wrong	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
right	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	
score	100	98.3	96.6	94.9	93.2	91.5	89.8	88.1	86.4	84.7	83.1	81.4	79.7	78.0	76.3	74.6	72.9	71.2	69.5	67.8	66.1	

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

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.

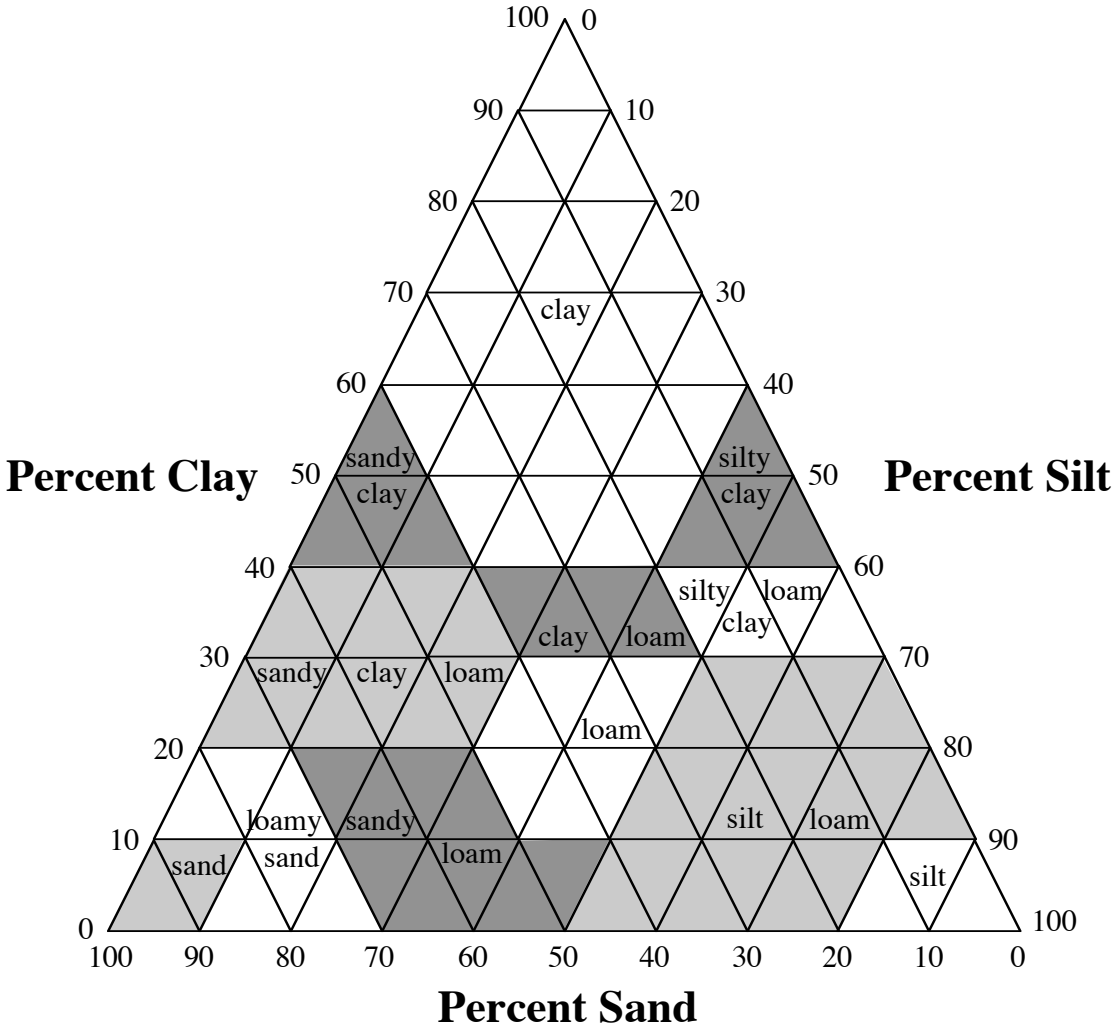
Volume of clay layer _____ mL

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 LaMotte EL soil test kit to determine the pH of your soil sample. The parts of the kit can be reused for up to 50 tests, so be sure not to discard any part of the kit, and to put everything back in the box as you found it!

A. Fill a test tube to line 4 with pH Indicator solution. Squeeze the bottle gently to carefully control the amount dispensed.
B. Use the 0.5 g (larger) spoon to add 3 level measures of your soil sample to the test tube.
C. Cap the test tube and mix gently for 1 full minute by inversion.
D. Allow the test tube to stand for 10 minutes to let the soil settle to the bottom.
E. Match the color of the clear liquid above the soil to the swatches on the pH color chart. Hold the tube in the middle area between the swatches about 1 cm in front of the chart.
F. **Circle** the pH indicated next to the color swatch matching ***most closely*** the color of the solution. If the color is in-between two swatches, you can interpolate the value.

8.0 7.5 7.0 6.5 6.0 5.5 5 4.5 4.0

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 6.5. 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 6.5, then do the calculation below assuming your results were pH 5.5 instead.

Name of Additive needed _____

pH change needed _____ units

Amount of additive to use on 1000 sq. ft. to change to pH 6.5 _____ lbs.

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

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

/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. Fill a test tube to line 7 with Nitrogen Extracting Solution.

B. Use the 0.5 g (larger) spoon to add 2 level measures of your soil sample to the test tube.

C. Cap the test tube and mix gently for one full minute by inversion.

D. Remove the cap and allow the soil to settle until the solution above the soil is clear.

E. Use a clean pipet to transfer the clear liquid to a second test tube up to line 3. To avoid remixing soil into the liquid, squeeze the bulb of the pipet before inserting the tip into the liquid. Then release the bulb slowly to draw up just the clear liquid into the pipet. Avoid transferring any soil into the second tube.

F. Use the 0.25g (smaller) spoon to transfer two level measures of Nitrogen Indicator Powder to the liquid in the second tube

G. Cap the test tube and mix gently for one full minute by inversion.

H. Let the tube stand for 5 minutes for full pink color development.

I. Compare the pink color of the solution to the Nitrogen Color Chart. Locate the color swatch matching ***most closely*** the color of the solution.

J. **Circle** the corresponding amount of Nitrogen to be added to the soil (lbs/1000 sq ft).

High	Medium	Low	Trace
2	3	4	5

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

= _____ lbs Ammonium nitrate/1000 sq ft

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

/3

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. Fill a test tube to line 6 with Phosphorus Extracting Solution

B. Use the 0.5 g (larger) spoon to add 3 level measures of your soil sample to the test tube.

C. Cap the test tube and mix gently for one full minute by inversion.

D. Remove the cap and allow the soil to settle until the solution above the soil is clear..

E. Use a clean pipet to transfer the clear liquid to a second test tube up to line 3. To avoid remixing soil into the liquid, squeeze the bulb of the pipet before inserting the tip into the liquid. Then release the bulb slowly to draw up just the clear liquid into the pipet. Avoid transferring any soil into the second tube.

F. Add six (6) drops of Phosphorus Indicator Reagent to the extract in the second tube.

G. Cap the test tube of extract and mix by an inversion or two.

H. Remove the cap and add one Phosphorus Test Tablet to the extract mixture.

I. Re-cap the test tube of extract and mix by inversion until the tablet dissolves and a blue color develops.

J. Compare the blue color of the solution to the Phosphorus Color Chart. Locate the color swatch matching ***most closely*** the color of the solution.

K. **Circle** the corresponding amount of Phosphorus to be added to the soil (lbs/1000 sq ft):

High	Medium	Low	Trace
3	4	5	6

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

= _____ lbs Superphosphate/1000 sq ft

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

/3

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. Fill a test tube to line 7 with Potassium Extracting Solution

B. Use the 0.5 g (larger) spoon to add 4 level measures of your soil sample to the test tube.

C. Cap the test tube and <u>shake vigorously</u> for one full minute by inversion.

D. Remove the cap and allow the soil to settle until the solution above the soil is clear..

E. Use a clean pipet to transfer the clear liquid to a second test tube up to line 5. To avoid remixing soil into the liquid, squeeze the bulb of the pipet before inserting the tip into the liquid. Then release the bulb slowly to draw up just the clear liquid into the pipet. Avoid transferring any soil into the second tube. [If there is insufficient clear liquid in the first tube to achieve this, Rinse out the first tube and repeat steps A-D to create more liquid.]

F. Add one (1) Potassium Indicator Tablet to the extract in the second tube.

G. Cap the test tube of extract and mix by inversion until the tablet dissolves and a purplish color develops.

H. Remove the cap and add Potassium Test Solution, two drops at a time, keeping count of the total drops added to the extract mixture. After each addition, mix the contents. Stop adding drops when the color changes from purplish to blue (use the Potassium End Point Color Char to help you decide when this “end point” is reached.

K. **<u>Circle</u>** the corresponding amount of Phosphorus to be added to the soil (lbs/1000 sq ft):

High: 0-10	Medium: 14	Low: 18	Trace: 22+ drops
2	3	4	5

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

= _____ lbs Potassium Sulfate/1000 sq ft

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

/3

Using Other Single Fertilizers

The calculations you have performed 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). How would the calculations be different if you had to use a different single fertilizer?

Single Fertilizer	Amount circled on a previous page	Amount needed per 1000 sq ft	Amount needed for 50x100 ft garden
Nitrate of Soda 16%N	Page 4:		
Triple Superphosphate 46%P	Page 5:		
Muriate of Potash 60%K	Page 6:		

Using "Balanced" Fertilizers

"Balanced" fertilizers 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**. By law, the sequence of numbers in the analysis 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. Repeat your calculations but this time imagine you are a sheep farmer:

Sheep Manure	Amount circled on a previous page	Amount needed per 1000 sq ft	Amount needed for 50x100 ft garden
0.8%N	Page 4:		
0.3%P	Page 5:		
0.9%K	Page 6:		

Obviously it is quite unlikely that a single amount of sheep manure will perfectly balance your soil nutrients, but a person might choose to apply the greatest amount shown above, hoping it is not too much of an overdose of the other nutrients.

Using Commercial "Balanced" Fertilizers

At a garden store, you can purchase a box of fertilizer that has the guaranteed analysis of 6-12-10. Repeat your calculations using this commercial fertilizer:

6-12-10 Fertilizer	Amount circled on a previous page	Amount needed per 1000 sq ft	Amount needed for 50x100 ft garden
%N	Page 4:		
%P	Page 5:		
%K	Page 6:		

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Here is a listing of other 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	45	0	0
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
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.