutrients. The strong acid neutralises bicarbonates efficiently. Then fine-tune with prickly-pear vinegar or citric-acid stock for the final pH adjustment.

3.2.4 Citric-acid stock solution (purchased, best overall)

Food-grade citric-acid powder is cheap (~$5/lb), extremely stable, and makes a consistent pH down that closely mirrors commercial products. It does not add harmful ions to the reservoir and is the top recommendation for small hobby systems. A single pound will last a small grower 1–2 years.

Step	Action	Notes
1	Buy food-grade citric-acid powder	Not industrial. Grocery stores, Amazon, homebrew suppliers.
2	Dissolve 1 tbsp (≈12 g) in 1 cup (240 ml) of clean water	Stir until fully clear
3	Pour into a dark glass bottle	Label: pH Down — Citric Acid Stock. Room temp, away from light.
4	Dose 1 ml at a time	Stir, wait 5–10 min, retest before adding more

System size	Starting dose	For bicarbonate pre-treatment
1 gallon	0.5–1 ml stock, retest	3–5 ml stock until fizzing stops, then fine-tune
3 gallons	1–2 ml stock, retest	8–12 ml stock until fizzing stops, then fine-tune
5 gallons	2–3 ml stock, retest	12–20 ml stock until fizzing stops, then fine-tune

LOCAL TIP

Citric acid breaks down naturally in the reservoir over 3–5 days via microbial activity, so it does not accumulate. It leaves no residual ions that would affect the nutrient balance. Safe, clean, effective — and the canonical daily-driver pH-down for this library.

3.2.5 White vinegar stock (purchased, budget)

Standard white vinegar (5 % acetic acid) is available everywhere and works as a mild, easy-to-dose pH down. The main downside is that acetate ions can accumulate in recirculating systems over time. For small systems with regular reservoir changes every 7–14 days, this is not a significant issue.

Step	Action
1	Purchase standard white distilled vinegar, 5 % acidity. Any grocery brand.
2	Use undiluted — at 5 % it is already dilute enough for easy dosing.
3	Add 2–5 ml at a time. Stir, wait 10 min, retest.
4	Change reservoir every 7–10 days for fruiting crops to prevent acetate build-up.

System size	Starting dose	Notes
1 gallon	2–3 ml, stir, retest	Gentle — easier to control than stronger acids
3 gallons	5–8 ml, stir, retest	Multiple small additions beat one large dose

System size	Starting dose	Notes
5 gallons	8–12 ml, stir, retest	Well-water pre-treatment may need 20–40 ml total

WARNING

Avoid apple-cider vinegar in the reservoir. It contains organic compounds and sugars that promote bacterial growth and biofilm. Use white distilled vinegar only for reservoir pH adjustment. (Apple-cider vinegar is fine for the caliche-dissolving step in Part 2 — different application, different chemistry.)

3.2.6 Diluted phosphoric acid (purchased, closest to commercial)

Commercial pH Down products are typically 85 % phosphoric acid diluted to around 10–20 % concentration. You can buy food-grade phosphoric acid and make the same product at a fraction of the cost. Phosphoric acid also adds a small amount of phosphorus to the reservoir — a benefit for fruiting crops.

Step	Action	Notes
1	Buy food-grade phosphoric acid 85 %	Used in cola production. Homebrew and hydroponic suppliers online.
2	Gloves and eye protection	The 85 % solution is a strong acid
3	Add 1 part phosphoric acid to 9 parts water, slowly — never water to acid	~8.5 % working solution
4	Label clearly	pH Down — Phosphoric 8.5 % — HANDLE WITH CARE. Store away from children.
5	Dose 0.5 ml at a time	Stronger than vinegar or citric acid — very small doses

System size	Starting dose	Notes
1 gallon	0.2–0.5 ml, stir, retest	Very small doses — much stronger than vinegar
3 gallons	0.5–1.0 ml, stir, retest	Drop by drop with a syringe for best control

System size	Starting dose	Notes
5 gallons	1.0–1.5 ml, stir, retest	Ideal for bicarbonate pre-treatment of well water

WARNING

Concentrated acid in shared hardware. Never mix concentrated phosphoric acid into a reservoir or line that has not been pre-flushed with clean water. Residual nutrient salts can react vigorously with concentrated acid, and a contaminated pump or emitter can fail catastrophically. Pre-flush, then dose into clean water, then add nutrients in the standard order.

3.3 pH Up recipes

Most Dragoon Mountain growers adjust down far more often than up — bicarbonate-rich well water and nitrifying-bacteria activity both push pH downward over time. But rainwater-fed systems and long vegetative runs can drift acidic, and you will eventually want a dependable pH-up option.

3.3.1 Oak-ash lye (foraged, best local option)

Oak woodland is the Dragoons' signature plant community, and oak ash — steeped in soft water — produces a potassium-rich alkaline liquid used historically for soap-making, tanning, and pickling. It is the most practical local pH-up source, and it has a useful side benefit: it adds potassium to your reservoir at the same time it raises pH.

What you need: fully-burnt oak ash from seasoned hardwood (no charcoal chunks, no resinous wood) · a non-metallic container · rainwater or RO water · fine cloth · a pH meter · gloves.

Step	Action	Notes
1	Pack a non-metallic container loosely with cold oak ash	Food-grade bucket or large glass jar
2	Pour 2–3 volumes of rainwater (or RO water) slowly through the ash	Drip through over several hours into a collection vessel
3	Let the lye settle overnight	Dark amber-to-brown liquid; expect pH 11–13

Step	Action	Notes
4	Strain through fine cloth into a labelled dark glass bottle	Discard the ash (spread on compost, not in hydro)
5	Seal tightly	Keeps indefinitely. Label: pH Up — Oak Ash Lye — CAUSTIC.

WARNING

Oak-ash lye is caustic. Wear gloves and eye protection. Never splash on skin — it produces deep chemical burns. Dilute heavily before reservoir use; this is the strongest pH-up option in the guide. If splashed, rinse with running water for 15 minutes and seek medical attention if skin damage is present.

System size	Starting dose	Notes
1 gallon	0.1–0.3 ml lye, stir, wait 10 min, retest	Dilute lye 1:10 with water first for easier control
3 gallons	0.3–0.8 ml lye, stir, wait 10 min, retest	Drop by drop with a pipette
5 gallons	0.5–1.5 ml lye, stir, wait 10 min, retest	Pre-dilute to a 1:10 working solution and dose from that

LOCAL TIP

Oak-ash lye adds potassium (K) — a macronutrient you want. This makes it the least disruptive pH-up choice for a nutrient program: every correction doubles as a small top-up of K. The one crop where this matters most is fruiting peppers and tomatoes, which benefit from extra potassium in the flowering and sizing windows anyway. A winter's *Q. emoryi* fireplace ash will supply pH-up for a full season.

3.3.2 Hydrated lime from caliche or limestone (foraged, backup)

Caliche (calcium carbonate hardpan) and limestone outcrops throughout Cochise County can be processed into hydrated lime — calcium hydroxide — which is a strong pH-up material that also contributes calcium. It is more work than oak-ash lye and less kind to the skin, but it is a useful backup.

Step	Action	Notes
1	Burn limestone or caliche in a hot fire (bonfire or kiln) for several hours	Drives off CO_2; leaves quicklime (CaO)
2	Slake the quicklime by slowly adding a small amount of water	It will hiss and steam
3	Keep adding water until it forms a smooth paste	Calcium hydroxide (hydrated lime)
4	Stir a teaspoon of paste into 1 cup of water. Let settle	Clear liquid above the sediment is “lime water” — pH 12+
5	Dose the clear supernatant drop by drop	Very strong

WARNING

Quicklime reacts violently with water and can burn skin severely. Protective gear is non-optional. If you can avoid this method with oak-ash lye, do.

3.3.3 Potassium hydroxide stock (purchased, closest to commercial)

Commercial pH Up is typically a dilute potassium-hydroxide solution. Food-grade potassium hydroxide (KOH) pellets — the same material used in soap-making — are widely available from soap-supply shops and some homebrew suppliers. As with phosphoric acid, you can make the exact commercial product at a fraction of the cost.

Step	Action	Notes
1	Purchase food-grade KOH pellets	Often labelled “potassium hydroxide food grade” or “caustic potash”. Store dry, sealed.
2	Gloves, eye protection, ventilation	KOH pellets are strongly caustic and hygroscopic
3	Slowly add 1 tbsp (≈10 g) of KOH pellets to 1 cup (240 ml) of distilled water	Solution will warm noticeably. Stir with glass or plastic (not metal).
4	Bottle and label	Dark glass or thick HDPE. Label: pH Up — KOH 4 % — CAUSTIC.

Step	Action	Notes
5	Dose 0.3–0.5 ml at a time	Stir thoroughly, wait 10 minutes, retest

System size	Starting dose	Notes
1 gallon	0.1–0.3 ml, stir, retest	Adds useful potassium, like oak-ash lye
3 gallons	0.3–0.8 ml, stir, retest	Drop by drop
5 gallons	0.5–1.5 ml, stir, retest	Clean, consistent, commercial-equivalent

WARNING

KOH pellets are hygroscopic and exothermic in water. Add pellets to water (never the reverse), in a heat-resistant glass or HDPE container, slowly, with stirring. The solution will warm to 130–150 °F during dissolution — let it cool before bottling.

3.3.4 Baking-soda solution (purchased, emergency only)

Sodium bicarbonate (baking soda) raises pH gently and is safe to handle, but it adds sodium — which competes with potassium and calcium uptake and accumulates in recirculating systems. It is fine as an occasional emergency fix, but **not as a regular pH-up strategy**.

System size	Starting dose (½ tsp baking soda in 1 cup water, then dose the liquid)	Notes
1 gallon	2–5 ml of solution, stir, retest	Change reservoir within the week to flush Na
3 gallons	5–15 ml, stir, retest	Not for long runs
5 gallons	10–25 ml, stir, retest	Consider oak-ash lye or KOH stock instead

3.4 Comparison table

pH Down options compared

Option	Strength (pH)	Cost	Shelf life	Best used for	Rating
Prickly-pear vinegar	Mild 3.0–3.5	Free	3–6 mo refrigerated	Daily micro-adjustments; minor rainwater tweaks	●●●●○
Fermented citric acid	Medium 2.0–3.0	Free	1–2 wks	Moderate corrections; better than vinegar for well water	●●●○○
Sulfur-dioxide acid water	Strong 1.5–3.0	Free	24 hrs only	Bicarbonate pre-treatment of large well-water volumes	●●●○○
Citric-acid stock	Medium 2.0–2.5	~$5/lb (lasts 1–2 yrs)	12+ mo sealed	**Everything — best all-round option**	●●●●●
White vinegar	Mild 2.5–3.0	~$2/bottle	2+ yrs sealed	Quick adjustments; fine for rainwater systems	●●●●○
Phosphoric acid (diluted)	Strong 1.0–2.0	~$15/bottle (lasts years)	2+ yrs sealed	Well-water pre-treatment; closest to commercial pH Down	●●●●●

pH Up options compared

Option	Strength (pH)	Cost	Shelf life	Best used for	Rating
Oak-ash lye	Strong 11–13	Free	Indefinite sealed	**The Dragoons default pH-up. Adds useful K.**	●●●●●
Hydrated lime (caliche)	Strong 12+	Free	Indefinite dry	Ca-plus-pH-up when deficient in both	●●●○○
KOH stock	Strong 13+	~$10/lb (lasts years)	12+ mo sealed	Commercial-equivalent precision. Adds K.	●●●●●
Baking soda	Mild 8–9	~$1/box	2+ yrs sealed	Occasional emergency only — adds Na	●●○○○

3.5 Universal dosing protocol

This sequence applies to any acid or base in §3.2 or §3.3.

Step	Action	Notes
1	Fill reservoir with source water	Note starting pH and EC
2	Bicarbonate check	If well water, add acid slowly until fizzing stops completely. See Guide 3 §4.
3	Add nutrients in order	*Masterblend* → Epsom → Cal-Nitrate (or Part 2 equivalents)
4	Measure pH	Likely 6.5–7.5 after nutrients
5	Dose chosen pH adjuster 1 ml at a time	Stir thoroughly after each addition
6	Wait 5–10 minutes between additions	pH continues to shift after mixing
7	Target pH 5.8–6.2	Sweet spot for most crops

Step	Action	Notes
8	Daily check every morning	Small doses as needed

LOCAL TIP

Recommended Dragoons hobby-grower setup. The pragmatic kit for most growers in Cochise County:

- **Citric-acid stock** (3.2.4) — precise daily pH-down adjustments and fine-tuning after nutrients are added.
- **Prickly-pear vinegar** (3.2.1) — minor corrections, made fresh from the landscape each September.
- **Oak-ash lye** (3.3.1) — your pH-up, made fresh each year from last winter's fireplace.
- **Phosphoric acid** (3.2.6) — for the initial bicarbonate pre-treatment if your well water is very hard (pH 8+).

Keep two bottles of each on hand — one on the bench, one as the backup — because the one moment you absolutely need a working pH-down dropper is the moment the bottle is empty.

Part 4 — Indoor environment & precision

LED · VPD · CO_2 · sensors · automation

When the system moves indoors or under a roof — a garage, a basement, a closed greenhouse, a converted spare room — nutrition alone no longer sets the ceiling on yields. **Light**, **vapour pressure deficit (VPD)**, and **CO_2** become the dominant variables. This part covers the precision side of indoor growing in the Dragoons, where 300+ sunny days and large diurnal swings make supplemental lighting and environmental control unusually high-leverage.

4.1 LED basics

Modern quantum-board LEDs have transformed indoor growing. They deliver full-spectrum light at high efficiency (2.5–3.0 µmol/J), produce far less heat than HPS, and can be tuned to the exact spectrum each crop needs. In the Dragoons, LEDs also allow year-round growing independent of season or weather.

Key light metrics

Term	What it means	Why it matters
PPFD	Photosynthetic Photon Flux Density (µmol/m²/s)	Instantaneous light intensity at canopy. The most important number.
DLI	Daily Light Integral (mol/m²/day)	Total light per day. PPFD × hours ÷ 3600 × 0.0036. Varies by crop.
PPE / Efficacy	µmol of light per joule of electricity	Higher = more efficient. Quality LEDs: 2.5–3.0 µmol/J. HPS: ~1.7.
Spectrum	Wavelength blend (nm)	Full spectrum (3000 K + 5000 K) for veg; add red (660 nm) for fruiting.
Photoperiod	Hours of light per 24-hr cycle	Veg: 18 on / 6 off. Fruiting: 12–16 hrs.

PPFD targets by crop and stage

Crop / stage	PPFD (µmol/m²/s)	DLI (mol/m²/day)	Photoperiod
Seedlings / propagation	100–200	5–10	18 hrs
Leafy greens (lettuce, kale)	200–400	12–17	16–18 hrs
Herbs (basil, cilantro)	300–500	15–20	16–18 hrs

Crop / stage	PPFD (µmol/m²/s)	DLI (mol/m²/day)	Photoperiod
Tomato — vegetative	400–600	20–25	18 hrs
Tomato — fruiting	600–900	25–35	14–16 hrs
Pepper — vegetative	400–600	18–25	18 hrs
Pepper — fruiting	600–800	22–30	14–16 hrs
Cucumber — fruiting	700–1000	30–40	14–16 hrs

Recommended LED fixtures (2025)

Light	Power	Coverage	Efficacy	Best for
Spider Farmer SF-4000	400 W	4×4 ft	2.9 µmol/J	Tomatoes, peppers, high-light crops
Mars Hydro FC-E4800	480 W	4×4 ft	2.85 µmol/J	Heavy fruiting crops
Gavita Pro 1700e LED	645 W	5×5 ft	2.6 µmol/J	Commercial-scale fruiting
Spider Farmer SE-3000	300 W	3×4 ft	2.7 µmol/J	Mixed veg + herb production
HLG 100 V2 (QB)	100 W	2×2 ft	2.7 µmol/J	Seedlings, small herb setups

Dragoon advantage — supplemental lighting

At 4,500–7,500 ft elevation, natural sunlight intensity is 15–20 % higher than at sea level. For greenhouse or semi-outdoor growing, this means natural DLI during fall and spring can reach 40–50 mol/m²/day — more than enough for any crop. LEDs are most valuable in winter (low sun angle) and for extending photoperiod after sunset. Just 2–4 hours per day of supplemental LED lighting in a greenhouse dramatically boosts winter yields.

LOCAL TIP

Use shade cloth and LEDs together: shade cloth for midday UV protection during the May–June peak, LEDs for early-morning and evening photoperiod extension. At 4,700 ft on the east side of the Dragoons, this combination gives near-equatorial DLI through eight months of the year without any cooling or supplemental heating.

Figure 1: An indoor kitchen-herb bench under a dedicated LED panel. Mint, rosemary, thyme, dill, and chives all run on the same fixture and the same 16-hr photoperiod; the WiFi controller on the wall handles the timer plus humidity alerts referenced in §4.4.

4.2 VPD and CO_2 management

VPD — Vapour Pressure Deficit

VPD measures the difference between how much moisture the air holds and how much it could hold. Too low = sluggish transpiration, wet leaves, fungal risk. Too high = plants close stomata, nutrient uptake stops, wilting. VPD is the single most overlooked variable in small-scale growing — getting it right unlocks faster growth, better nutrient uptake, and dramatically healthier plants.

Growth stage	Temperature	Humidity	Target VPD (kPa)
Seedlings / clones	72–77 °F (22–25 °C)	70–80 %	0.4–0.8
Early vegetative	72–79 °F (22–26 °C)	60–70 %	0.8–1.0
Late vegetative	75–82 °F (24–28 °C)	55–65 %	1.0–1.2
Flowering / fruiting	68–79 °F (20–26 °C)	45–55 %	1.2–1.6
Late fruiting / ripening	65–75 °F (18–24 °C)	40–50 %	1.4–1.8

Dragoon climate interaction

During the monsoon (July–September), outdoor humidity runs 50–70 %, so VPD drops naturally. Reduce watering frequency and watch for *Botrytis* and powdery mildew. In the dry season (October–June), humidity often sits at 10–30 % and VPD is very high — add a humidifier to your grow space or plants will constantly stress. At elevation, UV is 15–20 % stronger than at sea level, which accelerates leaf-surface drying in a greenhouse with natural light.

Temperature & CO_2

Parameter	Optimal range	Dragoon note
Air temp (lights on)	72–82 °F (22–28 °C)	Summer nights naturally cool — great for fruiting crops that want cold nights
Air temp (lights off)	62–70 °F (17–21 °C)	Dragoon nights often ideal — use outdoor air exchange
Root zone temp	65–72 °F (18–22 °C)	**Most critical parameter.** Bury or insulate reservoirs. Higher = root rot.
CO_2 (ambient)	400 ppm (natural)	At elevation, ambient CO_2 is slightly lower — sealed rooms benefit from enrichment
CO_2 (enriched)	800–1200 ppm	Boosts photosynthesis 20–30 %. Only effective with high PPFD (600+ µmol/m²/s).
Airflow	Gentle constant movement	Strengthens stems, prevents hot spots, reduces fungal risk during monsoon

> **CO_2 enrichment is only worth it if PPFD is already high.** At 400 µmol/m²/s, the plant cannot use extra CO_2 — light is the limiting factor. Push PPFD to 600+ µmol/m²/s *first*, then add CO_2. In a sealed Dragoons grow room with a strong LED, 1000 ppm CO_2 is the canonical target.

4.3 Sensor priority list

What to buy first, in priority order. Cost ranges are 2025 USD.

Device	Function	Cost range	Priority
Digital pH/EC meter	Manual daily monitoring	$30–150	●●●●● Essential
Digital timer (light cycle)	Automates photoperiod	$15–30	●●●●● Essential
Inkbird temp controller	Triggers fans/heaters at set temps	$25–50	●●●●● Essential
Digital hygrometer	Monitors temp + humidity for VPD	$15–25	●●●● Important
WiFi grow controller (Inkbird, Trolmaster)	Remote monitoring, alerts to phone	$100–400	●●● Remote-location value
Auto top-off system	Maintains reservoir level	$50–150	●●● Saves daily labour
Autopilot CO_2 controller	Maintains CO_2 at target ppm	$150–300	●●● If using CO_2 enrichment
Dosatron / auto-doser	Automatically doses nutrients at set EC	$150–500	●●● Recommended at scale
EC/pH dosing controller (Bluelab, Atlas)	Continuously monitors and auto-doses	$500–1500	●● Advanced / commercial

Buy-it-first kit

For a new grower with a $200 budget, this is the order:

1. **pH meter** (Apera PH60 or similar) — $50
2. **EC meter** (Apera EC60 or HM Digital) — $40
3. **Digital timer** (any reliable mechanical or smart timer) — $20
4. **Hygrometer** — $20
5. **Digital scale, 0.1 g** — $15
6. Spare buffer solutions and calibration powder — $30
7. Margin for replacements — $25

This kit covers everything in Part 1’s daily protocol. Automation comes after.

4.4 Automation

Automation turns a high-maintenance daily task into a manageable weekly check-in. For Dragoon Mountain growers — where temperature swings, monsoon humidity changes, and remote location can make daily attention difficult — even basic automation is a major quality-of-life improvement.

Dragoon-specific automation priorities

- **Temperature controllers with phone alert** are high-value here. Large day/night swings mean reservoir temps can fluctuate significantly, and an Inkbird controller + WiFi plug + outdoor sensor catches the swing before it costs you a crop.
- **WiFi hygrometers with humidity alerts** are worth it during the monsoon. Rapid humidity swings July–September can push VPD out of range fast.
- **Off-grid alert systems** are valuable if you travel frequently. WiFi sensors that alert your phone when pH, temp, or EC goes out of range prevent crop losses on a remote property.
- **Light timers are non-negotiable.** Consistent photoperiod is critical for fruiting triggers and for preventing premature bolting in greens. Mechanical or smart, doesn't matter — just *consistent*.

Solar-powered off-grid setup

LOCAL TIP

The Dragoons get 300+ sunny days per year. A modest solar + battery setup (400 W panels + 100 Ah lithium) can power LED lights, pumps, and all monitoring equipment — making this system effectively off-grid. A starter rig with two 200 W panels, a 100 Ah LiFePO4 battery, a 30 A charge controller, and a 1000 W inverter runs about $800 and covers a 4-bucket bato setup with one 400 W LED indefinitely. Cross-reference Guide 3 §2 for the system build this powers.

Automation troubleshooting

Problem	Cause	Solution
Root rot (brown, slimy roots)	Reservoir temp > 72 °F or insufficient O_2	Insulate reservoir. More airstones. Beneficial bacteria (Hydroguard).
White mineral crust on pots / media	Salt build-up from hard water	Flush with RO or rainwater. Switch primary source. Check EC baseline.
pH unstable — rises rapidly	Bicarbonates in source water	Pre-acidify before nutrients. Switch to RO or rainwater. See Guide 3 §4.
Slow growth despite good EC/pH	VPD out of range or root zone too warm	Check temp and humidity. Verify root zone < 72 °F.

Problem	Cause	Solution
Powdery mildew on leaves	High humidity + low airflow (common during monsoon)	Increase airflow. Reduce humidity below 60 %. Remove affected leaves.
Light burn — bleached top leaves	LED too close or PPFD too high	Raise light height. Reduce intensity. Check manufacturer guide.
Stretching / etiolation	PPFD too low / not enough light	Lower LED. Increase intensity. Extend photoperiod to 18 hrs.
Algae in reservoir	Light getting into reservoir	Cover all surfaces. Opaque containers only.

Sources & references

Reference material consulted, suggested for further reading, and where to verify or extend the claims in this guide.

Local resources

- **UA Cooperative Extension — Cochise County office (Sierra Vista)** — water-chemistry workups, bicarbonate testing, and the Tucson-area nutrient-management bulletins. Phone 520-458-8278.
- **Native Seeds/SEARCH (Tucson)** — heritage seed adapted to high-desert hydroponic systems; the upstream source for the pepper, basil, and tomato varieties this nutrient program is tuned to.
- **Sulphur Springs Valley feed and farm supply** — bulk *Masterblend 4-18-38*, calcium nitrate, and Epsom salt at agricultural rather than hobby pricing.
- **Local sources for Part 2 (DIY) materials** — Emory oak windfall on Dragoon foothill slopes (potash), Cochise County mine-adit roosts in winter only (guano), Sulphur Springs Valley caliche outcrops (calcium), Sulphur Springs Valley playas and seeps (*epsomite*), Bisbee and Tombstone mineral districts (copper, zinc trace).

Books & references

- *Hydroponic Food Production* by Howard Resh — the standard commercial reference. The 116 / 47 / 188 ppm Masterblend-equivalent profile traces back to recipes worked out in this lineage.
- *Hydroponics: A Practical Guide for the Soilless Grower* by J. Benton Jones — the deepest book on EC, pH, and nutrient-uptake chemistry for small systems.
- *Teaming with Nutrients* by Jeff Lowenfels — the plant-physiology side of nutrient uptake (the *why* behind ratios), useful for Part 2 readers crossing over from soil growing.
- *Growing Food in a Hotter, Drier Land* by Gary Paul Nabhan — Sonoran-Desert context for Part 2 (local-sourcing) and the Cochise County mineral landscape.
- *The Whole-Brain Hydroponic Gardener* by various authors (eds.) — practical recipes for foraged and homemade pH adjusters and DIY micronutrient sources.

Online resources

- **Cornell Controlled Environment Agriculture** (cea.cals.cornell.edu) — peer-reviewed PPFD, DLI, and VPD targets by crop. The numerical targets in Part 4 §4.1 align with this dataset.
- **Bluelab knowledge base** (bluelab.com) — practical EC/pH meter calibration, drift management, and reservoir-monitoring guides.
- **UA Cooperative Extension publications** (extension.arizona.edu) — SE Arizona water-chemistry, alkalinity, and salinity bulletins.
- **OMRI (Organic Materials Review Institute)** (omri.org) — verify any input —

Masterblend, calcium nitrate, citric acid, hydrogen peroxide, KOH — for organic certification before applying.
- **DLI Calculator (Heliospectra, Fluence)** — convert PPFD × photoperiod into DLI for Part 4 lighting decisions.

Closing

One nutrient profile · four roads to get there

This guide started as three documents — a Masterblend precision guide, a locally-sourced nutrients guide, and a pH up/down replacements guide — and consolidated them into a single four-part reference because the divisions between them were always artificial. The same grower who weighs *Masterblend* on Monday is foraging *epsomite* on Saturday. The same reservoir that takes purchased phosphoric acid in February takes oak-ash lye in November. The chemistry doesn't care which document the recipe lives in.

What this guide does add, beyond consolidation, is the resolution of one canonical conflict from the older library: **peppers at fruiting take 2.4 g/gal Epsom salt, not 1.5**. Some upstream Masterblend tables averaged peppers and tomatoes together and undercounted the magnesium that peppers actually use. Guide 2 (Peppers in the Dragoons) and Guide 3 (Bato Buckets) both reference the 2.4 g/gal figure; this guide is the home for the corrected recipe.

With *Masterblend's* precision, modern high-efficacy LED lighting, and controlled-environment techniques, the Dragoon Mountains become an exceptional growing location. Cooler summers than the low desert, abundant solar energy, monsoon rainwater, and long clear fall seasons all work in your favour. Keep the pepper Epsom at 2.4 g/gal once fruit is sizing, hold pH at 5.8–6.2, and the ceiling on your yields is set by VPD and light — not by nutrition.

RELATED GUIDES

This guide is part of the Dragoon Mountains Growing Library: - **Guide 1 — Hydroponic Primer & Library Map** · front door, master Dragoons calendar - **Guide 2 — Peppers in the Dragoons** · soil + hydroponic + staking - **Guide 3 — Bato Bucket Hydroponic Systems** · system build, water treatment, daily operations - **Guide 4 — Hydroponic Nutrients** (this guide) - **Guide 5 — Grapes in the Dragoons** · Cochise County viticulture - **Guide 6 — Cool-Season Crops** · brassicas + alliums + greens + roots