Soil and its effects on the Energy Crop: Pennycress

I will have paper copies of this assignment for you on Saturday, October 15th

Overview of pennycress:

Field pennycress (Thlaspi arvense) is primarily an annual weed, native to the Mediterranean region of Europe and Asia. A member of the mustard family (Brassicaceae), it is known by common names like frenchweed, fanweed or stinkweed in different areas of the country. Although established in every state except Hawaii, pennycress is abundant in the northern states, especially in the northwest, and more sparsely established in the southeast. It is found in waste places, open disturbed areas, roadsides, railroads, sometimes in grasslands, old fields, riparian areas and forest edges.

Pennycress produces a low-growing rosette in the fall after germination and this form protects the over-wintering plant from low temperatures and drying winds. The hearty plant is capable of being an effective ground cover protecting soil from the erosion forces of wind and water. In the spring Pennycress resumes growing, flowers and becomes a prolific seed producer with yields as high as 20,000 seeds per plant (averaging 7,000) and more than one ton per acre. The reported average date for mature seeds is between May 7 and May 23. This allows for an early June harvest.

This species is a prolific seeder and forms a long-lived (up to 20-30 years) seedbank, making it difficult to eradicate from an area once it becomes common.

Field pennycress has some potentially significant industrial applications. Its seeds contain about 26-36 percent oil, and this oil contains about 40 percent euric acid, a fatty acid. This fatty acid is similar to that of biodiesel resources, including animal fats and soybean and sunflower oils. Biodiesel from these sources can be used alone or mixed with petroleum-based diesel to lower the emission of hydrocarbons, carbon monoxide and other pollutants in engine exhaust. Crushed seed left over from biodiesel production, called meal, also has promise as an organic fertilizer and natural weed killer for low-acreage, high-value crops. USDA research shows that 150 gallons of fuel can be made from a ton of seeds when using both the seed oil and presscake biomass indicating that pennycress has the potential to produce about 6 billion gallons of liquid transportation biofuels per year. In the future yields are expected significantly increase thus raising the impact of this sustainable energy supply.

Tests to be completed on site:

- Permeability test/percolation rate ("perc test")
- pH
- Nitrates
- Phosphates
- Potassium
- Soil moisture

Location

At Anoka-Ramsey's Cambridge campus, about 10 acres of land on the south and southwest part of campus have been set aside as an energy crop demonstration plot, dedicated to educational purposes. Ever Cat fuels of Isanti/Anoka are currently partnering with Anoka-Ramsey Community College in this venture. We will be testing the soil in the plot to determine if there are differences in the soil that pennycress prefers or doesn't prefer to grow in.

Test Parameter information

Nitrates

Nitrogen is an essential element, needed by all life forms to build proteins. Nitrogen is a part of all living cells and is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy. Nitrogen is a part of chlorophyll, the green pigment of the plant that is responsible for photosynthesis. It also, helps plants with rapid growth, increasing seed and fruit production and improving the quality of leaf and forage crops. Animals obtain their nitrogen from the plant or animal foods they eat. Nitrogen initially enters the trophic interactions of an ecosystem by extraction by plants from soil or water. Nitrogen exists in a variety of chemical forms in nature. Ammonia (NH_3) and nitrate ($N0_3$-) are usable by plants but atmospheric nitrogen gas is not.

Specialized species of bacteria are able to convert nitrogen from one form to another. Some bacteria release ammonia when they decompose proteins in bodies of dead organisms. Body wastes of animals are rich in ammonia as well. Some bacteria convert ammonia to nitrate and other forms. This movement of nitrogen from one form to another constitutes the nitrogen cycle, in which various types of bacteria play incredibly important roles. Among the several dozen nutrients needed by plants, nitrogen or phosphorus generally serve as the factor limiting plant growth. When the availability of these substances is increased, plant growth typically increases as well.

Phosphates

The natural scarcity of phosphorus can be explained by its attraction to organic matter in soil particles. Total phosphorus includes organic and inorganic phosphate. Organic phosphate is a part of living and dead plants and animals. Like nitrogen, phosphorus (P) is an essential part of the process of photosynthesis. It's also involved in the formation of all oils, sugars, starches, etc. and it helps with the transformation of solar energy into chemical energy; proper plant maturation; withstanding stress. Phosphorus is considered to be a limiting factor, meaning that it is not freely available for easy consumption by organisms.

pH

A pH test measures the alkalinity or acidity of a substance. A pH of 7 is neutral, below 7 is acidic, and above 7 is basic or alkaline. Soil pH is one of the most important soil properties that affects the availability of nutrients. Macronutrients (nitrogen, phosphorus, potassium, calcium, sulfur, magnesium) tend to be less available in soils with low pH. Micronutrients (boron, copper, iron, chloride, manganese, zinc…) tend to be less available in soils with high pH. **Lime** can be added to the soil to make it less sour (acid) and also supplies calcium and magnesium for plants to use. Lime also raises the pH to the desired range of 6.0 to 6.5. In this pH range, nutrients are more readily available to plants, and microbial populations in the soil increase. **Microbes** convert nitrogen and sulfur to forms that plants can use. Lime also enhances the physical properties of the soil that promote water and air movement.

Potassium

Potassium is absorbed by plants in larger amounts than any other mineral element except nitrogen and, in some cases, calcium. Potassium helps in the building of protein, photosynthesis, fruit quality and reduction of diseases. Potassium is supplied to plants by soil minerals, organic materials, and fertilizer.

Moisture content

Water is essential for plant growth. When a soil gets too dry, plant transpiration drops because the water is becoming increasingly bound to the soil particles by suction. Below the wilting point plants are no longer able to extract water. At this point they wilt and cease transpiring altogether.

Topography of the test site and GPS coordinates for accurate location points

Topography or the "lay of the land" has a large impact on plant growth. Relief is a component of topography that refers to the difference in height between the hills and depressions in the field. Slope is important to soil formation and management because of its influence on runoff, soil drainage, erosion, use of machinery, and choice of crops. Slope is the incline or gradient of a surface and is commonly expressed in percent

Permeability/Percolation rate:

Percolation refers to the ability of the soil to absorb water or liquids. Percolation rate of water varies depending on the type of soil. In general, sandy soil will absorb more water than soil with a high concentration of clay or where the water table is close to the surface.

Map and info link of MN soil types: **http://www.thudscave.com/petroglyphs/pdf/mn_parentsoil.pdf**

Central Question:

Are there differences in the soil within the 10 acre demonstration plot, on the Cambridge campus, that effect Pennycress growth?

Hypothesis:

Reasoning

Prediction:

Reasoning

Cambridge campus directions link: http://www.anokaramsey.edu/en/about/Location.aspx

We will be meeting at 9am on Saturday, October 15th and Parking along the road at the Blue highlighted area on the map. I will be driving a Gray Toyota Prius with Critical Habitat Plates.

Determining Water Percolation Rate

1. Carefully scrape away surface litter and then using the auger make a hole at least 6” deep.
2. Measure the exact depth and keep the meter stick in the hole.
3. Pour water into the hole until it reaches the top surface.
4. At the moment you start pouring the water, start timing.
5. After 15 minutes, measure how much the water level has gone down or stop timing after the hole is completely drained.
6. Repeat this procedure for a total of 2 holes per group at each site
7. Replace the soil you just removed, back into the holes that were just made.
8. Divide the time interval by the drop in water level to determine the percolation rate in minutes per cm (MPC).

Table 1. Percolation time and distance for various soil types.

Sample	Initial water depth (cm)	Final water depth (cm)	Amount drained (cm)	Time elapsed (min)	minutes per cm traveled (mpc)
Sand plain outwash	---------------	---------------	---------------	------------------	--------------------
1					
2					
Averages					

Examples:

A. If the drop in water level is one cm in 30 minutes, the percolation rate is:

30/1= 30 mpc

B. If the drop is 25 cm in 10 minutes, then the percolation rate is:

10/25= 0.4 mpc

Number of penny cress at various Cambridge Campus Demonstration plot locations (4mx4m)

Test site	Pennycress amount
A	
B	
C	
D	
E	

Nitrate levels at various the Cambridge Campus Demonstration plot locations

Test site	level	Average level
A		
B		
C		
D		
E		

Phosphorus levels at various the Cambridge Campus Demonstration plot locations

Test site	level	Average level
A		
B		
C		
D		
E		

Potassium levels at various the Cambridge Campus Demonstration plot locations

Test site	level	Average level
A		
B		
C		
D		
E		

Soil Moisture at various the Cambridge Campus Demonstration plot locations

Test site	level	Average level
A		
B		
C		
D		
E		

pH levels at various the Cambridge Campus Demonstration plot locations

Test site	level	Average level
A		
B		
C		
D		
E		

Percolation rates at various the Cambridge Campus Demonstration plot locations

Test site	rate	Average rate
A		
B		
C		
D		
E		

GPS coordinates of various sites & site descriptions (including topography)

Site	GPS coordinates	site description
A		
B		
C		
D		
E		