PlantingScience – Agronomy Feeds the World
Plant Nutrition and Soil Fertility

<u>**Key Concept #1:** Plant Nutrition and Soil Fertility – How do plants get nutrients to grow?</u>

<u>Overview</u>

Goals, purposes and objectives centered around a core concept (big idea)

Understand the roles of soils and nutrients and how they affect plant growth

The goal of this project is to allow students to understand the roles of soil nutrients and how they affect plant growth and plant nutritional status.

The objectives are as follows:

- understand the roles of macronutrients (particularly N, P, K) and general nutrient cycling
- understand how these macronutrients affect plant growth
- determine how these macronutrients should be sourced or applied to promote plant growth
- determine how to measure plant growth and plant health status
- understand how a soil properties and/or nutrient amendment affects plant growth regardless of nutrient status
- understand the environmental importance of proper nutrient management

Related concepts and threads identified

- macronutrients other than N, P, K (S, Ca, Mg, Na, Cl)
- micronutrients (Fe, Zn, Cu, B, Mn, Mo, Na, Cl, Co, Si, Se)
- soil, plant and microbial genomic concepts
- beyond agriculture (horticulture, biofuels, etc.)
- explaining differences in conventional and organic systems
- soil health

Key skills identified

- understand the basics of soil nutrients that help plants grow
- understand general nutrient cycling and transformation
- ability to conduct basic soil analyses (e.g. texturing, moisture content)
- ability to conduct plant growth measurements (e.g. growth indices, fresh/dry weight)
- ability to observe and identify stressors to plants (e.g. disease, nutrient deficiencies, environmental)
- ability to analyze findings like a true scientist
- ability to communicate findings in written, visual and oral forms

Formative and summative assessments related to identified concepts and skills

Formative

- have students identified a topic focused on nutrient management?
- have students designed a practical and complete measurement strategy for the duration of the experiment? (ie is there too much or too little happening)
- have the students developed hypotheses and expected outcomes?

Summative

- did the students conduct measurements correctly?
- did the students actively collect and record all the necessary data on a weekly basis?
- did the students correctly summarize the final data?
- did the students come away with a proper understanding of the outcomes of the experiment?
- did the students understand the role of proper nutrient management and the environmental effects of too much fertilizer?

Suggested sequence of concept development

- safety in the laboratory
- proper soil/nutrient establishment
- plant seed germination
- analytical laboratory skills
- plant growth characteristics
- nutrient deficiencies, disease, effect of environmental stressors
- sample processing and data analysis (statistical analysis is a possibility?)
- summarization and communication of scientific results

Suggested weekly timeline / schedule

- before: soil moisture content, texture, pH, electrical conductivity
- after: soil moisture content, pH, electrical conductivity, radish root size and weight
- daily observation of plants for catastrophic problems (eg pot fell over, pest problem, plant wilting)
- watering schedule (depends on goal of project)
- weekly visual plant assessments
- weekly plant growth index measurements

<u>Content</u>

Background information and resources (from both scientist and teacher perspectives)

- general overview (check AFW book)
- macro and micronutrients (focus on N, P, K) (who it is, what it does, where it comes from (cycling), why plants need it, when do plants need it)
- basics of soil (CLORPT)

- nutrient cycling (role of soil microorganisms, plants can't get nutrients from air)
- basics of plant growth
- fertilizer/amendment/nutrient source basics
- amendment application rates (how to calculate)
- *basics of lab safety and procedures*

"Hooks" for engaging students – e.g., real world applications, current issues, unsolved puzzles

- dirt
- hidden hunger
- luxury consumption
- Star Trek tricorder
- N/P leaching problems leading to water quality issues
- Flint (MI)
- Mars, International Space Station
- algal blooms
- dead zone in Gulf of Mexico
- depletion of P sources
- organic vs conventional agriculture
- feed 9 billion people by 2050
- 50% of land used for crops and livestock
- climate change
- 2.5 billion people rely on agriculture for income
- geophagy for soil nutrients
- "A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people." *Franklin D. Roosevelt*
- soil health
- symbiotic organisms

Open-ended "juicy" questions for discourse

- What do plants need to grow?
- What is the best type of soil in which plants grow?
- How can fertilizers be used most efficiently and effectively?
- What is a synthetic fertilizer versus an organic fertilizer?

Suggestions for points of entry for on-line communication

- setting up the physical experiment
- developing a hypothesis and project goals
- designing a sampling and measurement strategy
- report midway through the experiment
- how to look for trends (or use statistics) in final data
- how to present final data

Clear and robust instructions for a guided hands-on inquiry related to core concepts and skills

- this can be easily written down or prepared in a video/podcast
- project design (having a 'high' treatment)
- step by step instructions to build pots, plant seeds, measure parameters correctly

Suggestions for related open-ended inquiry hands-on activities driven by student questions

- what soil media to use
- what amendment sources to use
- how much to water and/or apply nutrient amendment
- impose an environmental effect?
- data presentation

Description / examples of evidence to be collected

- soil (possibilities): texture, color, bulk density, organic matter content, moisture content, pH, electrical conductivity, macronutrient and micronutrient content (analysis or NRCS Soil Survey)
- plant (possibilities): observed quality (scale 0-10), observed disease/pest, fresh root/plant weight, dry root/plant weight, chlorophyll content (SPAD meter), plant nutrient content,
Growth Index 1 = (plant height + stem diameter) / 2,
Growth Index 2 = (maximum leaf width + 2^{nd}-3^{rd} internode length) / 2
- observed deficiency symptoms: chlorosis, stunted growth, wilting, discoloration (N = chlorosis, P = purpling, K = white spotting), twisting/cupping/folding of leaves
- microbial plating and culturing, microbial respiration

<u>Logistics:</u>

Materials list and sources

- soda bottles (collect at home or at school, contact local Material Recycling Facility)
- opaque paper, tape, writing markers, ruler or measuring tape, scissors, paper lunch bags
- basic laboratory glassware and supplies
- drying oven
- coarse gravel/stone (local quarry, fish tank supply store)
- soil (or compost, manure, etc.) media source (hardware or department store, plant nursery, composting location, local farm, school or home location)

- water source (tap, deionized, distilled, rain, ditch, lagoon, creek, river, etc.)
- liquid source (if using alternative water sources related to different nutrient content)
- fertilizer (if using a specific fertilizer source)
- proper laboratory instrumentation for specific tests

Description of activity / experimental set-up, space needed, environmental conditions

Based on a class of 20 students in which each student is assigned 1 pot, or a class of 20 students in which 4 groups of 5 students are established

- design experiment around the growth of radish seeds
- base experiment on a nutrient factor (and maybe and environmental factor, eg temperature)
- nutrient factors could include more than the following: soil type and texture, varying soil textures in the same pot, other organic media (eg compost, manure, biosolids, wood chips, sawdust, etc.), additions of solid or liquid fertility amendments, etc.
- environmental factors could include more than the following: light, moisture, temperature, soil compaction, etc.
- each group of 5 students should vary 1 nutrient topic, or vary 1 topic 4 ways and keep the other topic consistent

  eg 4 nutrient rates (high vs low) × 5 repetitions = 20 pots per group
- students will decide on experimental design based on advice from teachers and mentors
- plant seeds according to soda bottle example
- 20 pots (aka bottles) per group would require a 1 foot by 2 foot space (this is dependent on pot/bottle size and the environmental factor chosen)
- environmental conditions are to be determined per discussion with the students, teacher and mentor
- students will conduct simple scientific measurements and analyses over the course of the project
- final analyses will be more time consuming as previously described

Extensions, modifications, adaptations

Novice
- learners should focus on the basic processes
- embrace designing a project, collecting data, and simply presenting results

Experienced
- learners should consider including more than 1-2 factors to evaluate
- basic statistical assessment could be included
- focus on next steps in the research should be a desired outcome

Teaching tips – suggestions for preparations, common problems and solutions

- first, take a deep breath…you'll field a lot of questions
- it's ok to make mistakes…just roll with it
- don't be afraid to make changes and troubleshoot along the way
- plan ahead to collect enough soda bottles
- possibly plant seeds ahead of time for the students for the shorter projects
- describe the importance of replication and randomization in scientific experiments

- for analytical procedures, it will always take longer than expected, so factor in some wiggle room
- final analyses always take longer, so plan for that

Information about quantification of variables

- most variables can be quantified
- adhere to replication and good laboratory practices
- qualitative variables should be conducted by the same person each time for the sake of consistency

Photos, videos, podcasts of materials, plants, lab procedures ("how-to"), and expected outcomes

- photos should be conducted along the way to document as much as possible
- photos of the plants at the end of the experiment (grouped by treatment) on a similar scale are very good to look at plant differences
- videos of students performing plant measurements of laboratory procedures are great
- instructional videos/podcasts to conduct soil and plant measurements and expected outcomes would be great

Lab safety instructions and considerations

-With some substrates and water (ie compost or ditch water) contamination may be an issue. Wear gloves when handling and wash hands before and after

-Depending on nutrient additives there may be risks associated with exposure. I highly doubt this if they are using something from a home/garden store.

Description of what IT support is needed for the new module to interface with the web

- none unless video/podcast support is needed

-Possibly some tutorial with running stats and help with using WSS