PURDUE EXTENSION | LOCAL FACES COUNTLESS CONNECTIONS

Nutrition Calculations for Hydroponic Crops

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Nutrients are supplied to lettuce plants in hydroponics by maintaining a target EC in the fertilizer solution

Nutrient elements are taken by plants at different rates

- A fertilizer is comprised of several elements (N, P, K, Ca, Mg, S and micros like Fe, Zn, Mo, Mn, B, Cu)

- N, P, K and Mn: rapidly taken from the solution
- Ca and B: taken very slowly
- Other elements have intermediate uptake rates

- Elements like Ca, Mg and S accumulate in the recycled solution. These have high ionic conductivities and can significantly affect EC values

- We have observed up to 15% reduction in lettuce growth due to accumulated elements

How much fertilizer is optimal for lettuce?

- Composition of elements inside a healthy plant is a good starting point

- Optimal fertilizer ‘concentration’ should result in the desired ‘composition’ of elements inside the plants

Composition of elements to be present in 1 g of dry leaves for healthy growth

N	P	K	Ca	Mg	S	Fe	Zn	Mn	B	Cu
4.5%	0.5%	5%	0.5%	0.3%	0.3%	0.0015%	0.0005%	0.0005%	0.0003%	0.0002%

How much fertilizer is optimal for lettuce?

- Amount of N, P and K removed is proportional to **plant growth**
- Volume of water in the fertilizer solution is proportional to volume of **water used by plants**
- **For every 1 kg (2.2 lb) of dry weight produced (i.e., plant growth), lettuce plants use approximately 300 L of water**

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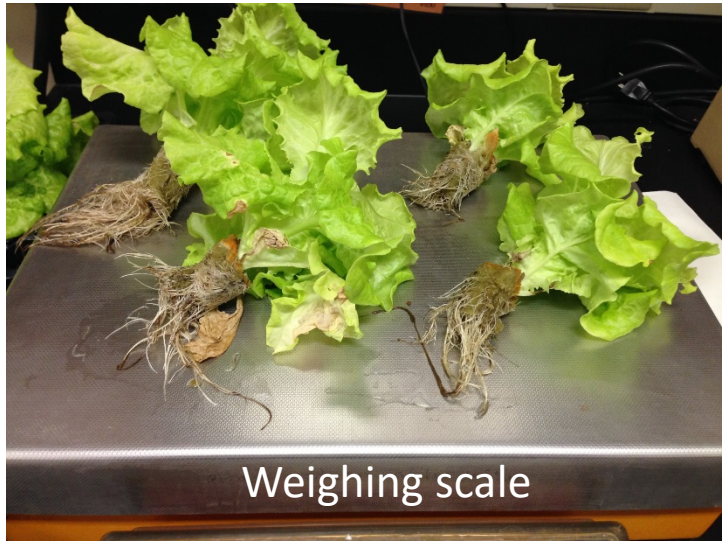
How to measure plant growth and water use in greenhouses?

- Randomly choose 10 plants from 3000 ft^2 greenhouse area
- Weigh **same** plants every week (grams)
- $$\text{Dry weight (kg) per m}^2 = \frac{\text{Collective weight (g)}}{1000\ \text{g}} \times \frac{1}{10\ \text{plants}} \times 0.1\ \frac{\text{Dry weight}}{\text{Fresh weight}} \times \frac{90\ \text{plants}}{\text{m}^2}$$
- Plant growth (kg) per m^2 per week = Dry weight (week 1) − Dry weight (week 2).....
- Estimate water use (L) per m^2 per week as plant growth (kg) per m^2 per week $\times 300$


Weighing scale

Exercise 1

You weighed 10 lettuce plants on two Sundays (week 1 and week 2). Below is the data. From this, calculate plant growth and water use for week 1 and 2.

(*Hint: follow steps and use the formulae below.*)

Collective fresh weight of 10 lettuce plants

Week 1	Week 2
100 g	200 g

- Step 1: *calculate dry weight of plants for each week*
  - Dry weight of plants (kg) per $\mathrm{m}^2 = \frac{\text{Collective weight (g)}}{1000\ \text{g}} \times \frac{1}{10\ \text{plants}} \times 0.1\ \frac{\text{Dry weight}}{\text{Fresh weight}} \times \frac{90\ \text{plants}}{\mathrm{m}^2}$
- Step 2: Calculate plant growth
  - Week 1 plant growth (kg) per m^2 = Dry weight (week)
  - Week 2 plant growth (kg) per m^2 = Dry weight (week 2) − Dry weight (week 1)
- Step 3: Calculate water use
  - Week 1 water use (L) per m^2 = week 1 plant growth × 300
  - Week 2 water use (L) per m^2 = week 2 plant growth × 300

Plant growth and water use of lettuce

Measurement	Week 1	Week 2	Week 3	Week 4
Water use (L/m^2)	53	112	120	126
Plant growth (kg/m^2)	0.135	0.414	0.594	0.315
Water use: Plant growth (L/kg)	392	270	202	400

Average water : plant growth ratio (L/kg) is 316

How much nitrogen is required for lettuce?

Measurement	Week 1
Water use (L/m^2)	53
Plant growth (kg/m^2)	0.135

- Nitrogen should be 4.5% of plant growth = $\frac{4.5}{100} \times 0.135 \times 1000 \frac{grams}{kilogram} \times 1000 \frac{milligrams}{gram}$ = 6075 mg
- As plants used 53 L of water, 6075 mg to be mixed in 53 L or $\frac{6075\ milligrams}{53\ L}$ = 114.6 ppm (1 ppm = $\frac{1\ mg}{L}$)
- Recommend that you add another 20% as N recovery in plants is only 80% (i.e., **136** ppm N during the first week)

How much phosphorus is required for lettuce?

Measurement	Week 1
Water use (L/m^2)	53
Plant growth (kg/m^2)	0.135

- Phosphorus should be 0.5% of plant growth = $\frac{0.5}{100} \times 0.135 \times 1000 \frac{grams}{kilogram} \times 1000 \frac{milligrams}{gram}$ = 675 mg
- As plants used 53 L of water, 675 mg to be mixed in 53 L or $\frac{675\ milligrams}{53\ L}$ = 12.7 ppm
- After adjusting for 80% recovery, required PPM for phosphorus is 15 ppm
- Note fertilizer contain P_2O_5 not just P. In P_2O_5 there is 44% P. This means required PPM of P_2O_5 is 15/0.44 = **35** ppm

How much potassium is required for lettuce?

Measurement	Week 1
Water use (L/m^2)	53
Plant growth (kg/m^2)	0.135

- Potassium should be 5% of plant growth = $\frac{5}{100} \times 0.135 \times 1000 \frac{grams}{kilogram} \times 1000 \frac{milligrams}{gram}$ = 6750 mg
- As plants used 53 L of water, 6750 mg to be mixed in 53 L or $\frac{6750\ milligrams}{53\ L}$ = 127 ppm
- After adjusting for 80% recovery, required PPM for potassium is 152 ppm
- Note fertilizer contain K_2O not just K. In K_2O there is 83% K. This means required PPM of K_2O is 152/0.83 = **184** ppm

What is the required fertilizer solution concentration for lettuce?

- We calculated required N, P and K concentration; most of the commercial fertilizers are based on the ratio of N : P_2O_5 : K_2O not N: P: K
- There is 100% N in N, 44% P in P_2O_5 and 83% K in K_2O.
- From this, the required ratio of N : P_2O_5 : K_2O is $\frac{136}{1}$: $\frac{15}{0.44}$: $\frac{152}{0.83}$ = **136 : 35 : 184** ppm
- N equivalent ratio of the above combination is $\frac{136}{136}$: $\frac{35}{136}$: $\frac{184}{136}$ = **1: 0.26: 1.35**
- A fertilizer like 15-5-20 can be used as its N equivalent ratio is similar (1: 0.3 : 1.33). Measure EC of the prepared solution and maintain it during the week.

Exercise 2

You calculated that plant growth was 0.09 kg/m^2/week and water use was 27 L/m^2/week. Use this information and calculate required ppm of K_2O in the fertilizer for the week.
(Hint: follow these steps and fill up '??'s)

- Step 1: Potassium should be 5% of plant growth; what is 5% of 0.09 kg?
  - $= \frac{5}{100} \times ?? \times 1000 \frac{grams}{kilogram} \times 1000 \frac{milligrams}{gram}$ = ?? mg
- Step 2: Plants used 27 L of water during the week, what is the desired ppm (mg/L)
  - $= \frac{?? milligrams}{?? L}$ = ?? ppm of K
- Step 3: What is the ppm after adjusting for 80% recovery?
  - = ??/0.8 = ?? ppm K
- Step 4: What is the required ppm of K_2O?
  - = ??/0.83 = **??** ppm K_2O