wrong	0	1	2	3	4	5	6	7	8	9	10	11	12		Group Name
right	41	40	39	38	37	36	35	34	33	32	31	30	29		
score	100	97.6	95.1	92.7	90.2	87.8	85.4	82.9	80.5	78.0	75.6	73.2	70.7		

Soil Analysis

Name _____

Today you will test some soil for five characteristics: soil texture, acidity, nitrogen content, phosphorus content, and potassium content. These characteristics determine how well plants will grow in a particular soil.

Soil Texture

Soil Source _____

The texture of a soil determines the amount of air and water the soil can hold. Plant roots need liberal supplies of both.

Air is critical as a source of oxygen gas and as a repository for excess carbon dioxide gas. These gases are needed for and produced by respiration in root cells, respectively. If there is not much air space in the soil, then roots "suffocate" because they cannot carry out respiration. The roots then die, the plant wilts, and then dies. Large soil particles do not pack tightly and therefore provide air spaces in the soil. On the other hand, soil consisting of extremely fine particles packs tightly and permits little air in the soil to support root function.

Water from the roots is the supply of this important chemical for the shoot system (stem, leaves, flowers, fruits, and seeds). The water is a reactant in photosynthesis and a product of respiration. Water makes up about 90% of plant cells by weight, and is the critical solvent in the cell. The evaporation of water through the stomata in the epidermis of the shoots cools the plants and prevents overheating. A soil with very large particles drains too extensively and plants will lack sufficient water, will wilt, and perhaps even die. A soil with extremely fine particles holds tremendous amounts of water and can hold so much as to exclude air from the soil. In that case, the roots die, the plants wilt, and perhaps will die as well.

Thus, the perfect soil texture for growing plants is a compromise between fine particles (clay), medium particles (silt), and coarse particles (sand). The range of soil textures that support plant growth are called "loam."

A. AT LEAST FIVE HOURS BEFORE LAB! Fill a 100 ml graduate cylinder to the 70 ml mark with ***sifted*** soil. Fill the cylinder with sodium hexametaphosphate (surfactant) solution (2 teaspoons of Calgon per quart). Cover the top of the cylinder with plastic wrap. Stir/agitate the soil completely and thoroughly so that there is no unmixed soil at the bottom of the cylinder. Top-off the cylinder with surfactant. Continue inversion-stirring for **at least five minutes**. Label the cylinder with your group name. Set the cylinder aside until the next class meeting in a place where it will not be disturbed.

B. On the regular Lab Exercise day, and disturbing the cylinder as little as possible, measure the volume of the sand layer in the bottom of the cylinder. Since this is the coarsest particle size, it will have dark voids between particles (ask your instructor to help you distinguish the sand from the silt).

Volume of the sand layer _____ mL

C. Determine the volume of the sand + silt layers. The measuring line will appear just below the clay layer which is very smooth and usually light in color. Silt has a few voids and the particles are visible; clay has no voids and the particles are too small to be visible.

Volume of the sand + silt layers _____ mL

D. Determine the volume of the sand + silt + clay layers. The measuring line will appear between the clay layer and the dark water above it.

Volume of the sand + silt + clay layers _____ mL

Koning, Ross. E. 1994. Soil Analysis. *Plant Physiology Information Website*. http://plantphys.info/plants_human/labpdf/soilanal.pdf

E. Calculate the volume of the silt layer by subtracting the number from part B above from the number in part C above.

Volume of silt layer _____ mL

F. Calculate the volume of the clay layer by subtracting the number from part C above from the number in part D above.

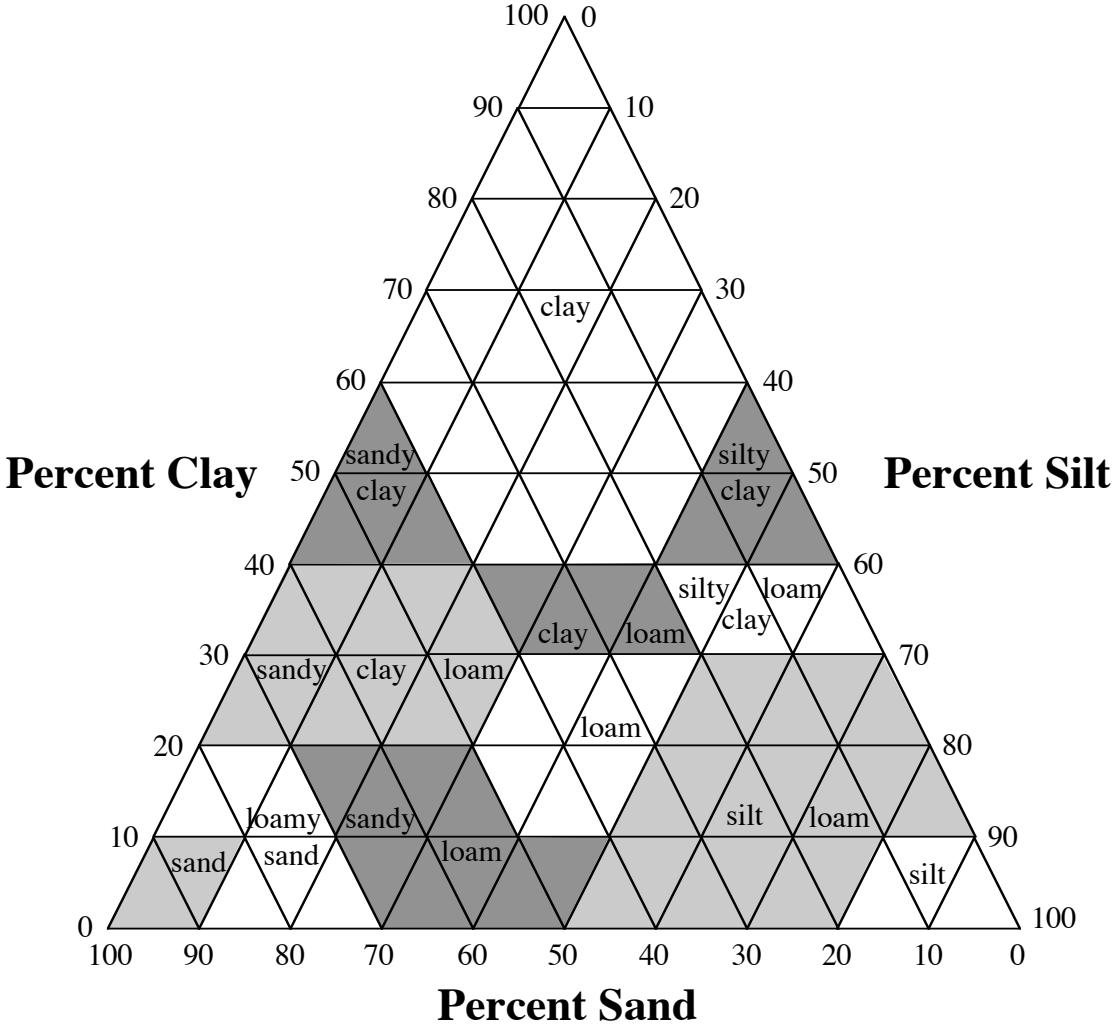
Volume of clay layer _____ mL

G. Rinse out your cylinder completely and thoroughly as described by the instructor. Dry it with a paper towel, and return it to the proper location.

H. Calculate the percentage contribution for each of the three layers by dividing their individual volumes by the total soil volume (D). If your calculations are correct, the sum of these percentages should be 100! Check your work!

Sand _____% Silt _____% Clay _____% **Total** _____%

G. **Place a small X on the diagram below** where the three layer percentages would plot out together. What is the texture classification for this soil? _____



/10

Soil Acidity (pH)

The amount of acid or alkalai in the soil determines the availability of many nutrients for plant growth and maintenance. It is important that the soil have the correct balance of acid and alkalai for the amount of nutrients to be released from the soil particles for their use. The balance is measured on a scale of acidity called **pH**. The scale goes from 1 (very acid) to 14 (very alkaline) with the neutral pH of 7 in the middle of the scale. Distilled water has a pH of 7, vinegar is typically pH 4, and soap has a pH of about 10. If the pH of soil is too high or too low, the nutrients are either locked onto the soil particles or are washed out of the soil by rain. Even applications of fertilizer to such a soil are useless and wasted.

Most plants grow best when the soil pH is between 5.5 and 6.5 (on the slightly acid side of neutral). If soil tests too low, the pH can be raised by applying lime (calcium and magnesium compounds). If soil tests too high, the pH can be lowered by applying sulfur or aluminum sulfate.

You will use a commercial soil test kit to determine the pH of your soil sample.

A. Fill the test tube to the shoulder with distilled water.
B. Add one soil pH tablet.
C. Use the green test tube cap to measure and add one capful of sifted soil..
D. Cap the tube and mix by inverting the tube 10 times.
E. Let the soil settle for one minute or until the solution is transparent above the soil.
F. Compare the color of the transparent solution with the pH color chart on the box. Record the pH indicated next to the color swatch matching ***most closely*** the color of the solution.

pH _____

G. Calculate the type and amount of soil additive needed to adjust a 50 ft. x 100 ft. garden of the soil you sampled to pH 6.0. Assume it takes 68 lbs. of ground limestone per 1000 sq. ft. to raise the pH 1 unit. Assume it takes 15 lbs. of aluminum sulfate per 1000 sq. ft. to lower the pH 1 unit. If your soil test indicates the pH is already 6.0, then do the calculation below assuming your results were pH 5.0 instead.

Name of Additive needed _____

pH change needed _____ units

Amount of additive to use on 1000 sq. ft. to change to pH 6.0 _____ lbs.

Area (=width x length) of 50' x 100' garden _____ sq. ft.

Amount of additive to use on 50' x 100' garden _____ lbs.

Extracting the Nutrients from the Soil

A. Fill the extraction tube to the 30 mL mark with distilled water.
B. Add two Floc-Ex tablets, cap the tube, and mix until the tablets are disintegrated.
C. Remove the cap and add 1 heaping teaspoon of soil.
D. Re-cap the tube and shake for 1 minute.
E. Let the tube stand until the soil settles out and the solution is transparent.

The transparent liquid above the soil will be used for the next three tests (N-P-K).

/6

Nitrogen Content

An appropriate supply of nitrogen gives plants healthy dark-green foliage. It promotes the growth of vegetative parts of the plant (root, stem, leaf). It should be abundant for crops like grass, cabbage, asparagus, onions, lettuce, and spinach. Too much nitrogen, however, can cause growth to be too rapid, can cause the plant to grow tall and soft, to fall over, and can reduce yield. Excess nitrogen can also delay and prevent flower and fruit formation in other crops. Therefore, you must compromise between the high nitrogen levels needed for true vegetables and the lower amounts needed for fruit crops (beans, corn, squash, peas, strawberries, etc).

Plants lacking sufficient nitrogen will be short, thin, and yellowish green, particularly in the lower leaves. The leaves will turn yellow, and will brown down to a crispy state. In monocots, such as grasses, the tip of the leaf browns first and the browning progresses toward the leaf sheath.

A. Use the pipette to transfer soil extract fluid into the square tube, up to its shoulder.
B. Add 1 Nitrate #1 tablet. Cap with the red cap. Mix until the tablet disintegrates.
C. Add 1 Nitrate #2 tablet. Re-cap with the red cap. Mix until the tablet disintegrates.
D. Wait 5 minutes for the color to develop.
E. Compare the pink color of the transparent solution to the Nitrogen color chart on the box. Record the level indicated next to the color swatch matching ***most closely*** the color of the solution.

Matching color bar label | L M H |

F. Use this chart to determine the nitrogen content of your soil.

	L	M	H	Your Soil Has	
lbs/1000 sq ft	0.9	3.7	7.4		lbs/1000 sq ft
lbs/acre	40	160	320		lbs/acre
ppm	20	80	160		ppm

G. Calculate the amount of fertilizer (Ammonium nitrate = 33 percent nitrogen content) needed for your 50' x 100' garden.

for this result:	L	M	H		Your Soil Needs	
add :	5	3	1	lbs N/1000 sq ft		lbs N/1000 sq ft

$$\frac{\text{Divide the amount needed}}{\text{by the percentage of N in fertilizer (0.33)}} = \_\_\_\_\_ \text{ lbs Ammonium nitrate/1000 sq ft}$$

Amount of Ammonium nitrate to buy for your whole garden: _____ lbs

Phosphorus Content

Phosphorus is essential for flower, fruit, and seed production. It is an important part of DNA (the genetic molecule). It also facilitates seed germination. The supply of phosphorus determines, in part, the rate that the plants reach sexual maturity. It is usually difficult to have too much phosphorus because the supplies in soil are typically so limited.

Plants lacking sufficient phosphorus usually have purplish leaves, petioles, and stems. They grow slowly and mature very late in the season (if then). The yield of crops like corn, beans, peas, squash, cucumber, etc. will be very low under phosphorus deficiency.

A. Use the pipette to transfer 1 mL of soil extract fluid into the square tube.
B. Add enough distilled water to bring the fluid up to the shoulder of the tube.
C. Add 1 Phosphorus tablet. Cap with the blue cap. Mix until the tablet disintegrates.
D. Wait 5 minutes for the color to develop.
E. Compare the blue color of the transparent solution to the Phosphorus color chart on the box. Record the level indicated next to the color swatch matching ***most closely*** the color of the solution.

Matching color bar label | L M H |

F. Use this chart to determine the phosphorus content of your soil.

	L	M	H	Your Soil Has	
lbs/1000 sq ft	0.2	0.5	1.5		lbs/1000 sq ft
lbs/acre	8	20	64		lbs/acre
ppm	4	10	32		ppm

G. Calculate the amount of fertilizer (Superphosphate = 18 percent phosphorus content) needed for your 50' x 100' garden.

for this result:	L	M	H		Your Soil Needs	
add :	1.0	0.75	0.25	lbs P/1000 sq ft		lbs P/1000 sq ft

$$\frac{\text{Divide the amount needed}}{\text{by the percentage of P in fertilizer (0.18)}} = \_\_\_\_\_ \text{ lbs Superphosphate/1000 sq ft}$$

Amount of Superphosphate to buy for your whole garden: _____ lbs

Potassium Content

Potassium is important for carbohydrate (sugar and starch) manufacture by plants. When sufficient potassium is available, plants produce stiff, erect stems, and the plants are more disease resistant. When insufficient or excess potassium is in the soil, plants contain too much water, are susceptible to frost injury, and growth is reduced. Since roots are important storage areas for carbohydrate, root crops like carrot, turnip, and radish and tuber crops like potatoes are enhanced by supplemented potassium.

Plants with deficient potassium have mottled, spotted, or streaked leaves. The leaves curl strongly at the ends. The leaf margins die and flake out, leaving a ragged edge. Poor root development may lead to the plant toppling over as the stem grows.

A. Use the pipette to transfer soil extract fluid into the square tube, up to its shoulder.
B. Add 1 Potassium tablet. Cap with the white cap. Mix until the tablet disintegrates.
C. Compare the cloudiness of the solution to the Potassium color chart on the box. Hold the tube over the black boxes in the left column, and compare the color to the shaded boxes in the right column. Record the level indicated next to the color swatch matching ***most closely*** the color of the solution.

Matching color bar label | L | M | H |

F. Use this chart to determine the potassium content of your soil.

	L	M	H	Your Soil Has	
lbs/1000 sq ft	0.9	1.8	3.7		lbs/1000 sq ft
lbs/acre	40	80	160		lbs/acre
ppm	20	40	80		ppm

G. Calculate the amount of fertilizer (Potassium sulfate = 50 percent potassium content) needed for your 50' x 100' garden.

for this result:	L	M	H		Your Soil Needs	
add :	3	2	1	lbs K/1000 sq ft		lbs K/1000 sq ft

Divide the amount needed / by the percentage of K in fertilizer (0.50) = _____ lbs Potassium sulfate/1000 sq ft

Amount of Potassium sulfate to buy for your whole garden: _____ lbs

Using Prepared Fertilizers

The calculations you have performed for the various fertilizers needed for your 50' x 100' garden were based upon use of a single fertilizer that contained an abundance of a single nutrient (N, P, or K). These calculations allow you to optimize the amount of each of the nutrients for your particular soil. It also turns out that this is probably the most inexpensive way to fertilize, providing you have learned how to do the calculations.

Most people do not have the knowledge to do the calculations, and many do not live near agricultural supply companies (there is just one in the Willimantic area). These folks rely upon prepared fertilizers that contain a mixture of all three major nutrients (N, P, and K). The amount of each nutrient in the mixture is shown on the packaging as the **guaranteed analysis**. This is a sequence of three numbers separated by hyphens. By convention, the sequence of numbers is always the percentage of N-P-K. So a fertilizer with an analysis of 5-10-15 contains 5% N, 10% P, and 15% K. Various combinations of nutrients are available in bags of fertilizer sold at lawn and garden shops. These are quite expensive compared to the single-nutrient fertilizers.

Here is a listing of fertilizers that might be less-expensive than boxed blends:

Material	% N	% P	% K
Animal Tankage	8	20	0
Bloodmeal	15	1	0.5
Bone Meal	4	25	0
Castor Pomace	5.5	1.5	1
Cocoa Shells	2.7	1.5	2.7
Coffee Grounds (dried)	2.0	0.3	0.5
Cottonseed Meal	8.0	2.5	1.5
Cow Manure	0.6	0.2	0.5
Legume Waste	3.0	0.5	2
Fish Scrap	8	13	4
Fly Ash	0	0	12
Granite Dust	0	0	5
Greensand	0	1.5	7
Mineral Phosphate	0	29	0
Guano	12	8	3
Chicken Manure	1.1	0.8	0.5
Horse Manure	0.7	0.3	0.6
Hoofmeal and Horndust	12.5	1.5	0

Material	% N	% P	% K
Incinerator Ash	0.2	5	2
Milorganite	6	3	0
Sodium Nitrate	16	0	0
Peanut Shells	3.6	0	0
Phosphate Rock	0	30	0
Pig Manure	0.5	0.3	0.4
Seaweed	1.5	1	5
Sheep Manure	0.8	0.3	0.9
Slag	0	8	0
Sludge	6	3	0
Steer Manure	0.8	0.3	0.4
Sugar Wastes	0	8	0
Ammonium Sulfate	21	0	0
Super Phosphate	0	18	0
Tobacco Stem Powder	3.3	0	7.0
Triple Super Phosphate	0	47	0
Urea			
Wood Ashes	0	1.5	8

Here is a listing of plants (by category) to tell of their fertilizing needs:

L=low M=medium H=high VH=very high

Flowers, perennials, bulbs & herbs	N	P	K	pH
Amaryllis	M	M	M	5.0-6.0
Bleeding Heart	M	M	M	5.0-6.0
Lily of valley	M	M	M	5.0-6.0
Parsley	M	M	M	5.0-7.0
Coreopsis	M	M	M	5.5-6.5
Gardenia	M	M	M	5.5-6.5
Daffodil	M	M	M	6.0-6.5
Ageratum	M	M	M	6.0-7.0
Candytuft	M	M	M	6.0-7.0
Snapdragon	M	M	M	6.0-7.0
Tulip	M	M	M	6.0-7.0
Alyssum	M	M	M	6.0-8.0
Begonia	M	M	M	6.0-8.0
Bell Flower	M	M	M	6.0-8.0
Calendula	M	M	M	6.0-8.0
Canna	M	M	M	6.0-8.0
Carnation	M	M	M	6.0-8.0
Clematis	M	M	M	6.0-8.0
Coleus	M	M	M	6.0-8.0
Columbine	M	M	M	6.0-8.0
Cone Flower	M	M	M	6.0-8.0
Crocus	M	M	M	6.0-8.0
Dahlia	M	M	M	6.0-8.0
Day Lily	M	M	M	6.0-8.0
English Ivy	M	M	M	6.0-8.0
Forget-Me-Not	M	M	M	6.0-8.0
Foxglove	M	M	M	6.0-8.0
Gaillardia	M	M	M	6.0-8.0
Geranium	M	M	M	6.0-8.0
Gladiolus	M	M	M	6.0-8.0
Gypsophila	M	M	M	6.0-8.0
Hibiscus	M	M	M	6.0-8.0
Hollyhock	M	M	M	6.0-8.0
Hydrangea	M	M	M	6.0-8.0
Larkspur	M	M	M	6.0-8.0
Loosestrife	M	M	M	6.0-8.0
Marjoram	M	M	M	6.0-8.0
Mint	M	M	M	6.0-8.0
Nasturtium	M	M	M	6.0-8.0
Pansy	M	M	M	6.0-8.0
Peony	M	M	M	6.0-8.0
Perwinkle	M	M	M	6.0-8.0
Petunia	M	M	M	6.0-8.0
Phlox	M	M	M	6.0-8.0
Poinsettia	M	M	M	6.0-8.0
Poppy	M	M	M	6.0-8.0
Primrose	M	M	M	6.0-8.0
Verbena	M	M	M	6.0-8.0
Violet	M	M	M	6.0-8.0
Yucca	M	M	M	6.0-8.0
Chrysanthemum	M	M	M	6.8-8.0
Iris	M	M	M	6.8-8.0
Zinnia	M	M	M	6.8-8.0

Shrubs, ornamentals, etc.	N	P	K	pH
Camellia	L	L	L	4.0-5 5
Azalea	L	L	L	5.0-6.0
Rhododendron	L	L	L	5.0-6.0
Junipers	L	L	L	5.5-7.0
Yew	L	L	L	5.5-7.0
Grass	L	L	L	6.0-7.0
Barberry	L	L	L	6.0-8.0
Bayberry	L	L	L	6.0-8.0
Boxwood	L	L	L	6.0-8.0
Butterfly Bush	L	L	L	6.0-8.0
Cotoneaster	L	L	L	6.0-8.0
Euonymus	L	L	L	6.0-8.0
Forsythia	L	L	L	6.0-8.0
Lilac	L	L	L	6.0-8.0
Privet	L	L	L	6.0-8.0
Rose	L	L	L	6.0-8.0
Spirea	L	L	L	6.0-8.0
Wisteria	L	L	L	6.0-8.0

Trees	N	P	K	pH
Mountain Ash	M	L	L	4.0-5.0
Hemlock	L	L	L	5.0-6.0
Holly	L	L	L	5.0-6.0
Magnolia	M	L	L	5.0-6.0
Pine	L	L	L	5.0-6.0
Spruce	L	L	L	5.0-6.0
Oak, White	M	L	L	5.5-7.0
Beech	M	L	L	6.0-7.0
Dogwood	M	L	L	6.0-7.0
Oak, Red	M	L	L	6.0-7.0
Spruce, Colorado	L	L	L	6.0-7.0
Arborvitae	L	L	L	6.0-8.0
Maple	M	L	L	6.0-8.0
Redbud	M	L	L	6.0-8.0

Fruits & vegetables	N	P	K	pH
Potato	M	H	H	4.5-6.5
Strawberries	M	M	M	5.0-6.0
Potato, Sweet	L	M	H	5.0-7.0
Apples	M	L	L	5.5-6.5
Bean	L	M	M	5.5-6.5
Carrot	M	H	H	5.5-6.5
Eggplant	H	H	H	5.5-6.5
Corn, Sweet	H	H	H	5.5-7.5
Beet	H	VH	H	5.8-7.0
Watermelon	M	M	M	6.0-7.0
Broccoli	H	H	H	6.0-7.0
Cabbage	H	H	H	6.0-7.0
Pumpkin	H	H	H	6.0-7.0
Tomato	M	VH	VH	6.0-7.0
Brussels Sprouts	H	H	H	6.0-7.5
Cauliflower	H	H	VH	6.0-7.5
Lettuce	H	VH	VH	6.0-7.5
Onion	H	H	H	6.0-7.5
Pea	M	H	H	6.0-7.5
Radish	M	VH	VH	6.0-7.5
Asparagus	VH	H	VH	6.0-8.0
Blackberries	L	L	L	6.0-8.0
Canteloupe	M	M	M	6.0-8.0
Cucumber	H	H	H	6.0-8.0
Grape	M	M	M	6.0-8.0
Squash	H	VH	VH	6.0-8.0
Spinach	VH	VH	VH	6.4-7.0

If you had no soil test results to help you determine which fertilizer to use, a good "shot in the dark" for general purpose would be 20-20-20 (a balanced fertilizer). For your vegetable garden 5-10-5 would be generally useful, but for fruit crops 5-15-5 would be better. For your lawn 20-5-5 or 20-0-0 would be appropriate. Understand however, that fertilization without a soil analysis can waste time, effort, and money, and is likely to not produce ideal conditions. Your local agricultural extension service can perform soil analyses for a modest fee. For this area UCONN is the appropriate contact.