CSU Organic Amendments Research Study-Summer & Fall of 2010

- Objective: Compare the chemical properties of different brands of bagged compost, soil amendments, top soils, potting soils and potting mixes that can be purchased locally at chain stores and garden centers. The chemical properties of these purchased bagged properties were also compared to the chemical properties of home-made composts.

Major Findings

1. Chemical properties of a given product may vary from bag to bag, both within a season and from year to year. Analysis of the chemical properties of a given bag of product will not necessarily represent the chemical properties of a different bag of the same product. The analysis represents just a "snap-shot" in time, and do not represent a definitive assessment of any particular product.
2. Composted manure products tend to be very salty (high electrical conductivity value), and often contain too very high concentrations of plant-available nutrients, particularly potassium, nitrogen and sodium. Plant-based composts are generally less salty and plant available nutrient concentrations are generally less excessive.

Major Findings

3. Although plant-available nutrient levels tend to be higher in manure-based vs. plant-based products, nearly all of the products analyzed contain 2-15 times more plant available phosphorous, and 3 to 110 times more plant-available potassium, then are needed for good plant growth.

Major Findings

4. Plant-available N contents were highly variable in the products analyzed. The N content of some products was nearly entirely in organic form and contained little if any plant-available N, whereas other products contained very high to excessive levels of plant-available N (ammonium and nitrate forms). High levels of plant-available N in the soil can inhibit flowering and fruit set in vegetables and fruits.
5. Home-made composts were generally less salty than commercial products.

CSU Study Recommendations

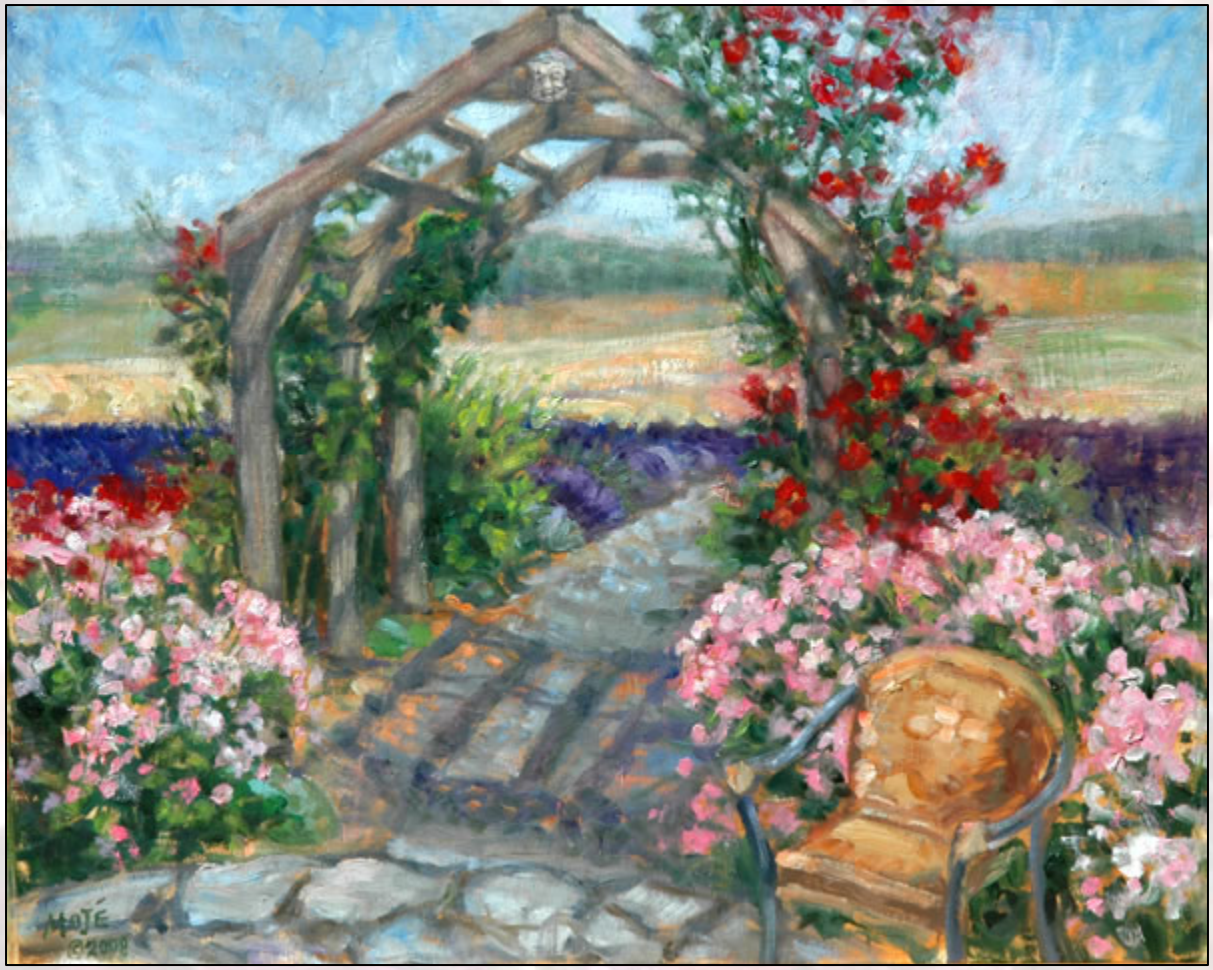
- Be conservative in the amount of organic amendment applied to the soil.
- Plant-based compost:
  - Apply no more than 2-3” of compost and mix into the top 6-8” of soil. Or apply 1 to 1.5” of compost and till into the top 3-4” of the soil.
  - Restrict composition to 25% or less compost (1 part compost to 3 parts soil).

CSU Study Recommendations

- Manure-based compost:
  - If the salinity level of the compost is unknown, apply no more than 1” manure-based compost and mix into the top 8” of soil, this low application may still result in too much salt in the soil.
  - Animal-based composts are best applied to the soil in the fall.
  - Note: 3 cubic yards of compost covers 1000 sq. feet approximately 1” inch deep.

CSU Study Recommendations

- Leaching an organic product before use may help lower salinity level.
- Covering the soil surface with mulch conserves soil organic matter and decreases irrigation needs. Conserving existing soil organic matter decreases the amount of purchased organic amendment product needed.
- Instead of applying an organic amendment to the soil to increase organic matter content, consider growing a cover crop to till into the soil as a green manure. See **http.//cmg.colostate.edu/pubs** for more information on organic amendments, organic fertilizers, and cover crops.



Thank you !

Analyses of Organic Amendments, Potting Soils and "Topsoils"

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March 23, 2011

This project was funded by David Whiting, Colorado Master Gardener Coordinator, Department of Horticulture and Landscape Architecture, Colorado State University.

Samples were analyzed by the Colorado State University Soil, Water and Plant Testing Laboratory, in collaboration with Dr. Jim Self, Lab Director.

Study Objective: Compare the chemical properties of different brands of bagged compost, soil amendments, topsoils, potting soils and potting mixes that can be purchased locally at chain stores and garden centers. The chemical properties of these purchased bagged products were also compared to the chemical properties of home-made composts.

Bagged products were purchased from various Fort Collins CO vendors during the summer and fall of 2010. Laboratory analyses were completed in December 2010. A second bag of each of nine randomly selected products was purchased at different stores and different dates to assess bag-to-bag variability of chemical properties of a given brand product.

NOTE: The results of this study do not reflect either an endorsement or a condemnation of any particular product.

Major Results:

1. Chemical properties of a given product may vary from bag to bag, both within a season and from year to year. Analyses of the chemical properties of a given bag of a productwill not necessarily represent the chemical properties of a different bag of the same product.The analyses represent just a "snap-shot" in time, and do not represent a definitive assessment of any particular product.

2. Composted manure products tend to be very salty (high electrical conductivity value), and often contain very high concentrations of plant-available nutrients, particularly potassium, nitrogen and sodium. Plant-based composts are generally less salty and plant-available nutrient concentrations are generally less excessive.

3. Although plant-available nutrient levels tend to be higher in manure-based vs. plant-based products, nearly all of the products analyzed contained 2 to 15 times more plant-available phosphorous, and 3 to 110times more plant-available potassium, than are needed for good plant growth.

4. Plant-available nitrogen contents were highly variable in the products analyzed. The N content of some products was nearly entirely in organic form and contained little if any plant-available N, whereas other products contained very high to excessive levels of plant-available N (ammonium and nitrate forms). High levels of plant-available N in the soil can inhibit flowering and fruit set in vegetables and fruits.

5. Home-made composts were generally less salty than commercial products.

Recommendations:

1. Be conservativein the amount of organic amendment applied to the soil.

   Suggested annual application rates are:

   a. Plant-based compost:
      i. Apply no more than 2-3" of compostand mix into the top 6-8" of soil. (orapply 1 to 1.5" of compost and till into the top 3-4" of the soil)

      ii. Restrict composition to 25%or less compost (1 part compost to 3 parts soil)

   b. Manure-based compost:
      i. If the salinity level of the compost is unknown, apply no more than 1" manure-based compost and mix into the top 8" soil (this low application rate may still result in too much salt in the soil).

      ii. Animal-based composts are best applied to the soil in the fall.

   c. Note: 3 cu yd. of compost covers 1000 sq.ft. approximately 1" deep

   The above are suggested annual application rates. Do not apply more than the above recommended application rates in any one year. Do not continue annual applications of compost beyond 2 or 3 years without analyzing the soil for salinity level, organic matter content, and plant-available nutrient concentrations.

   - An important goal is to keep the salinity level of the soil/compost mix to a laboratory-measured E.C. value that is less than 2.0. Knowing the salinity levels of both the product and the native soil to which the product will be appliedallows a calculation of maximum application rate possible that does not result in a soil/compost E.C. value greater than 2.0.

   - Building up the organic matter content of the soil to a level higher than about **5%** is unnecessary and may result in buildup of salts and unnecessary nutrients in the soil.

   - Buildup of a plant-available nutrient to high levels beyond plant needs not only results in a potential source of environmental pollution, but also causes an imbalance in nutrient levels in the soil, which can interfere with a plant's ability to take up other nutrients.

2. Leaching an organic product before use may help to lower salinity level.

3. Covering the soil surface with mulch conserves soil O.M. and decreases irrigation needs. Conserving existing soil O.M. decreases the amount of purchased product organic amendment needed.

4. Instead of applying an organic amendment to the soil to increase organic matter content, consider growing a cover crop to till into the soil as a green manure. See http://cmg.colostate.edu/pubs for more information on organic amendments, organic fertilizers, and cover crops.

Table 1. Desirable range of soil properties for healthy plants. *

pH	pH 6.0 to 7.2 is the preferred pH range for growth of most plants, but most garden and landscape plants tolerate pH 7.2 to 7.9 with little problem if supplemental nutrients are added when needed. Above pH = 8.0, it may be difficult to obtain optimal growth for plants not adapted to high pH soils.
E.C. or SALTS *(Electrical Conductivity)*	When E.C. is less than 2.0, salinity is not a problem for most plants. E.C. = 2 to 4 is slightly saline; many landscape plants are negatively affected. E.C. = 4 to 8 is moderately saline; most landscape plants are negatively affected. Xeriscape plants tend to be more salt tolerant and may survive this level of salinity. E.C. greater than 8 is strongly saline. Most plants do not survive this level of salinity.
SAR *(Sodium Adsorption Ratio)*	If SAR is less than 13, sodium is not a problem in the soil. SAR is the amount of sodium in the soil relative to the amount of calcium and magnesium.
%O.M. *(Organic Matter)*	Less than 2% O.M. is considered low for most plants. However, many native and/or xeriscape plants prefer low O.M. levels in the soil 2 to 3% O.M. is considered "adequate" for most plants grown in this area. However, vegetables and many ornamentals prefer a higher level of O.M. in the soil, and do better with about 5% soil O.M. It is not necessary to increase soil O.M. content beyond 5%.
C/N Ratio *(Carbon to Nitrogen Ratio of the O.M.)*	C/N less than 20 is acceptable for organic amendments e.g. compost, but 10-12 is better. A higher C/N ratio than 10-12 indicates that the organic matter is not yet stable and will further decompose. This decomposition process competes with plants for nitrogen and oxygen.
NH4-N *(Ammonium-Nitrogen)* **NO3-N** *(Nitrate-Nitrogen)*	Plant-available N is the sum of ammonium-N plus nitrate-N. Normally, most of the plant-available N in soil is in the nitrate form, so often only nitrate-N is analyzed for a standard soil test. 20 ppm nitrate-N is required for good growth of trees, shrubs, turf and xeriscape plants. For vegetables and flowers, the amount of nitrate-N required for good plant growth depends on the soil O.M. content. If the soil O.M. content is 5% or greater, 10 ppm nitrate-N is required for good plant growth, whereas if the O.M. content is less than 1%, 50 ppm nitrate-N is required for good plant growth.
P *(Plant-available phosphorus)*	Trees and shrubs require 10 ppm plant-available P for good plant growth; vegetables and flowers require 15 ppm, xeriscape plants require 20 ppm, and turf requires 45 ppm plant-available P for good growth.
K *(Plant-available potassium)*	Trees, shrubs, xeriscape plants and turf require 150 ppm plant-available potassium for good plant growth. Vegetables and flowers require 180 ppm plant-available K for good plant growth.
Zn *(Plant-available zinc)*	1.5 ppm plant-available zinc is adequate for good plant growth. Levels greater than about 100 ppm may inhibit plant growth
Fe *(Plant-available iron)*	10 ppm plant-available iron is adequate for good plant growth. Some plants tolerate 5-10 ppm.
Mn *(Plant-available manganese)*	0.5 ppm plant-available manganese is adequate for good plant growth. Levels greater than 40-50 ppm may inhibit plant growth.
Cu *(Plant-available copper)*	0.2 ppm plant-available copper is adequate for good plant growth. Levels greater than 20-30 ppm may inhibit plant growth.
B *(Plant-available boron)*	1 to 5 ppm plant-available boron is adequate for good plant growth. Greater than 5 ppm is very high may inhibit plant growth.

* Values presented are based on the methodology used by the Colorado State University Soil Testing Laboratory.

** When nutrient contents of the soil are at the adequacy levels indicated above, no additional fertilizer nutrient is needed.

Table 3

		pH	EC (salt) mmhos/cm	Organic Matter	C:N Ratio	Lime	SAR	---------- ppm ---------- NH_4-N	NO_3-N	Plant-available P	Plant-available K
								--------10 to 50---------			
			<2.0	*%*	*<20*	*%*	*<13*	*low*	*high*	*10 - 45*	*~200*
Soils: Garden Soil (GS), Lawn Soil (LS), Topsoil (TS) *(Some to be diluted, others ready-to-use)*											
1	Master Gardener's garden soil	7.1	1	14	11	1	1	2	129	337	1137
2	TS: compost, humus, sand. *Mix 1:1 with native soil*	7.4	28	31	22	8	6	5	1963	374	7951
3	TS: 100% organic. *Use to fill in low spots in landscape*	7.7	8	45	13	3	12	11	14	285	3978
4	TS: peat, forest products, compost, ash, sand or native TS *Mix 1:1 with native soil*	7.8	10	5	4	0	9	3	67	161	1865
5	GS * *For plantings mix 1:1. For beds mix 3" product into the top 6" of native soil*	7.7	2	60	26	1	5	6	3	445	4558
6	GS * *For plantings mix 1:1. For beds mix 3" product into the top 6" of native soil*	7.5	3	48	27	2	7	40	143	513	4543
7	*GS * Bag #1 Mix 1:1 with backfill soil*	*6.7*	*4*	*66*	*20*	*1*	*3*	*304*	*1209*	*429*	*6854*
8	*GS * Bag #2 Mix 1:1 with backfill soil*	*7.5*	*3*	*64*	*36*	*0*	*5*	*17*	*5*	*365*	*3182*
9	GS** Moisture Control. *For plantings mix 1:1. For beds mix 3" product into the top 6" of native soil*	7.6	3	65	23	1	5	25	114	377	7609
10	GS (Organic)*** Not for containers. *Mix with native soil and plant.*	7.9	3	48	22	1	9	2	10	208	2914
11	TS blend: topsoil, compost, and humus. *For lawns, yard-fill, or mix with native soil*	7.9	10	21	14	2	15	4	73	237	4957
12	LS: (peat, composted forest prod, or compost), sphagnum peat, wetting agent, fertilizer. *For lawn repair*	7.4	4	57	22	2	11	32	10	617	7898
13	LS: (peat, composted forest prod, or compost), sphagnum peat, wetting agent, fertilizer. *For lawn repair*	7.9	3	53	17	1	9	3	20	194	3148

** Soils # 5, 6, 7, 8, 9, and 10: "Includes one or more of the following: (peat, composted forest products, aged rice hulls or compost), sphagnum peat moss, manure, a wetting agent, and fertilizer"*

*** Soil # 9: "Includes one or more of the following: (peat, composted forest prod., aged rice hulls, or compost), sphagnum peat, coir pith fibers, manure, a wetting agent, and fertilizer"*

**** Soil #10: "Included one or more of the following: (forest prod., peat, humus, or compost), sphagnum peat, composted manure, poultry litter"*

Starter soils, Seed starting mixes *(Ready-to-use)*											
1	Sphagnum peat, perlite, earthworm castings, granite dust, humic acid, mycorrhizae/bacterial inoculant, oyster shell	5.5	1	49	44	0.4	2	75	94	21	158
2	Sphagnum peat, perlite, wetting agent, fertilizer	4.9	1	82	36	<0.01	1	63	243	345	619
3	(reed sedge peat, composted forest prod, and/or composted rice hulls), sphagnum peat, dolomitic limestone, wetting agent, fertilizer.	6.5	3	68	26	0.3	3	69	132	315	3866

Table 4

(Ready-to-use, no dilution)

		pH	EC (salts) mmhos/cm <2.0	Organic Matter %	C:N Ratio <20	Lime %	SAR <13	NH_4-N --------10 to 50--------- low	NO_3-N high	Plant-available P 10 -45	K ~200
Planting mixes, potting mixes, potting soil											
1	70% sphagnum peat, 20% regional fibers (reed sedge peat, fir or pine bark, or compost), 10% perlite, wetting agent and slow-release fertilizer	7.3	13	35	17	4	7	6	503	488	5395
2	Peat moss, sand, compost, aged sawdust, pumice	7.6	15	28	14	5	7	6	31	363	4744
3	Sphagnum peat, forest bark, compost, perlite, scoria, and dehydrated poultry manure	7.3	2.0	54	32	9	5	6	21	428	2691
4	*(Forest products & recycled wood products composted w /poultry manure, pumice), sphagnum peat moss (Bag #1)*	*7.1*	*2.3*	*37*	*35*	*2*	*4*	*5*	*108*	*392*	*2784*
5	*(Bag #2)*	*6.5*	*3.8*	*50*	*33*	*1*	*4*	*9*	*741*	*576*	*3106*
6	*Sphagnum peat, perlite, dolomitic limestone, calcitic limestone, and wetting agent.*	5.5	1.7	76	54	<0.01	1	5	571	162	1196
7	*Composted forest humus, sphagnum peat, fish emulsion, crab & shrimp meals, worm castings, sandy loam, perlite, fossilized bat guano, granite dust, kelp meal, oyster shell*	5.5	4.5	42	54	0.0	0	1	1362	113	572
8	*Forest humus, sphagnum peat, perlite, worm castings, bat guano, humic acid, oyster shell, dolomite lime*	5.8	4.3	46	37	1	0	17	1309	148	536
9	*Hypnum peat, forest products or compost, sand, perlite*	7.2	2.7	14	17	12	4	14	6	253	1274
10	*Sphagnum peat, forest prod. Compost, coir pith fiber, perlite, wetting agent, and fertilizer (Bag #1)*	*6.9*	*1.5*	*40*	*34*	*2*	*3*	*6*	*249*	*358*	*1797*
11	*Bag #2*	*5.7*	*2.6*	*78*	*32*	*0.2*	*1*	*1563*	*1089*	*761*	*2721*
12	*50-55% composted bark, sphagnum peat, pasteurized poultry litter, and organic wetting agent (Bag #1)*	*7.0*	*0.8*	*69*	*41*	*2*	*2*	*27*	*35*	*258*	*1862*
13	*Bag #2*	*6.3*	*0.8*	*76*	*46*	*1*	*1*	*9*	*9*	*81*	*1345*
14	*Forest products compost, sphagnum peat, perlite, wetting agent, and fertilizer (Bag #1)*	*5.7*	*3.3*	*68*	*31*	*<0.01*	*1*	*1056*	*1143*	*520*	*2992*
15	*Bag #2*	*6.2*	*2.1*	*71*	*35*	*0.5*	*1*	*179*	*120*	*531*	*3606*
16	*Sphagnum peat, vermiculite, wetting agent, lime*	5.9	1.8	49	36	1	1	2242	111	231	897
17	Aged/treated coconut husks, washed to E.C. <1, buffered w/Ca & Mg	5.6	0.8	78	80	3	1	10	14	30	206
18	Contains recycled yard waste	8.3	13	32	13	2	21	8	23	175	7590
19	Coarse peat, coco fiber, compost, perlite, pumice, worm castings, bat guano, and fish, soyfeather and kelp meals	5.8	1.7	39	30	1	2	4	433	152	842
20	Coco fiber, peat moss, perlite, pumice, compost, mulch, worm castings, bat guano, (kelp, fish, soybean, alfalfa and feather meals), prilled rock phosphate, green sand, Leonardite, oyster shell flower, glacial rock dust.	5.6	2.0	35	32	0.3	2	300	529	130	874
21	*(peat, forest products compost, or compost), sphagnum peat, perlite, wetting agent, hydrolyzed corn starch, fertilizer (Bag #1)*	*7.4*	*2.1*	*44*	*32*	*1*	*5*	*4*	*58*	*334*	*2700*
22	*(Bag #2)*	*7.9*	*2.8*	*67*	*17*	*1*	*5*	*27*	*52*	*196*	*3432*
23	*(reed sedge peat, composted forest products or rice hulls), sphagnum peat, perlite, wetting agent, lime to adjust pH, time release fertilizer (Bag #1)*	*7.5*	*1.0*	*40*	*71*	*3*	*2*	*3*	*4*	*26*	*705*
24	*(Bag #2)*	*7.1*	*1.7*	*37*	*48*	*2*	*2*	*9*	*96*	*181*	*1583*
25	*(reed sedge peat, composted forest products or rice hulls), sphagnum peat, perlite, dolomitic lime to adjust pH, time release fertilizer*	7.3	2.0	24	51	3	2	4	8	184	1134
26	*(reed sedge peat, composted forest products or rice hulls), sphagnum peat, perlite, dolomitic lime, wetting agent, water-holding crystals, time-release fertilizer)*	7.1	1.7	86	44	3	2	11	23	670	3887
27	*Sphagnum peat, perlite, dolomitic lime, gypsum, wetting agent*	5.7	1.0	64	44	1	0	38	129	40	137
28	*(peat, forest products compost, or compost), sphagnum peat, wetting agent, fertilizer*	6.6	1.7	72	30	1	2	17	4	169	2183

Table 5

(Products to be diluted with soil)

		pH	EC (salts) mmhos/cm	Organic Matter	C:N Ratio	Lime	SAR	ppm NH_4-N	ppm NO_3-N	ppm Plant-available P	ppm Plant-available K
			<2.0	*%*	*<20*	*%*	*<13*	*low*	*high*	*10 - 45*	*~200*
Compost: Home-made, plant-based											
1	BC: garden trimmings	7.4	4	19	10	2	1	2	461	360	2887
2	MT: Earth Machine Compost (kitchen scraps)	7.4	6	36	11	13	1	3	2137	388	4758
3	PM: Home Compost	8.1	3	62	13	4	6	1	146	370	2512
4	TC: leaves, garden trimmings	7.4	4	21	27	7	1	13	640	290	2374
5	SP: kitchen waste + brown tree leaves	8.1	3	44	12	2	1	32	487	239	4303
6	Community garden: garden trimmings	7.5	4	8	9	1	1	1	241	160	1441
Compost: Worm, vermicompost											
1	Home-madeBL #1 "Ideal"	7.1	4	22	11	6	1	3	938	493	3173
2	Home-made BL #2 "Worm Factory" *(not completely "finished")*	7.7	8	35	12	21	5	115	1158	338	5143
3	Home-made BL #3 "Old" (last year's)	7.4	5	45	11	6	1	1	796	293	2648
4	Home-made: KD vermicompost: horse manure + leaves	7.4	4	27	11	3	1	0	732	387	3692
5	Vermicompost, horse manure based	7.5	6	28	10	3	3	1	976	446	4397
6	Worm Castings *(worms fed organic compost, rock dust, & kelp)*	5.1	5	55	16	0	0	3	1293	57	680
Compost: Mushroom											
1	*Compost of horse and poultry manures , wheat straw, cottonseed hulls, forest products and sphagnum peat Bag #1*	*8.2*	*13*	*33*	*13*	*3*	*20*	*6*	*24*	*195*	*7736*
2	*(Bag #2)*	*8.4*	*11*	*30*	*13*	*3*	*18*	*6*	*148*	*293*	*9428*
3	Mushroom Compost *(19)*	7.4	22	41	10	9	6	5	2175	457	9388
Composted Manure											
1	Composted manure, peat, forest products, and compost	7.7	30	35	10	9	6	6	1459	395	21975
2	Composted buffalo manure	6.6	15	18	9	1	4	26	2328	215	11075
3	Aged and screened dairy manure and compost	7.9	12	31	11	3	16	11	363	276	5574
4	Aged and screened sheep manure and sphagnum peat moss	7.8	10	43	11	4	18	15	198	353	6954
5	*Blended steer manure and compost (Bag #1)*	*8.4*	*18*	*26*	*11*	*4*	*36*	*41*	*97*	*384*	*8738*
6	*(Bag #2)*	*8.3*	*10*	*28*	*13*	*2*	*20*	*9*	*284*	*283*	*8719*
7	Cow manure w/10% Lassemite soil amendment for moisture retention	7.6	31	18	6	4	36	4	548	314	7767
8	*Composted sheep manure, forest prod.,sphagnum peat, gypsum*	*8.1*	*15*	*31*	*13*	*2*	*27*	*11*	*218*	*282*	*8372*
9	*(Bag #2)*	*8.4*	*9*	*29*	*13*	*3*	*19*	*0.1*	*6*	*275*	*8233*
10	Composted, pulverized steer manure	8.1	10	25	14	2	14	5	6	275	5257
11	Compost and manure	7.8	1	56	44	4	1	3	5	140	1805
Bagged Compost											
1	Alfalfa, blood meal, sunflower meal, cotton seed meal	6.6	5	89	5	1	5	231	13	370	5330
2	Biosolids: wastewater solids + wood products	4.4	13	58	9	1	1	205	4624	279	1787
3	Humus Sod Conditioner w/micronutrients *(ingredients not specified)*	8.2	16	44	12	3	26	9	27	344	11069
4	Forest products, recycled wood products, composted with poultry manure & pumice	8.1	8	44	13	3	14	8	13	176	6730
5	Organic cotton boll compost, acidified with elemental sulfur	7.2	19	50	17	0	2	15	8	207	11614
6	Peat-based humus, includes beneficial bacteria	5.1	2	43	26	1	1	2	81	9	40
7	Blended/composted forest products, manures, straw, & other organics	8.2	19	30	11	3	27	8	318	153	8360
8	Blended & composted leaves, grass clippings, tree trimmings (other?)	*8.3*	*11*	*28*	*11*	*2*	*17*	*31*	*266*	*285*	*8754*
9	*(Bag #2)*	*7.8*	*7*	*32*	*17*	*3*	*9*	*4*	*6*	*285*	*3393*
10	Ingredients not specified, forest products?	7.3	1	67	11	1	1	5	5	40	734
11	(Peat, forest prod., aged rice hulls, or compost), sphagnum peat, manure, a wetting agent, and fertilizer	7.5	4	58	25	1	4	51	53	424	3800
Soil Amendments											
1	Forest products & recycled wood products composted with poultry manure and pumice	8.3	7	34	12	2	10	8	55	392	8513
2	Colorado forest materials	4.4	2	95	55	1	0	38	7	649	3365
3	Wetting agents, plant byproducts, organic and decompostion extracts on particles of natural organic matter, fortified with iron.	6.3	37	65	4	14	6	16531	60	81	9105
4	(Peat, forest prod., or compost), manure, wetting agent, fertilizer	7.9	3	61	38	1	7	4	6	392	5766

Colorado Master Gardener[sm] Program
Colorado Gardener Certificate Training
Colorado State University Extension

CMG GardenNotes #232

Understanding Fertilizers

Outline:

Fertility is only part of the soil management process. Colorado soils are naturally low in organic matter. To maximize productivity, our soils also need routine applications of organic matter to improve soil tilth. For flower and vegetable gardens, it is desirable to raise the soil organic content, over time, to four to five percent.

Manufactured fertilizers are popular with gardeners since they are readily available, inexpensive, easy to apply, and generally provide a quick release of nutrients for plant growth. Application rates depend on the nutrient need of the soil and the percent of nutrients in the specific fertilizer. **In products containing multiple nutrients, the application rate is always based on the nitrogen content.**

Fertilizer or Soil Amendment?

By legal definition, the term ***fertilizer*** refers to a soil amendment that guarantees the minimum percentages of nutrients (at least the minimum percentage of nitrogen, phosphate, and potash).

An ***organic fertilizer*** refers to a soil amendment derived from natural sources that guarantees the minimum percentages of nitrogen, phosphate, and potash. These should not be confused with products approved for use by the ***USDA National Organic Program***. The federal Certified Organic Label, USDA Organic, allows only certain regulated products as listed by the Organic Materials Review Institute (OMRI). For additional information on certified organic soil amendments and fertilizers, refer to the web site at www.omri.org.

The term ***soil amendment*** refers to any material mixed into a soil. ***Mulch*** refers to a material placed on the soil surface. By legal definition, soil amendments make no legal claims about nutrient content or other helpful (or harmful) affects they

will have on the soil and plant growth. In Colorado, the term ***compost*** is also unregulated, and could refer to any soil amendment regardless of active microorganism activity.

Many gardeners apply *organic soil amendments*, such as compost or manure, which most often do not meet the legal requirements as a "fertilizer" but add small amounts of nutrients.

What is in a Fertilizer?

Analysis or Grade

By law, all products sold as fertilizer require uniform labeling guaranteeing the minimum percentage of nutrients. The three-number combination (fertilizer ***grade*** or ***analysis***) on the product identifies percentages of nitrogen (N), phosphate (P_2O_5), and potash (K_2O), respectively. For example, a 20-10-5 fertilizer contains 20% nitrogen, 10% phosphate, and 5% potash.

> Note: ***Phosphorus, P***, is a primary nutrient in plant growth. The word ***phosphate, P_2O_5***, refers to the ionic compound containing two atoms of phosphorus with five atoms of oxygen. The *phosphorus* content of fertilizers is measured in percent *phosphate*.
>
> Note: ***Potassium, K,*** is a primary nutrient in plant growth. The word ***potash, K_2O,*** refers to the ionic compound containing two atoms of potassium with one atom of oxygen. The *potassium* content of fertilizers is measured in percent *potash*.

The product may also identify other nutrients, such as sulfur, iron, and zinc, if the manufacturer wants to guarantee the amount. This may be done by placing a fourth number on the product label and identifying what nutrient was added in the ingredients.

Ratio

Fertilizer ***ratio*** indicates a comparative proportion of nitrogen to phosphate to potash. For example, a 15-10-5 fertilizer has a ratio of 3-2-1, and an 8-12-4 fertilizer has a ratio of 2-3-1. **Fertilizer recommendations from a soil test are given in ratios.**

When shopping for a fertilizer, select a product with a ratio somewhat similar to that desired. For example, if a soil test recommended a 2-1-0 ratio, the ideal fertilizer would be something like 8-4-0, 10-5-0 or 20-10-0. However, if you cannot find that exact fertilizer, an 8-4-2 would be similar. If a garden soil test calls for a 1-0-0 ratio, a 21-0-0 or 24-2-2 fertilizer would be similar.

Formulation

The ***formulation*** tells what specific kinds of fertilizer are in the product. Table 1 gives examples of manufactured fertilizers that could be mixed to derive any specific analysis, ratio, or brand name.

Table 1. Examples of manufactured fertilizers

Product	N%	P_2O_5%	K_2O%
Ammonium nitrate	34	0	0
Ammonium sulfate	21	0	0
Urea	48	0	0
Ammoniated super-phosphate	3-6	48-53	0
Di-ammonium phosphate	11	48	0
Mono-ammonium phosphate	11	48	0
Super-phosphate	0	18-50	0
Triple super phosphate	0	46	0
Potassium chloride	0	0	60
Potassium nitrate	13	0	44
Potassium sulfate	0	0	50
Potassium-magnesium sulfate	0	0	22

What else is in the fertilizer? In a manufactured fertilizer, the grade does not add up to 100% since the fertilizer also contains other elements like carbon, hydrogen, oxygen, sulfur, iron, zinc, etc. For example, ammonium nitrate (NH_4^+ NO_3^-) has a grade of 34-0-0 with 34% of the content from nitrogen and 66% from hydrogen and oxygen. Ammonium sulfate (NH_4^+ SO_2^- has a grade of 21-0-0 with 21% from the nitrogen and 79% from the hydrogen, sulfur and oxygen.

Time release or ***slow release*** fertilizers contain coating materials or are otherwise formulated to release the nutrients over a period of time as water, heat, and/or microorganisms break down the material.

In an "organic" type fertilizer, the base is decomposed or processed plant and/or animal by-products. For example, fish emulsion is ground and processed non-edible fish or fish scraps. Its nutrient content would be around 8-4-2, with 8% from nitrogen, 4% from phosphate, and 2% from potash.

Some manufactured and "organic" fertilizers contain fillers, used to prevent caking, control dust, derive the desired grade, or to facilitate ease of application.

Table 2. Examples of Quickly and Slowly Available Nitrogen

Quickly available nitrogen	Ammonium sulfate
Lasts 4-6 weeks	Ammonium nitrate
	Calcium nitrate
	Potassium nitrate
	Urea
Slowly available nitrogen	Resin-coated urea
Available over weeks to months	Sulfur-coated urea
	Isobutylidene diurea (IBDU)
Regulated by solubility or	Methylene urea
Microorganism activity	Urea formaldehyde
	Manure
	Poultry wastes
	Blood meal

Complete fertilizer is a term used to identify fertilizers that contains nitrogen, phosphorus, and potassium. In the national home garden trade, most fertilizers are complete. However, in Colorado the majority of gardens do not need phosphorus or potassium. It is advisable to avoid heavy applications of phosphate and potash when unneeded as they contribute to soil salts.

Nitrogen Applications

Nitrogen is the nutrient needed in largest quantities as a fertilizer**.** Nitrogen is annually applied by manufactured fertilizer, organic fertilizers, and/or organic soil amendments. **Application rates are critical, since too much or too little directly affect crop growth**.

Application rate is based on the soil organic content. As the organic content increases, nitrogen will be slowly *mineralized* (released) by the activity of soil microorganisms. Standard application rates for gardens are given in Table 3.

Nitrogen fertilizer can be broadcast and watered in, or broadcast and tilled into the top few inches of soil. It can be banded 3-4" to the side of the seed row. Do not place the fertilizer in the seed row or root injury may occur.

For additional information on fertilizers refer to the CMG GardenNotes #234, *Organic Fertilizers* and #711, *Vegetable Garden: Soil Management and Fertilization.*

Table 3. Nitrogen fertilizer application rates for home gardens

	Soil Organic Content		
	Typical garden soil low in organic matter (1% OM)	Moderate level of organic matter (2-3% OM)	High level of organic matter (4-5% OM)
Nitrogen needed	**0.2 lb. actual N per 100 sq. ft.**	**0.1 lb actual N per 100 sq. ft**	**0**
Fertilizer to apply			
Ammonium sulfate 21-0-0	1 lb. fertilizer per 100 sq. ft (approx. 2 cups)	0.5 lb. fertilizer per 100 sq. ft (approx. 1 cup)	0
OR			
Ammonium nitrate 34-0-0	0.6 lb. fertilizer per 100 sq. ft. (approx. 1 1/3 cups)	0.3 lb. fertilizer per 100 sq. ft (approx. 2/3 cup)	0
OR			
Urea, 45-0-0	0.4 lb. fertilizer per 100 sq. ft. (approx. 1 cup)	0.2 lb. fertilizer per 100 sq. ft (approx. ½ cup)	0

Phosphate and Potash Applications

A soil test is the best method to determine the need for phosphate and potash. When a fertilizer contains a combination of nitrogen with phosphate and/or potash, the application rate is always based on the nitrogen percentage, since nitrogen levels are most critical to plant growth. Phosphate and potash fertilizers are best applied in the spring or fall when they can be tilled into the soil.

Phosphorus

Phosphate levels are adequate in the majority of Colorado soil. With annual applications of compost or manure, phosphorus levels will likely be adequate. Deficiencies are most likely to occur in new gardens where the organic matter content is low and in soils with a high pH (7.8 to 8.3).

Excessive phosphorus fertilizer can aggravate iron and zinc deficiencies and increase soil salt content.

Where phosphate levels are believed to be low, the standard application rate without a soil test is ¼ to 1 pound triple super phosphate (0-46-0) or ammonium phosphate (18-46-0) per 100 square feet.

When a phosphate fertilizer is applied to a soil, the phosphorus is quickly immobilized in the soil profile. It typically moves only about an inch. Therefore, it needs be tilled into the rooting zone to be most effective.

Phosphorus and Water Quality

In surface water, low phosphorus levels limit the growth of algae and water weeds. However, when the phosphorus content of surface water increases, algae and water weeds often grow unchecked, a process call *eutrophication*. This significant decrease in water quality is a major problem related to manure management in production agriculture and the handling of yard wastes from the landscape environment.

Popular press articles often incorrectly point to phosphorus-containing lawn and garden fertilizers as the major source of phosphate water pollution. Actually, phosphate fertilizers are rather immobile when applied at correct rates to lawn and garden soils. Phosphate is so immobile in the typical soil that it generally moves less than one inch after application and thus needs to be tilled into the rooting zone to be effective.

However, high rates of manure applied year after year will build soil phosphorus content where leaching becomes a water quality problem. On sandy soils coupled with high rainfall/irrigation, excessive application rates of organic or manufactured fertilizers may also lead to water quality concerns.

The primary source of water polluting phosphorus in the landscape environment is the mowing, sweeping or blowing of lawn clipping and leaves onto the gutter and street. When mowing, mow in a direction to blow the clippings onto the lawn rather than onto the sidewalk or street. Also sweep any grass on the sidewalk/driveway onto the grass. When dealing with autumn leaves, avoid blowing them into the street!

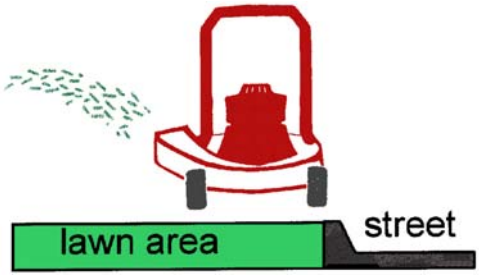

Figure 1. Grass clippings and leaves mowed or blown into the street are the major source of phosphate pollution from the landscape environment. Mow in a direction to discharge clippings back onto the lawn and not into the street.

Phosphate in fertilizer is immobilized upon contact with soil and is not a source of phosphate pollution when applied to a lawn (or garden) soil. However, fertilizer over-spread onto the sidewalk, driveway, and street move with surface runoff into local lakes, streams and ponds. Exercise caution when fertilizing to keep the phosphate out of the street.

It is also important to leave an unmowed buffer strip edging all lakes, streams, ponds and wetlands rather than mowing plant residues into the water.

Second to yard waste management, over-spreading fertilizers onto hard surface (sidewalks, driveways and streets) adds to surface water pollution. When applying fertilizer, avoid spreading the fertilizer onto hard surfaces where it will wash into local surface water through the storm sewer system. Sweep any fertilizer that landed on the sidewalk/driveway onto the lawn area.

Another very important source of phosphorus pollution in the landscape setting is erosion of soil from new construction sites, unplanted slopes and poorly maintained landscapes. When the soil moves, it takes the soil bound phosphorus with it. For water quality, sloping ground needs to be planted with year-round plant cover to prevent soil erosion.

Potassium

Potassium levels are naturally adequate to high in most Colorado soils. With annual applications of compost or manure, potassium levels will likely be adequate. Deficiencies occasionally occur in new gardens low in organic matter and in sandy soils low in organic matter. A soil test is the best method to determine the need for potassium.

Excessive potash fertilizer can increase soil salt content.

Where potash levels are believed to be low, the standard application rate without a soil test is ¼ to ½ pound potassium chloride (0-0-60) or potassium sulfate (0-0-50) per 100 square feet.

Movement of potassium in soils is dependent on soil texture. As the clay content increases, movement decreases. For most soils, it is important that applied potash be tilled into the root zone. In sandy soils, potassium could leach down past the root zone.

Specialty fertilizers

For specific uses, specialty fertilizers may be preferred. For example, on lawns slow release fertilizers are recommended, (see lawn care information for details). ***Slow release*** or ***time release*** fertilizers give out small quantities of nutrients over a time period. The release may be controlled by water, temperature, or microbial activity. On trees and shrubs, use only slow release products.

In planters and hanging baskets, two popular specialty fertilizers include Osmocote and water solubles (MiracleGro, Peters, etc.).

Osmocote is a time release fertilizer designed for indoor and outdoor potted plants. Each time the soil is watered, a small amount of nutrients are released. Depending on the specific formulation, it would be applied to the soil once every 3 to 9 months. In outdoor pots watered daily, it releases faster, having about half the life span of the product used on indoor plants. Gardeners sometimes see the Osmocote pellets in potted plants and mistake it for insect eggs.

Numerous brands of ***water solubles*** are popular in the home garden trade, for example, MiracleGro, Peters, Schultz Plant Food, Fertilome Root Stimulator, etc. Water soluble fertilizers are mixed with the irrigation water, typically giving a blue or green color. This can be done in a bucket or hose-on fertilizer applicator. It is important to water the soil with the fertilizer water, not just wet the leaves. (Note: hose-on fertilizer applicators and hose-on pesticide sprayers are not the same thing. Fertilizer applicators apply a heavier volume since the purpose is to water the soil. Pesticide applicators release a lower volume, since wetting the leaf is the objective.) Water solubles are the standard in greenhouse production where the fertilizer is injected into the irrigation water.

For herbaceous transplants (flowers and vegetables), water soluble fertilizer are recommend at planting and possibly two and four weeks after planting (depending on soil organic matter content). These are often marketed as *root stimulators*. It is the nitrogen content that promotes growth rather than any hormones or vitamins in the product. On cool springtime soils, the readily available phosphate may also be helpful. Woody plants (trees and shrubs) do not respond to water soluble fertilizer at planting.

Authors: David Whiting, Adrian Card and Carl Wilson: Colorado State University Extension; and Jean Reeder, Ph.D., USDA-ARS (retired. Artwork by David Whiting.

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- Colorado State University, U.S. Department of Agriculture and Colorado counties cooperating.
- Extension programs are available to all without discrimination.
- No endorsement of products mentioned is intended nor is criticism implied of products not mentioned.

Revised December 2009

Colorado Master Gardener
Extension

Colorado Master Gardener[sm] Program
Colorado Gardener Certificate Training
Colorado State University Extension

CMG GardenNotes #241

Soil Amendments

Outline:

Terms

The term ***soil amendment*** refers to any material mixed into a soil. ***Mulch*** refers to a material placed on the soil surface. By legal definition, soil amendments make no legal claims about nutrient content or other helpful (or harmful) effects that it will have on the soil and plant growth. In Colorado, the term ***compost*** is also unregulated, and could refer to any soil amendment regardless of microorganism activity.

By legal definition, the term ***fertilizer*** refers to soil amendments that guarantee the minimum percentages of nutrients (at least the minimum percentage of nitrogen, phosphate, and potash).

An ***organic fertilizer*** refers to soil amendments derived from natural sources that guarantee the minimum percentages of nitrogen, phosphate, and potash. These should not be confused with products approved for use by the ***USDA National Organic Program***. The federal Certified Organic Label, USDA Organic, allows only certain regulated products as listed by the Organic Materials Review Institute (OMRI). For additional information on certified organic soil amendments and fertilizers, refer the web site at www.omri.org.

Many gardeners apply *organic soil amendments*, such as compost or manure, which most often do not meet the legal requirements as a "fertilizer" and generally add only small quantities of plant nutrients.

Managing Soil Texture and Structure

Routine applications of organic matter should be considered an essential component of gardening and soil management. Organic matter improves the water and nutrient holding capacity of coarse-textured sandy soil. On a fine-textured clayey soil, the organic matter over time glues the tiny clay particles into larger chunks or *aggregates* creating large pore space. This improves water infiltration and drainage, air infiltration (often the most limiting aspect of plant growth), and allows for deeper rooting depths (allowing the plant to tap a larger supply of water and nutrients). For additional discussion, refer to the CMG GardenNotes #213, *Managing Soil Tilth*.

Using ***organic soil amendments*** is a great way to turn otherwise useless products, like fall leaves and livestock manure, into compost for improving soil tilth.

When using organic soil amendments, it is important to understand that only a portion of the nutrients in the product are available to plants in any one growing season. Soil microorganisms must process the organic compounds into chemical ions (NO_3^-, NH_4^+, HPO_4^{-2}, $H_2PO_4^-$, K^+) before plants can use them.

Cultivate or hand-turn the organic matter thoroughly into the soil. Never leave it in chunks as this will interfere with root growth and water movement.

Selecting Soil Amendment

For details on selecting a soil amendment, see the CSU Extension Fact Sheet #7.235, *Choosing a Soil Amendment.*

Desired results – In selecting soil amendments, first consider the desired results. To improve the water and nutrient holding capacity on sandy, gravelly, and decomposed granite soils, select well decomposed materials like finished compost, aged manure, and peat. To improve aeration and infiltration (improve structure on clayey soils) select fibrous materials like composted wood chips, peat and straw.

Potential for routine applications – Another important consideration is the potential for routine applications to improve the soil over time, as in a vegetable garden or annual flowerbed. In many landscape settings, the amendment is a one-time application added before planting lawns, perennials, trees and shrubs.

Longevity of the product merits consideration. Produces that decompose rapidly (like grass clippings and manure) give quick results, while products that decompose slowly (like wood chips, bark chips and peat) provide longer lasting results. For quick improvement that last, use a combination of materials.

Salts are a primary consideration. Products made with manure and/or biosolids are often very high in salts. Salt level may actually increase in the composting process, although water moving through the compost pile leaches out the salts. Use with caution! Plant-based products are naturally low in salts.

Routine application rates depend on the salt potential of the material and the depth to which it will be cultivated into the soil. Table 1 gives standard rates.

Table 1. Routine Application Rate for Soil Amendments			
Site	**Incorporation Depth**[2]	**Depth of compost before incorporation**[1]	
		Plant-Based Compost and other compost known to be low in salts[3]	**Compost made with manure or biosolids** for which the salt content is unknown[4]
One-time application—such as lawn area	6-8”	2-3”	1”
	3-4”	1-1½”	½”
Annual application to vegetable and flower gardens – **first three years**	6-8”	2-3”	1”
	3-4”	1-1½”	½”
Annual application to vegetable and flower gardens – **fourth year and beyond**	6-8”	1-2”	1”
	3-4”	1”	½”

1 3 cubic yards (67 bushels) covers 1,000 square feet approximately 1 inch deep.
2 Cultivate compost into the top 6-8 inches of the soil. On compacted/clayey soils, anything less may result in a shallow rooting depth predisposing plants to reduced growth, low vigor and low stress tolerance. The 3-4” inch depth is shown as an illustration of how application rates need to be adjusted when the deep cultivate is not practiced.
3 Plant-based composts are derived solely from plant materials (leaves, grass clippings, wood chips and other wards wastes). Use this application rate also for other compost known, by soil test, to be low in salts.
4 Use this application rate for any compost made with manure or biosolids unless the salt content is known, by soil test, to be low. Excessive salts are common in many commercially available products sold in Colorado. For a few products in the market with extremely high salt levels, even this low rate may be too high.

In purchasing products, gardeners need to understand that there are no regulations about the quality of the product, salt content or other beneficial or harmful qualities of bagged products. Voluntary standards for bulk products may help in product evaluation. Use with caution! Many of the soil amendments sold in Colorado are high in salts!

Need for nitrogen fertilizer – Soil microorganisms release nitrogen tied-up in organic matter over a period of time. Release rates from compost are very slow, over a period of years. The need for nitrogen fertilizer is based on the soil organic content. As the soil organic content increases, the need for fertilizer decreases. [Table 2]

Table 2.
Need for nitrogen fertilizer based on soil organic content

Soil Organic Content	Routine Application Rate For Gardens
1%	2 pounds actual N / 1000 square feet
2-3%	1 pound actual N / 1000 square feet
4-5%	0

Over Amending

Over-amending is a common problem. Some gardeners try to fix their soil limitations by adding large quantities of amendment in a single season. This can result in following problems:

- High salts
- High nitrogen
- Low nitrogen (from the tie-up of nitrogen due to a carbon to nitrogen ratio imbalance)
- Holding too much water
- High ammonia (burns roots and leaves)

Problems may also arise, over time, from the continual application of high rates. This can result in the following problems:

- High salts
- Excessive N, P or K
- Ground water contamination
- Micronutrient imbalance

Evaluating the Quality of Organic Smendments

The quality of organic amendments can be determined by both visual evaluation and lab testing.

Visual Evaluation

Color – dark brown to black
Odor – earthy, no ammonia smell
Texture – less than ½ inch particle size; lawn top dressing less than ¼ inch
Foreign materials – less than 1% and smaller than ½ inch size
Uniformity within the batch
Consistency between different batches
Raw materials – concern of heavy metals (biosolids), human pathogens (manure), and salts (manure and biosolids)
Weed seeds – test by germinating some material

Laboratory Testing

C:N ratio – less than 20 to 1 acceptable; 10-12 to 1 is better

Ash content – (This measurement of the mineral portion after the organic matter is burned off will determine if soil was a primary part of the mix.)

- 20-30% common
- Keep below 50%
- If greater than 50-60% it probably contains a lot of soil

Bulk density – less than 1.0 gm/cc

pH – 6.0 to 7.8

- May be higher in manure
- Near neutral (6.8 to 7.2) is best

Salts – acceptable levels depend on use

- Potting grade: < 2.5 mmhos/cm
- Potting media amendment: < 6 mmhos/cm
- Top dressing: < 5 mmhos/cm
- Soil amendment in a low salt soil: <10 mmhos/cm

Sodium – sodium adsorption ratio less than 13%

Ammonium – less than 1/3 of total nitrogen. If higher, it may not be finished composting.

Heavy metals – A concern with biosolids but regulated by application permits.

Pesticide residues – Rarely a problem since they breakdown in composting.

Pathogens – *E-coli* and other human pathogens are a potential in manure.

Nutrient content varies greatly from product to product.

Germination test – Seeds are started to check potential of toxic chemicals.

Stability (respiration rate) vs. maturity – relative measurement of the completeness of microbial activity. If microorganisms are highly active, they may consume oxygen in the root zone causing root problems.

Bacterial and fungal diversity – Some compost has been found to suppress plant diseases. This is a high-tech field with commercial applications.

Examples of Soil Amendments

There are two broad categories of soil amendments: organic and inorganic. Organic amendments come from something that is or was alive. Inorganic amendments, on the other hand, are either mined or man-made. Organic amendments include sphagnum peat, wood chips, grass clippings, straw, compost, manure, biosolids, sawdust, and wood ash. Inorganic amendments include vermiculite, perlite, tire chunks, pea gravel, and sand.

Peat

Sphagnum peat is a good soil amendment, especially for sandy soils, which will retain more water after sphagnum peat application. Sphagnum peat is generally acidic (i.e., low pH) and may help gardeners grow plants that require a more acidic soil. Sphagnum peat is harvested from bogs in Canada and the northern United States. The bogs can be revegetated after harvest and grow back relatively quickly in this moist environment. In recent years however, harvest rates have become so high that it is raising questions on renewability.

Colorado mountain peat is not an acceptable soil amendment. It often is too fine in texture and generally has a higher pH. Mountain peat is mined from high-altitude wetlands that will take hundreds of years to rejuvenate, if ever. This mining is extremely disruptive to hydrologic cycles and mountain ecosystems.

Biosolids

Biosolids (sewage sludge) are a way to add slow release nutrients and organic matter to soil. They are available from some communities or sewer treatment districts in bulk and from garden stores in bags.

Some biosolids are extremely high in salts. For example, tests on MetroGro report a salt content of 38.3 dS/m (38.3 mmhos/cm), which is considerably above acceptable tolerances for soil amendments. (A soil amendment above 10 dS/m is considered questionable.) For details on salty soil amendments, refer to CMG GardenNotes #224, *Saline Soils.*

Biosolids typically have 5-6% nitrogen content. Annual applications should be made only when the biosolids and garden soil are routinely tested for salt content.

Compost, Cover Crops, Green Manure Crops, Manure, and Organic Fertilizers

For details on these soil amendments, refer to the following CMG GardenNotes:

#234, Organic Fertilizers
#242, Using Manure
#243, Using Compost
#244, Cover Crops and Green Manure Crops

Worm Castings

Versatile worm castings can be used in potted plants, soil mixes, and in garden beds. Worm castings pose no threat of burning potted plants. Worms should have digested the batch of vermicompost for 4 months to ensure that microbial oxygen consumption has diminished sufficiently.

Red worm castings are the feces from compost worms. It has a slow release performance due to a mucus covering which is slowly degraded with microorganism activity. It contains highly available forms of plant nutrients that are water-soluble, has a neutral pH, and contains trace elements, enzymes, and beneficial microorganisms. The release time for nutrients is around 4 months. For continual release of nutrients, repeat application at 4-month intervals.

Some batches made from livestock manure may have high salts depending if the animals producing the manure had access to a salt lick, and if the vermicompost maker leached them or not.

Castings can be applied as a top dressing, 1/4 inch deep, on potted plants, as 25% of a soil mix (1 to 4 mix) or tilled into a garden at 1 gallon per 13 square feet or 7.5 gallons (1 cubic foot) per 100 square feet. Due to the high cost in Colorado, they are generally used in small gardens or potting mixes.

Perlite and Vermiculite

Perlite and vermiculite are common inorganic amendments used in potting soils and planter mixes.

Vermiculite is made from heat expanded silica (mica). It is used to increase pore space and has a high water holding capacity. Perlite is made from heat expanded volcanic rock. It is used to increase pore space and has a low water holding capacity.

Summary: Considerations in Selecting Soil Amendments

Gardeners often inquire about the **best** amendments to use for their situation. There really is not a best. What is practical and available varies from gardener to gardener and within different communities. The important aspects are that 1) soils are routine amended improving soil tilth and 2) the gardener follows the limitations for the specific product used. The following summarizes considerations in selecting soil amendments:

- Cost
  - Local availability
  - Cost of product
  - Size of area to be treated (quantity needed)
  - Depth of incorporation (application rate / quantity needed)
  - Transportation costs

- Need for fertilizer after amending
  - Soil organic content

- Precautions with specific products
  - Salts (manure and biosolids)
  - Weed seeds (manure and compost)
  - Plant pathogens (compost)
  - Human pathogens (manure)

- Alternatives to amending
  - Potential to incorporate amendments
  - Accepting a reduction in plant growth and vigor
  - Accepting increased maintenance requirements
  - Selecting plants more tolerant of poor soils
  - Avoid crowding plants competing for limited soil resources
  - Mulching with organic mulch to slowly improve soil over time
  - Container and raised-bed gardening
  - Preventing compaction forces

Authors: David Whiting, Adrian Card, Catherine Moravec, and Carl Wilson: Colorado State University Extension; and Jean Reeder, Ph.D., USDA-ARS (retired)

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Minor revisions November 2010