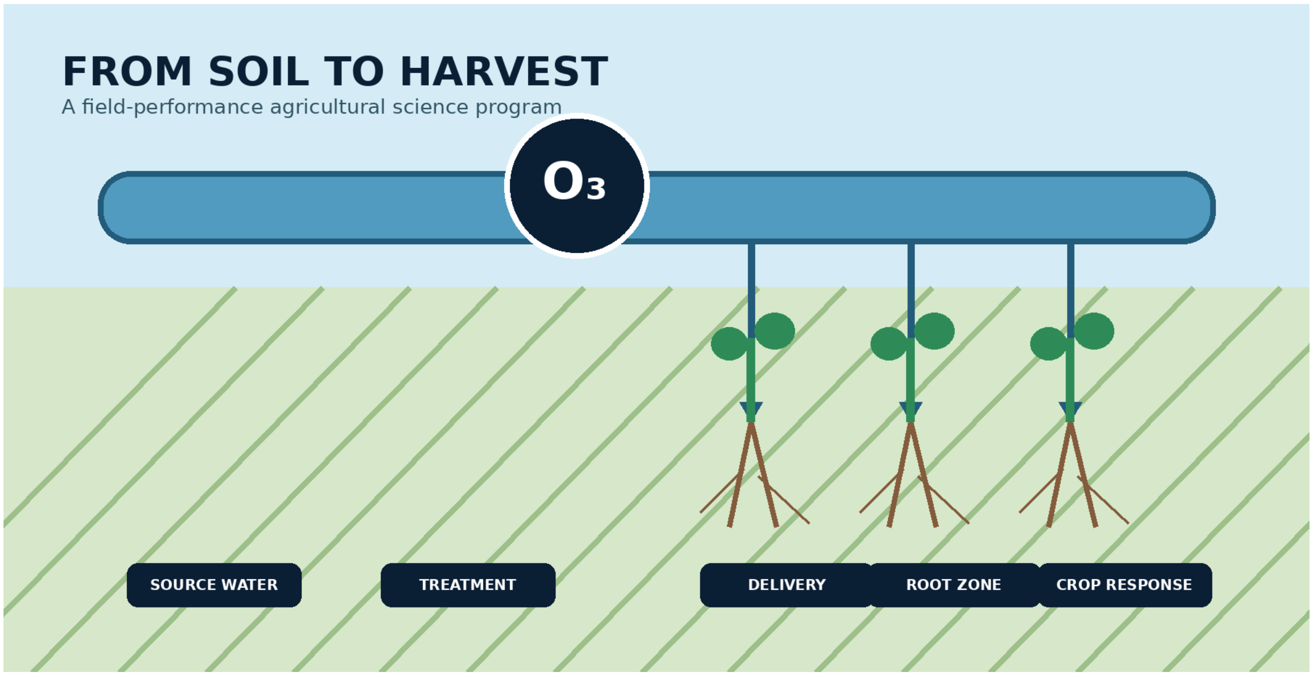
O3 AG Science Course Binder

From Soil to Harvest - Complete 15-Week Publication Master



O3 AG Science Institute

How to Use This Binder

O3 AG TECH INTEGRATION

O3 AG Tech is the app name only.

Live Farm is the primary/default app experience.

Training & Education is secondary and is used for course App Labs.

Training records remain separate from Live Farm production records.

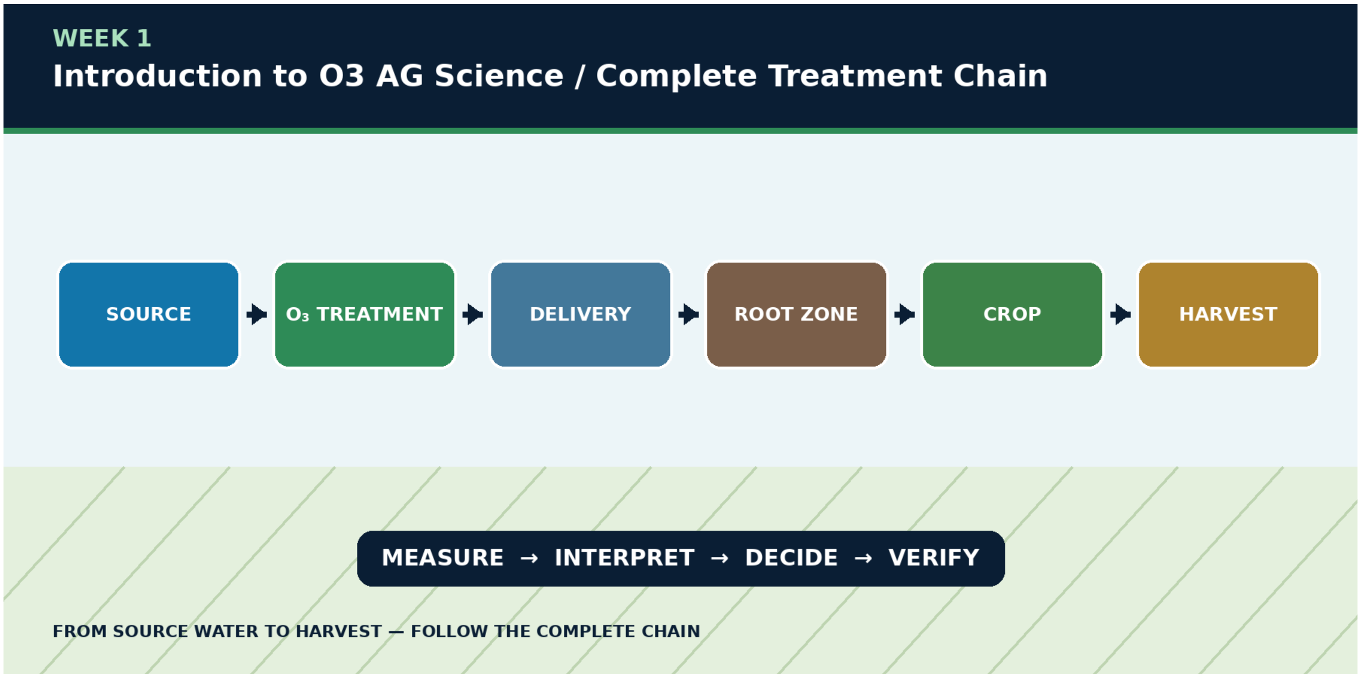
Course pattern: LESSON -> APP LAB -> DATA ENTERED -> TOOL / WORKFLOW -> DECISION -> REPORT -> COMPETENCY

15-Week Master Roadmap

Week	Topic	O3 AG Tech App Lab	Evidence
1	Introduction to O3 AG Science / Complete Treatment Chain	App Onboarding + Training Farm	System map + baseline field record
2	Water Quality, Nutrient Contribution & O3 AG Treatment Delivery	Baseline Water & Treatment Lab	Baseline comparison record
3	Living Soil, Carbon, Aeration & Root-Zone Management	Soil / Root-Zone Baseline Lab	Soil/root-zone baseline
4	CEC, Base Saturation & Nutrient Exchange	Nutrient & Test Interpretation Lab	Interpretation worksheet
5	Crop Nutrition & Fertility Planning	Water–Soil–Plant Record Lab	Field condition summary
6	Soil Biology, Microorganisms, Salts & the Root-Zone Environment	Crop / Growth-Stage Lab	Crop-stage record
7	Plant Physiology, Roots, Nutrient Transport & Crop Response	Testing Calendar Lab	Testing calendar + event record
8	Crop Stress, Plant Diagnostics & Corrective Management	Moisture Status Lab	Moisture-status result
9	Crop Management,	Irrigation Scheduling Lab	Standard irrigation

	Growth Stages & In-Season Decision Making		schedule
10	Field Performance, Yield, Quality & Economics	O3 AG Irrigation Dial-In Lab	O3 AG dial-in log + candidate baseline
11	Greenhouse, Hydroponic & Aquaponic O3 AG Systems	Compaction / Aeration Lab	Aeration decision record
12	O3 AG FIELD RESEARCH, DATA INTEGRITY & PROVING PERFORMANCE	End-of-Season Soil-Building Lab	Soil-building plan
13	O3 AG SYSTEM OPERATION, MONITORING, TROUBLESHOOTING & PROFESSIONAL FIELD PRACTICE	O3 AG System Operation Lab	O3 AG operating verification report
14	COMPREHENSIVE CAPSTONE & PROFESSIONAL CERTIFICATION	Integrated Case / Capstone Lab	Integrated field case file
15	WHOLE-SYSTEM IMPLEMENTATION & ANNUAL MANAGEMENT PLANNING	Whole-System Implementation Lab	Final next-crop action plan + competency record

WEEK 1 - Introduction to O3 AG Science / Complete Treatment Chain



Competencies

- Treatment-chain mapping
- O3/O2/DO/ORP differentiation
- Source-water baseline collection
- Sampling-point selection
- Transfer/contact/flow interpretation
- Treatment-event documentation
- Root-zone and crop evidence-chain interpretation

O3 AG Tech App Lab - Week 1

Lab: App Onboarding + Training Farm

Student action: Create student account; enter Training Mode; build a mock farm/field; map source → O3 treatment → delivery → root zone.

Data entered: Training farm, field ID, source/treatment/delivery points

Required evidence: System map + baseline field record

Week 1 Orientation: O3 AG and the Complete Agricultural Treatment Chain

Guided lesson time: 4 minutes

WEEK 1 — O3 AG TECHNOLOGY AND THE COMPLETE AGRICULTURAL TREATMENT CHAIN

What you will be able to do

By the end of this week, you should be able to map an O3 AG agricultural treatment system from source water to crop response; identify the major places where water and treatment conditions can be measured; explain O3, O2, dissolved oxygen (DO), and oxidation-reduction potential (ORP) in practical agricultural language; document a treatment event; and connect equipment operation to water, root-zone, plant, harvest, and economic observations.

Start with the whole system

O3 AG Science follows a complete chain: SOURCE / BASELINE → O3 TREATMENT → CONTACT / TRANSFER → DELIVERY → ROOT ZONE → BIOLOGY / NUTRIENTS → ROOTS / PLANT → HARVEST / QUALITY → ECONOMICS.

The first skill is learning to follow the water. Stand at the source and identify where the water originates, where treatment is introduced, where gas and water make contact, where water is stored or mixed, how it travels to the crop, and where it enters the root zone. Then continue beyond the irrigation hardware. Observe roots, soil or substrate conditions, crop growth, quality, harvest timing, yield, input use, and economics.

How to map a system

Draw the system as a line with arrows. Label: 1) source water, 2) baseline sampling point, 3) O3 AG treatment equipment, 4) transfer/contact point, 5) post-treatment sampling point, 6) storage or distribution components, 7) crop-delivery point, and 8) root-zone observation point. Add flow direction and any branches, reservoirs, filters, injectors, long pipe runs, or return-water loops.

This map becomes the student's first field tool. It tells you where to measure and helps you compare conditions through the system instead of treating the equipment as an isolated machine.

O3, O2, DO and ORP: What Each Shows and Why It Matters

Guided lesson time: 5 minutes

O3, O2, DO AND ORP — WHAT EACH SHOWS AND WHY IT MATTERS

O3 — Ozone

Ozone, written O3, is a molecule containing three oxygen atoms. In an O3 AG system it is generated and introduced into the treatment process because it is highly reactive. When ozone contacts substances that can be oxidized, it reacts and is consumed as part of that process. Measuring ozone at a defined location can demonstrate ozone presence at that sampling point and time. The practical lesson is to record where the sample was taken, when it was taken, and the operating and flow conditions at that moment.

O2 — Molecular oxygen

Molecular oxygen, written O2, contains two oxygen atoms. It is different from ozone. Oxygen availability matters throughout agricultural systems because roots and many beneficial aerobic organisms depend on oxygen for respiration. Water management, pore space, drainage, temperature, root activity, and microbial activity all influence the oxygen environment around roots.

DO — Dissolved oxygen

Dissolved oxygen, or DO, is oxygen gas dissolved in water. A DO meter reports how much dissolved oxygen is present in the water at the sampling location. Teach the student to rinse and prepare the probe according to the instrument instructions, allow the reading to stabilize, record water temperature, record the sampling location, and compare readings taken using the same method.

A useful O3 AG comparison can follow DO from source water to treated water and then to the delivery point. The positive value of the measurement is that it shows the oxygen condition of the water at those points and helps the student see whether the delivered water is carrying a different dissolved-oxygen condition toward the crop.

ORP — Oxidation-reduction potential

Oxidation-reduction potential, or ORP, describes the tendency of a water environment to participate in oxidation or reduction reactions. It is commonly expressed in millivolts. A more positive ORP generally indicates a more oxidizing environment, while a lower value indicates a more reducing environment. ORP becomes especially useful when the student records it consistently at defined points and follows change through treatment and delivery.

Put the measurements together

Use O3, DO, ORP, pH, temperature, electrical conductivity (EC), flow, and location as complementary pieces of the treatment record. The course approach is positive and evidence-based: WHAT IS IT? → HOW DO I MEASURE IT? → WHAT DOES THE READING SHOW? → WHY DOES THAT MATTER? → HOW DOES IT CONNECT TO O3 AG? → WHAT SHOULD I MEASURE NEXT? → HOW DO I VERIFY THE AGRICULTURAL RESPONSE?

A measurement is most valuable when it helps the student make the next correct observation or management decision.

Source-Water Demand: Learn the Water Before You Treat It

Guided lesson time: 4 minutes

SOURCE-WATER DEMAND — LEARN THE WATER BEFORE YOU TREAT IT

O3 AG treatment begins with the water that enters the system. Source water can differ between wells, canals, reservoirs, municipal supplies, recycled water, and recirculating greenhouse systems. Temperature, pH, electrical conductivity, dissolved and suspended material, organic matter, minerals, and other reactive constituents can influence treatment conditions.

How to establish a baseline

Before changing treatment, collect a baseline using a repeatable method. Record the source, date, time, sampling point, temperature, pH, EC, DO and ORP when those measurements apply, and flow or volume. Note visible color, turbidity, sediment, odor, algae or biological growth when relevant. If laboratory water analysis is available, attach it to the field record rather than trying to infer individual ions from EC alone.

Why baseline matters

The baseline gives the treated measurement something meaningful to compare with. If two farms have different source-water conditions, the same equipment settings may interact with different treatment demand. That is why O3 AG Science teaches the system rather than a single generator number.

Student procedure

Take the source sample first. Label the container or electronic record immediately. Measure temperature-sensitive values promptly. Use the same instrument, calibration procedure, sampling depth, and timing whenever possible. Then repeat the same measurements after treatment and at delivery. The objective is a comparable series, not a collection of unrelated numbers.

Field decision

When the source condition changes, document the change before interpreting downstream performance. Seasonal water changes, reservoir conditions, irrigation source changes, and large temperature changes can all become part of the treatment history. Good records let the agronomist connect a change in water to a change in treatment and then to the crop.

Transfer, Contact, Flow and Delivery: Follow the Treatment to the Crop

Guided lesson time: 5 minutes

TRANSFER, CONTACT, FLOW AND DELIVERY

Generation is the beginning of the process. Agricultural treatment depends on getting treatment into the water and moving that treated water through the actual irrigation system.

How to inspect the treatment path

Start at the O3 AG equipment and identify the gas path and water path. Locate the injection or transfer point. Identify the contact section, tank, loop, mixer, or other component used to bring gas and water together. Record water flow. Note pressure where it is part of system operation. Identify how long the water remains in contact or how far it travels before the first sampling point.

Flow matters

Flow connects equipment output to the amount of water being treated. A treatment event should therefore include the operating condition and the water flow or total volume whenever available. Students should learn to ask: How much water passed through? At what rate? Where was treatment introduced? Where was the sample taken? How long or how far did the treated water travel?

Delivery matters

Now follow the water away from the equipment. Mark reservoirs, filters, manifolds, main lines, laterals, emitters, pivots, drip tape, greenhouse benches, or return loops. Treatment conditions can change as water moves, mixes, warms, cools, contacts pipe surfaces, enters storage, or reacts with constituents in the water.

The crop-delivery point is therefore a major measurement location. It shows the condition of water where agriculture actually receives it. For a large field, more than one delivery location may be useful: near, middle, and far locations can help characterize distribution.

Worked example

A grower records source water at the pump, post-treatment water after the contact point, and delivered water at the end of a drip zone. The grower records pH, temperature, DO, ORP, EC, flow, treatment status, and sampling time at each point. The resulting sequence shows how water conditions changed through treatment and how much of that change remained at crop delivery. The next step is to pair those records with root-zone and crop observations.

From Delivered Water to Root Zone, Nutrients and Plant Response

Guided lesson time: 4 minutes

FROM DELIVERED WATER TO THE ROOT ZONE

The agricultural story continues after water leaves the emitter. Roots live in a pore system containing solids, water, gases, living organisms, organic material, and nutrients. Water application changes that environment, so the student must connect irrigation records to root-zone observations.

How to observe the root zone

Choose a representative plant and a representative irrigation location. Record soil or substrate type, moisture condition, drainage, compaction or restriction, rooting depth, root color and branching, odor or signs of anaerobic conditions, and visible biological or organic-material conditions. Where instruments are available, add volumetric water content (VWC), EC, temperature, pH, or other measurements appropriate to the production system.

Connect nutrients correctly

Water carries dissolved nutrients and affects nutrient movement toward roots. Root activity, moisture, aeration, pH, biological processes, fertilizer source, soil properties, and crop demand all influence nutrient availability and uptake. Week 1 introduces this connection; later weeks teach the calculations and interpretation in depth.

Observe the plant

Record crop, variety, planting or emergence date, growth stage, plant vigor, leaf condition, canopy development, stress patterns, and any available quality measurements. Photographs should be taken from consistent locations when possible. The purpose is to build a sequence that can be compared over time.

Positive evidence chain

The student learns to build a connected record: source condition → treatment condition → delivered-water condition → root-zone condition → plant response. Later the same record extends to harvest date, total growing days, yield, quality, fertilizer and water inputs, and economics. This is how O3 AG performance becomes something a student can document, analyze, and communicate.

How to Document an O3 AG Treatment Event

Guided lesson time: 4 minutes

HOW TO DOCUMENT AN O3 AG TREATMENT EVENT

A professional field record should allow another trained person to understand what happened without relying on memory.

Step 1 — Identify the event

Record farm/site, field or zone, crop, date, start and stop time, operator, water source, and reason for the irrigation or treatment event.

Step 2 — Record system conditions

Record O3 AG system status and the operating settings that are part of the approved equipment procedure. Record flow rate or total water volume, relevant pressure, contact/delivery configuration, maintenance condition, and any unusual event.

Step 3 — Record measurements by location

Use clearly named sampling points such as SOURCE, POST-TREATMENT, DELIVERY-NEAR, DELIVERY-FAR, and ROOT ZONE. At each point record the applicable measurements and units. Never write a number without a unit when a unit is required.

Step 4 — Record agricultural observations

Add irrigation amount, root-zone moisture, root observations, crop stage, visible plant response, and any pest, disease, nutrient, or stress observations. Take photographs using a repeatable viewpoint when possible.

Step 5 — Compare and interpret

Ask: What changed from source to treatment? What condition reached the crop? What changed in the root zone or plant over time? Is the pattern consistent across the field? What measurement should be repeated at the next event?

Step 6 — Verify over time

One treatment event is a data point. A repeated series becomes a management record. Consistent sampling allows the grower or agronomist to see trends, compare management periods, and connect treatment records with crop performance, harvest, and economics.

Week 1 Field Lab, Worked Scenario and Mastery Gate

Guided lesson time: 4 minutes

WEEK 1 FIELD LAB — MAP, MEASURE, INTERPRET, VERIFY

Field/Lab option

Draw or photograph an actual treatment system. Label source, baseline sample, O3 AG treatment, contact/transfer, post-treatment sample, distribution, crop-delivery sample, and root-zone observation point. Add flow direction. Identify at least three places where water conditions may change.

Collect or review the available measurements at those points. For each measurement write: what it is, how it was measured, what the value shows at that location, why it matters, and what you would measure or observe next.

Verified case-study option

If direct field access is not available, use a supplied O3 AG case-study data package. Reconstruct the treatment chain, organize the measurements by location and time, and explain the agricultural response sequence supported by the case data.

Worked interpretation

Suppose source and delivered water have measurements for temperature, pH, DO, ORP, and EC, plus treatment status and flow. Do not simply circle the largest number. Put the values in treatment-chain order. Describe the change from source to post-treatment and from post-treatment to crop delivery. Then connect the water record to root-zone observations. Finally identify the next crop measurement that would strengthen the performance record.

Mastery gate

To complete Week 1, the student should be able to: map the complete treatment chain; correctly distinguish O3, O2, DO and ORP; establish a source-water baseline; identify appropriate sampling locations; explain why flow, transfer, contact and delivery matter; document a treatment event; and connect water measurements to root-zone and plant observations.

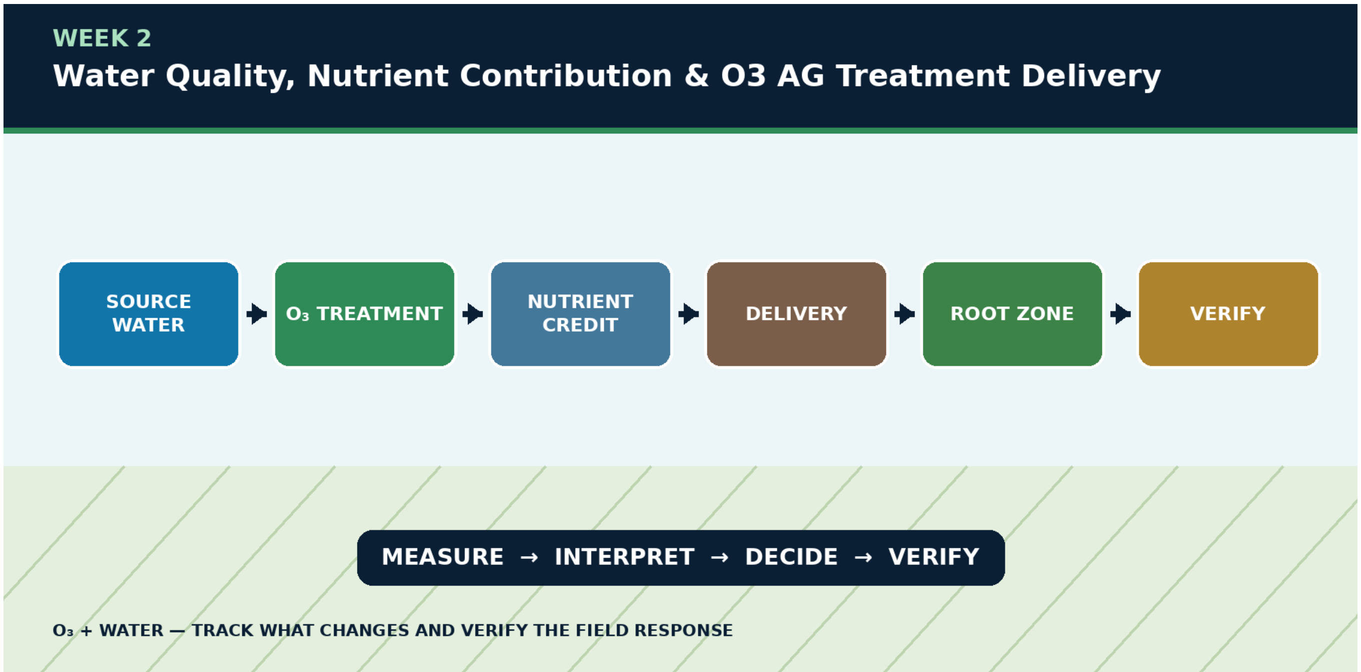
Week 1 field record

Submit the treatment-chain map plus one completed measurement/observation record. The record becomes the first item in the student's O3 AG Science field portfolio and establishes the format used in later weeks.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	______________________

WEEK 2 - Water Quality, Nutrient Contribution & O3 AG Treatment Delivery



Competencies

- Source-water baseline collection
- pH/alkalinity/EC/TDS interpretation
- Water nutrient and ion interpretation
- Water nutrient mass calculation
- Nitrogen-form recognition
- O3/O2/DO/ORP measurement interpretation
- Treatment-chain sampling
- Irrigation-volume documentation
- Root-zone verification
- Water-to-nutrition evidence-chain documentation

O3 AG Tech App Lab - Week 2

Lab: Baseline Water & Treatment Lab

Student action: Enter baseline water/treatment observations and practice consistent sampling records.

Data entered: Water/sample record, units, sampling point, operating conditions

Required evidence: Baseline comparison record

2.1 Irrigation Water Is Part of the Fertility System

Guided lesson time: 4 minutes

2.1 Irrigation Water Is Part of the Fertility System

Water is not an empty carrier. A source can contain measurable nitrate and other nitrogen forms, calcium (Ca), magnesium (Mg), potassium (K), sulfur or sulfate, sodium (Na), chloride, bicarbonate and other dissolved constituents. Those materials enter the farm every time irrigation water is applied.

The first practical skill is to build a source-water baseline. Identify the source, date, sample location, flow condition and temperature. Record pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), alkalinity or bicarbonate, and a laboratory ion analysis where nutrient accounting is needed.

How to do it

1. Collect a representative source-water sample before treatment or fertilizer injection.

2. Use clean containers and the laboratory's sampling instructions.

3. Record the source and exact sampling point.

4. Measure field parameters with calibrated instruments.

5. Request individual nutrient/ion concentrations when the purpose is nutrient budgeting.

6. Enter both concentration and irrigation volume into the water nutrient record.

What it shows

The analysis establishes what the irrigation water is already bringing to the production system. This lets the student treat water as a measurable input in the nutrient budget instead of assuming every nutrient must come from purchased fertilizer.

O3 AG connection

O3 AG treatment does not create mineral elements from nothing. The agricultural question is whether treatment changes the water and root-zone environment in ways that improve delivery, cycling, accessibility or crop uptake of nutrients already present. That response is demonstrated by following the water, root zone and crop with measurements over time.

2.2 pH, Alkalinity, EC and TDS — Read the Water Correctly

Guided lesson time: 4 minutes

2.2 pH, Alkalinity, EC and TDS — Read the Water Correctly

pH describes acidity or basicity. Alkalinity describes acid-neutralizing capacity and is often influenced by bicarbonate and carbonate. Electrical Conductivity (EC) describes the water's ability to conduct electricity and is useful as an indicator of the overall ionic environment. Total Dissolved Solids (TDS) is an estimate or measurement of dissolved material, depending on the method used.

How to do it

Record every value with units, sample point, date, time and temperature. For EC, record units such as millisiemens per centimeter (mS/cm). For TDS, record milligrams per liter (mg/L) or parts per million (ppm) and note whether the value came from a laboratory or was estimated by a meter from EC.

Two waters can have similar TDS or EC but contain very different ions. One may contain useful calcium and magnesium while another may contain more sodium or chloride. Therefore, use TDS and EC to understand the overall dissolved/ionic load, and use laboratory analysis to identify what makes up that load.

What it shows

Repeated EC and TDS readings are valuable for following change through a system. Individual ion results explain the agricultural meaning of that dissolved material.

O3 AG connection

Compare source, treated and delivered water under consistent conditions. A change in a field reading is a signal to investigate the chemistry and treatment chain. The goal is to connect the water measurement to nutrient delivery and the crop response rather than treating a single number as the entire answer.

2.3 Nitrogen, Calcium, Magnesium and Other Nutrients in Irrigation Water

Guided lesson time: 5 minutes

2.3 Nitrogen, Calcium, Magnesium and Other Nutrients in Irrigation Water

A laboratory water report can become a fertilizer-management tool when the student knows how to read it. Pay particular attention to nitrogen reported as nitrate, nitrate-nitrogen or other stated forms; calcium (Ca); magnesium (Mg); potassium (K); sulfur or sulfate; sodium (Na); chloride; bicarbonate/alkalinity; and other constituents important to the crop or water source.

Read the units before calculating

A concentration reported as nitrate (NO_3) is not numerically the same as nitrate-nitrogen (NO_3-N). The report's stated form must be preserved. Do not convert or credit nitrogen until the reported form is known.

Calcium and magnesium in irrigation water can contribute real pounds of nutrients over a season. Sodium, chloride and bicarbonate are also important because their accumulation and balance can affect soil and irrigation management. The student should learn to see both nutrient value and potential management concerns in the same water analysis.

How to build the nutrient inventory

1. List each constituent exactly as the laboratory reports it.

2. Record concentration and units.

3. Record the irrigation volume applied to the acre or production area.

4. Convert the water concentration into pounds delivered.

5. Decide which portion can legitimately be counted as a nutrient credit using the applicable crop, soil and agronomic recommendation.

6. Verify with soil, tissue/sap, root and crop observations as appropriate.

This creates a bridge from water chemistry to fertility planning.

2.4 Water Nutrient Credit Calculator — Learn the Math

Guided lesson time: 5 minutes

2.4 Water Nutrient Credit Calculator — Learn the Math

The app calculator is a tool, but students first learn the calculation.

Core calculation

When a constituent is reported in milligrams per liter (mg/L), the pounds delivered are calculated from concentration and water volume.

Pounds delivered = **mg/L** × **gallons applied** × **8.3454** ÷ **1,000,000**

Because one acre-inch is approximately 27,154 gallons, an equivalent shortcut is:

Pounds per acre per acre-inch ≈ mg/L × 0.2266

Worked example

Assume a water analysis reports calcium at 40 mg/L and the field receives 12 acre-inches of that water during the season.

40 × 0.2266 × 12 ≈ **108.8 pounds of calcium delivered per acre**.

That number is a delivered mass, not automatically a fertilizer recommendation or a guarantee that all 108.8 pounds are plant available. The student now asks how much is relevant to the crop program, what the soil already contains, and what the calibrated recommendation allows as a credit.

Student workflow

Enter concentration → enter irrigation volume → calculate delivered pounds → identify the reported nutrient form → determine an appropriate credit → calculate remaining requirement → document the decision.

For nitrogen, the calculator must require the student to specify whether the laboratory reports nitrate, nitrate-nitrogen, ammonium-nitrogen or another form before a nutrient credit is calculated.

Why this matters

A farm applying large volumes of mineral-bearing water may be bringing substantial nutrient mass into the field. Measuring that contribution can improve fertilizer accounting and later helps the student evaluate synthetic-to-organic nutrient transitions without guessing.

2.5 O3, O2, Dissolved Oxygen and ORP — Follow Positive Change

Guided lesson time: 4 minutes

2.5 O3, O2, Dissolved Oxygen and ORP — Follow Positive Change

O3 is ozone. O2 is molecular oxygen. Dissolved Oxygen (DO) is molecular oxygen dissolved in water. Oxidation-Reduction Potential (ORP) describes the oxidation-reduction condition of the solution.

How to measure

Use calibrated instruments appropriate to the measurement. Record water temperature with DO. Record ORP with the sample point and conditions. Where ozone concentration is measured, use the approved method and record the location and time relative to treatment.

What the measurements show

Ozone measurements can show ozone presence at the measured location and time. DO shows the concentration of dissolved molecular oxygen in the water. ORP helps characterize whether the measured water environment is more oxidizing or reducing. Together with pH, temperature, flow and chemistry, these readings help students follow treatment through the water system.

Why the changes matter

Roots and aerobic biological processes depend on an appropriate oxygen environment. Water chemistry, organic/reduced material, temperature, contact and biological demand influence what happens as treated water moves through the system.

O3 AG connection

The student follows the evidence chain: treatment conditions → water measurements → delivery measurements → root-zone conditions → nutrient measurements → tissue/crop response. This teaches students how to demonstrate beneficial change with field evidence.

2.6 Sampling Chain, Irrigation Volume and Root-Zone Verification

Guided lesson time: 4 minutes

2.6 Sampling Chain, Irrigation Volume and Root-Zone Verification

A useful treatment study follows the same water through defined locations. Depending on the system, use source water, before treatment, after treatment/contact, midpoint, end of line or emitter, root-zone delivery and return water where appropriate.

Keep comparisons consistent

Sample under comparable flow and operating conditions. Record date, time, treatment status, flow, pressure where relevant, temperature, irrigation set, fertilizer injection status and recent management events.

Irrigation quantity matters

Concentration alone does not tell the student how many pounds of a nutrient entered the field. The total water volume is required. Record gallons, acre-inches or another defined unit and convert it consistently.

Root-zone verification

After water reaches the field, examine infiltration, moisture distribution, compaction, pore space, root depth, root color/condition and signs of prolonged saturation. Where appropriate, compare soil solution, soil test, tissue/sap analysis and crop response.

The purpose is to connect what was delivered in the water to what happened in the soil–root–plant system.

2.7 Field Lab — Build the Water-to-Nutrition Evidence Chain

Guided lesson time: 4 minutes

2.7 Field Lab — Build the Water-to-Nutrition Evidence Chain

The Week 2 field lab turns the lesson into a working agricultural investigation.

Student assignment

Create a Water-to-Nutrition Record for one field, greenhouse, orchard or other production system.

Record:

- water source and sampling locations;
- pH, EC, TDS, temperature, DO and ORP where applicable;
- laboratory nitrogen form and concentration;
- calcium, magnesium, potassium, sulfur/sulfate, sodium, bicarbonate/alkalinity, chloride and other relevant constituents;
- irrigation volume;

- calculated pounds delivered per acre or production area;
- fertilizer and organic nutrient inputs;
- root-zone observations;
- tissue/sap or other crop measurements when available;
- O3 AG treatment conditions;
- follow-up measurements and crop response.

Interpretation

The student explains which nutrients the water is contributing, which measurements changed through treatment and delivery, how the root-zone environment responded, and what additional measurement should be collected next.

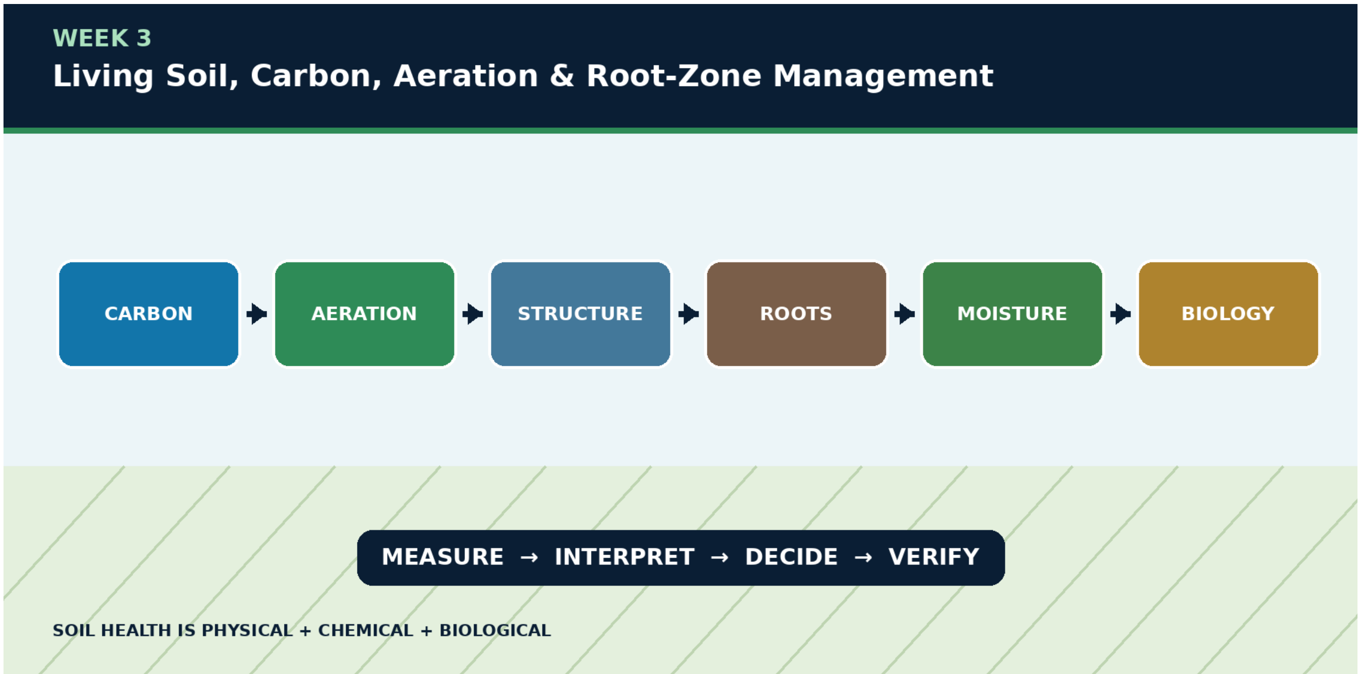
Mastery gate

The student must demonstrate that they can distinguish TDS from individual nutrient analysis, calculate nutrient mass from water, preserve the reported nitrogen form, follow the sampling chain, and connect O3 AG water measurements to root-zone and crop evidence.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 3 - Living Soil, Carbon, Aeration & Root-Zone Management



Competencies

- Living soil assessment
- Carbon-pool interpretation
- Organic matter and nutrient-cycle explanation
- Amendment timing and nitrogen-immobilization planning
- Biochar evaluation and conditioning
- Compaction/aeration diagnosis
- Nutrient placement and efficiency calculation
- Management-input/biology evaluation
- Field-variable identification
- Paired-zone verification

O3 AG Tech App Lab - Week 3

Lab: Soil / Root-Zone Baseline Lab

Student action: Create soil/media profile and enter a practice soil/root-zone test.

Data entered: Soil/media type, depth, test values, field notes

Required evidence: Soil/root-zone baseline

3.1 The Living Soil: Organic Matter, Water & Nutrient Storage

Guided lesson time: 4 minutes

3.1 The Living Soil: Organic Matter, Water & Nutrient Storage

A productive root zone is more than mineral particles and fertilizer. It is a changing system made of sand, silt and clay; pores containing air and water; living roots; microorganisms; fresh residues; decomposing organic materials; and more persistent soil organic matter.

Organic material matters because it helps connect three resources the crop needs: **water, nutrients and biological activity**. Organic matter can improve aggregation and pore structure, contribute to water-holding capacity, provide exchange sites that retain positively charged nutrients, and supply carbon and nutrients that enter biological cycling.

How to evaluate it

1. Dig at least one representative soil profile and one comparison profile.

2. Record surface residue, color, aggregation, rooting depth, visible pores and moisture by depth.

3. Obtain laboratory soil organic matter or soil organic carbon where available.

4. Record soil texture, pH, Electrical Conductivity (EC) and Cation Exchange Capacity (CEC) when available.

5. Compare productive and weak areas rather than assuming one sample represents the whole field.

Field Variables & Verification: soil can change over a short distance. Record the location and conditions so a future sample can be compared with the same zone.

3.2 Carbon Continuum: Liquid, Active, Organic & Persistent Carbon

Guided lesson time: 5 minutes

3.2 Carbon Continuum: Liquid, Active, Organic & Persistent Carbon

Not all carbon behaves the same way. Students must learn the difference between rapidly available carbon and carbon that persists for years.

Dissolved or liquid organic carbon includes carbon-containing compounds dissolved in soil water. Some fractions can be used rapidly by microorganisms and can move with water through the root zone.

Active/decomposable organic carbon includes relatively fresh roots, residues, compost fractions and microbial materials that can be transformed over shorter time scales. Microorganisms use carbon for energy and growth while nutrients may be mineralized or temporarily immobilized.

Soil organic carbon and more stabilized organic matter represent a mixture of materials with different turnover times. These pools contribute to soil structure, nutrient retention and long-term soil function.

Persistent carbon such as biochar can remain much longer than readily decomposable residues. Biochar properties vary with feedstock and production conditions. Its porosity, surface chemistry, pH, ash and nutrient content can influence water and nutrient interactions, but it is not a universal fertilizer and should be evaluated before use.

Carbon cycle students should be able to explain

Plant/root residue + organic inputs → microbial use and decomposition → nutrient immobilization/mineralization → microbial products and stabilized organic matter → nutrient/water retention and plant access → crop growth → new roots and residues → cycle repeats.

The practical lesson is not to chase one carbon number. Identify **which carbon pool is being measured, what management created it, and what soil function is expected to change**.

3.3 The "Mud Layer," Humic Materials & Nutrient Recycling

Guided lesson time: 4 minutes

3.3 The "Mud Layer," Humic Materials & Nutrient Recycling

O3 AG field discussions sometimes use the term **mud layer** for a dark, biologically active, organic-rich zone seen near the surface or root zone. In this course, that field term must be connected to what is actually present.

A dark layer can contain mineral soil, fine particles, water, living and dead roots, decomposing crop residue, microbial biomass and products, and more stabilized organic matter. It should not automatically be labeled a single "humic layer" without observation or analysis.

How nutrients are recycled

Organic residues contain nutrients in organic and mineral forms. Soil organisms break down and transform those materials. During **mineralization**, nutrients can be converted into inorganic forms that may become available to plants. During **immobilization**, microorganisms temporarily incorporate available nutrients into microbial biomass. As organisms and roots turn over, nutrients continue cycling.

Field procedure

Excavate the zone rather than judging only the surface. Record depth, color, odor, moisture, roots, residue decomposition and structure. Compare it with a second location. If the management question depends on nutrient status, collect a properly handled laboratory sample.

The goal is to teach the student to follow the cycle: **organic input → biological processing → nutrient pool → root access → crop uptake → residue return**.

3.4 Amendment Timing, Biochar Conditioning & Avoiding Early-Crop Stall

Guided lesson time: 4 minutes

3.4 Amendment Timing, Biochar Conditioning & Avoiding Early-Crop Stall

Some amendments need time to interact with soil before peak crop demand. Fall, rotation windows or sufficiently early pre-plant periods can be useful opportunities for selected composts, manures, carbon materials, biochars and heavier nutrient programs when the product, crop, climate and regulations make that timing appropriate.

A high-carbon, low-nitrogen material can stimulate microbial demand for nitrogen during decomposition. This **temporary nitrogen immobilization** can reduce the nitrogen immediately available to a young crop. That is why students must know the amendment analysis and timing instead of assuming every organic input supplies nutrients immediately.

Biochar also deserves preparation. Depending on the product and objective, conditioning it with compost or appropriate nutrient-containing materials before or during incorporation may help integrate it into the fertility program. Product pH, salinity, ash, nutrient analysis and application rate still matter.

Pre-plant amendment decision

Know the amendment → review analysis → evaluate soil test → identify crop and planting date → estimate nutrient availability → choose timing and placement → incorporate/condition when appropriate → maintain suitable moisture → retest/verify → supply remaining crop need.

Do not teach “fall application” as a universal rule. Teach **lead time matched to material, climate, crop demand and field conditions**.

3.5 Aeration, Nutrient Placement & Fertilizer-Use Efficiency

Guided lesson time: 5 minutes

3.5 Aeration, Nutrient Placement & Fertilizer-Use Efficiency

Aeration or appropriate soil loosening can be valuable when a restrictive layer, surface sealing or poor infiltration is limiting root exploration and water movement. It can also create an opportunity to place selected nutrients or amendments where they can interact with soil and roots rather than remaining entirely on the surface.

But aeration is a **diagnosed management tool**, not an automatic treatment. Excessive disturbance can damage aggregation, increase erosion risk and accelerate organic-matter loss. First determine whether a physical restriction exists.

How to make the decision

1. Measure compaction by depth under comparable moisture conditions.

2. Excavate roots and identify where rooting changes.

3. Compare infiltration and soil structure in productive and weak zones.

4. Review the soil test and nutrient requirement.

5. Select nutrient source, rate, timing and placement.

6. Aerate/incorporate only where agronomically appropriate.

7. Record rainfall or irrigation following application.

8. Retest soil/plant response and calculate yield and economics.

Surface application example — verify locally

O3 AG field observations have included cases where surface-applied fertilizer appeared to achieve roughly **28% utilization** under the conditions measured. This is an **illustrative O3 AG field observation, not a universal constant**. Actual efficiency can change with nutrient source, soil texture, organic matter, microbial activity, placement, rainfall, irrigation, temperature, humidity, wind, crop demand and many other variables.

Students therefore calculate their own result when adequate data are available:

Apparent nutrient-use efficiency (%) = measured crop nutrient uptake attributable to the program ÷ nutrient applied × 100

For economics:

Fertilizer cost per bushel = fertilizer program cost per acre ÷ marketable bushels per acre

or

Fertilizer cost per ton = fertilizer program cost per acre ÷ marketable tons per acre

The goal is not the lowest pounds applied. The goal is an efficient, verified program that protects yield, quality, soil function and profitability.

3.6 Management Chemistry, Biology & the Root-Zone Environment

Guided lesson time: 4 minutes

3.6 Management Chemistry, Biology & the Root-Zone Environment

Every input becomes part of the field environment. Herbicides, insecticides, fungicides, fertilizers, organic amendments and irrigation practices can influence soil and root-zone biology directly or indirectly. The response depends on the active ingredient or material, rate, frequency, soil chemistry, moisture, temperature, crop and organisms present.

Herbicides should **not** be taught as though most are antibiotics. Some agricultural chemicals can affect particular microorganisms or biological processes, but effects differ by chemistry and conditions. Likewise, mineral fertilizer is not automatically harmful to microorganisms. Poorly managed or excessive inputs can contribute to salinity, osmotic stress, pH shifts or nutrient imbalance, while well-managed fertility can support productive crop growth and residue return.

How to evaluate management effects

Build a management history: products, rates, dates, placement, irrigation, tillage/aeration and crop rotation. Then compare that history with soil EC, pH, organic matter, roots, residue decomposition, infiltration, crop condition and appropriate biological or laboratory measurements.

For a transition toward greater use of organic nutrient sources, use a measured sequence: **baseline → identify excess/unnecessary inputs → improve carbon and water management → calculate nutrient credits → introduce appropriate organic sources → reduce synthetic inputs only where measurements justify it → monitor crop response → verify and adjust**.

3.7 O3 AG Field Variables & Consistency Lab

Guided lesson time: 4 minutes

3.7 O3 AG Field Variables & Consistency Lab

Agriculture contains interacting variables. Even within a few feet, soil texture, organic matter, compaction, drainage, moisture, roots and nutrient status may differ. Management adds more variables: crop rotation, tillage, aeration, fertilizer source and placement, organic versus conventional programs, pesticide history, irrigation and equipment traffic. Weather adds temperature, rainfall, humidity, wind and heat stress. The crop adds genetics, planting date, growth stage, pest and disease pressure.

O3 AG cannot remove weather or make every soil identical. The management objective is to use the O3 AG system as part of a program that can help the grower manage water, treatment delivery and root-zone conditions more consistently, then **measure whether crop nutrition and performance become more consistent**.

Paired-zone field lab

Select at least one weak/problem zone and one productive comparison zone. At each location record GPS/field position, soil type/texture, management history, residue and organic layer, compaction by depth, infiltration, moisture, roots, pH/EC where appropriate, irrigation-water information, O3 AG treatment conditions, crop stage and photographs. Add laboratory soil/tissue data where the management question requires them.

Classify evidence in four ways:

- **O3 AG Verified Field Result** — documented result from O3 AG field-performance records.
- **Agronomic Reference** — external agricultural science used to explain or contextualize a process.
- **Illustrative Example** — a number used to teach a calculation or decision.
- **Student/Operation Result** — the result measured under the student's own conditions.

Finish with: **Observe → Measure → Compare → Interpret → Manage → Retest → Verify.**

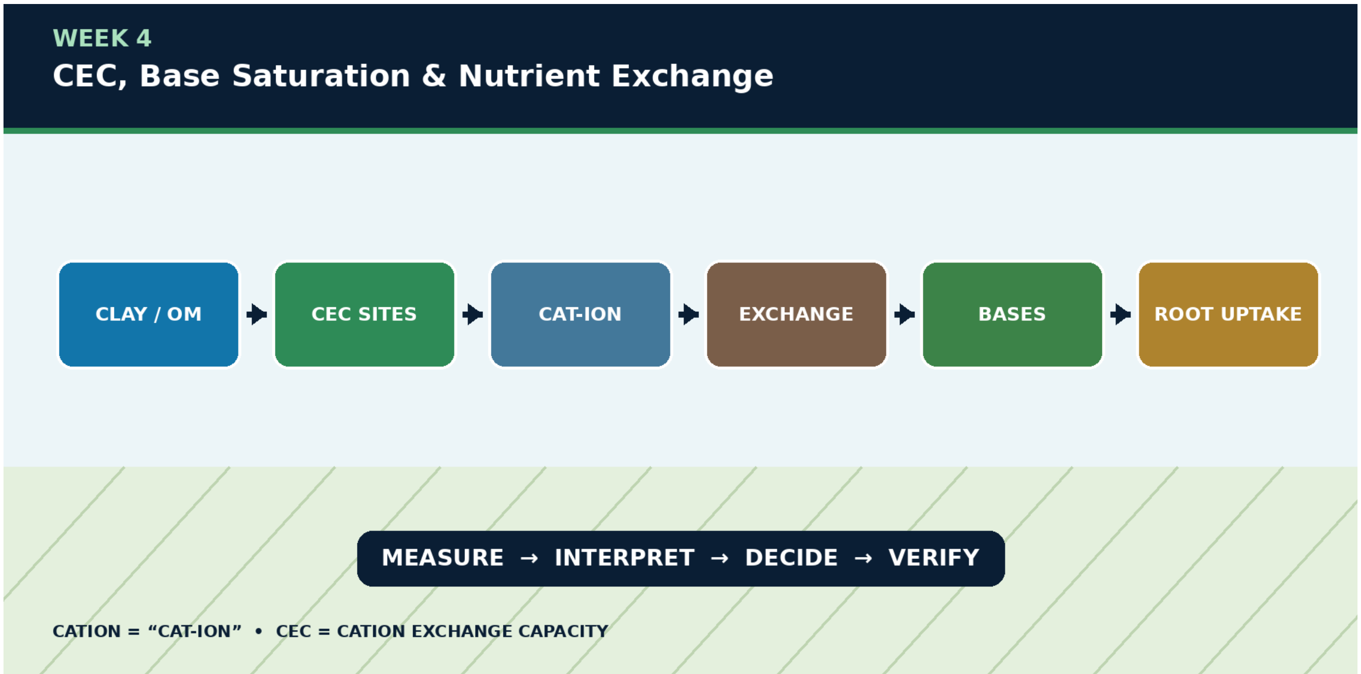
Week 3 mastery evidence

The student submits a Living Soil & Root-Zone Assessment and explains which variables differ between zones, which conclusions are supported now, and which require more measurements.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 4 - CEC, Base Saturation & Nutrient Exchange



Competencies

- Explain CEC as exchange capacity rather than a fertilizer recommendation
- Calculate base saturation from compatible charge-based laboratory values
- Build and interpret the 100-block Soil Exchange Parking Lot model
- Distinguish CEC capacity from base-saturation percentage
- Explain how organic matter and carbon contribute to nutrient holding and cycling
- Distinguish cation exchange from nitrate, phosphate, sulfate, micronutrient, and carbon pathways
- Integrate irrigation-water nutrient contributions with soil and amendment data
- Compare organic and soluble/mineral nutrient sources by release, carbon contribution, timing, and salt considerations
- Explain and evaluate O3 AG influence through the water–soil–root-zone environment without claiming element creation
- Make and document a nutrient-management decision with a verification plan
- Diagnose nutrient antagonism and tie-up
- Differentiate tied/bound, stored/reserve, exchangeable, available, root-accessible, uptaken, and used nutrient pools
- Evaluate O3 AG/oxygen/redox influence on nutrient-pool movement using measured evidence
- Explain how O3 AG can influence nutrient accessibility through oxidation/redox, oxygen, biology and root-zone conditions
- Distinguish added nutrient, changed nutrient accessibility, and improved plant access using measured evidence

O3 AG Tech App Lab - Week 4

Lab: Nutrient & Test Interpretation Lab

Student action: Enter practice nutrient/test data and identify what needs verification before action.

Data entered: Nutrient/test values, units, methods, source

Required evidence: Interpretation worksheet

4.1 The Soil Exchange System: Capacity, Solution & Roots

Guided lesson time: 4 minutes

4.1 The Soil Exchange System: Capacity, Solution & Roots

Week 4 connects water, living soil, carbon, nutrients, and roots into one working nutrient-exchange system. Cation Exchange Capacity (CEC) describes the soil's capacity to retain and exchange positively charged ions. Think of CEC as the size of a nutrient parking area, not as a fertilizer recommendation.

The exchange sites are associated mainly with clay minerals and soil organic matter. Their negative charges attract positively charged ions such as calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), sodium (Na^+), and ammonium (NH_4^+). These ions can move between exchange sites and the soil solution. Roots obtain nutrients from the soil solution, while exchange reactions can help replenish that solution.

The nutrient journey

Nutrient source → soil solution → exchange sites → release/exchange → rhizosphere → root uptake → plant use → residue/root return → microbial recycling → nutrient pool.

This is a dynamic system. A nutrient can be present in the soil without being immediately available to the crop. The student will use six stages throughout this course: **Present → Held → Exchangeable → Available → Uptaken → Used.**

How to do it

1. Obtain a soil report and identify CEC and exchangeable cations.

2. Record soil texture, organic matter, pH, sampling depth, crop, and field zone.

3. Identify the water source and carry forward relevant water nutrient data from Week 2.

4. Compare the soil report with root condition and, when available, plant tissue data.

5. Ask where each nutrient is in the six-stage pathway before deciding to add more.

Field Variables & Verification: CEC and nutrient behavior vary with mineralogy, texture, organic matter, pH, moisture, temperature, root activity, water chemistry, management, and crop demand. Interpret the numbers in context.

4.2 Build the 100-Block Soil Exchange “Parking Lot”

Guided lesson time: 4 minutes

4.2 Build the 100-Block Soil Exchange “Parking Lot”

The 100-block model turns base saturation into something students can see. Imagine 100 teaching blocks representing 100 percent of the exchange complex. If a laboratory calculation shows 60% calcium saturation, 60 of the 100 blocks are assigned to calcium. If magnesium is 15%, 15 blocks are magnesium, and so on.

The model is a visualization of percentages, not a claim that every soil should have one fixed distribution.

Base-saturation calculation

Cation base saturation (%) = exchangeable cation ÷ CEC × 100

Use compatible charge-based units such as cmolc/kg (or meq/100 g where reported equivalently). Do not divide ppm directly by CEC without converting the laboratory values appropriately.

Worked teaching example

Assume CEC = 20 cmolc/kg and exchangeable calcium = 12 cmolc/kg.

Calcium saturation = 12 ÷ 20 × 100 = **60%**.

If magnesium = 3, potassium = 0.8, and sodium = 0.4 cmolc/kg, their teaching-model saturations are 15%, 4%, and 2%. These figures are illustrative, not universal targets.

Student activity

Build a 100-block model from a real soil report. Label every value as measured, calculated, or unknown. If the laboratory reports percentages directly, compare your calculation with the laboratory result and investigate any difference in method or reporting basis.

4.3 CEC Capacity vs. Base Saturation: Same Percent, Different Reserve

Guided lesson time: 4 minutes

4.3 CEC Capacity vs. Base Saturation: Same Percent, Different Reserve

CEC and base saturation answer different questions. CEC describes exchange capacity. Base saturation describes how a portion of that capacity is occupied by base cations.

Two soils can both show 60% calcium saturation while holding very different quantities of exchangeable calcium. A low-CEC sandy soil has a smaller exchange reservoir. A higher-CEC soil containing more clay and/or organic matter can have a larger exchange reservoir.

Worked comparison

Soil A: CEC 5, calcium saturation 60% → exchangeable Ca equivalent = 3 cmolc/kg.

Soil B: CEC 25, calcium saturation 60% → exchangeable Ca equivalent = 15 cmolc/kg.

The percentage is the same. The amount represented by the exchange complex is not.

Management lesson

This is why the same fertilizer rate, timing, or placement should not automatically be copied from one field to another. Lower-CEC soils may require closer attention to timing and smaller or split applications for some nutrients. Higher-CEC soils may hold larger exchangeable pools, but high capacity does not guarantee that roots can access them under every condition.

Students should ask: **How big is the exchange system? What occupies it? What is in solution? What does the crop require? What are the roots actually taking up?**

4.4 Organic Matter, Carbon & Nutrient-Holding Capacity

Guided lesson time: 4 minutes

4.4 Organic Matter, Carbon & Nutrient-Holding Capacity

Week 3 introduced active carbon, decomposable organic materials, stabilized organic matter, and persistent carbon such as biochar. Week 4 shows why those materials matter to nutrient exchange.

Soil organic matter can contribute substantial negatively charged exchange surfaces, especially as pH-dependent functional groups develop charge. It also influences aggregation, water retention, microbial habitat, and nutrient cycling. Building organic matter can therefore strengthen the overall nutrient-management system, but it does not instantly convert every nutrient into plant-available form.

Organic nutrient sources

Compost, manure, residues, cover crops, and other organic amendments can contribute carbon and nutrients. Some nutrients are present in organic forms and require biological decomposition and mineralization before plants can use them. Timing, moisture, temperature, C:N characteristics, amendment analysis, and microbial activity influence release.

Soluble/mineral nutrient sources

Many mineral fertilizers supply nutrients in soluble or readily transformed forms and can meet immediate crop demand efficiently when rate, timing, placement, and water management are appropriate. They generally contribute little carbon and can increase salt concentration if overapplied or poorly placed.

Professional decision

The goal is not to label one source “good” and another “bad.” The goal is to account for **all sources**, understand their release behavior, protect the root zone, and supply crop demand efficiently while building long-term soil function where appropriate.

4.5 Whole Nutrient System: Not Every Nutrient Uses the Same Parking Space

Guided lesson time: 4 minutes

4.5 Whole Nutrient System: Not Every Nutrient Uses the Same Parking Space

The parking-lot model is specifically a cation-exchange teaching model. Not every essential nutrient behaves the same way.

Cations: Ca^{2+}, Mg^{2+}, K^+, Na^+, and NH_4^+ can participate in cation exchange to different degrees.

Nitrate (NO_3^-): an anion that generally remains more mobile in many soils and is not retained on ordinary negatively charged cation-exchange sites.

Phosphate: an anion whose availability is strongly influenced by adsorption and precipitation reactions with soil minerals and by pH; it does not simply “park” like calcium or potassium.

Sulfate: another anion whose retention and movement differ from cations and vary by soil.

Micronutrients: zinc, manganese, copper, iron, boron, molybdenum and others have distinct chemical behavior controlled by pH, oxidation state, organic matter, mineral surfaces, moisture, and biological processes.

Carbon: carbon is present in plant residues, roots, microbial biomass, dissolved organic forms, soil organic matter, and persistent carbon pools. It is not a base-saturation percentage.

Student skill

For each nutrient, identify its source, chemical form, likely storage/retention pool, movement pathway, root-access pathway, and best measurement. This prevents the common mistake of treating every number on a soil report as if it represents the same kind of nutrient availability.

4.6 O3 AG, Water Chemistry & the Nutrient-Exchange Environment

Guided lesson time: 5 minutes

4.6 O3 AG, Water Chemistry & the Nutrient-Exchange Environment

O3 AG is taught here as part of the water–soil–root-zone environment surrounding nutrient exchange. Ozone treatment does not create calcium, magnesium, potassium, nitrogen, carbon, or new CEC sites from nothing. The management question is whether treatment changes conditions in ways that improve how the existing nutrient system functions.

Carry forward Week 2 measurements: source-water nutrients, pH, EC/TDS, dissolved oxygen (DO), oxidation-reduction potential (ORP), temperature, flow, and irrigation volume. Then compare treated-water delivery and root-zone conditions.

Potentially relevant pathways to investigate include water quality, oxidation of susceptible compounds, oxygen conditions after ozone decomposition, root-zone redox environment, residue/decomposition conditions, microbial processes, root development, nutrient solubility/speciation, and plant uptake. The importance of each pathway depends on the field and must be measured.

O3 AG verification chain

Water baseline → treatment → delivery → soil solution/exchange environment → root zone → tissue uptake → crop response.

A positive O3 AG interpretation should state what changed and how it was measured. For example: "Treated irrigation water showed a higher DO at the delivery point, root-zone observations improved, and tissue potassium increased during the comparison period." That is stronger than saying "ozone made potassium."

Consistency objective

O3 AG cannot remove weather, soil variability, or management differences. It can be evaluated as a tool for managing important water/root-zone conditions more consistently. Students compare zones and dates to determine whether nutrient access and crop performance become more uniform.

4.7 Nutrient Balance, Antagonism, Tie-Up & Release

Guided lesson time: 5 minutes

4.7 Nutrient Balance, Antagonism, Tie-Up & Release

More fertilizer does not automatically create more plant nutrition. Nutrients interact with soil minerals, organic matter, water chemistry, exchange sites, microorganisms, roots, pH, salinity, and one another. When one nutrient is excessive—or when the chemical environment is unfavorable—it can reduce the accessibility or uptake of another nutrient. This is called **nutrient antagonism**. Nutrients can also be adsorbed, precipitated, fixed, immobilized in biological material, held on exchange sites, or stored in reserve pools.

Week 4 expands the nutrient-status model to include side pools:

TIED / BOUND ↔ STORED / RESERVE ↔ EXCHANGEABLE ↔ SOIL SOLUTION / AVAILABLE → ROOT-ACCESSIBLE → UPTAKEN → USED BY THE CROP

The arrows matter. Nutrients can move between pools as pH, moisture, oxidation-reduction conditions, biology, root activity, and management change. The goal is not to force every nutrient into solution at once. The goal is to maintain a balanced system that supplies crop demand without creating unnecessary loss, toxicity, salinity, or antagonism.

Important interaction examples

- **Potassium–magnesium:** high K supply can reduce Mg uptake in some crops and soils; high Mg can also affect K relationships. Interpret with CEC, soil test, crop demand, and tissue data.
- **Calcium–magnesium–potassium:** these cations share the exchange environment and can compete for root uptake. Do not chase a universal ratio; evaluate the measured soil and crop response.
- **Phosphorus–zinc:** excessive P can contribute to Zn deficiency or reduced Zn uptake/physiological availability in some conditions.
- **pH–micronutrients:** high pH commonly reduces Fe, Mn, Zn, and Cu availability; very low pH can create other nutrient limitations or toxicities.
- **Sodium and salinity:** excessive Na and soluble salts can damage soil physical condition and make water and nutrient uptake more difficult.
- **Ammonium and other cations:** NH_4^+ participates in cation exchange and high concentrations of competing cations can influence uptake relationships.

These are **diagnostic relationships, not automatic prescriptions**. Soil texture, mineralogy, CEC, organic matter, water quality, temperature, moisture, crop genetics, growth stage, roots, and management all change the response.

O3 AG, oxygen/redox conditions, and nutrient pools

O3 AG treatment is evaluated for how it changes the water and root-zone environment surrounding these nutrient pools. Ozone is a strong oxidant; after reaction/decomposition, oxygen and dissolved-oxygen conditions can also be part of the managed system. Changes in oxidation-reduction potential (ORP), oxygen status, pH, biological activity, and root condition can influence chemical form, solubility, biological transformations, and movement of particular nutrients.

This does **not** mean ozone universally breaks every nutrient bond or makes every element more soluble. Depending on the element and conditions, oxidation can increase availability, decrease availability, or move an element into a different chemical or storage pool. Iron and manganese are especially sensitive to redox conditions; nitrogen transformations are strongly influenced by oxygen and microorganisms; phosphorus availability can shift indirectly through pH and Fe/Al/Ca chemistry.

How to diagnose a suspected tie-up

1. Identify the crop symptom or tissue result.

2. Check whether the nutrient is actually low in soil/water or merely low in the plant.

3. Review pH, EC/salinity, CEC/base saturation, water chemistry, moisture, temperature, roots, and compaction.

4. Check likely antagonistic or competing nutrients.

5. Compare source water, treated water, soil/root-zone, and tissue measurements where appropriate.

6. Make the smallest defensible management change.

7. Re-measure to determine whether the nutrient moved from tied/stored status toward root accessibility and plant uptake.

Professional rule

RIGHT NUTRIENT + RIGHT AMOUNT + RIGHT FORM + RIGHT PLACE + RIGHT TIME + RIGHT ROOT-ZONE CONDITIONS = BETTER NUTRIENT USE.

Do not respond to every deficiency symptom by adding more fertilizer. First determine whether the problem is supply, storage, chemistry, antagonism, roots, water, biology, or access.

How O3 AG Influences the Nutrient Environment

Guided lesson time: 6 minutes

4.8 How O3 AG Influences the Nutrient Environment

Week 4 now brings the exchange system, nutrient pools, water chemistry, oxygen, biology and roots together. O3 AG should not be taught as creating mineral elements or automatically increasing CEC. The useful question is: **How can treatment influence the conditions that control nutrient form, cycling, accessibility and uptake?**

Follow the pathway:

O3 AG treatment → ozone reactions in water → oxidation/redox conditions → O2/DO environment → water and root-zone chemistry → biological nutrient cycling → nutrient accessibility → root access → plant uptake → crop response.

Oxidation and chemical form

Ozone is a strong oxidant. Reactions in treated water can change oxidation state or chemical form of susceptible compounds. Those changes can influence solubility, precipitation, mobility and later biological reactions. The direction is nutrient- and condition-specific; oxidation does not universally make every nutrient more soluble.

Oxygen, roots and biology

Ozone reactions ultimately return oxygen-containing products to the water system. Students evaluate DO and root-zone oxygen conditions because roots and aerobic organisms require suitable oxygen conditions. Oxygen, moisture, carbon, temperature, pH and nutrient supply interact in decomposition, mineralization, nitrification and other biological processes.

Redox and nutrient pools

Use the Week 4 pool model:

TIED/BOUND ↔️ STORED/RESERVE ↔️ EXCHANGEABLE ↔️ SOIL SOLUTION/AVAILABLE → ROOT-ACCESSIBLE → UPTAKEN → USED.

O3, O2/DO and ORP are overlaid with pH, water, carbon, microbes and roots as factors that can influence movement among pools. Iron and manganese are useful redox examples; nitrogen transformations are strongly biological and oxygen-sensitive; phosphorus availability can be influenced indirectly through pH, calcium, iron/aluminum chemistry, mineral surfaces and biology.

Three different outcomes must not be confused

1. **More nutrient was added.** The nutrient inventory increased because fertilizer, amendment or irrigation water supplied it.

2. **Existing nutrient changed pools or accessibility.** Chemistry or biology changed how an existing nutrient was held, transformed or presented to roots.

3. **The plant became better able to access/use existing nutrient.** Root development, water movement or root-zone conditions improved uptake without the same increase in nutrient input.

How to verify the O3 AG influence

Measure a chain rather than one number: **source water → treated water → delivery/emitter → root zone → soil → roots → tissue/sap → plant → yield/quality.** Record O3 where appropriate, DO, ORP, pH, EC/TDS, individual nutrients, treatment timing, irrigation amount, fertilizer/amendment history, roots and crop stage.

The student conclusion should state what changed, which mechanism is plausible, what other variables could explain the result, and what measurement will verify it next. The goal is not to assume release; the goal is to demonstrate improved nutrient function when it occurs.

4.8 Soil Report Practicum: Calculate, Balance, Decide, Verify

Guided lesson time: 5 minutes

4.8 Soil Report Practicum: Calculate, Decide, Verify

The Week 4 practicum combines Weeks 2–4. The student receives or collects a soil analysis, water analysis, crop information, and management history.

Step 1 — Describe the field

Record crop/variety, growth stage, field zone, soil texture, organic matter, pH, CEC, irrigation source, recent amendments/fertilizers, O3 AG treatment status, weather, and visible root/crop condition.

Step 2 — Build the exchange model

Calculate or verify Ca, Mg, K, and Na saturation using compatible laboratory units. Build the 100-block visualization. Mark any portion that is acidity or other exchangeable cations according to the laboratory method.

Step 3 — Add the water contribution

Carry forward nutrient mass delivered through irrigation from Week 2. Keep **concentration**, **mass delivered**, **soil reserve**, and **plant-available credit** as separate concepts.

Step 4 — Account for organic and mineral sources

List compost, manure, residue, biochar/conditioned carbon, commercial fertilizers, and other nutrient sources. Identify whether their nutrients are immediately soluble, biologically released, slowly released, or uncertain.

Step 5 — Follow one nutrient

Choose Ca, Mg, K, or NH_4-N and trace: source → solution → exchange → rhizosphere → uptake → tissue/crop response.

Step 6 — Check balance and interactions

Before adding a nutrient, review pH, CEC, EC/salinity, Ca–Mg–K relationships, phosphorus–zinc risk, sodium, nitrogen form, water chemistry, tissue results, and root condition. A nutrient can be present yet poorly accessed because of antagonism, precipitation/adsorption, redox state, pH, moisture, root stress, or other conditions.

Step 7 — Make a defensible decision

State what the evidence supports. If the soil contains adequate nutrient but tissue is low, investigate moisture, roots, compaction, pH, salinity, antagonism, temperature, sampling, and other access limitations before automatically adding more fertilizer.

Step 8 — Verify

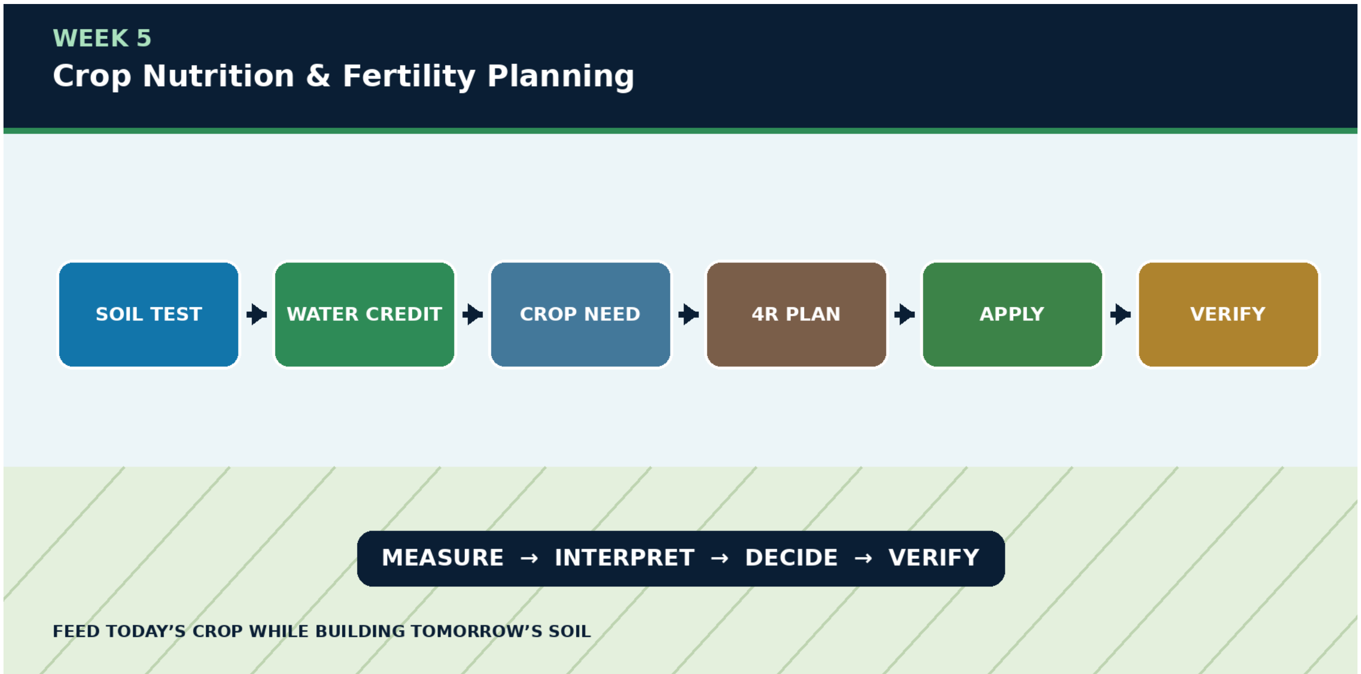
Define the next measurement and date. A professional recommendation includes a verification plan.

Week 4 mastery: The student must demonstrate that they can calculate base saturation, explain CEC capacity, distinguish nutrient pathways, integrate water/organic/mineral sources, and make a measured O3 AG root-zone management decision.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 5 - Crop Nutrition & Fertility Planning



Competencies

- Determine crop nutrient demand from an appropriate crop/yield framework without using an unsupported universal rate
- Build a nutrient inventory from soil, irrigation water, organic amendments, residual credits and planned mineral inputs
- Distinguish total nutrient content from expected plant-available nutrient contribution
- Calculate fertilizer product rate from nutrient requirement and guaranteed analysis
- Calculate irrigation-water nutrient contribution and incorporate it into a nutrient budget
- Estimate organic nutrient contribution using documented analysis and an appropriate availability/mineralization assumption
- Check nutrient antagonism, pH, salinity, CEC and root-zone constraints before adding more nutrient
- Choose nutrient timing and placement based on crop demand, soil conditions and nutrient behavior
- Explain how O3 AG management can influence the environment for nutrient cycling, root access and uptake without creating mineral elements
- Build a measured fertility plan with baseline, in-season and post-harvest verification
- Calculate nutrient input per unit of yield and fertilizer cost per bushel, ton or other marketable unit
- Create a staged synthetic-to-organic transition scenario that requires measurement before each further reduction
- Distinguish immediate crop-feeding functions from longer-term soil/nutrient-system-building functions
- Build a staged transition map that replaces nutrient function before reducing an existing source
- Adapt nutrient-system-building strategy for field soil, greenhouse/substrate, hydroponic, aquaponic and perennial systems
- Evaluate regenerative practices by measurable agronomic function and economics rather than by label alone

Lab: Water–Soil–Plant Record Lab

Student action: Connect water, soil/root-zone, and crop observations in one field record.

Data entered: Linked water/soil/crop observations

Required evidence: Field condition summary

Start With Crop Demand, Not a Fertilizer Bag

Guided lesson time: 5 minutes

5.1 Start With Crop Demand, Not a Fertilizer Bag

A fertility plan begins with the crop, field and production goal. Students identify crop and variety, realistic yield target, growth stage, rooting pattern, expected harvest/removal, soil type, previous crop and management history. Then use a locally appropriate calibrated recommendation or crop-removal framework.

The central equation is:

Crop nutrient requirement − validated nutrient credits = remaining nutrient requirement.

A yield goal is not permission to over-apply. Use realistic multi-year production history and the appropriate regional recommendation system. Separate **crop uptake** from **harvest removal**: the crop may take up more nutrient than leaves the field in the harvested product. Residue returned to the field remains part of the cycling system.

Students build a demand calendar: establishment, vegetative growth, reproductive/fruiting stage, fill/maturity and harvest. The question is not only how much nutrient the crop needs, but **when the crop needs it and whether the root zone can supply it then.**

Build the Whole Nutrient Inventory: Soil + Water + Organic + Mineral

Guided lesson time: 5 minutes

5.2 Build the Whole Nutrient Inventory

Before purchasing fertilizer, inventory what is already entering or stored in the production system. Carry forward Week 2 water analysis and Week 4 exchange/pool concepts.

List: soil-test nutrient status; exchangeable/reserve pools where relevant; irrigation-water nitrate/N, Ca, Mg, K, S and other useful constituents; previous crop/legume credits where locally validated; manure, compost and organic amendment analyses; planned soluble/mineral fertilizer; and other documented nutrient sources.

Do not count the same nutrient twice. Do not treat total nutrient concentration as automatically plant available.

For irrigation water:

lb/acre delivered = mg/L × gallons/acre × 8.3454 ÷ 1,000,000.

For acre-inches:

lb/acre ≈ mg/L × acre-inches × 0.2266.

Students calculate the delivered mass, then decide what portion can legitimately be credited using the nutrient form, crop, timing and local guidance.

Organic Nutrients, Mineralization & the Availability Clock

Guided lesson time: 5 minutes

5.3 Organic Nutrients, Mineralization & the Availability Clock

Organic fertilizers and amendments can supply nutrients while also contributing carbon or organic material, but release is not identical to a soluble fertilizer. Students evaluate laboratory analysis, nutrient form, C:N characteristics, maturity/stability, application timing, temperature, moisture, oxygen and expected biological processing.

Use:

Estimated plant-available nutrient = nutrient applied × documented availability fraction.

The availability fraction must come from an appropriate product analysis, extension/regional guidance or validated field information—not a universal percentage invented by the calculator.

This connects to Week 3 timing. Some carbon-rich or slowly cycling materials are better planned sufficiently pre-plant so wetting, conditioning and biological processing can begin before peak crop demand. High-carbon inputs can temporarily immobilize nitrogen. Biochar is evaluated by feedstock, production properties, pH, ash/nutrients and conditioning strategy rather than treated as one uniform fertilizer product.

Product-Rate Calculations: Put the Right Amount in the Right Place

Guided lesson time: 5 minutes

5.4 Product-Rate Calculations

Students must understand the math before using an app calculator.

Product required = nutrient required ÷ nutrient fraction in the product.

Example: if a validated plan calls for 40 lb/acre of K_2O and the fertilizer is 0-0-50, product rate = 40 ÷ 0.50 = **80 lb product/acre**.

The same method works for other guaranteed-analysis nutrients when units and nutrient expressions match. Students learn to check whether a recommendation is expressed as elemental nutrient or oxide equivalent such as P_2O_5 or K_2O before calculating.

Then choose placement: broadcast, incorporated, banded, injected/fertigated, sidedressed or another appropriate method. Placement decisions consider nutrient mobility, soil test, CEC, root location, erosion/runoff risk, irrigation, crop stage and equipment. Aeration/incorporation is used when agronomically appropriate—not automatically—and students document why they selected it.

Balance Before Adding: Antagonism, pH, Salinity & Root Access

Guided lesson time: 5 minutes

5.5 Balance Before Adding

A low tissue value does not always mean the field needs more of that nutrient. Before increasing a rate, students run the Week 4 interaction check.

Ask: Is the nutrient low in soil, or merely low in tissue? Is pH limiting availability? Is salinity or sodium restricting water uptake? Are K, Ca, Mg or NH4 interactions relevant? Is high P associated with a Zn concern? Are roots shallow, diseased, compacted or oxygen-limited? Is irrigation uniform?

The working rule is:

MORE NUTRIENT ≠ MORE UPTAKE.

Use the 4R framework—right source, right rate, right time, right place—plus the O3 AG course requirement of **right root-zone conditions and verification**. A balanced program protects yield while avoiding unnecessary cost, tie-up, salt loading and environmental loss.

O3 AG Nutrient Accessibility: Manage the Environment Around the Nutrient

Guided lesson time: 5 minutes

5.6 O3 AG Nutrient Accessibility

O3 AG is integrated into the fertility plan as management of the treatment-water/root-zone environment, not as a replacement for essential elements. Students follow:

O3 treatment → oxidation/redox conditions → O2/DO → water/root-zone chemistry and biology → nutrient cycling/accessibility → root access → uptake → plant response.

Three outcomes are tracked separately: nutrient added; existing nutrient changing pools/accessibility; and improved root/plant access to nutrient already present.

Use source and treated-water chemistry, DO/ORP, pH, EC/TDS, individual ions, soil tests, roots, tissue/sap, Brix where appropriate, crop stage, fertilizer history, yield and quality. If fertilizer inputs are reduced while performance is maintained or improved, document the exact rates and all important variables rather than assuming causation.

The objective is measurable nutrient-use efficiency: getting more productive crop response from the complete nutrient/water/soil system while maintaining adequate nutrition.

Build the Fertility Plan, Economics & Organic-Transition Scenario

Guided lesson time: 5 minutes

5.7 Build the Fertility Plan, Economics & Organic-Transition Scenario

Students combine the week into one working plan:

1. Crop demand and timing.

2. Soil nutrient status and exchange/availability constraints.

3. Irrigation-water nutrient credits.

4. Organic/amendment contribution and expected availability.

5. Remaining requirement.

6. Mineral/soluble fertilizer needed, if any.

7. Source, rate, timing and placement.

8. O3 AG treatment and water/root-zone measurements.

9. In-season tissue/root/crop verification.

10. Harvest removal, yield, quality and economics.

Calculate **fertilizer cost per bushel/ton/unit** = **fertility-program cost per acre ÷ marketable yield per acre.** Also calculate nutrient input per unit of yield.

For a synthetic-to-organic transition, students create staged scenarios rather than a universal reduction schedule. A reduction is made only when soil, water, tissue, root and crop evidence supports it. Each step records what synthetic input was reduced, what organic/biological nutrient source or existing credit replaced it, how availability was estimated, and what happened to crop performance.

Measure → calculate → balance → apply → verify → adjust.

Feed Today’s Crop While Building Tomorrow’s Soil and Nutrient System

Guided lesson time: 7 minutes

5.8 Feed Today’s Crop While Building Tomorrow’s Soil and Nutrient System

A strong fertility program has **two jobs at the same time**. Job 1 is to meet immediate crop demand. Job 2 is to build a production system that can retain, cycle and supply more of its nutrient requirement over time.

Job 1 — Feed today’s crop

When testing and crop stage show an immediate requirement, an appropriately selected soluble/mineral nutrient source can be a useful tool because many products provide nutrients in relatively predictable and readily available forms. Students still calculate source, rate, timing and placement and verify crop response.

Job 2 — Build tomorrow’s nutrient system

Roots and crop residues, composts, manures, appropriate organic fertilizers, cover crops and selected carbon amendments can contribute organic material and nutrients that enter biological and soil nutrient pools. Depending on the material and conditions, these inputs can support aggregation, water retention, nutrient-holding capacity, biological cycling and longer-term nutrient reserves. Release is not necessarily immediate; mineralization, immobilization, moisture, temperature, oxygen, pH and C:N characteristics matter.

Mineral elements do not become “short-term” merely because they came from a synthetic fertilizer. Their fate depends on chemistry, soil or media properties, crop removal, leaching, precipitation/fixation, exchange, water and management. The important difference is that many soluble mineral fertilizers supply concentrated mineral nutrition without supplying the carbon/organic-material functions provided by many organic amendments.

Build before you reduce

Do not remove a nutrient source until you understand what will replace its function.

Use the transition sequence:

BASELINE → CORRECT LIMITATIONS → BUILD → CREDIT → FEED IMMEDIATE NEED → VERIFY → REDUCE/REPLACE WHERE JUSTIFIED → VERIFY AGAIN → MAINTAIN & CONTINUE BUILDING

At every stage, calculate:

Crop requirement − validated soil/residual credits − irrigation-water credits − expected organic/mineralization contribution − other validated sources = remaining requirement.

Different production systems require different maps

Field soils: branch by texture/CEC, organic matter, pH, salinity/sodicity, drainage, climate, crop and water chemistry.

Greenhouse/substrate: emphasize substrate volume and buffering, irrigation frequency, leach fraction, solution chemistry, roots, EC/pH and intentionally managed biological inputs.

Hydroponics: there is no conventional soil nutrient bank. Build system stability through source-water accounting, complete nutrient-solution formulation, reservoir management, pH/EC/DO/temperature, root health, recirculation and nutrient recovery where appropriate.

Aquaponics: integrate feed inputs, fish loading, ammonia/ammonium, nitrification, nitrate, mineralization of solids, pH/alkalinity, DO, biofilter function and plant demand. O3 AG treatment must be managed so required aquatic and nitrifying biology is protected.

Orchards/perennials: account for perennial roots, stored reserves, canopy/crop load, long-term amendments, irrigation zones and multi-year soil change.

Where O3 AG fits

O3 AG is not a substitute for N, P, K, Ca, Mg, S or micronutrients. It is positioned within the water/root-zone management chain:

O3 treatment → water oxidation/redox and oxygen conditions → root-zone chemistry/biology → nutrient transformation/accessibility → root access → uptake → crop response.

The student verifies whether that pathway improves nutrient-use efficiency and consistency under the operation's actual conditions.

Regenerative agriculture: evaluate function, not the label

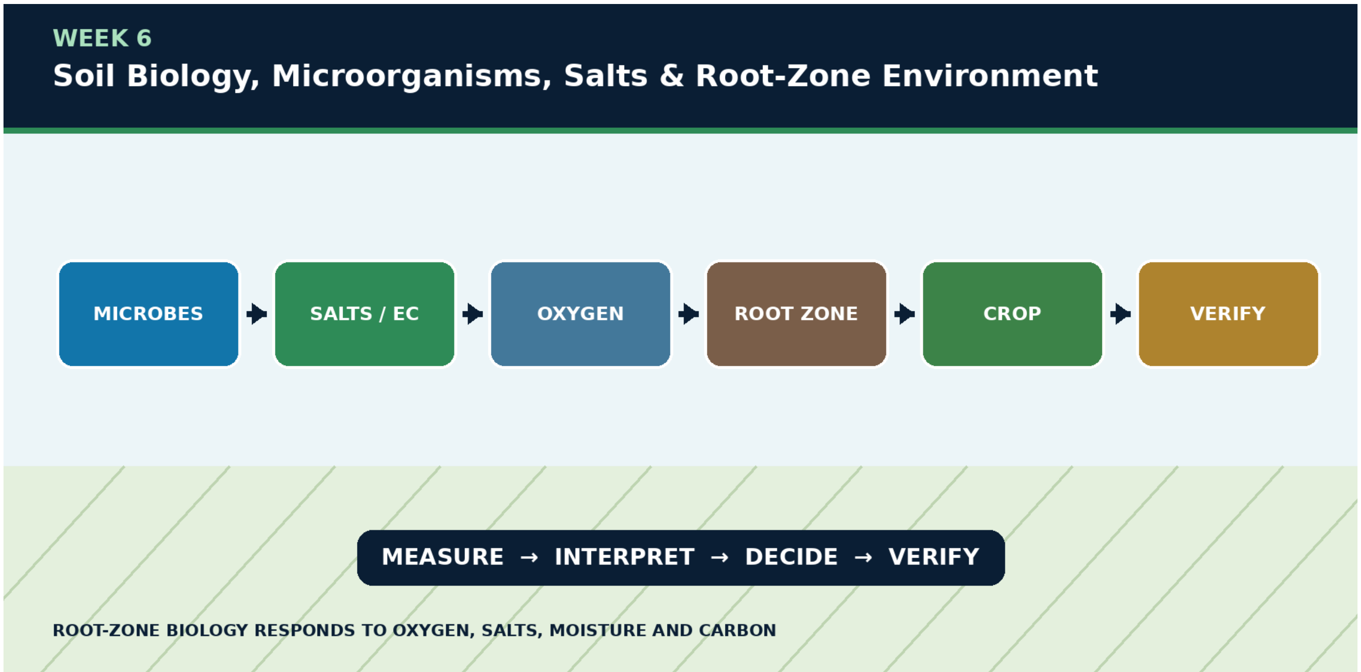
Many practices now grouped under the term regenerative agriculture—rotation, residue return, manure/compost use, cover crops, diversified production and biological nutrient cycling—have long agricultural histories. This course does not require a student to adopt an identity or philosophy. It requires the student to evaluate practices by agronomic function, measurable crop response, economics, nutrient efficiency and long-term soil/water/root-zone performance.

Course principle: Feed today's crop while building tomorrow's soil and nutrient system. Measure both.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 6 - Soil Biology, Microorganisms, Salts & the Root-Zone Environment



Competencies

- Distinguish rhizosphere functions and major carbon pools
- Explain mineralization and immobilization
- Differentiate salinity, sodicity, alkalinity, hardness, scale and corrosion
- Interpret sodium/chloride as concentration- and crop-dependent rather than universally good or bad
- Select water tests needed to diagnose irrigation scaling/corrosion
- Apply the O3 AG evidence-label standard
- Explain where proprietary O3 AG treatment can influence mineral chemistry without assuming identical reactions for every ion
- Separate O3, O2, DO and ORP
- Build a before/after treatment chemistry record
- Compare productive and problem zones and specify a verification plan

O3 AG Tech App Lab - Week 6

Lab: Crop / Growth-Stage Lab

Student action: Set crop and growth stage; practice stage-specific observations and testing.

Data entered: Crop, variety, stage, dates

Required evidence: Crop-stage record

The Living Root Zone: Rhizosphere, Carbon & Microbial Function

Guided lesson time: 6 minutes

6.1 The Living Root Zone: Rhizosphere, Carbon & Microbial Function

Week 6 begins with the rhizosphere: the living interface among roots, water, pore space, carbon compounds, minerals and microorganisms. The goal is not to memorize a list of microbes. Students learn what biological functions must occur for a productive nutrient-cycling system: residue decomposition, mineralization and immobilization, nutrient transformation, aggregation, root association and competition with undesirable organisms.

Carbon is both structural material and biological energy. Distinguish fresh residue, dissolved/active carbon, microbial biomass, stabilized organic matter and persistent carbon such as appropriately characterized biochar. These pools turn over at different rates. A high total-carbon number does not prove that the biologically active pool is adequate, and high respiration alone does not prove that the system is balanced.

Core pathway: ORGANIC MATERIAL → MICROBIAL PROCESSING → DECOMPOSITION → NUTRIENT TRANSFORMATION → STORED/RESERVE ↔ AVAILABLE → ROOT UPTAKE → PLANT → ROOT EXUDATES/RESIDUE → BIOLOGICAL SYSTEM.

Measure biology rather than assuming it from appearance. Use the same method over time when comparing microbial biomass, respiration, active carbon, enzyme or DNA-based indicators.

Mineralization, Immobilization & Nutrient Cycling

Guided lesson time: 6 minutes

6.2 Mineralization, Immobilization & Nutrient Cycling

Mineralization converts nutrients contained in organic material into mineral forms that can enter plant-available pools. Immobilization temporarily incorporates mineral nutrients into microbial biomass or other biological pools. Both are normal parts of nutrient cycling.

Students connect carbon-to-nitrogen characteristics, moisture, temperature, oxygen, pH and amendment maturity to the expected availability clock. High-carbon material can temporarily compete with a crop for available nitrogen; mature compost, manure, residues and liquid organic products must therefore be evaluated by analysis and timing rather than by the word organic.

Nitrogen is followed through organic N, ammonium, nitrate, plant uptake and loss pathways. Phosphorus is followed through organic pools, mineral surfaces, precipitation/adsorption and biological cycling. Micronutrients are evaluated by chemical form, pH, redox conditions, organic interactions and root access.

This reinforces the Week 5 rule: FEED TODAY'S CROP WHILE BUILDING TOMORROW'S SOIL AND NUTRIENT SYSTEM.

Salts Are Not One Thing: Salinity, Sodicity, Alkalinity & Hardness

Guided lesson time: 7 minutes

6.3 Salts Are Not One Thing: Salinity, Sodicity, Alkalinity & Hardness

Agricultural use of the word salt often causes confusion. Chemically, many fertilizers are salts that dissociate into useful nutrient ions in water. Sodium chloride is one salt, not the definition of all salts.

Students separate five measurements and conditions: SALINITY = overall soluble-ion environment, commonly evaluated with EC; SODICITY = sodium hazard on the soil exchange system; ALKALINITY = acid-neutralizing capacity, commonly associated with bicarbonate/carbonate; HARDNESS = primarily calcium and magnesium behavior in water; SCALE = mineral precipitation/deposition. These terms can interact but are not interchangeable.

Chloride is an essential plant micronutrient at appropriate concentrations but can become toxic to sensitive crops when excessive. Sodium can have useful/beneficial physiological roles in some species and systems, but excessive sodium can damage structure, infiltration and plant-water relations. There is no universal ‘good NaCl number’; interpret concentration by crop, soil/media, CEC, drainage, irrigation method and water chemistry.

Where appropriate, students calculate and interpret sodium hazard using laboratory-reported SAR and evaluate exchangeable sodium with soil-test information rather than relying on EC alone.

Scale, Corrosion & Irrigation-System Diagnostics

Guided lesson time: 5 minutes

6.4 Scale, Corrosion & Irrigation-System Diagnostics

A white deposit, clogged nozzle or damaged pipe should not automatically be called a salt problem. Students distinguish scale from corrosion and identify the measurements needed to diagnose each.

Investigate pH, alkalinity/bicarbonate/carbonate, EC/TDS, chloride, sulfate, sodium, calcium, magnesium/hardness, iron/manganese where relevant, temperature, dissolved oxygen/ORP where useful, and the material being exposed. High-alkalinity waters encountered in O3 AG field work have been associated with severe irrigation-component deterioration; the course records that as field performance/observation while requiring complete chemistry and material evaluation before assigning a single cause.

Diagnostic sequence: OBSERVE → TEST → IDENTIFY WATER CHEMISTRY → IDENTIFY MATERIAL/SYSTEM → DIAGNOSE MECHANISM → MANAGE → RETEST → VERIFY.

Students apply this to pivots, pressurized irrigation, sprinkler systems, pumps, emitters, reservoirs, fittings, seals and other wetted components. Ozone compatibility of materials is evaluated as part of O3 AG system design and operation.

O3 AG High-Strength Oxidation & Mineral-Ion Chemistry

Guided lesson time: 7 minutes

6.5 O3 AG High-Strength Oxidation & Mineral-Ion Chemistry

NOT ALL OZONE IS CREATED EQUAL. In this course, O3 AG refers to O3 Science proprietary, patented high-strength ozone-generation and treatment technology. Conventional UV or standard commercial ozone-system performance is not automatically used to define O3 AG capability.

Course evidence labels are used deliberately: ESTABLISHED SCIENCE; INDEPENDENT RESEARCH; O3 AG VERIFIED PERFORMANCE; O3 AG PROPRIETARY TECHNOLOGY/MECHANISM; and ILLUSTRATIVE TEACHING EXAMPLE.

O3 AG treatment is taught as a high-strength oxidative treatment environment that can influence oxidation state, speciation, precipitation/solubility, complexation/chelation behavior, biological reactions and subsequent mineral accessibility under the conditions of the treatment system. Iron, manganese, copper, calcium, magnesium, sodium/chloride and other constituents are evaluated individually because they do not all follow the same reaction pathway.

The course does not require disclosure of proprietary generator details and does not use a fixed published half-life claim. Instead, students measure the treatment delivered under actual operating conditions and follow the constituent through water, root zone, soil/media, tissue and crop response.

Where O3 AG Meets Biology, Oxygen & the Root Zone

Guided lesson time: 5 minutes

6.6 Where O3 AG Meets Biology, Oxygen & the Root Zone

Ozone (O3), molecular oxygen (O2), dissolved oxygen (DO) and oxidation-reduction potential (ORP) are related to the treatment environment but are not interchangeable measurements. O3 AG is not taught as simply 'feeding microbes ozone.'

Students follow: O3 AG TREATMENT → WATER CHEMISTRY/REACTION ENVIRONMENT → O2/DO & ORP CONDITIONS → ROOT-ZONE CHEMISTRY + MOISTURE + PORE SPACE → BIOLOGICAL PROCESSES → NUTRIENT CYCLING/ACCESSIBILITY → ROOT FUNCTION → PLANT UPTAKE → CROP RESPONSE.

A compacted or saturated soil can remain oxygen-limited even when delivery water has favorable DO. Conversely, improved physical structure and drainage can change how the same irrigation water performs. Biology, water and soil physics are therefore diagnosed together.

Students distinguish three outcomes: more nutrient was added; existing nutrient changed form/pool/accessibility; or roots/plants became better able to access nutrient already present. The measurements must show which explanation is supported.

Before/After Water & Root-Zone Chemistry Worksheet

Guided lesson time: 4 minutes

6.7 Before/After Water & Root-Zone Chemistry Worksheet

Students build a traceable treatment record using RAW/SOURCE WATER → O3 AG TREATMENT → POST-TREATMENT WATER → DELIVERY POINT → ROOT ZONE → SOIL/GROWING MEDIA → ROOT/TISSUE → CROP.

The worksheet records, where applicable: pH, EC, TDS, alkalinity/bicarbonate, hardness, Na, Cl, Ca, Mg, K, Fe, Mn, sulfate, nitrate-N, temperature, DO, ORP, flow, treatment conditions and sampling time/location. Production-system-specific analytes are added as needed.

For every apparent change, ask: What changed chemically? What remained dissolved? What changed form? What precipitated or deposited? What entered exchange/storage pools? What reached the root? What entered plant tissue? What other management or weather variable changed at the same time?

The purpose is conservation-of-mass and system thinking—not chasing a single meter reading.

Field Practicum: Productive Zone vs Problem Zone

Guided lesson time: 5 minutes

6.8 Field Practicum: Productive Zone vs Problem Zone

Select a productive zone and a problem zone, or two comparable production units. Record GPS/location identity and management history. Compare soil/media texture and structure, compaction, moisture/drainage, residue decomposition, roots, odor or oxygen-limited indicators, pH/EC, irrigation uniformity, organic inputs, fertilizer/pesticide history and relevant biological measurements.

Add water chemistry and O3 AG treatment records. Where practical, include tissue/sap, Brix, crop stage, plant vigor, pest/disease pressure, days of growth and yield/quality.

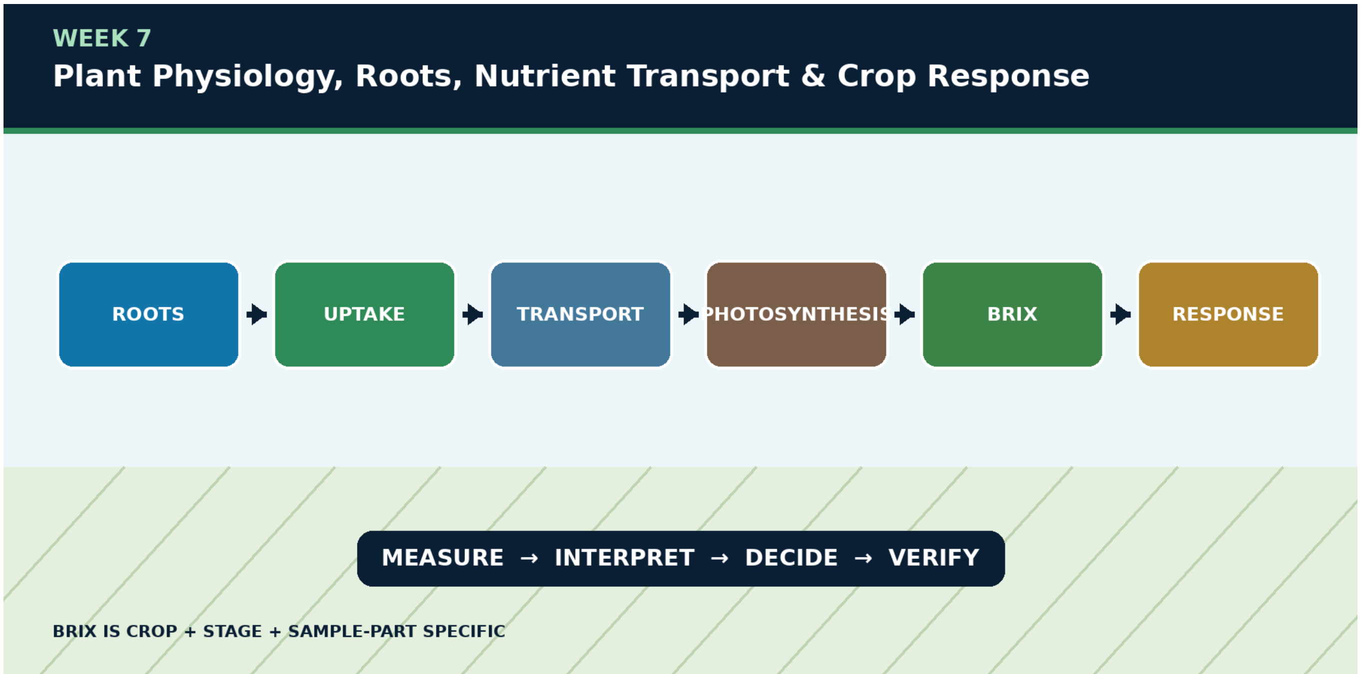
The student submits: (1) observed differences; (2) likely limiting processes; (3) salt/alkalinity/hardness/corrosion diagnosis where relevant; (4) the O3 AG point of influence; (5) what is established science versus O3 AG verified/proprietary performance; (6) the management action; and (7) the retest plan.

Final rule: OBSERVE → MEASURE → INTERPRET → MANAGE → RETEST → VERIFY.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 7 - Plant Physiology, Roots, Nutrient Transport & Crop Response



O3 AG Tech App Lab - Week 7

Lab: Testing Calendar Lab

Student action: Build a sampling schedule and log a mock testing event.

Data entered: Test type, timing, location, environmental conditions

Required evidence: Testing calendar + event record

7.1 — From Root Zone to Crop: The Plant as a Living Transport System

Guided lesson time: 5 minutes

WEEK 7 — PLANT PHYSIOLOGY, ROOTS, NUTRIENT TRANSPORT & CROP RESPONSE

What you will be able to do

By the end of Week 7, the student should be able to trace water and nutrients from the root-zone solution into the root, through the plant, and into growth and harvest; distinguish mass flow, diffusion, and root interception; explain root respiration, xylem, phloem, transpiration, photosynthesis, and nutrient mobility; separate a true nutrient shortage from an access or uptake problem; document crop growth days and growth stages; and identify where O3 AG treatment may influence the chain and how that response must be verified.

Follow the system into the plant

Weeks 2–6 established the water, soil/media, carbon, exchange chemistry, fertility, biology, and root-zone environment. Week 7 asks the next question: what does the plant do with those conditions?

SOURCE WATER → O3 AG TREATMENT → DELIVERY → ROOT-ZONE SOLUTION → ROOT SURFACE → ROOT UPTAKE → XYLEM/PHLOEM TRANSPORT → LEAF METABOLISM → GROWTH/REPRODUCTION → HARVEST.

A plant can only use a nutrient after it becomes accessible to a functioning root and is transported to the tissue where it is needed. Therefore PRESENT is not the same as AVAILABLE, and AVAILABLE is not the same as UPTAKEN or USED. This week connects the Week 4 nutrient-pool model directly to plant physiology.

7.2 — Roots, Root Hairs & Root Respiration

Guided lesson time: 6 minutes

ROOTS ARE THE WORKING INTERFACE

Roots anchor the crop, explore soil or media, absorb water and mineral nutrients, interact with microorganisms, release exudates, store compounds, and respire. Fine roots and root hairs greatly increase the contact area between the plant and the root-zone solution.

Root respiration

Living root cells require energy. Respiration uses oxygen to help release usable energy from plant carbohydrates. Poor aeration, saturation, compaction, excessive temperature, root disease, salinity, or damaged root systems can reduce root function even when a laboratory report shows adequate nutrients.

Field root assessment

Expose roots carefully and record rooting depth, lateral spread, fine-root density, branching, color, odor, lesions, sloughing, restricted layers, moisture, compaction, and distribution relative to irrigation. Compare a productive zone with a stressed zone.

O3 AG connection

O3 AG is evaluated at the water/root-zone interface. The student asks whether treatment changed delivered-water conditions and whether those changes correspond with measurable root-zone and root responses. Record treatment conditions together with DO/ORP where appropriate, pH, EC, moisture, temperature, root observations, tissue status, and crop response. Do not infer root benefit from one water reading alone.

7.3 — How Water & Nutrients Reach the Root

Guided lesson time: 6 minutes

THREE PATHWAYS TO THE ROOT

Mass flow

Water moving toward the root carries dissolved ions with it. Nutrients commonly influenced strongly by mass flow include nitrate, calcium, magnesium, and sulfur, although the relative contribution varies with crop and conditions. Transpiration, soil moisture, concentration, rooting volume, and irrigation management influence this pathway.

Diffusion

Roots deplete nutrients immediately around themselves. A concentration gradient can then drive nutrients from a higher-concentration area toward the depleted root surface. Phosphorus and potassium are important teaching examples of nutrients for which diffusion can be significant. Moisture, temperature, soil texture, buffering, and root density affect the distance and rate of movement.

Root interception

As roots grow into new soil or media, they physically contact additional exchange surfaces and nutrient pools. Root architecture therefore changes how much of the production volume the crop can explore.

Practical rule

A fertilizer recommendation is incomplete if it ignores delivery to the root. Ask: Is the nutrient present? Is it in an accessible form? Can water move it? Can it diffuse? Can roots reach it? Are roots functioning? Is another nutrient or environmental condition interfering?

7.4 — Uptake, Xylem, Phloem & Nutrient Mobility

Guided lesson time: 6 minutes

FROM ROOT SURFACE TO PLANT TISSUE

Root membranes regulate ion uptake. Once inside the plant, water and dissolved minerals are transported through vascular tissues. Xylem moves water and many mineral nutrients primarily from roots toward shoots as part of the transpiration stream. Phloem distributes sugars and other mobile compounds from source tissues to growing or storage tissues.

Why nutrient mobility matters in diagnosis

Some nutrients can be redistributed from older tissue to new growth more readily than others. This helps explain why certain deficiencies tend to appear first on older leaves while others appear first on younger tissue. Students should use symptom location as a clue—not as proof—and confirm with tissue/sap, soil/media, water, roots, pH/EC, and management history.

The diagnostic question

LOW TISSUE VALUE does not automatically mean LOW SOIL SUPPLY. The cause may be insufficient supply, antagonism, unsuitable pH, salinity/osmotic stress, restricted roots, poor aeration, moisture extremes, temperature, disease, damaged transport tissue, or timing/growth-stage effects.

7.5 — Photosynthesis, Transpiration, Stomata & Plant Energy

Guided lesson time: 6 minutes

THE ABOVE-GROUND ENGINE

Photosynthesis captures light energy and uses carbon dioxide and water to build carbohydrates. Those carbohydrates support growth, storage, root exudation, respiration, reproduction, and yield formation. Respiration then releases usable energy from those compounds for cellular work.

Stomata and transpiration

Stomata regulate gas exchange and water loss. Transpiration helps create the water-potential gradient that moves water through the plant and contributes to mass-flow nutrient delivery. Heat, humidity, wind, light, soil moisture, salinity, root condition, and crop genetics all influence stomatal behavior and transpiration.

Why this matters to fertility

A crop can have nutrients around the root and still fail to use them efficiently when water movement, root respiration, leaf function, or stress is limiting. That is why Week 7 connects fertilizer decisions to the whole plant rather than treating nutrient concentration as an isolated number.

7.6 — Deficiency, Antagonism or Uptake Problem? Diagnose Before Adding

Guided lesson time: 6 minutes

DIAGNOSE BEFORE ADDING MORE

When a crop looks deficient, follow a repeatable sequence:

1. MAP THE PATTERN — field edge, low spot, wheel track, irrigation pattern, variety, row, bed, greenhouse zone, or isolated plants.

2. IDENTIFY THE GROWTH STAGE — nutrient demand and symptom interpretation change with crop stage.

3. INSPECT ROOTS — depth, density, fine roots, color, injury, compaction, saturation, disease.

4. CHECK WATER AND ROOT ZONE — moisture, pH, EC/TDS, temperature, relevant ions, DO/ORP where appropriate.

5. CHECK NUTRIENT INTERACTIONS — use Week 4 antagonism/tie-up logic.

6. TEST THE PLANT — standardized tissue/sap sampling and Brix where appropriate.

7. REVIEW MANAGEMENT — fertilizer source/rate/timing/placement, pesticides, irrigation, weather, O3 AG treatment status.

8. CORRECT THE LIMITING FACTOR — do not automatically add fertilizer.

9. RETEST AND VERIFY — root, tissue, growth, quality, yield, and economics.

The purpose is to distinguish a nutrient quantity problem from an accessibility, transport, or plant-function problem.

7.7 — O3 AG: From Treated Water to Plant Response

Guided lesson time: 6 minutes

WHERE O3 AG COMES INTO THE PLANT PHYSIOLOGY CHAIN

O3 AG should be positioned at its actual point of influence rather than treated as a substitute for plant physiology. The working chain is:

O3 AG TREATMENT → WATER CHEMISTRY / OXIDATIVE ENVIRONMENT → DELIVERY CONDITION → ROOT-ZONE CONDITIONS → MINERAL ACCESSIBILITY / BIOLOGICAL PROCESSES → ROOT FUNCTION → WATER & NUTRIENT UPTAKE → PLANT TRANSPORT / METABOLISM → CROP RESPONSE.

Not All Ozone Is Created Equal

O3 AG uses proprietary patented treatment technology. Course statements about O3 AG performance are not automatically statements about conventional UV or standard commercial ozone systems. Apply the course Evidence & Verification Standard: distinguish established science, independent research, O3 AG verified performance, proprietary technology/mechanism, and teaching examples.

What to verify

Compare baseline and treatment periods using defined sampling points. Depending on the operation, record treatment status, water pH/EC/TDS, relevant mineral ions, DO/ORP, root-zone moisture and chemistry, root development, tissue/sap nutrients, Brix, plant growth, stress, yield, quality, harvest timing, water use, fertilizer use, and economics.

The student must be able to state what changed, where it changed, what measurement supports the conclusion, and what alternative explanation still needs to be ruled out.

7.8 — Growth Stages, Days of Growth & Harvest Performance

Guided lesson time: 5 minutes

TIME IS A CROP-PERFORMANCE MEASUREMENT

Record the crop calendar rather than relying only on expected days-to-harvest. Establish Day 0 consistently—planting, emergence, transplanting, or another defined biological start point—and record major growth stages through harvest.

Growth-day record

Record crop and variety; planting/transplant/emergence date; vegetative milestones; flowering; fruit set or reproductive stage; maturity indicators; first harvest; final harvest where relevant; accumulated heat units/GDD when appropriate; weather; irrigation; fertility changes; O3 AG treatment status; yield and quality.

Basic calculation

Days to stage = Date stage reached − defined Day 0 date.

Compare treatment and historical/control baselines only when the starting definition and crop conditions are comparable. A shorter crop cycle is not automatically better if yield, quality, size, maturity, storage, or economics decline.

Production metric

Connect time to output: yield per acre or growing unit, bushels/tons/pounds, marketable yield, quality grade, and days occupied. Where useful, calculate production per growing day and input cost per unit of marketable yield.

This becomes a core dataset for later O3 AG economics and transition-planning lessons.

7.9 — Plant Physiology Field Practicum & Mastery

Guided lesson time: 4 minutes

WEEK 7 PRACTICUM — FOLLOW THE LIMITATION INTO THE PLANT

Select a productive zone and a problem zone, or use a verified O3 AG case-study dataset. Document crop/variety, growth stage and days of growth; irrigation/treatment status; root architecture and condition; root-zone moisture/pH/EC and relevant water chemistry; soil/media nutrient information; tissue/sap data; Brix where appropriate; visible symptoms and their location on the plant; weather/management history; and yield/quality observations available to date.

Then build a one-page diagnosis using this chain:

PRESENT → ACCESSIBLE → ROOT-REACHABLE → UPTAKEN → TRANSPORTED → USED → CROP RESPONSE.

Identify the most likely limiting step, at least two alternative explanations, the management action justified by the evidence, and the exact measurements/date you will use to verify the response.

Mastery standard

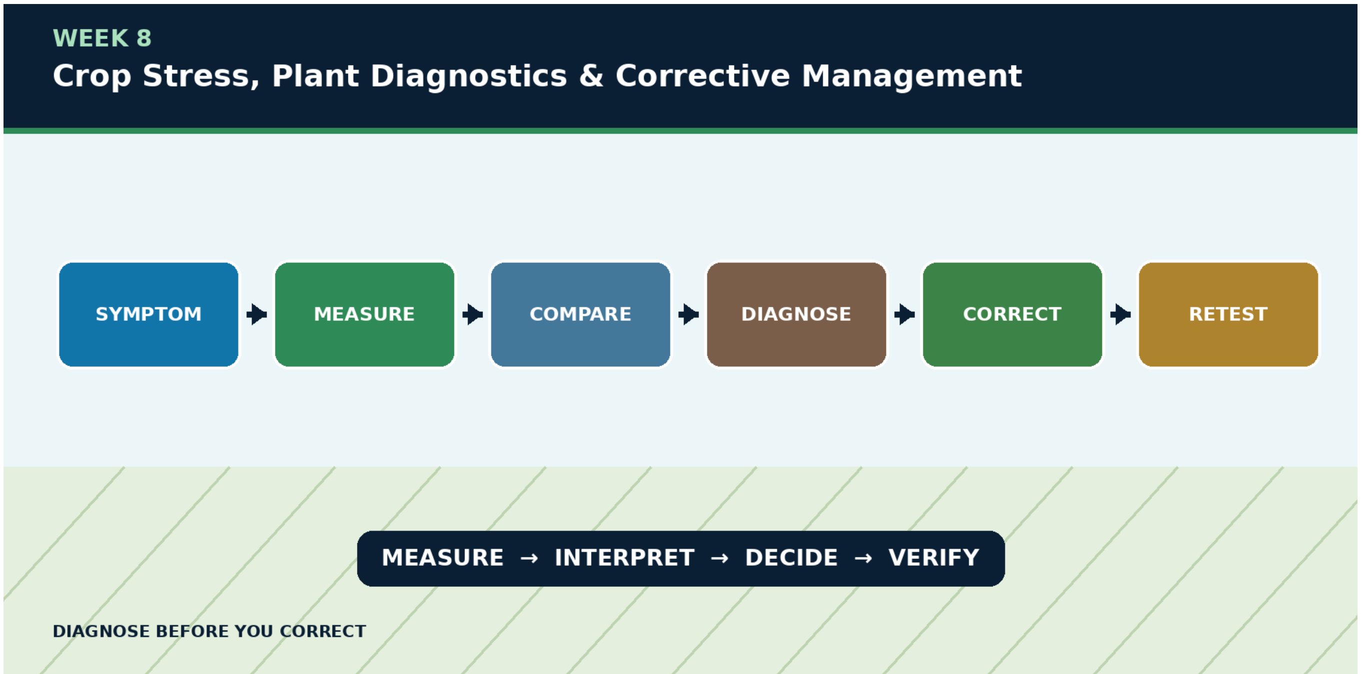
The student passes Week 7 by demonstrating that they can explain plant transport and physiology, diagnose without automatically adding fertilizer, place O3 AG correctly in the treatment chain, and document crop-time and plant-response measurements.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete

Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	______________________

WEEK 8 - Crop Stress, Plant Diagnostics & Corrective Management



O3 AG Tech App Lab - Week 8

Lab: Moisture Status Lab

Student action: Use crop × stage × soil/media profile with a practice moisture reading to classify LOW / OPTIMAL / HIGH.

Data entered: Moisture %, soil/media, crop, stage

Required evidence: Moisture-status result

Symptom Is Not Cause: Build the Diagnostic Mindset

Guided lesson time: 6 minutes

WEEK 8 — CROP STRESS, PLANT DIAGNOSTICS & CORRECTIVE MANAGEMENT

What you will be able to do

By the end of Week 8, the student should be able to separate visible symptoms from underlying causes; map field or production-system patterns; inspect plant and root symptoms; evaluate water, soil/media, nutrient, biological, environmental and management factors; form competing diagnoses; select confirmatory tests; identify where O3 AG can appropriately influence the limitation; prescribe a measured corrective action; and verify recovery.

The diagnostic rule

A yellow leaf, wilted plant, burned margin, short root system, weak stand, weed patch, disease lesion or low Brix reading is an OBSERVATION—not yet a diagnosis. Several different stresses can produce similar symptoms, and several stresses can occur at the same time.

Use the Week 8 chain:

OBSERVE → MAP THE PATTERN → IDENTIFY GROWTH STAGE → INSPECT PLANT → INSPECT ROOTS → TEST WATER → TEST SOIL/MEDIA → CHECK NUTRIENT BALANCE → CHECK BIOLOGY → CHECK ENVIRONMENT & MANAGEMENT → CHECK O3 AG CONDITIONS → FORM COMPETING DIAGNOSES → TEST → CORRECT → RETEST → VERIFY.

The goal is not to guess quickly. The goal is to reduce uncertainty with evidence and make the smallest justified correction that addresses the limiting factor.

Read the Pattern Before the Plant

Guided lesson time: 5 minutes

THE FIELD OR FACILITY IS A DIAGNOSTIC MAP

Before pulling a leaf, step back. Pattern often tells you where to look next.

Record whether symptoms follow an irrigation line, pivot span, emitter zone, bed, row, wheel track, low area, field edge, soil boundary, elevation change, spray pass, fertilizer band, variety, greenhouse bay, reservoir, hydroponic channel or aquaponic loop. Note whether the pattern is uniform, scattered, expanding, sharply bounded or associated with weather exposure.

Healthy comparison

Establish a healthy reference area of the same crop, variety and growth stage whenever possible. Sample the healthy and problem areas using the same method and timing. GPS or otherwise mark the points so you can return after corrective action.

Weeds and compaction as clues

Retain the earlier Week 8 concept: weed populations and compacted zones can be useful clues to differences in soil structure, moisture, fertility, disturbance and management. They are not single-cause indicators. A weed does not prove a specific nutrient deficiency. Map the weed/problem zone, compaction by depth, crop condition and a healthy comparison, then test the conditions that differ.

Plant Symptoms: Location, Age & Growth Stage

Guided lesson time: 6 minutes

READ THE PLANT SYSTEMATICALLY

Record crop, variety, days of growth and growth stage first. Then document where symptoms begin: oldest leaves, newest growth, margins, interveinal tissue, whole leaf, stems, crown, flowers, fruit, grain, or the entire plant.

Describe color, chlorosis pattern, necrosis, spotting, distortion, cupping, scorching, stunting, abnormal internodes, lodging, poor flowering, poor fruit set, premature senescence and maturity differences. Photograph the whole plant and close-up tissue with a scale and location/date record.

Nutrient mobility can help narrow possibilities, but symptom appearance alone is not proof of nutrient deficiency. Herbicide injury, salinity, root damage, disease, heat, cold, drought, saturation, pH, antagonism and nutrient excess can imitate nutritional symptoms.

Sampling discipline

Use standardized tissue or sap sampling for the correct plant part and growth stage. Compare results with the appropriate crop/laboratory interpretation and with soil/media, water and root information. Brix may be used as one crop-condition indicator where appropriate, but it does not identify a cause by itself.

Roots, Water & Oxygen: Diagnose Below Ground

Guided lesson time: 6 minutes

MANY ABOVE-GROUND PROBLEMS BEGIN BELOW GROUND

Excavate roots from both healthy and problem zones. Record depth, lateral spread, fine-root density, branching, color, odor, lesions, sloughing, crown condition, compaction, crusting, saturation, dry layers, irrigation distribution and rooting relative to fertilizer placement.

Check root-zone moisture and temperature together with pH and EC/TDS. Where appropriate, record delivered-water and root-zone DO/ORP as supporting measurements. Poor infiltration, saturation, compaction, salinity, extreme temperature and root disease can all restrict water and nutrient uptake.

Water stress can mean too little or too much

Wilting does not always mean the crop needs more irrigation. A saturated or damaged root system can fail to supply the shoot even while the soil is wet. Verify moisture profile and root condition before changing irrigation.

Diagnostic comparison

If the healthy zone has deeper fine roots, better aggregation, different moisture, lower EC, or a different irrigation pattern, treat that difference as a hypothesis to test—not automatic proof of cause.

Nutrients: Deficiency, Excess, Antagonism or Access?

Guided lesson time: 6 minutes

DO NOT TREAT EVERY DEFICIENCY SYMPTOM WITH MORE FERTILIZER

Use the Week 4 and Week 5 models. Ask whether the nutrient is PRESENT, HELD/RESERVE, EXCHANGEABLE, IN SOLUTION, ROOT-ACCESSIBLE, UPTAKEN and USED.

A low tissue value can result from inadequate supply, unsuitable pH, antagonism, salinity/osmotic stress, poor roots, moisture extremes, temperature, placement, timing, damaged transport tissue or rapid growth dilution. Excess nutrient can also create toxicity or interfere with uptake of another nutrient.

Review Ca–Mg–K relationships, phosphorus–zinc interactions, sodium/chloride, ammonium/cation competition and pH-dependent micronutrient availability where relevant. Do not use one universal ratio as a diagnosis.

Minimum evidence set

Before a major fertility correction, review the crop requirement and growth stage; soil/media test; irrigation-water nutrient contribution; tissue/sap result; pH and EC/TDS; roots; recent fertilizer source/rate/timing/placement; weather and irrigation; and known nutrient interactions.

Then calculate the correction from the actual deficit or management need rather than from symptom severity.

Salts, Alkalinity, Environment & Management Injury

Guided lesson time: 6 minutes

SEPARATE THE STRESS CATEGORIES

SALINITY ≠ SODICITY ≠ ALKALINITY ≠ HARDNESS ≠ SCALE ≠ CORROSION.

High soluble salts can create osmotic stress. Excess sodium can affect exchange chemistry and soil structure. Chloride can be an essential micronutrient at appropriate levels and harmful in excess. Alkalinity reflects acid-neutralizing capacity, commonly associated with bicarbonate/carbonate chemistry. Hardness primarily reflects calcium and magnesium. Scaling and corrosion require diagnosis of the complete water chemistry and equipment conditions.

Also investigate heat, cold, wind, frost, hail, light intensity, humidity, drought, flooding, compaction, spray injury, fertilizer burn, application overlap, mixing errors and equipment malfunction.

For pivot, sprinkler and pressurized irrigation systems, document deposits, nozzle/emitter performance, pressure/flow, corrosion or pitting, and the material involved. Pair observations with appropriate water tests rather than labeling every deposit or equipment problem as 'salt.'

A strong diagnosis can include multiple interacting stresses—for example high EC + heat + shallow roots + an application error.

O3 AG in Corrective Diagnostics: Find the Point of Influence

Guided lesson time: 6 minutes

PLACE O3 AG WHERE THE LIMITATION ACTUALLY OCCURS

O3 AG is not the diagnosis. First identify the likely limiting process, then determine whether the proprietary treatment can influence that part of the system.

Working pathway:

O3 AG TREATMENT → WATER / OXIDATIVE REACTION ENVIRONMENT → DELIVERY → MINERAL / ORGANIC / BIOLOGICAL CONDITIONS → ROOT ZONE → ROOT FUNCTION → NUTRIENT & WATER ACCESS → PLANT PHYSIOLOGY → STRESS RESPONSE → CROP PERFORMANCE.

Not All Ozone Is Created Equal

Course statements about O3 AG refer to O3 Science proprietary patented technology and should not automatically be generalized to conventional UV or standard commercial ozone systems.

Diagnostic evidence standard

Label conclusions appropriately as Established Science, Independent Research, O3 AG Verified Performance, O3 AG Proprietary Technology/Mechanism, or Illustrative Teaching Example.

When evaluating a corrective response, compare defined sampling points before and after treatment. Depending on the case, measure water chemistry, pH, EC/TDS, relevant minerals, alkalinity/hardness, DO/ORP, root-zone conditions, roots, tissue/sap, Brix, pest/disease pressure, growth rate, days to stage, yield, quality, water use and fertilizer use.

The student must be able to say what changed, where it changed, and what evidence connects that change to the crop response.

Healthy vs. Stress Diagnostic Reference System

Guided lesson time: 5 minutes

BUILD A REFERENCE LIBRARY THAT TEACHES HOW TO LOOK

The course/app will use paired HEALTHY and STRESSED references rather than isolated symptom photographs. Each case should include, where available: whole-canopy image; close leaf/tissue image; root image; root-zone/soil/media image; growth stage and days of growth; water data; soil/media data; tissue/sap data;

weather and management history; O3 AG treatment status; diagnosis confidence; corrective action; and follow-up result.

Required labels

Do not label a photo 'calcium deficiency' or 'salt injury' unless the evidence supports that diagnosis. Use labels such as OBSERVED SYMPTOM, SUSPECTED CAUSE, CONFIRMED CAUSE, and RECOVERY/OUTCOME.

Students should learn to compare:

HEALTHY REFERENCE ↔️ PROBLEM AREA ↔️ CORRECTIVE ACTION ↔️ FOLLOW-UP.

This reference system can grow crop by crop—corn, alfalfa, small grains, vegetables, orchards, greenhouse crops, hydroponics and aquaponics—and become a practical diagnostic library inside the O3 AG app.

Crop Diagnostic Case File & Mastery

Guided lesson time: 4 minutes

WEEK 8 PRACTICUM — BUILD A DEFENSIBLE DIAGNOSIS

Select a real productive/problem comparison or use a verified case dataset. Build a Crop Diagnostic Case File containing: crop/variety and growth stage; days of growth; mapped symptom pattern; whole-plant and close-up observations; root assessment; irrigation and O3 AG operating status; water chemistry; soil/media pH, EC and nutrient information; tissue/sap and Brix where appropriate; salinity/sodicity/alkalinity information where relevant; compaction/weed observations; weather; pesticide/fertilizer/irrigation history; and current yield/quality indicators.

Then submit:

1. MOST LIKELY DIAGNOSIS.

2. AT LEAST TWO COMPETING DIAGNOSES.

3. EVIDENCE FOR AND AGAINST EACH.

4. THE NEXT TEST OR OBSERVATION THAT BEST REDUCES UNCERTAINTY.

5. CORRECTIVE ACTION JUSTIFIED BY CURRENT EVIDENCE.

6. WHERE O3 AG CAN OR CANNOT INFLUENCE THE LIMITATION.

7. RETEST DATE, MEASUREMENTS AND SUCCESS CRITERIA.

8. ECONOMIC OR PRODUCTION CONSEQUENCE IF THE DIAGNOSIS IS WRONG.

Mastery standard

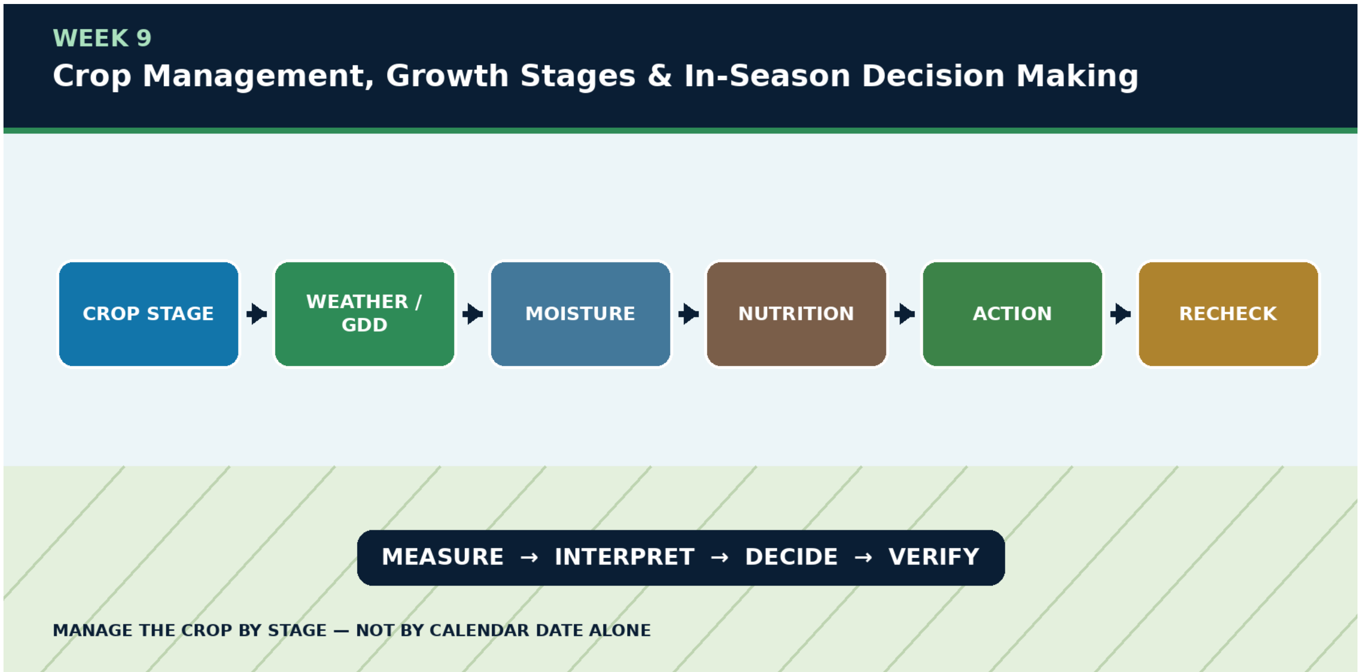
The student passes Week 8 by demonstrating a repeatable diagnostic process, avoiding symptom-only conclusions, integrating plant/root/water/soil/management evidence, placing O3 AG correctly in the chain, and defining how recovery will be verified.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete

Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 9 - Crop Management, Growth Stages & In-Season Decision Making



O3 AG Tech App Lab - Week 9

Lab: Irrigation Scheduling Lab

Student action: Compare standard irrigation with field moisture and crop demand; record irrigation-system inputs.

Data entered: System type, flow/capacity, ET context, moisture status

Required evidence: Standard irrigation schedule

9.1 — Manage the Crop as a Seasonal System

Guided lesson time: 6 minutes

WEEK 9 — CROP MANAGEMENT, GROWTH STAGES & IN-SEASON DECISION MAKING

What you will be able to do

By the end of Week 9, the student should be able to build a crop-specific seasonal management calendar; establish Day 0 and key growth stages; identify what should be measured at each stage; schedule water, soil/media, tissue/sap, root and O3 AG checks according to the management question; distinguish decisions that can still change the current crop from observations that should inform the next crop; and connect growing days, yield, quality, inputs and economics.

The seasonal management chain

BASELINE → PREPLANT → PLANT/EMERGENCE → VEGETATIVE GROWTH → REPRODUCTIVE/YIELD-BUILDING → FILL/BULKING → MATURITY → HARVEST → POST-HARVEST REVIEW → NEXT-CROP BUILD.

Every stage asks five questions: What should the crop be doing now? What can we observe? What should we measure? What decision is still actionable? What must be recorded for the next decision?

A calendar is not a rigid date sheet. Crop stage, weather, soil, water, variety, production system and management can move the timing. The student manages the biological crop, not merely the calendar date.

9.2 — Day 0, Days of Growth & Stage Tracking

Guided lesson time: 5 minutes

DEFINE THE CLOCK BEFORE COMPARING PERFORMANCE

Choose a consistent Day 0 appropriate to the production system: planting, emergence, transplanting, cutting/regrowth, bud break, or another clearly defined biological start point. Record the definition so comparisons are meaningful.

Track actual dates and days after Day 0 for emergence/establishment, major vegetative stages, flowering/reproduction, fruit/grain/tuber/bulking stages, physiological maturity and harvest.

Do not confuse faster with better

A shorter number of days to harvest is beneficial only when the crop also meets the required maturity, marketable yield, quality and economics. Heat, drought or stress can accelerate apparent maturity while reducing production.

Compare O3 AG-managed performance with the operation's own historical baseline and an appropriate comparison where available. Record variety/hybrid, planting date, weather, irrigation, fertility, O3 AG operation, pest/disease pressure and harvest criteria so days-of-growth differences have context.

Crop-specific units

Record production in the unit that matters: bushels/ac, tons/ac, lb/acre, marketable boxes, fruit count/weight, dry matter, cuttings, or another defined unit. Days of growth becomes meaningful when connected to production per acre and production per day.

9.3 — Build the Crop Growth & Testing Calendar

Guided lesson time: 6 minutes

TEST ACCORDING TO THE QUESTION

There is no single universal 'best day' to sample every crop. Build testing around crop stage and the question being answered.

PRE-SEASON/BASELINE: characterize source water, soil/media, nutrient reserves, pH, EC/TDS, organic matter/carbon, CEC/exchange where applicable, compaction/root-zone condition and management history.

ACTIVE VEGETATIVE GROWTH: evaluate establishment, roots, irrigation delivery, tissue/sap status, soil/media conditions, biological activity indicators and whether nutrition is keeping pace with growth.

REPRODUCTIVE/YIELD-BUILDING: evaluate water demand, tissue nutrition, root function, stress, pollination/fruit set or yield-forming structures, and whether a correction can still affect yield or quality.

LATE SEASON/PRE-HARVEST: document plant status while the crop is still active, expected removal, maturity, quality, remaining nutrient concerns and the information needed for post-harvest planning.

POST-HARVEST: record actual yield/removal, residues returned/removed, final soil/media condition, water and input totals, economics, and next-crop building needs.

Use consistent sample locations and methods. A trend is only useful when the sampling process is comparable.

9.4 — In-Season Decision Gates: Measure Before You Change

Guided lesson time: 5 minutes

NOT EVERY OBSERVATION REQUIRES AN INPUT

At each stage classify the finding:

GREEN — crop/system is within the expected operating range; continue monitoring.

WATCH — trend is moving toward a limit; increase observation or schedule a confirmatory test.

ACTION — evidence supports a corrective management change now.

NEXT CROP — the issue is real, but the safest/economic correction belongs in post-harvest or preplant planning.

Before changing fertilizer, irrigation, aeration, chemistry or O3 AG operation, define the limiting factor, the measurement supporting the change, the expected response and the retest point.

Correct the limiting step

A tissue deficiency may originate from supply, pH, antagonism, roots, moisture, salinity, temperature or placement. A wilted crop may need irrigation—or it may have saturated damaged roots. Week 9 uses the Week 8 diagnostic process before making an in-season correction.

Where practical, change one major variable at a time or document simultaneous changes so the response can be interpreted.

9.5 — O3 AG Monitoring Through the Season

Guided lesson time: 6 minutes

FOLLOW O3 AG THROUGH THE CROP, NOT JUST THE EQUIPMENT

Use the established pathway:

O3 AG OPERATING CONDITIONS → TREATED WATER → DELIVERY → ROOT-ZONE CONDITIONS → MINERAL/ORGANIC/BIOLOGICAL PROCESSES → ROOT FUNCTION → PLANT RESPONSE → GROWTH STAGE → YIELD/QUALITY → VERIFICATION.

Monitoring needs can change as crop demand, irrigation frequency, temperature, root mass, biology and nutrient demand change. Define the sampling point: source, post-treatment, delivery, root zone, return water where applicable, plant/tissue and harvest.

Not All Ozone Is Created Equal

Course statements about O3 AG refer to O3 Science proprietary patented technology and should not automatically be generalized to conventional UV or standard commercial ozone systems.

Use the Evidence & Verification Standard. Distinguish Established Science, Independent Research, O3 AG Verified Performance, O3 AG Proprietary Technology/Mechanism and Illustrative Teaching Example.

Do not claim that a change in one water reading proves a crop response. Connect treatment measurements with roots, plant condition, nutrient status, growth stage, yield and quality.

9.6 — Crop Requirements, Yield History & What Leaves the Field

Guided lesson time: 6 minutes

BEGIN WITH THE CROP AND THE HARVESTED PORTION

Record crop, variety/hybrid, annual/perennial status, planting/establishment date, expected harvests, previous crop, next crop, irrigation system and realistic yield target.

Use multi-year field history when available. An optimistic yield goal can drive unnecessary nutrient applications. Consider field capability, water, soil limitations, variety potential, management changes and documented O3 AG performance history.

Nutrient removal depends on what actually leaves the field. Grain harvest differs from silage; hay differs from grazed pasture; grain plus straw differs from grain alone; root, fruit and whole-plant crops remove different material.

Critical distinction

CROP REMOVAL ≠ AUTOMATIC FERTILIZER APPLICATION RATE.

Removal is one input to a recommendation. Soil/media supply, calibrated crop response, water nutrients, tissue status, organic amendments, biological credits, nutrient interactions and management objectives also matter.

Feed today's crop while building tomorrow's soil and nutrient system.

9.7 — Rotations, Perennials & Repeated Harvests

Guided lesson time: 5 minutes

ONE SEASON'S DECISION AFFECTS THE NEXT

For rotations, preserve previous-crop information, legume credits where applicable, manure/compost, residue returned or removed, cover/biomass crops, irrigation-water nutrients, fertilizer history and actual yield/removal. The next recommendation should start with what the previous crop changed.

Perennial and multi-cut crops require a continuing record rather than a single annual snapshot. For alfalfa or other forage, record each cutting date, acres, bale or load count, average weight, moisture/dry matter where available, quality measurements, Brix where used, nutrient analysis where appropriate, irrigation and fertility between cuttings.

Calculate total annual dry matter and removal from all harvests. Track stand age, root/crown condition and soil trends across years.

A long-term O3 AG record should compare nutrient inputs, water, pest/disease inputs, yield, quality, days of growth and soil/plant trends. Improved efficiency should not be confused with mining a nutrient reserve.

9.8 — Seasonal Data + In-Season Crop Management Calculator

Guided lesson time: 5 minutes

BUILD ONE FIELD RECORD THAT FEEDS THE TOOLS

The future O3 AG app should not require the farmer to re-enter the same data into separate calculators. Week 9 defines the shared seasonal dataset.

Core inputs: field/growing-unit ID; crop/variety; Day 0; expected and actual growth stages; soil/media tests; water chemistry; tissue/sap/Brix where appropriate; irrigation volume; fertilizer/amendment source, rate, timing and placement; O3 AG operating records; weather/temperature; roots/compaction; pests/disease; photographs; corrective actions; harvest dates; yield/quality; and costs.

The In-Season Crop Management Calculator should answer: What stage is the crop in? What measurements are due? What trend is outside the expected range? What decision is still actionable? What test is needed before changing management? What must be carried into the end-of-season nutrient and economic calculations?

Calculator outputs are decision support—not automatic prescriptions. Crop-specific interpretation, local recommendations, label/legal requirements and field verification still apply.

9.9 — Practicum: Full-Season Crop Management Plan

Guided lesson time: 6 minutes

BUILD A REAL MANAGEMENT CALENDAR

Select an actual crop or an instructor-approved case. Build the complete season from baseline through post-harvest.

Submit: 1) crop/variety and production system; 2) Day 0 definition; 3) realistic yield/quality target based on history; 4) major growth stages and expected timing; 5) water, soil/media, tissue/sap, root/Brix and O3 AG monitoring points; 6) decision gates and corrective-action triggers; 7) nutrient sources and credits; 8) irrigation plan and measurement; 9) pest/disease and stress observations; 10) harvest/removal method; 11) days-of-growth record; 12) yield and quality units; 13) input/economic records; 14) post-harvest tests; and 15) what must be built for the next crop.

Required seasonal closeout

At harvest, calculate actual days of growth and actual production. Compare them with baseline/target. Document water and nutrient inputs, crop removal, quality, major corrections and O3 AG operating history. State what improved, what did not, what remains uncertain and what should change next season.

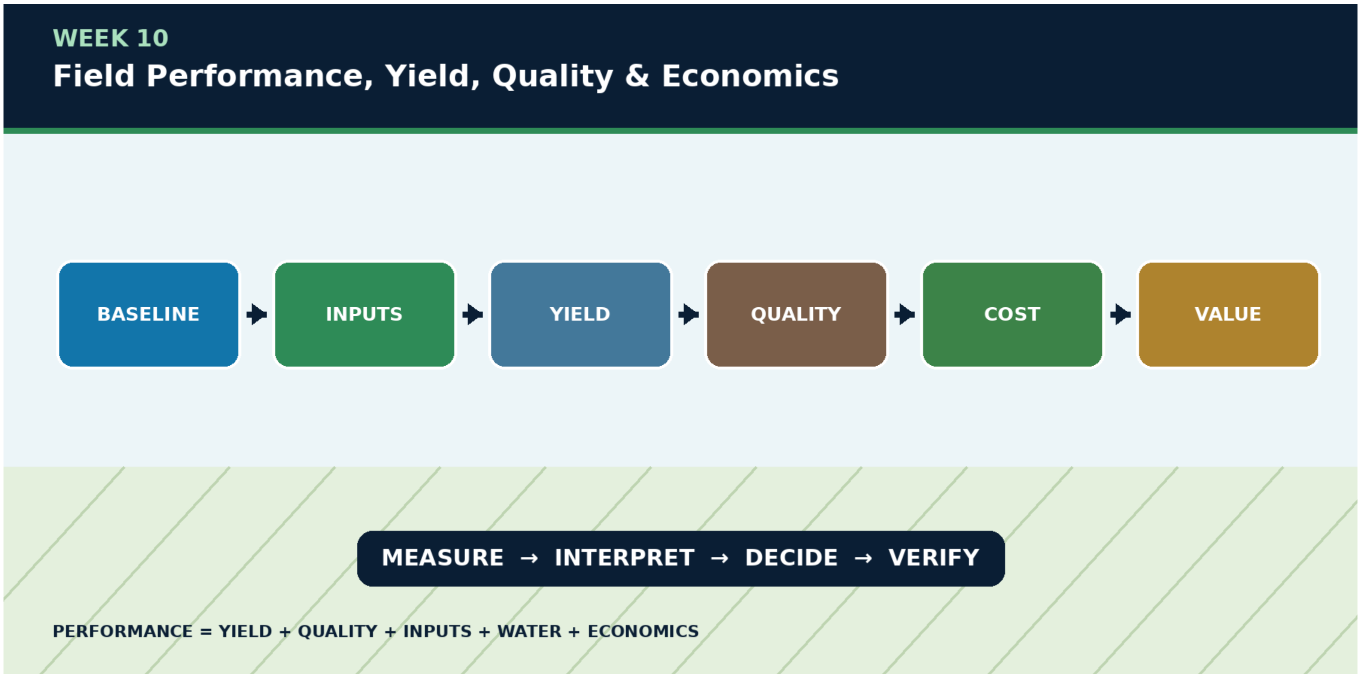
Mastery standard

The student passes Week 9 by demonstrating that crop-stage timing controls what is measured and managed, recommendations use evidence rather than calendar habit, O3 AG is followed through the complete treatment-response chain, and the season closes with data that can improve the next crop.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 10 - Field Performance, Yield, Quality & Economics



O3 AG Tech App Lab - Week 10

Lab: O3 AG Irrigation Dial-In Lab

Student action: Switch a training field to O3 AG mode; apply 10–20% startup speed protocol; log top-12-inch checks.

Data entered: Conventional setting, O3 AG adjustment, moisture checks

Required evidence: O3 AG dial-in log + candidate baseline

10.1 — Measure Performance From a Comparable Baseline

Guided lesson time: 6 minutes

WEEK 10 — FIELD PERFORMANCE, YIELD, QUALITY & ECONOMICS

What you will be able to do

By the end of Week 10, the student should be able to convert harvest records into comparable production units; calculate yield, marketable yield, water productivity, fertilizer/input productivity, cost per acre and cost per unit produced; connect days of growth with yield and quality; separate gross revenue from tracked net economic effect; calculate a defensible program return; and build an O3 AG field-performance report that distinguishes measured improvement from uncertain attribution.

Performance is a chain, not one number

BASELINE → INPUTS → O3 AG OPERATING RECORD → WATER/ROOT-ZONE RESPONSE → PLANT RESPONSE → GROWING DAYS → HARVEST → QUALITY → MARKETABLE PRODUCTION → COST → REVENUE → NET ECONOMIC EFFECT → NEXT-CROP DECISION.

Use the same crop, harvest definition and units when comparing seasons or fields. A higher yield can be meaningful, but it does not by itself identify the cause. Strong evidence connects production with water, nutrient, root, plant, management and O3 AG records.

Establish the comparison

Use 3–5 years of field history where available, an appropriate comparison area where practical, and the current O3 AG-managed season. Record acreage, variety/hybrid, Day 0, harvest criteria, weather, irrigation, fertility, pest/disease inputs and any other management changes. Document what is known and what is uncertain.

10.2 — Convert Harvest Records Into Real Yield

Guided lesson time: 6 minutes

COUNTS ARE NOT YIELD UNTIL THEY ARE CONVERTED

Use the production unit that fits the crop: bushels/acre, tons/acre, lb/acre, marketable boxes/acre, lb/plant, lb/square foot, fruit count and weight, dry matter, or another defined unit. Preserve the original harvest unit and the conversion method.

Forage example

TOTAL HARVEST WEIGHT (lb) = BALE COUNT × AVERAGE BALE WEIGHT (lb)

TOTAL TONS = TOTAL HARVEST WEIGHT ÷ 2,000

TONS/ACRE = TOTAL TONS ÷ HARVESTED ACRES

Example: 420 bales × 95 lb = 39,900 lb = 19.95 tons. If harvested from 5 acres, yield = 3.99 tons/acre.

Record moisture or dry matter when comparing forage or silage if it materially changes interpretation. A wetter crop can appear heavier without containing more dry matter.

Repeated harvests

For alfalfa, vegetables, greenhouse crops and other repeated-harvest systems, calculate every cutting or harvest separately and then total the season. This allows the student to align production with water, fertility, O3 AG operation, weather and quality during the same period.

Do not convert grain bushels to weight unless the crop-specific standard and moisture basis are defined. The app should preserve crop-specific conventions rather than applying one universal conversion.

10.3 — Growing Days, Yield per Day & Crop-Cycle Productivity

Guided lesson time: 5 minutes

CONNECT TIME WITH PRODUCTION

Week 9 established Day 0 and actual harvest date. Week 10 turns that record into a productivity measurement.

ACTUAL GROWING DAYS = HARVEST DATE − DEFINED DAY 0

YIELD PER GROWING DAY = MARKETABLE YIELD ÷ ACTUAL GROWING DAYS

Use this only when comparing the same crop or a defensibly similar crop with the same maturity/harvest standard. It is an efficiency indicator—not a replacement for yield, quality or crop maturity.

Example: 8.0 tons/acre harvested in 100 growing days = 0.080 tons/acre/day. A comparison crop at 7.5 tons/acre in 105 days = 0.071 tons/acre/day. The first crop produced more marketable yield in fewer days, but the student must still verify quality, maturity, water, inputs and economics.

Earlier is not automatically better

Heat or stress can shorten a crop cycle while reducing yield or quality. A beneficial change in days of growth should be supported by acceptable or improved marketable production, quality and economics.

Track the same metric across years so O3 AG performance can be evaluated as a trend rather than a one-season claim.

10.4 — Water Productivity & Water-Cost Efficiency

Guided lesson time: 6 minutes

HOW MUCH MARKETABLE CROP DID THE WATER PRODUCE?

Record irrigation volume using a consistent unit such as acre-inches, gallons, cubic feet or another measured farm unit. Include rainfall separately when it materially affects the comparison.

WATER PRODUCTIVITY = MARKETABLE YIELD ÷ IRRIGATION WATER APPLIED

Example: 8 tons/acre ÷ 24 acre-inches = 0.333 tons per acre-inch. A comparison of 7 tons/acre ÷ 30 acre-inches = 0.233 tons per acre-inch.

WATER-USE CHANGE (%) = (BASELINE WATER − CURRENT WATER) ÷ BASELINE WATER × 100

Convert water into economics

Track pumping electricity/fuel, water charges, labor, equipment runtime and maintenance where measurable.

WATER COST/ACRE = TOTAL TRACKED IRRIGATION COST ÷ IRRIGATED ACRES

WATER COST PER UNIT YIELD = WATER COST/ACRE ÷ YIELD/ACRE

A water reduction has economic value only when the reduction is actually measured and the crop remains adequately supplied. Do not reduce irrigation simply to produce a favorable percentage.

For O3 AG, connect water-use efficiency with source/treatment/delivery records, root-zone moisture, roots, crop stage, yield and quality.

10.5 — Nutrient/Input Efficiency & Cost per Unit Produced

Guided lesson time: 6 minutes

THE GOAL IS NOT MINIMUM INPUT — IT IS EFFICIENT, PROFITABLE INPUT

Record each fertilizer/amendment source, nutrient analysis, product rate, timing, placement and cost. Carry forward irrigation-water nutrient credits and organic/mineral contributions from Weeks 2–5.

For a fertilizer labeled with a nutrient percentage:

NUTRIENT APPLIED (lb/ac) = PRODUCT RATE (lb/ac) × NUTRIENT FRACTION

Example: 200 lb/ac of a product containing 20% N supplies 40 lb N/ac. Use P2O5 and K2O label conventions correctly when the recommendation/report is expressed in those forms.

Useful farm efficiency measures

FERTILIZER COST PER UNIT YIELD = FERTILIZER COST/ACRE ÷ YIELD/ACRE

NUTRIENT INPUT PRODUCTIVITY = YIELD/ACRE ÷ NUTRIENT APPLIED/ACRE

The second metric is an input-productivity indicator, not proof of nutrient recovery by the plant. True recovery requires additional nutrient-uptake measurements.

Check the system before adding more

A low tissue value can result from low supply, pH, antagonism, root restriction, salinity, water, temperature or placement. Do not automatically correct an uptake problem by increasing fertilizer.

Feed today's crop while building tomorrow's soil and nutrient system.

10.6 — Quality, Marketable Yield & Revenue Quality

Guided lesson time: 5 minutes

THE FARM SELLS MARKETABLE PRODUCTION, NOT JUST BIOLOGICAL WEIGHT

Quality can change the economic value of the same gross yield. Depending on the crop, preserve forage protein/digestibility and feed-value data; grain test weight, protein or grade; fruit/vegetable size, grade, Brix, shelf life and rejection percentage; or other contract/market specifications.

MARKETABLE YIELD = TOTAL YIELD × MARKETABLE FRACTION

Example: 20,000 lb/acre total yield × 0.92 marketable = 18,400 lb/acre marketable yield.

If a second field produces 21,000 lb/acre but only 80% is marketable, its marketable yield is 16,800 lb/acre. Higher biological yield did not create higher saleable production.

Where prices vary by grade, calculate revenue by grade or quality class rather than using one average price.

O3 AG performance reports should preserve quality measurements that were actually collected. Do not assign financial value to a quality improvement unless the operation receives a real price, loss reduction or use-value benefit from it.

10.7 — Farm Economics: Revenue, Cost, Break-Even & ROI

Guided lesson time: 6 minutes

TURN AGRONOMIC PERFORMANCE INTO FARM-BUSINESS INFORMATION

GROSS REVENUE/ACRE = MARKETABLE YIELD/ACRE × PRICE PER UNIT

COST PER UNIT PRODUCED = TRACKED PRODUCTION COST/ACRE ÷ MARKETABLE YIELD/ACRE

A lower cost per ton or bushel can be an important efficiency gain even when total cost per acre rises slightly.

Tracked incremental economic change

CURRENT GROSS REVENUE − BASELINE GROSS REVENUE

+ ACTUAL AVOIDED WATER/INPUT/APPLICATION COSTS

− ACTUAL ADDED INPUT/MANAGEMENT COSTS

− O3 AG PROGRAM COST ALLOCATED TO THE FIELD

= TRACKED NET ECONOMIC CHANGE

Do not subtract savings; avoided costs increase the economic result. Do not count a 'saving' for an application the farmer did not historically make. Separate quantity changes from price changes when prices differ sharply between years.

Break-even

If all other effects are held constant:

BREAK-EVEN ADDITIONAL YIELD = ADDED PROGRAM COST/ACRE ÷ CROP PRICE PER UNIT

Return on program cost

NET PROGRAM BENEFIT = VERIFIED/REASONABLY ATTRIBUTABLE BENEFITS − PROGRAM COST

ROI (%) = NET PROGRAM BENEFIT ÷ PROGRAM COST × 100

Attribution must be stated honestly. If fertilizer, irrigation, variety and other management all changed, the report should not assign the entire economic change to O3 AG without evidence.

10.8 — O3 AG Verified Performance, Attribution & Multi-Year Evidence

Guided lesson time: 5 minutes

USE PERFORMANCE DATA AS EVIDENCE, NOT AS A UNIVERSAL PROMISE

O3 AG has supplied verified field-performance records used in this course. One documented forage comparison includes 16 additional bales, approximately 30,000 lb greater total harvested weight and approximately 22% less water use, together with recorded forage-quality information. These values are classified as O3 AG VERIFIED FIELD-PERFORMANCE DATA.

The lesson is not that every farm will obtain the same percentages. The lesson is how to analyze what happened: acreage and crop comparability, actual bale weights, irrigation measurement, fertilizer and chemical inputs, O3 AG operating condition, roots, plant condition, weather and other changes.

Evidence ladder

HISTORICAL BASELINE → EARLY O3 AG → ESTABLISHED O3 AG → MULTI-YEAR TREND → COMPARISON FIELD/ZONE WHERE PRACTICAL.

Report favorable, neutral and unfavorable outcomes. A credible performance system gets stronger by learning where response is greatest, where it is limited, and which variables matter.

Use the course Evidence & Verification Standard: Established Science, Independent Research, O3 AG Verified Performance, O3 AG Proprietary Technology/Mechanism and Illustrative Teaching Example.

10.9 — Practicum: Whole-Farm Performance Dashboard & Closeout Report

Guided lesson time: 5 minutes

PUT THE WHOLE SYSTEM ON ONE PAGE

Build a completed-season performance dashboard using an actual operation or instructor-approved case.

WATER: total use, use/acre, water productivity, cost/acre, percent change.

SOIL/ROOT ZONE: pH, EC/TDS where relevant, compaction/infiltration, carbon/organic matter, roots, biology indicators and end-of-season trends.

NUTRIENTS: source, amount, water credits, fertilizer/amendment cost, nutrient-input productivity and identified carryover/build needs.

O3 AG: operating period, treatment/delivery observations, water/root-zone measurements and verified treatment records.

CROP: Day 0, growing days, harvest dates, total and marketable yield, quality, Brix/tissue where used, pest/disease inputs.

ECONOMICS: gross revenue/acre, tracked costs/acre, cost per marketable unit, avoided costs, added costs, O3 AG allocated cost, tracked net economic change and ROI where attribution is defensible.

Final report questions

1. What changed? 2. What measurements support the change? 3. What other variables changed? 4. What improved economically? 5. What did not improve? 6. What remains uncertain? 7. What should be changed next season?

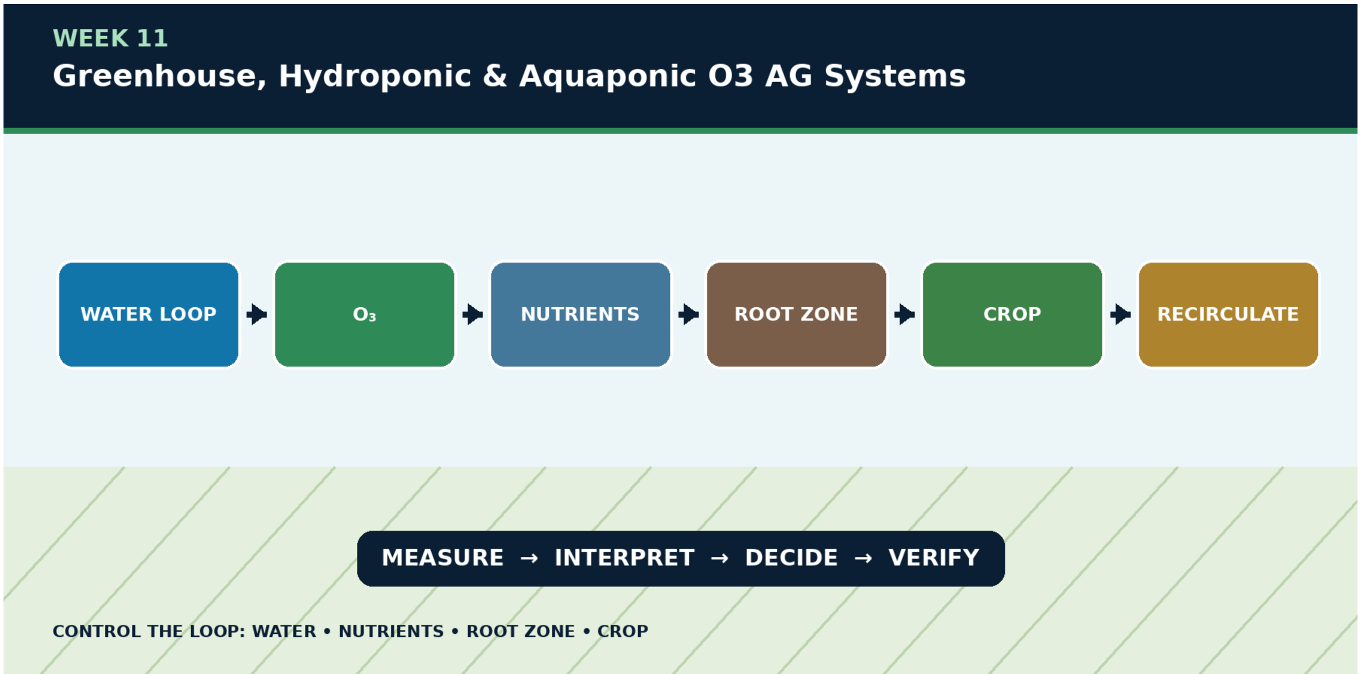
Mastery standard

The student passes Week 10 by showing correct units and calculations, refusing to count hypothetical savings, distinguishing marketable production from gross biological yield, connecting O3 AG records with agronomic outcomes, and making an economic conclusion that matches the evidence.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 11 - Greenhouse, Hydroponic & Aquaponic O3 AG Systems



O3 AG Tech App Lab - Week 11

Lab: Compaction / Aeration Lab

Student action: Record restriction observations and build an aeration/timing decision with moisture and soil context.

Data entered: Compaction observations, moisture, soil type, timing

Required evidence: Aeration decision record

11.1 — Identify the Production System & Map the Water–Nutrient Loop

Guided lesson time: 6 minutes

WEEK 11 — GREENHOUSE, HYDROPONIC & AQUAPONIC O3 AG SYSTEMS

What you will be able to do

By the end of Week 11, the student should be able to classify a controlled-environment production system; map its water and nutrient loop; identify the correct O3 AG treatment and sampling points; interpret pH, EC, TDS, DO, ORP, temperature, alkalinity, hardness and individual nutrient ions in context; distinguish soil-building from solution-management strategies; protect desirable biology in aquaponics; diagnose root-zone and recirculation problems; and build a complete controlled-environment monitoring and verification plan.

Start with the system, not the meter

Before collecting data, identify the growing system:

GREENHOUSE — SOIL — crops grown in native or constructed soil under cover.

GREENHOUSE — SUBSTRATE — crops grown in peat, coco, bark, rockwool, perlite, blends or other media.

HYDROPONIC — crops grown without conventional field soil using nutrient solution and/or inert media.

AQUAPONIC — aquatic animals, microbial nutrient conversion and crop production linked by recirculating water.

The system determines what can be stored, what must be replenished, what biology must be protected, and how O3 AG treatment is evaluated.

Map the loop

WATER SOURCE → STORAGE/RESERVOIR → NUTRIENT INPUT → O3 AG TREATMENT/CONTACT → DELIVERY → ROOT ZONE → RETURN/DRAINAGE → FILTRATION/BIOLOGY → RECIRCULATION.

For aquaponics add: FEED/FISH → WASTE → MICROBIAL CONVERSION → PLANT NUTRIENT UPTAKE → WATER RETURN.

The first assignment is to draw the operation and label every measurement point. A generator reading is not the same as the condition experienced by roots, fish, biofilters or plants.

11.2 — Water Chemistry, Nutrient Solution & Salt Balance

Guided lesson time: 6 minutes

THE ROOTS LIVE IN THE WATER CHEMISTRY

Controlled-environment systems compress many of the water, nutrient and root-zone processes from Weeks 2–6 into a smaller, faster-changing volume. That makes measurement frequency and context especially important.

Record at minimum where appropriate: **pH, EC, TDS, temperature, DO, ORP, alkalinity/bicarbonate, hardness, nitrate/ammonium, calcium, magnesium, potassium, sulfate/sulfur, sodium and chloride**. Add phosphorus and micronutrients through the laboratory or nutrient-management method appropriate to the system.

EC and TDS are totals, not identities

EC/TDS can indicate dissolved-ion load, but they do not tell the student which ions are present. Two reservoirs can have the same EC and very different nutrient value or salt risk.

Build the nutrient inventory

For a recirculating solution:

ENDING NUTRIENT INVENTORY = STARTING INVENTORY + NUTRIENTS ADDED + SOURCE-WATER CONTRIBUTION − PLANT REMOVAL − MEASURED/ESTIMATED SYSTEM LOSSES

Use laboratory or validated system measurements to check the estimate. Do not assume a drop in EC equals crop uptake of the nutrient the grower intended to supply.

Salinity ≠ sodicity ≠ alkalinity ≠ hardness

Carry forward Week 6 terminology. High EC may indicate salinity; sodium hazard requires sodium in context; alkalinity is primarily acid-neutralizing capacity associated with bicarbonate/carbonate chemistry; hardness reflects mainly Ca/Mg; scale and corrosion require their own diagnosis.

The student should identify **which ions are present, how much, what the crop requires, and what the water/system is doing with them**.

11.3 — Dissolved Oxygen, Root Respiration & O3 AG Treatment Placement

Guided lesson time: 6 minutes

ROOTS NEED OXYGEN AS WELL AS WATER

Roots respire. Microorganisms also consume oxygen. Warm nutrient solution generally holds less dissolved oxygen than cool solution, and dense roots or biological loading can increase oxygen demand. Therefore DO is recorded with **temperature, location, time, crop stage and O3 AG operating status**.

Follow the treatment chain

O3 AG TREATMENT → WATER CONDITION → DELIVERY → ROOT-ZONE CONDITION → ROOT RESPONSE → NUTRIENT UPTAKE → PLANT RESPONSE.

Use DO, ORP and other appropriate treatment measurements as parts of the evidence chain, not as isolated proof. The central question is: **What condition actually reaches the roots?**

Treatment placement matters

In recirculating systems, treatment location, contact time, mixing, return flow and the distance between treatment and the biological/root zone can change exposure. The student must map the contact area and measure at source, post-treatment, delivery and root-zone/return points as appropriate.

O3 AG language standard

Not All Ozone Is Created Equal. O3 AG uses proprietary patented treatment technology. In this course, established ozone chemistry, conventional ozone research, O3 AG verified performance and O3 AG proprietary mechanisms are labeled separately. Students evaluate the O3 AG system by its measured operating conditions and agricultural response rather than assuming the limits of a different ozone platform automatically define this technology.

11.4 — Root Health, Biofilms, Disease Pressure & Corrective Diagnosis

Guided lesson time: 6 minutes

ROOTS ARE THE FIRST CROP DIAGNOSTIC

In hydroponic and recirculating systems, root problems can develop quickly and can spread through shared water. Inspect roots for color, branching, root hairs, firmness, odor, sloughing, lesions and new-root development. Record crop stage and compare healthy and stressed zones.

Diagnose the system

OBSERVE ROOTS → MAP DISTRIBUTION → CHECK WATER TEMPERATURE/DO → CHECK pH/EC/NUTRIENTS → CHECK FLOW/IRRIGATION → CHECK SANITATION/BIOFILM → CHECK PATHOGEN EVIDENCE → CHECK O3 AG CONDITIONS → TEST → CORRECT → RETEST.

Do not label every brown root as a pathogen. Oxygen limitation, heat, salinity, nutrient imbalance, physical damage and chemical injury can create similar symptoms.

Two separate O3 AG questions

DIRECT SYSTEM QUESTION: Did treatment change measurable undesirable biological/pathogen pressure or biofilm conditions in the water/system?

PLANT QUESTION: Did the crop subsequently develop healthier roots and perform better?

These should be measured separately and then connected.

Where laboratory diagnosis is available, retain pathogen identification, incidence and severity. Where it is not, classify the result as observed/suspected rather than confirmed.

11.5 — Organic Nutrition, Mineral Nutrition & Long-Term System Building Without Field Soil

Guided lesson time: 6 minutes

"BUILD THE SYSTEM" MEANS DIFFERENT THINGS IN DIFFERENT GROWING MEDIA

Week 5 established the principle: **Feed today's crop while building tomorrow's soil and nutrient system.** In a field soil, long-term building can include organic matter, stable carbon, aggregate structure, CEC and biologically cycled nutrient reserves.

In hydroponics there may be little or no soil reserve to build. The long-term objective becomes **water-quality control, stable nutrient inventory, healthy roots, appropriate biological management, clean delivery surfaces, efficient recirculation and lower nutrient loss**.

In substrate systems, the medium may provide some water/nutrient buffering, but its CEC, decomposition and physical properties differ from field soil.

In aquaponics, feed inputs and microbial transformations are part of the nutrient-generating engine. "Organic" does not mean simply adding unprocessed material to a reservoir. Every input must be compatible with oxygen demand, filtration, animal health, microbial conversion and crop needs.

Transition rule

Do not remove a nutrient source until you understand what will replace its function.

For controlled systems, calculate crop demand, source-water contributions, current solution inventory, organic/biological contributions where valid, and the remaining requirement. Reduce or replace inputs only after the new pathway is measured and verified.

11.6 — Aquaponics: Protect Fish, Biofilters & Desirable Biology

Guided lesson time: 6 minutes

AQUAPONICS IS A MULTI-ORGANISM PRODUCTION SYSTEM

A simplified nutrient pathway is:

FISH/ANIMAL FEED → WASTE/AMMONIA-AMMONIUM → MICROBIAL NITRIFICATION/TRANSFORMATION → PLANT-AVAILABLE NUTRIENTS → PLANT UPTAKE → WATER RETURN.

The microbial community is not incidental. It performs essential nutrient conversion. Therefore treatment strategy must consider **fish/animal health, biofilter function, desired microorganisms, root health and water quality together**.

Measure both sides of biology

UNDESIRABLE BIOLOGY/PATHOGEN PRESSURE

versus

DESIRABLE/FUNCTIONAL BIOLOGY

then

ROOT + PLANT + AQUATIC-ANIMAL RESPONSE.

Monitor the nitrogen pathway appropriate to the operation, including ammonia/ammonium, nitrite and nitrate, plus pH, temperature, DO and other relevant chemistry. Abrupt changes in the nitrogen-conversion pathway require investigation before adjusting nutrients or treatment.

O3 AG placement and separation

Students should identify where treatment/contact occurs relative to fish tanks, biofilters, roots and return water. The objective is not to expose every organism indiscriminately; it is to manage the water-treatment process while preserving the biological functions the production system requires.

Any aquaponic application plan should include conservative startup, defined measurement points, animal observations, biofilter indicators, root observations and clear stop/adjust criteria.

11.7 — Greenhouse Climate, Transpiration, Fertigation & Crop Demand

Guided lesson time: 6 minutes

CONTROLLED ENVIRONMENT DOES NOT MEAN NO VARIABLES

Greenhouses reduce some weather variability but create tightly coupled climate variables. Record **air temperature, root-zone/water temperature, humidity, light/solar load, irrigation frequency, crop stage and ventilation/air movement** where relevant.

Transpiration affects water and nutrient movement. When the crop transpires faster, nutrient-solution demand may change. When humidity is high and transpiration slows, a nutrient that is abundant in solution may still move differently into plant tissues.

Fertigation is a timing problem as well as a concentration problem

Track nutrient concentration, irrigation frequency, drain/return fraction, media moisture and EC at the root zone. A correct reservoir analysis can still produce a crop problem if delivery timing, root-zone EC or moisture is wrong.

Brix and plant measurements

Brix can be part of the crop-response record, but use crop-specific interpretation. Pair Brix with tissue/sap analysis where appropriate, growth stage, root condition, yield, quality and stress observations.

O3 AG evaluation

Connect O3 AG operation with the climate and crop-demand record. If crop water demand increases because of heat/light, treatment dose/contact and delivery conditions may differ from a cool, low-demand period. The student learns to manage treatment as part of a dynamic production system.

11.8 — Controlled-System Calculators, Cost & Resource Efficiency

Guided lesson time: 6 minutes

TURN THE CONTROLLED SYSTEM INTO A MEASURABLE BUSINESS UNIT

Use the shared field/operation record to calculate production and resource efficiency. Choose units appropriate to the operation: **lb/plant, lb/square foot, kg/m^2, boxes/house, harvests/cycle, gallons per marketable pound, nutrient cost per pound produced, energy cost per crop cycle** or another defensible unit.

Core calculations

WATER PRODUCTIVITY = MARKETABLE YIELD ÷ WATER USED

NUTRIENT INPUT PRODUCTIVITY = MARKETABLE YIELD ÷ DEFINED NUTRIENT INPUT

COST PER UNIT YIELD = TRACKED PRODUCTION COST ÷ MARKETABLE YIELD

CROP-CYCLE PRODUCTIVITY = MARKETABLE YIELD ÷ ACTUAL GROWING DAYS

For recirculating systems also track solution replacement/dump volume, nutrient additions, filtration/maintenance, pump/energy runtime and crop losses.

Planned app calculators

The controlled-environment toolset should share data with the Week 2 water nutrient calculator and Weeks 9–10 performance tools. Planned calculators include reservoir nutrient inventory, replenishment requirement, water-use efficiency, nutrient-use/input productivity, crop-cycle productivity, treatment cost per unit yield and economic comparison.

The calculator never replaces measurement. It organizes measured data and makes the management question visible.

11.9 — Practicum: Build a Complete Controlled-Environment O3 AG Management Plan

Guided lesson time: 6 minutes

WEEK 11 PRACTICUM — MAP, MEASURE, MANAGE, VERIFY

Choose a greenhouse-soil, greenhouse-substrate, hydroponic or aquaponic operation. If direct access is unavailable, use a supplied O3 AG case-study or simulated dataset.

Build the system map

Identify water source, reservoir/storage, nutrient inputs, O3 AG treatment/contact, delivery, root zone, return/drainage, filtration, biofilter where applicable, and every sampling location.

Build the measurement schedule

Define what will be measured at startup, during active crop demand, after management changes and before harvest. Include water chemistry, nutrient inventory, root observations, plant/tissue/Brix where appropriate, disease/pest pressure, crop stage, yield/quality and O3 AG operating records.

Diagnose one management problem

Examples: rising root-zone EC, declining DO, nutrient imbalance, unexplained chlorosis, root browning, biofilm, scale/clogging, unstable pH, aquaponic nitrogen imbalance or declining yield. State the most likely cause and at least two competing explanations.

Build the corrective plan

Explain what will change, where O3 AG influences the process, what O3 AG does not replace, what measurement will be repeated and what result would justify keeping or changing the plan.

Close with economics

Calculate at least one production-efficiency metric and one cost-per-unit metric.

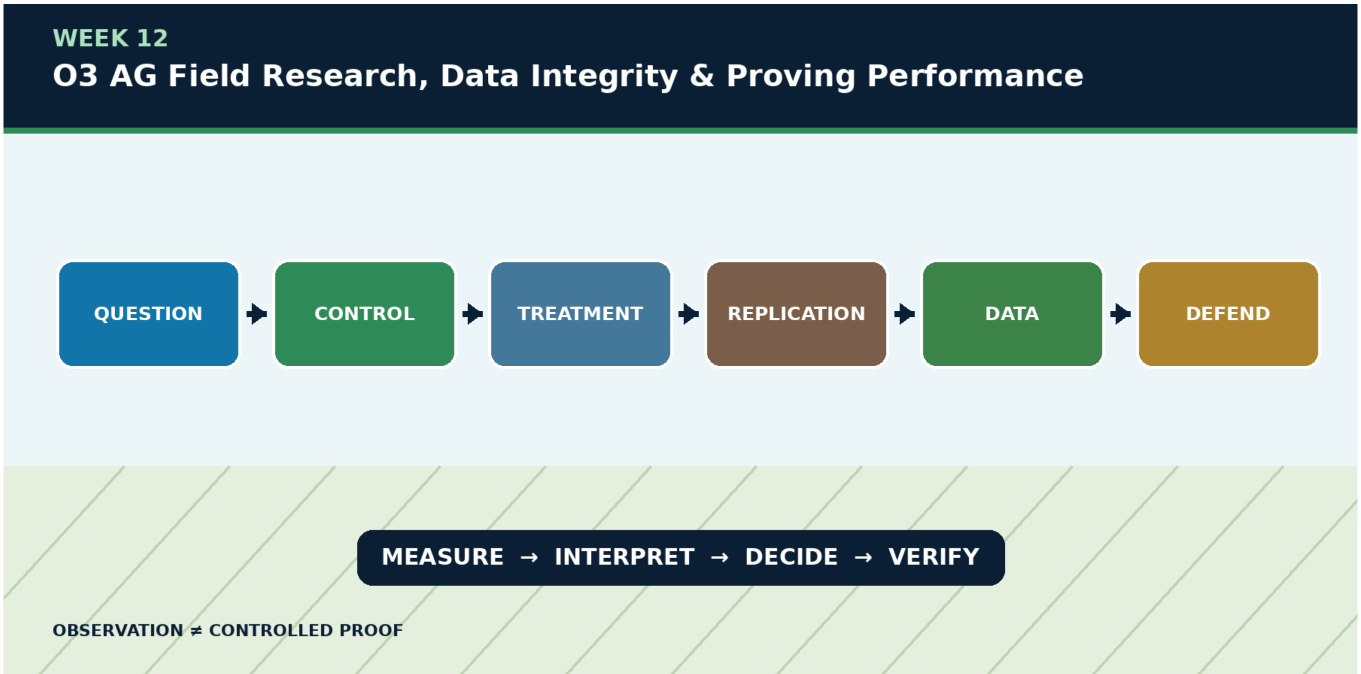
Teaching standard: TEACH IT → MEASURE IT → CALCULATE IT → APPLY IT → RECORD IT → VERIFY IT → IMPROVE THE NEXT CROP.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete

Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 12 - O3 AG FIELD RESEARCH, DATA INTEGRITY & PROVING PERFORMANCE



O3 AG Tech App Lab - Week 12

Lab: End-of-Season Soil-Building Lab

Student action: Combine tests, crop removal, water credits, applications, and ending position into next-cycle planning.

Data entered: Beginning/ending tests, removal, applications, credits

Required evidence: Soil-building plan

12.1 — Ask a Measurable Question & Define Success Before the Trial

Guided lesson time: 6 minutes

WEEK 12 — O3 AG FIELD RESEARCH, DATA INTEGRITY & PROVING PERFORMANCE

What you will be able to do

By the end of Week 12, the student should be able to turn a field observation into a measurable research question; define a baseline and comparison; design repeatable sampling; document O3 AG operation and confounding variables; preserve original data; calculate meaningful changes; separate observation from interpretation; classify the strength of a conclusion; and assemble an O3 AG Field Performance Case File that another qualified person can audit and repeat.

Start with a question that can be tested

Weak question: **Did O3 AG make the crop better?**

Stronger question: **Under the documented management conditions, did the O3 AG-treated area differ from the comparison in marketable yield, water use, tissue status, root condition, disease incidence, days to harvest, or cost per unit yield?**

Before the trial begins, write down what will count as improvement, what will be measured, when it will be measured, and what comparison will be used. This reduces the temptation to select only favorable measurements afterward.

Research chain

QUESTION → BASELINE → HYPOTHESIS → MEASUREMENT PLAN → COMPARISON → TREATMENT RECORD → SAMPLE → OBSERVE → MEASURE → CALCULATE → ANALYZE → VERIFY → REPEAT → CONCLUSION.

Teaching rule: Measure what happened. Document the conditions. Separate observation from explanation. Then determine what the evidence actually supports.

12.2 — Baselines, Comparisons, Replication & Field Variability

Guided lesson time: 6 minutes

Baseline is the starting condition

A baseline may include historical yield and quality, soil/media tests, irrigation-water chemistry, tissue/sap results, Brix where appropriate, root observations, disease/pest records, input rates, irrigation volume, energy use, labor, and production cost.

Build a fair comparison

Where practical, compare O3 AG treatment with an untreated or differently managed area that is as similar as possible in soil, crop, variety, planting date, irrigation, fertility, harvest timing and management. When a true control is not feasible, use a clearly documented historical baseline or before/after design and state its limitations.

Replicate the measurement

One plant, one soil core, one Brix reading, one emitter, or one harvest unit is not a field. Replication means collecting enough independent observations across the management unit to understand variation rather than selecting the best-looking location.

Use permanent sample IDs and mapped locations. Include productive, average and problem zones when the research question requires them.

Variables that can change the result

Record weather, heat, frost, rainfall, irrigation, fertilizer, compost/manure, pesticide/fungicide, cultivar, planting population, tillage/aeration, disease pressure, harvest date, equipment changes and any other management difference that could influence the outcome.

A variable is not an inconvenience to hide. It is information needed to interpret the result.

12.3 — Build the Sampling & Measurement Plan

Guided lesson time: 6 minutes

Sample according to the question

Every sample must answer a defined question. Establish the location, depth or plant part, timing, method, number of replicates and laboratory/instrument before collection.

Water: source → pre-treatment → post-treatment/contact → delivery → end of line → return water where applicable.

Soil/media: fixed depth, mapped zone, consistent sampling method and timing.

Plant/tissue/sap: correct plant part and growth stage, with treated and comparison samples collected consistently.

Roots: depth, color, branching, root hairs, restriction, disease symptoms, moisture and compaction/root-zone condition.

Crop response: emergence, stand, growth stage, days of growth, marketable yield, quality, harvest units and crop-specific measurements.

Timing matters

Use comparable growth stages whenever possible. A treated sample collected during active uptake and a comparison collected after stress or at a different stage may create a false difference.

Create a written sampling calendar before the trial and record deviations when weather or operations force a change.

12.4 — The O3 AG Treatment Record & Chain of Delivery

Guided lesson time: 6 minutes

Proving performance requires proving treatment delivery

The field record must show what happened between the water source and the crop. Record the O3 AG system identity, operating period, treatment location, flow/pressure where applicable, irrigation duration, relevant sensor readings, maintenance events, downtime, and sampling points.

Follow the treatment chain:

SOURCE WATER → O3 AG GENERATION/TREATMENT → CONTACT/TRANSFER → STORAGE IF USED → DISTRIBUTION → END OF LINE → ROOT ZONE → PLANT RESPONSE.

Do not assume a generator setting proves what reached the root zone. Distribution uniformity, storage time, flow, clogged emitters, leaks, water chemistry, temperature and field conditions can alter the delivered treatment environment.

Evidence classification

When describing proprietary performance, use the approved course standard: **Established Science; Independent Research; O3 AG Verified Performance; O3 AG Proprietary Technology/Mechanism; Illustrative Teaching Example.**

“Not All Ozone Is Created Equal” identifies the proprietary O3 AG technology distinction; it does not remove the need to measure the actual operating system and crop response.

12.5 — Data Integrity: Preserve the Original Evidence

Guided lesson time: 6 minutes

Never improve the data by cleaning away inconvenient results

Data integrity means the original record remains traceable. Preserve laboratory reports, sample IDs, dates, locations, methods, instrument readings, calibration records, photographs, field notes, maintenance logs, weather records and harvest tickets where available.

Negative, neutral and unexpected results remain in the dataset. If a sample is excluded, record the reason rather than deleting it silently.

Photograph correctly

Use the same location, angle, scale and growth stage where practical. Include a field identifier and date. Photograph healthy, average and stressed areas—not only the strongest response.

A photograph proves what was visible at that time. It does not by itself prove the cause.

Laboratory results

Keep the original laboratory units and methods. Convert units only in a separate calculation field so the source result remains intact. When comparing tests, note changes in laboratory, extraction method, sampling depth or tissue protocol.

Audit question: Could another qualified person trace every important number in the conclusion back to its original source?

12.6 — Calculations: Change, Efficiency, Yield & Economics

Guided lesson time: 6 minutes

Calculate what changed

Common calculations include:

Absolute change = **Treatment − Baseline/Comparison**

Percent change = **((Treatment − Baseline/Comparison) ÷ Baseline/Comparison)** × **100**

Yield per acre = **Harvested marketable units** ÷ **harvested acres**

Water productivity = **Marketable yield** ÷ **irrigation water applied**

Input productivity = **Marketable yield** ÷ **measured input quantity**

Cost per unit = **Total attributable production cost** ÷ **marketable yield**

Net economic change = **Added crop value** + **actual avoided costs − added costs − allocated O3 AG program cost**

Always show the units, period and denominator. A percentage without the starting value can mislead.

Do not confuse precision with certainty

A calculator can produce many decimal places even when field sampling is weak. Report only the precision supported by the measurement method and field design.

Where replicated data are available, summarize the average and the spread/variability. Larger research programs may require formal statistical analysis; the course does not treat a simple percentage difference as proof of causation.

12.7 — Correlation, Causation & Competing Explanations

Guided lesson time: 6 minutes

A change after treatment is not automatically caused by treatment

If yield increases after O3 AG installation, the observation is important—but weather, variety, fertility, irrigation, pest pressure, planting date, harvest timing or another management change may also have contributed.

Students must write at least one competing explanation for every major performance conclusion and identify the evidence that would strengthen or weaken each explanation.

Stronger evidence comes from stronger design

Confidence generally increases when the result has a defined baseline, fair comparison, repeated measurements, consistent sampling, documented treatment delivery, stable management, independent laboratory data, repeated seasons/locations, and results that agree across related indicators.

Do not overgeneralize. A result verified on one crop, soil, water source and season is evidence for those documented conditions. Broader claims require broader evidence.

This protects O3 AG credibility because the course teaches students to say exactly what the data supports—no less and no more.

12.8 — Build the O3 AG Field Performance Case File

Guided lesson time: 6 minutes

One case file should tell the whole story

The case file connects agronomy, O3 AG operation and economics in one auditable record.

Include: operation and field/growing-unit ID; crop/variety; planting and harvest dates; soil/media description; source-water chemistry; baseline; hypothesis; comparison design; sampling map; O3 AG configuration and operating record; fertilizer/amendment program; irrigation; weather/environment; soil/media tests; tissue/sap/Brix where used; root observations; pest/disease records; photographs; growth-stage timeline; yield/quality; days of growth; input costs; cost per unit; deviations; unexpected events; and conclusion.

Close every case with uncertainty and next steps

State what changed, what did not change, what remains uncertain, what evidence category is justified, what management recommendation follows, and what must be retested next season.

The case file is designed to feed the future O3 AG app evidence library so field records, calculations, photographs, laboratory documents and operating data remain connected rather than living in separate notebooks.

12.9 — Practicum: Design a Defensible O3 AG Verification Trial

Guided lesson time: 6 minutes

Week 12 practicum

Choose an actual or instructor-provided production system and design a complete verification trial.

Your submission must contain:

1. A measurable research question and hypothesis.

2. The baseline and comparison strategy.

3. A mapped sampling plan with sample IDs.

4. Measurements, units, methods, timing and replication.

5. O3 AG treatment/operation records required.

6. Confounding variables that will be tracked.

7. Crop-stage and harvest measurements.

8. The calculations that will be performed.

9. Data-integrity and photograph protocol.

10. At least two competing explanations for a possible result.

11. The evidence wording you would use for weak, moderate and strong outcomes.

12. A retest/repetition plan.

Mastery standard

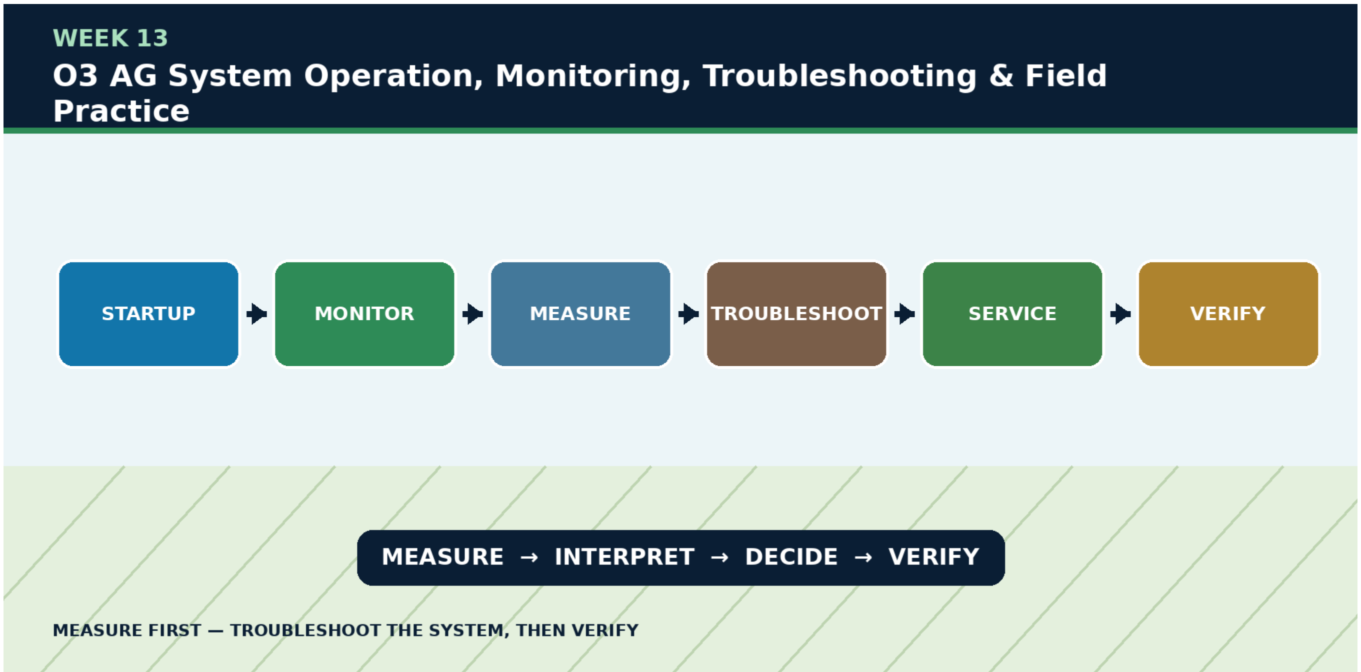
A passing plan must be repeatable by another qualified person and must make it possible to trace the final conclusion back through the measurements to the original field and laboratory records.

Week 12 principle: A result becomes valuable when it can be traced, tested, repeated and defended.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 13 - O3 AG SYSTEM OPERATION, MONITORING, TROUBLESHOOTING & PROFESSIONAL FIELD PRACTICE



O3 AG Tech App Lab - Week 13

Lab: O3 AG System Operation Lab

Student action: Run a mock operational verification from source through delivery/root zone and document exceptions.

Data entered: Operating checks, sampling points, treatment record

Required evidence: O3 AG operating verification report

SYSTEM OPERATION, MONITORING & TROUBLESHOOTING + WEEK 13 — TEACHING CHAPTER

Guided lesson time: 6 minutes

SYSTEM OPERATION, MONITORING & TROUBLESHOOTING

Find where the treatment-response chain broke before changing the system

Learning objectives

Measurement-first troubleshooting

Equipment versus irrigation problems

Root-zone limitations

Sensors and calibration

The week in the complete treatment chain

SOURCE / BASELINE → O3 TREATMENT → DELIVERY → ROOT ZONE → BIOLOGY / NUTRIENTS → PLANT → HARVEST → ECONOMICS

This chapter should be read as part of that complete chain. The purpose is not to isolate one measurement, but to understand how it connects to the agricultural response.

WEEK 13 — TEACHING CHAPTER

Measurement-first troubleshooting + Equipment versus irrigation problems

Guided lesson time: 6 minutes

Measurement-first troubleshooting

When expected performance is missing, verify source water, equipment operation, gas preparation/transfer, treated-water condition, distribution, root environment, biology, plant nutrition, Brix, pest/disease pressure and production response in sequence.

What to measure

Sampling point and date/time

Water temperature, pH and EC where relevant

DO and/or ORP where relevant

Flow or volume

O3 treatment status and delivery condition

Interpretation rule

Do not turn one measurement into a complete diagnosis. Compare it with the rest of the system and state what additional information would confirm or reject the working explanation.

Equipment versus irrigation problems

Flow, pressure, clogged emitters/nozzles, poor uniformity, storage, leaks and timing can make a treatment appear ineffective even when generation is normal. Irrigation problems can look like O3 problems.

What to measure + Root-zone limitations

Guided lesson time: 6 minutes

What to measure

Location or GPS/growing-unit ID

Crop and growth stage

Baseline condition

Relevant physical/chemical/biological measurement

O3 treatment status and follow-up result

Interpretation rule

Do not turn one measurement into a complete diagnosis. Compare it with the rest of the system and state what additional information would confirm or reject the working explanation.

WEEK 13 — TEACHING CHAPTER

Root-zone limitations

Compaction, saturation, salinity, crusting, poor drainage, root disease and nutrient imbalance can prevent a crop response. Check roots and soil/medium before simply increasing treatment or fertilizer.

What to measure + What to measure

Guided lesson time: 6 minutes

What to measure

Soil/medium result with method and units

Plant tissue/sap result

Root condition and moisture

Input sources and rates

Interpretation rule

Do not turn one measurement into a complete diagnosis. Compare it with the rest of the system and state what additional information would confirm or reject the working explanation.

Sensors and calibration

A bad sensor can create a false conclusion. Record calibration, maintenance, replacement components and instrument location. Compare questionable readings with another method or instrument when possible.

What to measure

Location or GPS/growing-unit ID

Crop and growth stage

Baseline condition

Relevant physical/chemical/biological measurement

O3 treatment status and follow-up result

Interpretation rule + What to measure

Guided lesson time: 6 minutes

Interpretation rule

Do not turn one measurement into a complete diagnosis. Compare it with the rest of the system and state what additional information would confirm or reject the working explanation.

WEEK 13 — TEACHING CHAPTER

Change one major variable

When troubleshooting, avoid changing flow, fertilizer, irrigation timing and treatment setting all at once. Change one major variable at a time where practical so the response can be interpreted.

What to measure

Location or GPS/growing-unit ID

Crop and growth stage

Baseline condition

Relevant physical/chemical/biological measurement

O3 treatment status and follow-up result

Interpretation rule + Interpretation rule

Guided lesson time: 6 minutes

Interpretation rule

Do not turn one measurement into a complete diagnosis. Compare it with the rest of the system and state what additional information would confirm or reject the working explanation.

Maintenance is agricultural data

Equipment condition can coincide with changes in delivered water and crop response. Maintenance records belong with the field data, especially when a performance change appears suddenly.

What to measure

Sampling point and date/time

Water temperature, pH and EC where relevant

DO and/or ORP where relevant

Flow or volume

O3 treatment status and delivery condition

Interpretation rule

Do not turn one measurement into a complete diagnosis. Compare it with the rest of the system and state what additional information would confirm or reject the working explanation.

Practical exercise + Field record

Guided lesson time: 6 minutes

Practical exercise

Diagnose a treatment chain using actual or simulated data. Identify where the expected response disappears and specify the next measurement before changing settings.

Three ways to complete

Option A - Field/Lab: collect and document the measurements directly.

Option B - Verified O3 AG Case Study: analyze a supplied real-world data package.

Field record

Ten-question review and instructor discussion prompts

Why can source water change treatment behavior?

How do generation and transfer differ?

Why sample multiple distribution points?

Name four irrigation problems that can mimic O3 failure.

Why check roots before adding fertilizer?

Why can a bad sensor create a false conclusion?

What does “measure before you adjust” mean?

Why record maintenance events?

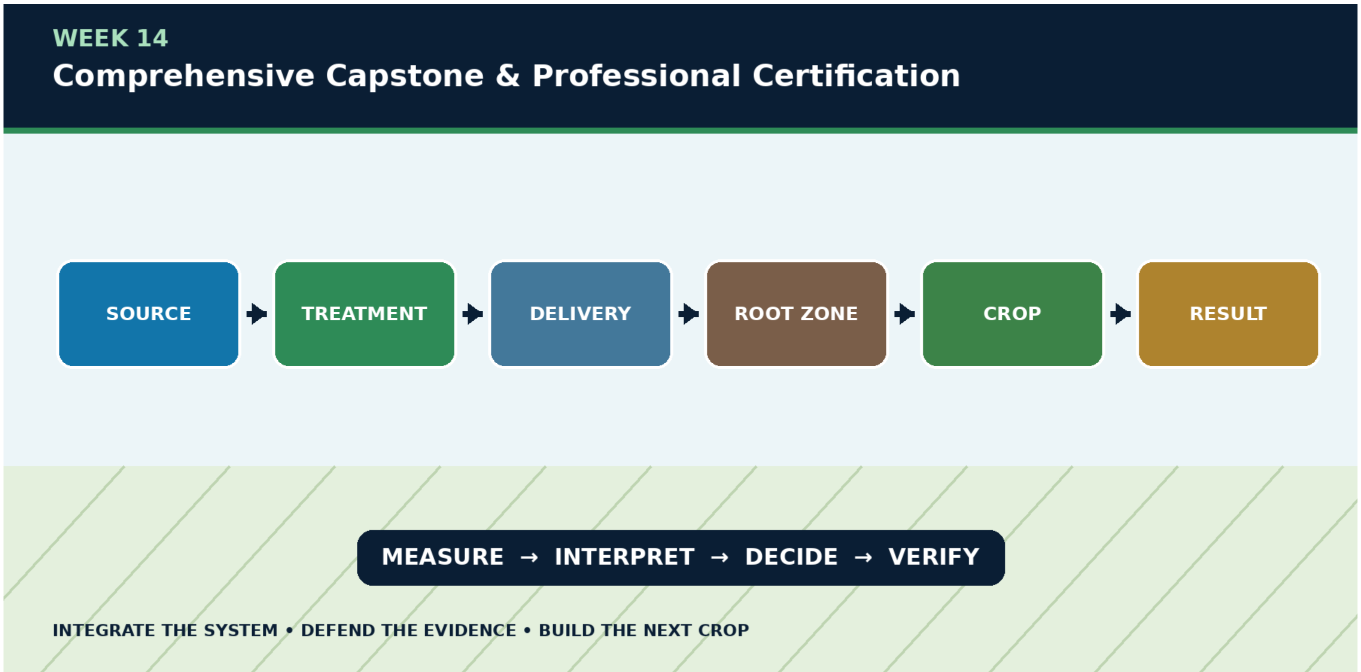
Why should one major variable be changed at a time when possible?

What is the final agricultural performance measurement?

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 14 - COMPREHENSIVE CAPSTONE & PROFESSIONAL CERTIFICATION



O3 AG Tech App Lab - Week 14

Lab: Integrated Case / Capstone Lab

Student action: Diagnose a supplied training field, choose actions, document reasons, and generate a management report.

Data entered: All accumulated training-field data

Required evidence: Integrated field case file

14.1 — Define the Production Goal, Baseline & Success Criteria

Guided lesson time: 7 minutes

The capstone begins with a real production question, not a desired conclusion. Define the crop or production system, field/growing-unit ID, acreage or system size, variety, planting or start date, historical baseline, current management, O3 AG configuration and the measurable outcome to be evaluated.

Success may involve marketable yield, quality, days of growth, water productivity, nutrient-input efficiency, root condition, soil/media condition, pest or disease pressure, operating reliability, cost per unit or net return. State the primary goal and secondary goals separately.

Write the baseline before reviewing the final result. A defensible capstone shows where the operation started, what was changed, what was held reasonably consistent, and what evidence would count as success, no change or an inconclusive result.

14.2 — Build the Permanent Sampling & Field-Record Map

Guided lesson time: 7 minutes

Create one map that follows the production system through time. Assign repeatable IDs to source water, treatment points, mainline/mid-line/end-line locations, healthy and problem zones, soil/media samples, roots, tissue/sap/Brix stations where appropriate, pest/disease stations, photographs and harvest units.

The same location ID should follow laboratory reports, photographs, field observations, applications, O3 AG operating records and harvest data. This prevents a common failure: comparing measurements that came from different places or conditions.

Record date/time, crop stage, sampling depth or plant part, instrument/method, units, weather or controlled-environment conditions, irrigation status and treatment status. The map becomes the backbone of the final evidence package and future retesting.

14.3 — Integrate Water, Soil/Media, Biology, Roots & Nutrient Budget

Guided lesson time: 7 minutes

Bring the resource system into one nutrient-and-root-zone account. Include soil/media test results, pH, EC/TDS where relevant, organic matter/carbon, CEC/base saturation where appropriate, compaction/aeration observations, irrigation-water nutrients, fertilizer and organic amendments, residue/cover-crop contributions, biological nitrogen fixation where applicable, and crop-removal estimates.

Use the nutrient-budget relationship: beginning status + measured/known inputs + credited contributions − crop removal − defensible losses = estimated ending position. Then compare that estimate with actual late-season/post-harvest testing. Differences are diagnostic clues, not permission to invent missing nutrients.

Students must identify whether a limitation is supply, accessibility, root reach, water movement, chemistry/antagonism, biological cycling, physical restriction or another documented factor before recommending additional fertilizer.

14.4 — Integrate O3 AG Treatment, Irrigation & System Operation

Guided lesson time: 7 minutes

Map O3 AG into the complete delivery chain: SOURCE → TREATMENT → TRANSFER/CONTACT → STORAGE IF USED → PUMP/FILTRATION → DISTRIBUTION → ROOT ZONE/RESERVOIR → PLANT. Document the site-specific operating indicators and approved monitoring points without inventing universal setpoints.

Separate equipment operation from agronomic response. Verify hydraulics, flow, pressure, distribution uniformity, filtration, emitter/nozzle condition, storage and timing before attributing a crop pattern to treatment. Include calibration, maintenance, downtime and change-control records.

The capstone must state what O3 AG-related conditions were actually measured, what crop/root/soil changes were observed, and which proposed mechanisms remain proprietary, inferred or require additional verification.

14.5 — Integrate Plant Health, Growth Stages & Corrective Management

Guided lesson time: 7 minutes

Follow the crop from Day 0 through vegetative growth, reproductive/yield-building stages, maturity and harvest. Track days of growth, root observations, plant vigor, tissue/sap and Brix where appropriate, nutrient symptoms, pest life stages, beneficial organisms, disease incidence/severity, weather or climate stress and pesticide/herbicide/fungicide history.

Use the diagnostic pathway: OBSERVE → MAP PATTERN → GROWTH STAGE → PLANT → ROOTS → WATER → SOIL/MEDIA → NUTRIENTS → BIOLOGY → ENVIRONMENT/MANAGEMENT → O3 AG CONDITIONS → COMPETING DIAGNOSES → TEST → CORRECT → RETEST.

A photograph documents a symptom; it does not prove the cause. The student must show evidence for the leading diagnosis, evidence against competing explanations and the measurement used to verify recovery.

14.6 — Calculate Harvest, Quality, Resource Efficiency & Economics

Guided lesson time: 7 minutes

Convert production into comparable units. Report yield per acre or production unit, marketable yield, repeated harvests/cuttings where applicable, quality measurements appropriate to the crop, and days of growth. For forage, include relevant dry matter and feed-quality measurements when available; for produce, grade/marketable packout; for controlled systems, crop-cycle and recirculation performance.

Calculate water productivity, input productivity, cost per acre, cost per bushel/ton/marketable unit, gross revenue, tracked avoided costs, added costs, allocated O3 AG program cost and net economic change. Use the same denominator and harvest definition when comparing periods or fields.

Economic success cannot be claimed from yield alone. A result must be interpreted with quality, marketability, inputs, water, operating costs and the conditions under which the result occurred.

14.7 — Analyze Evidence, Uncertainty & Alternative Explanations

Guided lesson time: 7 minutes

Separate observation from explanation. Summarize absolute change, percentage change and trends, then document field variability, weather, irrigation, fertility, variety, planting population, pest/disease pressure, harvest timing, management changes and other confounders.

Classify statements using the course evidence standard: Established Science; Independent Research; O3 AG Verified Performance; O3 AG Proprietary Technology/Mechanism; or Illustrative Teaching Example. Do not upgrade an observation into independent proof.

State what the data support, what they do not prove, what remains uncertain and what additional comparison, replication or laboratory/field measurement would strengthen the conclusion. Credibility increases when uncertainty is documented rather than hidden.

14.8 — Build & Defend the Complete O3 AG Farm Management Plan

Guided lesson time: 7 minutes

The final written capstone becomes an operating plan for the next production cycle. It must contain the baseline, maps, testing calendar, nutrient budget, water and irrigation plan, O3 AG monitoring plan, soil-building/aeration or incorporation decisions where appropriate, in-season decision gates, plant-health diagnostics, harvest plan, economics and evidence/verification plan.

End with the next-crop sequence: TEST → DIAGNOSE → CALCULATE → PLAN → APPLY → AERATE/INCORPORATE WHERE APPROPRIATE → O3 AG MANAGEMENT → GROW → MONITOR → CORRECT → HARVEST → CALCULATE REMOVAL & ECONOMICS → LATE-SEASON TEST → BUILD FOR NEXT CROP → VERIFY.

The student must be able to explain why each recommendation was made, what measurement triggered it, what could make it inappropriate, and how success will be verified.

14.9 — Final Capstone Practicum, Professional Defense & Follow-Up

Guided lesson time: 8 minutes

Submit and defend one complete O3 AG agricultural case. The case may be field soil, greenhouse, substrate, hydroponic or aquaponic, but it must use the correct measurements for that production system.

Required deliverables: 1) production goal and baseline; 2) permanent sampling map; 3) source-water and delivery-chain record; 4) soil/media/root-zone assessment; 5) nutrient budget; 6) growth-stage/testing calendar; 7) plant-health diagnostic record; 8) O3 AG operating/maintenance record; 9) harvest and quality calculations; 10) economic analysis; 11) at least three competing explanations for major observed changes; 12) evidence classification; 13) corrective-management decisions; 14) next-season soil/system-building plan; 15) retest dates and verification criteria; and 16) a producer-facing executive summary.

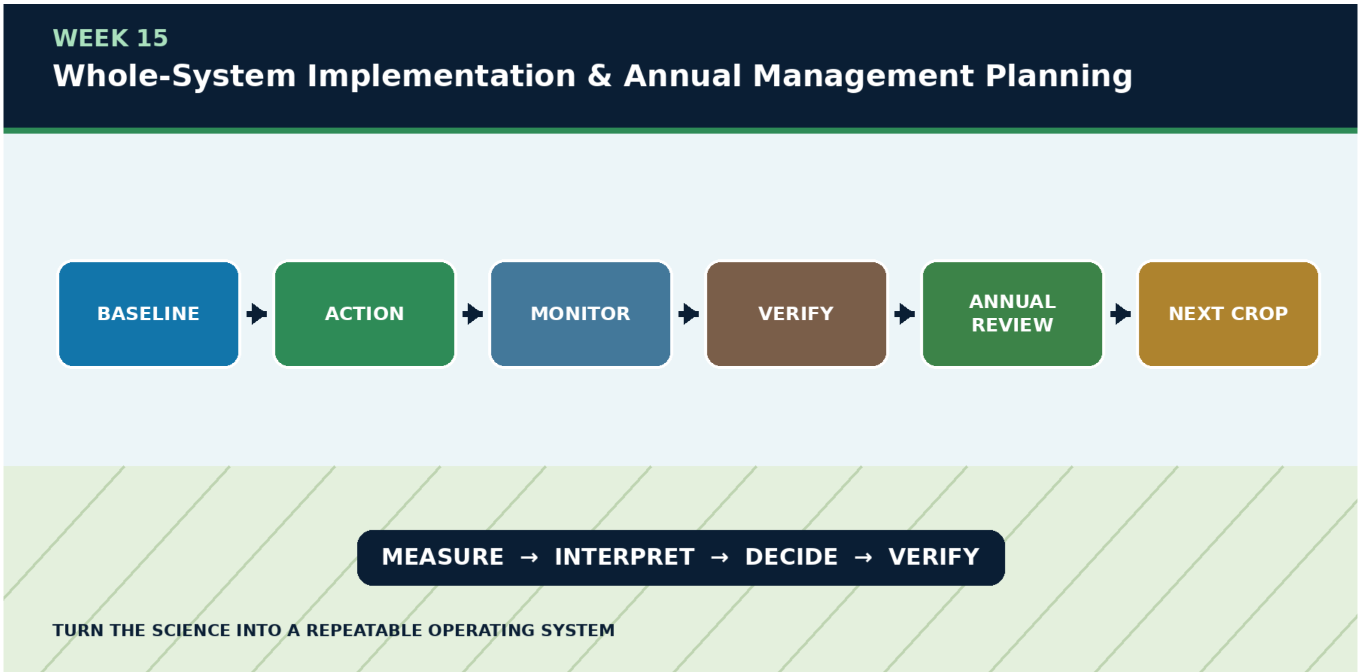
Professional defense: distinguish what was measured, calculated, observed, inferred and independently supported. Answer instructor questions using the record rather than memory. The capstone is complete only when it states what happens next.

Week 14 principle: Integrate the system. Defend the evidence. Build the next crop.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

WEEK 15 - WHOLE-SYSTEM IMPLEMENTATION & ANNUAL MANAGEMENT PLANNING



Competencies

- Build a crop-specific annual testing and sampling calendar
- Construct and interpret an end-of-season nutrient budget
- Diagnose compaction and justify aeration/incorporation decisions where appropriate
- Plan a biological processing window using site conditions
- Integrate O3 AG operation and verification into the seasonal management calendar
- Define in-season decision gates and corrective-action verification
- Calculate days of growth, yield/quality, resource efficiency and economics
- Use a shared field record across course, app, calculators and evidence files
- Defend a complete annual or crop-cycle implementation plan

O3 AG Tech App Lab - Week 15

Lab: Whole-System Implementation Lab

Student action: Convert the completed training case into an annual next-crop plan; demonstrate app competency.

Data entered: Dashboard statuses, economics, next tests, next crop

Required evidence: Final next-crop action plan + competency record

15.1 — Convert the Capstone into an Annual Operating Plan

Guided lesson time: 7 minutes

Week 14 proved that the student can integrate the science and defend a case. Week 15 converts that case into a repeatable management system. Begin with the operation, production unit, crop or production system, historical baseline, current O3 AG configuration, management objectives and the decisions that must occur before, during and after the production cycle.

Build one annual timeline rather than a collection of disconnected tasks. Every test, observation, application, irrigation event, O3 AG check, correction, harvest record and economic calculation should answer a management question and feed the next decision.

The operating sequence is: BASELINE → TEST → DIAGNOSE → CALCULATE → PLAN → APPLY → AERATE/INCORPORATE WHERE APPROPRIATE → O3 AG MANAGEMENT → PLANT/START → MONITOR → RETEST → CORRECT → HARVEST → VERIFY → POST-HARVEST TEST → BUILD THE NEXT CYCLE.

15.2 — Build the Crop-Specific Testing & Sampling Calendar

Guided lesson time: 7 minutes

Testing must be timed to the question being asked. Establish crop- or system-specific checkpoints for pre-season baseline, active vegetative growth, reproductive/yield-building demand, late-season/pre-harvest assessment, harvest and post-harvest planning. Controlled-environment systems may require shorter recurring intervals because reservoir chemistry and root-zone conditions can change rapidly.

For each checkpoint identify what will be sampled: source and treated water, soil/media, roots, tissue/sap, Brix where appropriate, biological/physical observations, O3 AG operating conditions, irrigation distribution, crop stage, photographs, yield/quality and economics. Define the sample location IDs and use the same locations when comparing change through time.

The calendar must state why each test is being collected, what decision it can influence and when the result would arrive too late to change the current crop and should instead inform the next one.

15.3 — End-of-Season Nutrient Budget & Soil/System-Building Calculator

Guided lesson time: 8 minutes

Use the previous crop and end-of-season record to build the next nutrient plan. Enter beginning and ending soil/media results, irrigation-water nutrient contribution, tissue/sap results where available, actual yield, crop-removal estimates, residue removed or returned, fertilizer and amendment applications, organic inputs, soil type, organic matter/carbon, CEC/base saturation where appropriate, pH, EC/TDS and documented losses or constraints.

Use the planning relationship: BEGINNING STATUS + MEASURED/KNOWN INPUTS + CREDITED CONTRIBUTIONS − CROP REMOVAL − DEFENSIBLE LOSSES = ESTIMATED ENDING POSITION. Compare the estimate with actual testing. A mismatch is a diagnostic signal; it may reflect sampling variability, availability, immobilization, fixation/precipitation, leaching, erosion, uneven application, root restriction, pH, antagonism, biological cycling or another documented variable.

The calculator is a decision aid, not permission to automatically replace every pound removed. Recommendations must remain crop-, soil-, water-, climate-, regulation- and management-specific.

15.4 — Fertility, Aeration/Compaction & the Biological Processing Window

Guided lesson time: 7 minutes

Before planning fall or rotation-period amendments, diagnose physical condition. Review root depth and direction, aggregation, infiltration, traffic patterns, hard layers, moisture, residue breakdown and penetrometer information where appropriate. Compaction can restrict roots, water, oxygen and biological activity even when a soil test shows nutrients are present.

Where agronomically appropriate, applying selected amendments before aeration/incorporation can create pathways and improve contact with the active soil zone. This is not a universal prescription. Nutrient source, placement, soil texture, slope, erosion/runoff risk, tillage system, cover crop, moisture, temperature, crop, regulations and equipment all affect the decision.

Define the biological processing window between application and the next crop. Soil temperature, moisture, oxygen, carbon/substrate availability and pH influence biological activity. Record the application date, soil conditions, expected freeze/dormancy period, spring planting/start date and retest point rather than promising a fixed decomposition or mineralization rate.

15.5 — O3 AG Seasonal Operating & Verification Plan

Guided lesson time: 6 minutes

Map the O3 AG system into the annual management calendar. Identify source-water conditions, treatment and approved monitoring points, hydraulics/distribution checks, root-zone or reservoir observations, maintenance, calibration, downtime and the crop stages at which operating verification is most important.

Do not use one measurement as proof of the whole system. O3, O2/DO, ORP, pH, EC/TDS, individual ions and other measurements answer different questions. Use the applicable measurements and site-specific O3 Science operating documentation for the installed system rather than inventing universal setpoints.

Connect operating records to agronomic records so a crop response can be compared with treatment status, irrigation, weather/environment, nutrient program and other variables.

15.6 — In-Season Decision Gates & Corrective Action Triggers

Guided lesson time: 6 minutes

Predefine the conditions that trigger investigation. Examples include unexpected growth-stage delay, root restriction, nutrient symptoms, irrigation nonuniformity, changing water chemistry, reservoir drift, abnormal EC/TDS, disease/pest pressure, compaction, declining quality or an O3 AG operating deviation.

Use the diagnostic chain: OBSERVE → MAP → CHECK GROWTH STAGE → ROOTS → WATER → SOIL/MEDIA → NUTRIENTS → BIOLOGY → ENVIRONMENT/MANAGEMENT → O3 AG CONDITIONS → COMPETING EXPLANATIONS → TEST → CORRECT → RETEST → VERIFY.

A trigger does not automatically prescribe a product. It starts a diagnostic process. Record what changed, what evidence supports the correction, what alternatives were considered and what measurement will determine whether the correction worked.

15.7 — Harvest, Days of Growth, Resource Efficiency & Economics

Guided lesson time: 6 minutes

Close the production cycle with comparable harvest and economic records. Record Day 0, key growth stages, physiological maturity where applicable, harvest date, total days of growth, marketable yield, quality, repeated cuttings/harvests, water used, nutrient inputs and operating costs.

Calculate cost per acre or production unit, cost per bushel/ton/marketable unit, water productivity, nutrient-input productivity, gross revenue, documented avoided costs, added costs, allocated O3 AG program cost and net economic change. Earlier harvest is not automatically better; interpret days of growth with maturity, yield, quality, marketability, resource use and economics.

Use the same units and definitions when comparing fields, years, treatments or production systems.

15.8 — One Shared Field Record: Course → App → Calculator → Evidence File

Guided lesson time: 6 minutes

The finished system should avoid duplicate data entry. A soil test, water test, tissue result, crop stage, fertilizer application, O3 AG operating record, photograph, harvest weight or cost entered once should be available to the appropriate calculator, diagnostic workflow, annual plan and evidence case file.

Organize the shared record around stable IDs for farm/site, field or growing unit, crop cycle, sample location, sample/event date and treatment status. Preserve units, laboratory/method, source document and who entered or verified the record.

This is the bridge between education and field management: the course teaches why; the field form captures what happened; the calculator organizes the math; the app connects the record; and the evidence file supports verification and future decisions.

15.9 — Annual Management Plan Practicum & Professional Handoff

Guided lesson time: 7 minutes

Build and defend a 12-month or complete crop-cycle implementation plan for one real or approved simulated operation. Required deliverables: 1) baseline and goals; 2) annual/crop-stage testing calendar; 3) permanent sample-location map; 4) end-of-season nutrient budget; 5) soil/system-building plan; 6) compaction/aeration decision with conditions and cautions; 7) biological processing-window plan; 8) O3 AG operating/verification calendar; 9) in-season decision gates; 10) harvest/days-of-growth plan; 11) yield/quality/resource-efficiency/economic calculations; 12) post-harvest review; 13) next-cycle actions; and 14) the records/calculators/app tools used at each step.

Professional handoff: explain the plan to a producer, manager or instructor in plain language. Separate required actions from optional actions, measured facts from assumptions, and current-crop decisions from next-crop decisions. Identify the first three actions that must occur after the plan is approved and the dates or triggers that control them.

Week 15 principle: Turn the science into a repeatable operating system.

Week Completion & Competency Record

Lesson / reading	[ ] Complete
O3 AG Tech App Lab	[ ] Complete
Worksheet / evidence	[ ] Complete
Mastery quiz	[ ] Complete
Instructor verification	________________________

Course Appendices

Appendix A - Calculator Worked Examples

Core and advanced calculators, moisture, irrigation, nutrient budget, crop removal, economics.

Appendix B - Printable Field Forms

Sampling, moisture, irrigation, pivot dial-in, nutrient, annual planning and reporting forms.

Appendix C - Controlled Reference Tables

Only APPROVED Master Reference Engine values.

Appendix D - Molecules / Ions / Abbreviations

Controlled glossary used by course, field manual and O3 AG Tech.

Appendix E - O3 AG Tech Workflow

Live Farm primary; Training & Education secondary; role-based Technician Tools and Reference Library.

Appendix F - Certification Records

App-lab evidence, mastery, capstone and instructor verification.