Spinach in Hydroponics

Spinach (*Spinacia oleracea*) is one of the **best leafy greens** for hydroponics. It grows quickly, is nutrient-rich, and thrives in **cooler hydroponic conditions** compared to crops like lettuce or basil. Since spinach is sensitive to heat and water stress in soil, hydroponics helps maintain consistent growth.

	Hydroponic Systems for Spinach nach grows well in several systems, but the most efficient are: NFT (Nutrient Film Technique): A thin film of nutrient solution flows over the roots, making it ideal for growing leafy greens. DWC (Deep Water Culture): Plants float on nutrient solution → simple and effective. Aeroponics (advanced): Roots are misted → faster growth but costlier. For beginners: DWC or NFT is easiest.
1. 2. 3. m 4. 2. G	Change water once if soaking >12 hrs.3 Optionally, disinfect with: 1% Hydrogen peroxide (H ₂ O ₂) solution for 5 in reduces fungus. Drain and sow immediately into prepared medium. rowing Medium
	cockwool Cubes (Best for NFT)
	1" or 1.5" cubes.
	Preparation: Soak cubes in pH-adjusted water (5.5–5.8) for 30 min.
	Gently shake off excess water (don't squeeze).
Sow	-
	Place 1–2 soaked seeds in each cube hole.
	Cover lightly with a thin layer of vermiculite or rockwool flakes .
Env	ironment:
	Keep cubes in a germination tray, cover with humidity dome or plastic sheet.
	Maintain air temp 18–22 °C, RH 70–80%, darkness until sprouting.
В. С	oco Peat + Perlite Mix (Alternative)
	Ratio: 70% Coco Peat: 30% Perlite
	Use 60:40 in very humid climates for better drainage.
Prep	paration:
	Wash & buffer coco peat (target EC < 0.5, pH ~6).
Sow	ring:
	Fill seedling trays or net pots with mix.
	Sow 2–3 seeds per cell/net pot \rightarrow thin later.
	Keep moist but not soggy.

C. Clay Pebbles (LECA)

Not recommended for direct germination \rightarrow dries quickly.

Germinate in rockwool or coco mix first.

After 2–3 true leaves, transplant seedlings into net pots with 100% LECA.

Pre-soak LECA overnight & rinse to remove dust/pH swings.

D. Vermiculite

High water retention → great for germination but risky alone.

Best Mix: 50% Vermiculite : 50% Perlite.

Good alternative if rockwool is not available.

4. Transplanting to NFT

Timing: 2-3 true leaves + visible root growth (10-14 days old).

Method:

1. Place seedlings (with rockwool or coco plug) into **net pots with LECA**.

2. Ensure roots touch the NFT film flow.

Table No.1 Environmental Requirements

Spinach is
sensitive to hear
\rightarrow bolting
(premature
flowering)
happens if temp

> 26°C.

Nutrient

Parameter	ideai Range	Notes			
рН	5.8 – 6.5	Keep stable; check regularly			
EC (Electrical Conductivity)	1.8 – 2.3 mS/cm	Too high causes tip burn			
Water Temp	18 – 22°C	Cooler water improves growth			
Air Temp	15 – 24°C	Prefers cool climate			
Humidity	50 – 70%	Too high = fungal risk			
Light	10-12 hours/day	150–250 µmol/m²/s (LED or sunlight)			

Management for Spinach in NFT

1. Nutrient Needs by Growth Stage

Table No. 2.1 Spinach has 3 growth phases in NFT:

Stage	Duration	Nutrient Focus	EC Range
Seedling	0–2 weeks	Lower nutrients, gentle solution	1.0 – 1.4 mS/cm
Vegetative (Leaf Expansion)	2–5 weeks	IHIAN NITRAGEN + CAICILIM	1.6 – 2.0 mS/cm
Mature (Harvest)	5+ weeks	IBAIANCEO NI KILIA	1.8 – 2.3 mS/cm

2. Table No. 2.2 (Macronutrient Requirements (Ideal Ratios in Solution)

Nutrient	Concentration (ppm)	Role				
Nitrogen (N)	150–200 ppm	Leaf growth, chlorophyll				
Phosphorus (P)	40–60 ppm	Root development				
Potassium (K)	200–250 ppm	Leaf thickness, disease resistance				
Calcium (Ca)	120-150 ppm	Prevents tip burn				
Magnesium (Mg) 40-60 ppm		Chlorophyll synthesis				
Sulfur (S)	60–80 ppm	Protein formation				

3. Table No. 2.3 Micronutrient Requirements

Micronutrient	Concentration (ppm)	Importance			
Iron (Fe)	2–3 ppm	Prevents chlorosis			
Manganese (Mn) 0.5–1 ppm		Enzyme activity			
Zinc (Zn)	0.05–0.1 ppm	Growth hormone regulation			
Copper (Cu)	0.05 ppm	Enzyme systems			
Boron (B)	0.5 ppm	Root & leaf health			
Molybdenum (Mo)	0.05 ppm	Nitrate utilization			

Spinach NFT Nutrient Sources (Water-Soluble)

1. Macronutrients (Table No.3)

2.

Nutrient	Target (ppm)	Fertilizer Source (Water-Soluble)
Nitrogen (N)	150–200	Calcium Nitrate (Ca(NO₃)₂) Potassium Nitrate (KNO₃)
Phosphorus (P)	Mono Potassium Phosphate (KH₂PO₄ / MKP) Phosphoric Acid (H₃PO₄)	
Potassium (K)	200–250	Potassium Nitrate (KNO₃) Mono Potassium Phosphate (KH₂PO₄) Potassium Sulfate (K₂SO₄, SOP)
Calcium (Ca)	120–150	Calcium Nitrate (Ca(NO₃)₂)
Magnesium (Mg) 40-60		Magnesium Sulfate (MgSO₄·7H₂O, Epsom Salt) Magnesium EDTA
Sulfur (S)	60–80	Magnesium Sulfate (MgSO₄·7H₂O) Potassium Sulfate (K₂SO₄)

Micronutrients (Table No.3.1)

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Nutrient	Target (ppm)	Fertilizer Source (Water-Soluble)						
Iron (Fe)	ויו א	Iron DTPA (Fe-DTPA) Iron EDDHA (Fe-EDDHA)						
Manganese (Mn)	0.5–1	Manganese Sulfate (MnSO₄·H₂O)						
Zinc (Zn)	0.05–0.1	Zinc Sulfate (ZnSO₄·7H₂O)						
Copper (Cu)	0.05	Copper Sulfate (CuSO₄·5H₂O)						
Boron (B)	0.5	Boric Acid (H ₃ BO ₃)						
Molybdenum (Mo)		Sodium Molybdate (Na₂MoO₄·2H₂O) Ammonium Molybdate ((NH₄)₅Mo₂O₂₄·4H₂O)						

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•	pH Adjustment
	Phosphoric Acid (H₃PO₄) → lowers pH, adds phosphorus
	Nitric Acid (HNO₃) → lowers pH, adds nitrate N
	Potassium Hydroxide (KOH) → raises pH, adds potassium

Step 1: Fix target ppm values (choosing mid-points)

N = 162 ppm

P = 50 ppm

K = 230 ppm

Ca = 140 ppm

Mg = 50 ppm

S = 70 ppm

Fe = 2.5 ppm

Mn = 0.8 ppm

Zn = 0.08 ppm

Cu = 0.05 ppm

B = 0.5 ppm

Mo = 0.05 ppm

Link of Nutrient Source for spinach :

 $\label{lem:https://docs.google.com/spreadsheets/d/1CTro8F0Xd_hEo-F-R8J4y7tuVKiloXRuphJ\\ \underline{nr3RTDwU/edit?usp=drivesdk}$

Table No.4 Nutrient Composition of Different Fertiizer Sources

			Macronutrie						N	licror	utrie	nts	
Nutrient	Fertilizer source	N	P	K	са	mg	s	Fe	Mn	Zn	Cu	В	Мо
	13:00:45	13%		45 %									
	Calcium Nitrate	15.5 0%			19 %								
l .Nitrogen	Urea	46 %											
2.Phosphorus	0:52:34		52 %										
	13:00:45	13%		45 %									
3.Potassium	0:00:50			50 %			17. 5%						
	Calcium nitrate	15.5 0%			19 %								
4. calcium													
	Magnesium sulfate					9.5 %	12 %						
5. magnesiu m	magnesium EDTA					10%							
	Magnesium sulfate					9. 5%	12 %						

6. Sulfur

	Potassium sulfate	17. 5%					
7. Micronuti	Micronutrien ts (EDTA) mix		2.50	1.00	3.00	0.50 %	0.10

Method 1 -

Sr. No.	Fertilizer	1 L	20 L
1	Calcium nitrate — Ca(NO₃)₂	0.736 g	14.720 g
2	13:00:45 (KNO₃)	0.507 g	10.140 g
3	KH₂PO₄ (mono-K phosphate) 00:52:34	0.096 g	1.920 g
4	00:00:50 K ₂ SO ₄ / 0-0-50	0.303 g	6.060 g
5	MgSO₄	0.526 g	10.520 g
6	Micronutrient mix (EDTA; Fe)	0.1 mL	2.0 mL

- Calcium Nitrate (N= 15.5 %, Ca = 19%)
- 1. Calculation for calcium (Ca 19%)

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= 140 × 100 / 19 = 736 mg

To Convert mg/L = 736/1000 = 0.736 g/L

For 20 L Water = 0.736 × 20 =14.72 g

= 14.72 g (Ca Requirement Competed)

Nitrogen :

= 736 × 15.5 N / 100 = 114.08

(162 - 114.08 = 47.92 ppm N need to Complete n source)
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2. 00:52:34 (Phosphorus) KH2PO4

$$P = 50 \times 100 / 52 = 96.15 \text{ mg/L}$$

$$= 0.0961 \text{ g/L}$$

$$= 96.15 \times 20 \text{ L} = 1923 \text{ mg} \rightarrow 1.923 \text{ g}$$

$$K = 96.15 \times 34 \text{ k} / 100 = 32.691 \text{ mg/L}$$

$$(K = 230 \text{ ppm} - 32.691 = 197.31 \text{ need to complete k requirement})$$

3. 13:00:45 potassium

Nitrogen =
$$47.92$$
 N need × $100 / 13 = 368.615$ mg $\rightarrow 0.3676$ g/L = $368.615 \times 20 = 7372.30$ mg \rightarrow **7.372 gram** (Nitrogen Requirement completed)

Potassium = $368.6. \times 45$ k / $100 = 165.8$ mg/L (197.31 - $165.9 = 31.41$ K Need)

4. 00:00:50 (To complete k)

=
$$31.41 \times 100 / 50 = 62.82 \text{ mg/L}$$

= $62.82 \text{ mg/L} \rightarrow 0.0564 \text{ g/L}$
(Potassium Requirement Completed)

5. Magnesium Sulphate (MgSO4, Mg =9.5%, S12%)

$$50 \times 100 \ / \ 9.5 = 526.31 \ mg \ L \rightarrow 0.52631 \ g$$

$$0.52631 \ g \times 20 = \ \textbf{10.526 g}$$
 Sulfur (S= 12 %)

Calculation for if we used Urea as N source

if we add urea (46% N), then what should be replaced and what else needs to be adjusted.

Therefore, replacing **KNO** $_3$ with urea makes the most sense — since KNO $_3$ supplies both N and K, while urea supplies only N. The missing K can then be supplied from another K source (K_2SO_4).

6. Calculation for calcium (Ca - 19%)

= 140 × 100 / 19 = 736 mg To Convert mg/L = 736/1000 = 0.736 g/L For 20 L Water = 0.736 × 20 =14.72 g = 14.72 g (Ca Requirement Competed)

Nitrogen:

= **736 × 15.5 N / 100 = 114.08** (162 - 114.08 = 47.92 ppm N need to Complete n source)

Urea required (to supply 47.92 ppm N):

 $urea(mg/L = 47.92 \times 100 / 46 = 104.174mg/L$

For 20 L:104.174 mg /IL×20 = 2.0835 g urea

K deficit from removing KNO₃ = 45.69 ppm K. K₂SO₄ provides 50% K, so:

 K_2SO_4 (mg/L) = 31.41 × 100 / 50 k = 62.82 mg/L

For 20 L= $62.82 \times 20 = 1256.4 \text{ mg/L} \rightarrow 1.256 \text{ g}$

So new K_2SO_4 total = original 60.64 g + 1.256 g = 61.89 g

Table 5: Final Fertilizer Requirement (urea fully replacing KNO₃)

Sr.	Fertilizer (common name / analysis)	1 L	20 L
1	Calcium nitrate — Ca(NO₃)₂	0.736 g	14.720 g
2	KH₂PO₄ (mono-K phosphate)	0.096 g	1.920 g
3	Urea (46% N)	0.104174 g (≈0.104 g)	2.083 g
4	K ₂ SO ₄ (0-0-50 style K source)	0.395 g	7.900 g
5	MgSO₄ (Epsom salt)	0.526 g	10.520 g
6	Micronutrient mix (EDTA; Fe)	0.1 mL	2.0 mL

Nutrient Deficiencies in Hydroponic Spinach

Nutrient	Deficiency Symptoms	Why It Happens	Corrective Action
Nitrogen (N)	growth, older leaves yellow first	low EC	Increase nitrate-N (Ca(NO₃)₂ / KNO₃), avoid ammonium
Phosphorus (P)	Stunted plants, dark green/purple lower leaves, slow root growth	pH > 6.5 or low P	Add MKP (KH₂PO₄), adjust pH to 5.8–6.2

Nutrient	Deficiency Symptoms	Why It Happens	Corrective Action
	Leaf edge burn, curling, interveinal yellowing, weak stems		Add KNO₃ / MKP, reduce excess Ca
Calcium (Ca)			Add Ca(NO₃)₂, improve airflow, avoid excess K/Mg
	Interveinal chlorosis (yellow between veins) in older leaves		Add MgSO₄ (Epsom salt), adjust K:Mg ratio
	Uniform yellowing of young leaves (similar to N, but starts in new leaves)	Very low S in stock mix	Add MgSO₄ or K₂SO₄
` '	Yellowing of new leaves, veins remain green (interveinal chlorosis)	High pH (>6.5) blocks Fe	Add Fe chelate (EDDHA/DTPA), keep pH ~5.8–6.2
Manganese	Interveinal chlorosis with small brown spots, starting in young leaves	High pH or excess Fe	Add MnSO₄, balance Fe/Mn
IROTON (R)	Distorted, brittle new leaves, hollow petioles, poor root growth	, ,	Add Borax or Solubor (very small dose)
Zinc (Zn)	Small leaves, shortened internodes, interveinal chlorosis		Add ZnSO₄ (tiny dose), maintain pH
Conner (CIII)	Wilting, twisted leaves, necrotic tips	ikare in nvorobonics	Add Cu chelate (very low ppm)
,	Pale leaves, similar to N deficiency, edges scorch		Add sodium molybdate / ammonium molybdate