Study guide for DPM soil test section

Exam format

The exam will consist of three sections, each worth about 1/3 of the grade (see below).

- Multiple choice questions on key concepts of soil science and soil fertility
  - The availability of which nutrient increases with increasing pH?
  - Which soil order is known for its shrink-swell clays?
  - A fertilizer label indicates 12-12-12; what is the content of N-P-K?
- Short answers
  - Describe the benefits of SOM on soil physics, water movement, and nutrient cycling
  - Describe why the leaching potential varies among KCl, K_2SO_4 and K_3PO_4? What soil properties might influence the leaching potential of these fertilizers?
- Case studies
  - As an extension agent, you must prepare a fact sheet on N fertilization. Compare the use of synthetic N fertilizers to organic amendments in terms of energy costs, N:P ratio, and N availability to crops.
  - As a crop consultant, you receive a soil test from one of your customer; interpret what the grower should do in terms of fertilization. You decide to send the same soil to a different lab and get similar nutrient concentration values but a different input recommendation – why?

All multiple choice questions count, but only a subset of the other two sections: if there are 7 questions, you have to answer all 7 but only the 5-6 best will count towards your final grade.

General soil science

- Soil formation state factors: parent material, climate, topography, organisms, time
- Soil classification: 12 orders of US classification + know other classifications exist
- Basic soil mineralogy
  - Physical and biogeochemical weathering and how it affects other soil properties
  - Primary vs. secondary minerals, 2:1 vs. 1:1 clays, crystalline vs. amorphous mineral + how it affects other properties (e.g., CEC)
- Soil textural classes
  - Understand how to read a texture triangle + how texture affects other soil properties
- Soil pH
  - What is pH, active vs. potential acidity, H^+ vs. Al^{3+}
  - Why is a low or high pH bad for plants
  - Effects on other soil properties: nutrient availability, CEC, microbial activity
- Difference between saline, sodic and saline-sodic soils

- CEC
  - What is CEC, how it compares to AEC, what is base saturation
  - What are the main drivers of CEC, and which ones are pH-dependent
- SOM
  - What is soil organic matter + benefits on soil physics, water, biology and fertility
  - Consists of diverse molecules + these mineralize at a variable rate
  - Understand how SOM is related to soil aggregates
  - Understand how SOM is related to the C cycle + difference between SOM and SOC
- Soil water/physics
  - What is the difference between porosity, water-filled pore space, bulk density;
  - What is water-holding capacity, field capacity, permanent wilting point;
  - What is plant-available water, how it's determined, how it varies based on soil textural classes;
  - What are the differences among infiltration, runoff, percolation, leaching, and erosion
  - What is the difference between volumetric and gravimetric soil water
- Soil biology
  - Mycorrhizal fungi: role in crop nutrition + which group(s) doesn't form this symbiosis
  - Bacteria and archaea + rhizobium for legumes
  - Earthworms

Soil fertility

- N cycle in detail
  - Species: organic N (pool of multiple forms), NH_4^+, NO_3^-, N_2O, NH_3, N_2
  - Processes: mineralization, nitrification, denitrification, volatilization, fixation, leaching
  - What controls the importance of each in different soils and agroecosystems
- P cycle in detail
  - No major gas species for P (unlike N) + only one dominant anion, PO_4^{3-}
  - Major pools in soils: P bound to calcium, Al/Fe oxides, or organic matter
  - What controls the importance of each pool in different soils and agroecosystems
- K cycle in detail
  - Minor role of soil organic matter and biology
  - Can be conceptualized as different pools: exchangeable, non-exchangeable, primary mineral
  - K and NH_4^+ compete for fixation on interlayer of 2:1 clays; not the same as legume N fixation
- Some idea of other cycles
  - S: similar to N, driven by organic matter mineralization
  - Ca and Mg: similar to K but no fixation on interlayer of 2:1 clays, lime inputs important
  - Micronutrient cycles: similar cycle depends on element, know how Mo and B are special
- The importance of temperature and moisture on nutrient cycling
  - Biological cycling: mineralization, nitrification, denitrification

- Diffusion in soils (important for P availability) + NH_3 volatilization (along with pH)

– How to read a N-P-K rating on a fertilizer bag
  - N is N, P is labeled as P_2O_5, K is labeled as K_2O
  - It is a minimum certified analysis: could be higher in reality, especially for organic ones
  - How to use them to compute input rates: 18-0-0 applied at 100 kg ha^{-1} will add 100 kg fertilizer ha^{-1} x 18 kg N kg^{-1} fertilizer = 18 kg N ha^{-1}. And the reverse as well (e.g., how much of a 34-10-0 fertilizer needed to get 100 kg N ha^{-1}, and much P you will add)
– What are the main fertilizer additives and how they improve nutrient-use efficiency
  - Urease and nitrification inhibitors for N fertilizers
  - Slow-release and controlled-release, mostly for N but also for other nutrients
  - Chelates for micronutrients
– How to compute the following
  - A nutrient removal rate from a crop: yield (dry matter) x nutrient concentration
  - Given a N mass ploughed into the soil from a residue and a given transfer coefficient, compute how much N will be transferred to the following crop and resulting N savings
  - Given a N credit provided by a given soil N concentration, compute a fertilizer reduction
– Issues related to use of organic amendments
  - How to estimate N mineralization from a table/graph and apply a correction factor to inputs
  - How to use a N:P ratio to determine the N and P balance between inputs and outputs
  - Given a specific input rate (e.g., determined for N), compute how much C, salts, etc. get added
  - Strengths/weaknesses of organic amendments: high C and H_2O, salts, contaminants, coliforms
  - Difference between manure, compost, and biosolid + how composting affects C and nutrients
– Key steps in soil testing
  - Differences between grid sampling and using homogeneous areas + depth, frequency, time
  - Different soil extractions used in different conditions and measure indicators of nutrient availability to crops (but none truly measures “plant-available nutrients”)
  - Soil labs express results as fertility classes (very low, low, medium, high, very high) and typically use these classes for recommendations vs. the actual nutrient concentration
  - Different labs get different concentrations via extract used, preparation (sieving, drying), etc.
  - Labs convert from concentration to lb ac^{-1} but that’s typically not right – know why
  - Fertilization recommendation vary among labs based on nutrient management strategies: build-up and maintain, sufficiency of plant-available nutrients, basic cation ratios
  - Other tools beside soil testing: tissue testing, sap testing, SPAD meters, remote sensing
– Managing soil acidity and alkalinity
  - Calcitic vs. dolomitic lime, Ca not neutralizing in lime, calcium carbonate equivalents
  - Acidifying fertilizers most effective for alkaline soils (e.g., elemental S, NH_4^+ containing)
– What is soil quality/health
  - What are the key indicators (e.g., SOM)
  - How it differs from soil fertility but is key to long-term fertility
  - How it relates to different practices - tillage, organic amendments, cover cropping, etc.