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ORGANIC FERTILIZERS

by
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CONTENTS

An organic fertilizer is carbon (C) based and is derived from living organisms or their excrement. These natural materials have been successfully used by man for thousands of years.

Using crop residues, animal wastes, domestic wastes and industrial wastes recycles nutrients. Nutrient recycling involves returning to the soil essential elements taken up by plants that are then incorporated into animal, domestic, and industrial products. Recycling reduces the need for additional fertilizer elements and simultaneously provides organic matter that has numerous beneficial effects on the soil.

ORGANIC MATTER

Adding organic fertilizers on a short-term basis usually isn't sufficient to increase soil organic matter content enough to have significant effects on some soil properties. However, organic matter added to the soil at high levels provides the following benefits:

- Serves as the main storehouse for some essential plant nutrients such as nitrogen (N), phosphorus (P), sulfur (S), boron (B), molybdenum (Mo), and chlorine (Cl).
- Increases the cation exchange capacity (CEC) of soils by a factor of 5 to 10 times that of clay. (See *Soil Fundamentals* - Soil Chemistry, CES publication FGV-00242)
- Buffers the soil against rapid changes due to acidity, alkalinity, salinity, pesticides, and toxic heavy metals.
- Protects the surface soil against erosion by wind and water by reducing the impact of raindrops, increasing infiltration, increasing total and available soil water holding capacity, and increasing surface wetness.
- Supplies food for beneficial soil organisms.
- Reduces extremes of soil surface temperature.

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- Decreases surface crust formation by reducing the soil-dispersing action of beating raindrops.
- Supplies small quantities of all essential plant nutrients to growing plants as organic residues decompose.
- Provides P and micronutrients more readily over a wider pH range; a function especially of soil humus.
- Decreases the bulk density of soil.

Organic matter composition, ambient temperature and moisture determine the rate of microbial decomposition (mineralization) and transformation to available plant nutrients.

MINERALIZATION

Mineralization is an element's microbial transformation from organic to inorganic form. The opposite process is immobilization; conversion of a mineral element or compound from the inorganic to the organic form. Mineralization is the main pathway for organic N in organic residues to become available to plants for nutrition and growth. Not all the N released from organic residues will be available to plants. As much as 10 to 50% can be lost as atmospheric N_2, as oxides of N by denitrification, by leaching of nitrate (NO_3^-), runoff and erosion, or by fixation as ammonium (NH_4^+) between clay platelets.

CROP RESIDUES

If crop residues are added to a soil, the N and other nutrients may be mineralized and soon become available for plant growth, or the N may be immobilized (not decomposed) and unavailable to plants. With optimum water and temperature conditions for microbial decomposition, the limiting factor in immobilization may be the ratio of organic C to total N (C/N) in the plant residue.

Organic residues with very high C/N ratios tend to cause immobilization of soil N during decomposition, whereas N is mineralized during decomposition of residues with low C/N ratios. When residues with high C/N ratios are added a period of net immobilization usually occurs where higher plants can obtain little N from the soil. The time interval of N tie-up may be only a week or may last throughout the growing season. The normal C/N ratio in soils is about 10:1. Organic residues with high C/N ratios, such as timothy (80:1) and oat straw (75:1), should have a N fertilizer added to prevent N deficiency if a crop is planted soon after incorporation with the soil. If residues are turned into the soil in the fall, N should not be added in the fall, but in the spring to enhance breakdown of the residues. Decomposed manure (20:1), mature clovers (20:1) or sewage sludge (10-12:1) can be incorporated into the soil and a crop can be planted within a few days with very little chance of N deficiency.

Crop residues, which are low in N, may decrease water pollution potential by immobilizing excess fertilizer N or mineral soil N. The N can be retained in a nonmobile form until later when it becomes available to growing crops. However, mineralization and crop uptake of N may not coincide. High N containing crop resides returned to the soil when N isn't needed by growing crops may pose a water pollution hazard. When these residues are incorporated into the soil and begin to decompose rapidly, the N will be subject to nitrification (i.e. conversion of ammonium to nitrate). This nitrate (NO_3^-), like any fertilizer N that is applied at the wrong time, can leach and pollute ground water. Crop residues should be managed to minimize N pollution hazards.

Most crop residues are left on or near the surface with conservation tillage practices. Conservation tillage systems vary from those that reduce excess tillage to the no-tillage system, which permits direct planting in the previous crop's residue and uses only the tillage necessary to plant.

Such organic material conservation has definite benefits. Returning crop residues to the soil aids in maintaining soil organic matter content. Higher populations of bacteria, actinomycetes, and fungi are encouraged. Surface erosion by wind and water is reduced. The use of chemical herbicides to provide weed control without cultivating the soil has become an important tool in reducing evaporation. Water vapor loss from the soil is reduced when crop residues cover most of the soil. Lower tractor fuel costs and less soil compaction are also benefits when reduced tillage is practiced.

There are also disadvantages with conservation tillage systems including the possibility of more insects, diseases, and weeds (unless herbicides are used); a wetter and colder soil surface; plus difficulty in getting good seed-soil contact unless more expensive proper seeding equipment is used.

GREEN-MANURE (COVER) CROPS

A green-manure crop is grown and incorporated in the soil when it is still actively growing (usually prior to flowering) to improve crop yields. Green manuring establishes a temporarily high biologically active soil with rapid nutrient availability for crop uptake. Green-manures also smother weeds, reduce soil erosion potential, and keep nutrients from leaching if they are mineralized during rapid uptake of nutrients. Green-manure growth is not practiced where water is a limiting factor to plant growth, since considerable water is lost from the green-manure plant during transpiration.

A closely related term is cover crop, which is planted between regular field crops to reduce erosion and loss of nutrients by leaching. Definitions merge when cover crops are incorporated into the soil to enhance crop yields.

Choices for green-manure crops include small grains, various legumes, rape, and annual grasses suited for the growth conditions present. Rape *(Brassica napus)* has been used as a green-manure occasionally and is a good choice, as long as it is not followed by another brassica to avoid disease problems. Legumes are often used because they "fix" atmospheric N into their tissues, which is returned to the soil when green-manuring.

MANURE

Manure provides organic matter and a wide variety of nutrients when applied to soil. In spite of its high labor and handling costs, along with relatively low nutrient analysis, manure remains a valuable nutrient and organic matter source. Crop and animal production and soil conservation are enhanced by its use. However, there can be problems associated with manure use, such as introducing weed seeds (especially if bedding material is included) and N leaching into groundwater under certain conditions.

Large quantities of farm manure are available each year for possible return to the land. About 44 tons of manure is generated for each 22,040 lb live weight of farm animals each year. Proper disposal and handling techniques are necessary to obtain the greatest nutrient benefit from animal manure.

Disposal

A solid waste disposal system requires collecting and field applying manure and bedding every day the weather, soil, and crop permits. Spreading manure on frozen soils should be avoided to prevent runoff and surface water pollution from phosphates and nitrates.

Liquid waste systems are more recent in origin. There are four types discussed, liquid pit, oxidation ditch, lagoon and earthen storage basins. A liquid pit is a fairly deep pit that is not agitated and therefore is anaerobic. An oxidation ditch may be any size and depth in which manure is collected in slurry form. A lagoon is a large receiving basin containing more water than either a liquid pit or an oxidation ditch. Earthen storage basins are another possible liquid storage system in Alaska. They are designed and constructed for a low to moderate investment to prevent ground and surface water contamination while providing long-term manure storage near the barn. Each method of handling manure affects the nutrient content and is important when manure is used as a fertilizer.

Manure can be applied to the field in several different ways. One method spreads solid wastes on soil. Other methods include injecting a slurry of water and manure directly into the soil, spraying it on the soil surface, or applying through an irrigation system. Nutrient loss and odors are disadvantages of the irrigation method. Injecting through a trailing hose is one possible remedy to decrease the nutrient loss and odor. Attaching a manifold system to a chisel plow or soil saver can also accomplish both tilling and manure injecting in one trip, minimizing soil compaction.

Composting solid wastes in small aerobic piles or large anaerobic piles is an alternative to the solid or liquid waste disposal systems. Dehydrated manures can also be applied to the soil. Composted or dehydrated manures are a popular natural organic material that can be sold if a farm has excess manure above crop needs.

Composition

Manure composition is variable because it is a combination of feces, urine, bedding and feed waste obtained from sources practicing different waste management systems. Table 1 shows the approximate nutrient content of several manures using different storage or handling techniques.

Portions of the nutrient elements consumed in animal feeds are found in the voided excrement. As a generalization, three-fourths of the N, four-fifths of the P, and nine-tenths of the potassium (K) ingested in feeds appear in manure. Thus, animal manure is a valuable source of primary and secondary nutrients and micronutrients. Micronutrient content of manure is listed in Table 2.

The higher nutrient content of solid manure is offset by the ready availability of constituents carried in the urine. Care must be taken during manure handling and storing to minimize loss of the liquid portion.

Losses

To conserve ammonia (NH_3) between excretion and time of application, several options are available. Manure can be incorporated into the soil almost immediately after spreading to prevent NH_3 volatilization. Application of manure should occur a short time before rapid crop uptake. Composting, adding materials that will absorb NH_3 directly, or adding chemicals to stabilize NH_3 by neutralizing the rise in pH are options to reduce N losses.

Table 1. Approximate nutrient content of several manures.

		Nutrient Content (lb/T)			
Type of Livestock	Storage/ Handling[a]	Total N	Ammonium (NH_4^+)	Phosphate (P_2O_5)	Potash (K_2O)
Swine	Solid NB	10	6	9	8
	Solid B	8	5	7	7
	Liquid P	36	26	27	22
	Liquid L	4	3	2	4
Beef cattle	Solid NB	21	7	14	23
	Solid B	21	8	18	26
	Liquid P	40	24	27	34
	Liquid L	4	2	9	5
Dairy cattle	Solid NB	9	4	4	10
	Solid B	9	5	4	10
	Liquid P	24	12	18	29
	Liquid L	4	2.5	4	5
Turkeys	Solid NB	27	17	20	17
	Solid B	20	13	16	13
Horses	Solid B	14	4	4	14

[a]NB = No bedding; B = bedding; P = pit; L = Lagoon.

Source: Sutton, A.L., D.W. Nelson, and D.D. Jones. 1985. *Utilization of Animal Manure as Fertilizer*. University of Minnesota Cooperative Extension Service Bulletin AG-F0-2613.

Table 2. Micronutrient content of various materials.

Fertilizer	Boron (B)	Copper (Cu)	Iron (Fe)	Manganese (Mn)	Molybdenum (Mo)	Zinc (Zn)
	Quantities in lb/T Fresh weight basis for manure, dry weight basis for other					
ORGANIC						
Manure						
Cow	0.03	0.01	0.27	0.02	0.002	0.03
Horse	0.03	0.01	0.08	0.02	0.002	0.03
Sheep	0.02	0.01	0.32	0.02	0.002	0.05
Pig	0.08	0.01	0.56	0.04	0.002	0.12
Poultry						
Cage layer	0.12	0.03	0.93	0.18	0.011	0.18
Broiler	0.08	0.06	2.00	0.46	0.007	0.25
Hay						
Legume	up to 5	0.02	0.20	0.20	0.006	0.10
Non-legume		0.01		0.14		0.06
Straw		0.009	0.27			0.06
Average crop	0.20	0.01	0.20	0.40	0.01-0.001	0.05
Alfalfa pellets	0.09	0.02	0.60	0.06		0.03
Seaweed	0.10	0.01	0.04	0.10	0.002	0.02

Source: Parnes, R. 1990. *Fertile Soil: A grower's guide to inorganic and organic fertilizers*. agAccess, 603 Fourth St., Davis, CA 95616.

Soon after manure is incorporated into the soil, decomposition begins. Nitrate concentration in the soil sometimes increases to high levels with large applications of manure. Unfavorable conditions may develop in soil and ground water as a result of high NO_3^- concentrations. High NO_3^- concentrations can be toxic to animals or humans consuming the products grown. When soils are loaded with large amounts of manure, denitrification is the key mechanism in preventing or decreasing NO_3^- leaching beyond the root zone. Denitrification is a favorable factor in decreasing ground water and soil pollution from NO_3^- at manure disposal sites. However, denitrification also results in loss of N from the soil.

Application Rates

The rate of manure application will depend upon the specific needs of the crop grown. Usual application rates of cow manure are 5-40 T/a. Vegetables would benefit from 5-20 T/a, and small grains from 0-8 T/a (depending on the potential for lodging) applied before seeding. The rates should be decreased if manure is applied annually. Contact your local Cooperative Extension Service agent for specific recommendations.

Horse manure could be applied at rates similar to cow manure. Sheep and pig manures usually have a higher N content and less should be applied. Decomposed manure should also be applied at a lower rate. A customary practice is to use decomposed manure on fast-growing crops and fresh manure on slower growing crops. Fresh manure has adverse effects on root crops, especially carrots, which tend to produce forked roots. Decomposed manure is good for improving nutrient and water retention capability of sandy soils.

Poultry manure is much more concentrated and its N is rapidly available. Pollution from poultry manure is a greater threat to ground water than other manures. Application rates of 2 T/a are often satisfactory. Rates should not exceed 5 T/a without monitoring ground water quality.

Long Term Effects

If applied in sufficient quantity over a period of several years, manures usually result in increased organic C and N content, increased soil porosity, reduced bulk density, increased mineralizable N, and enhanced microbial activity. The salt content of manure, particularly feedlot manure, can increase the soil electrical conductivity (EC).

Only one fifth to one half of the nutrients supplied by animal manures are recovered by the first crop following application. Much of the remainder is held in compounds subject to slow decomposition. In these forms, the elements are released very slowly, rates of 2-4% per year being common. The slowly decomposable compounds in manure will have continuing effects on soils years after their application.

SEWAGE SLUDGE

Sewage sludge is the by-product of domestic and/or industrial waste water treatment plants. It contains settled sewage solids combined with varying amounts of water and dissolved materials removed from sewage by screening, sedimentation, chemical precipitation, or bacterial digestion. Concentrated efforts to prevent surface water pollution by city sewage effluent have encouraged land application of either the sewage effluent or the sludge emanating from sewage systems. Municipal waste effluents can be used for irrigation and fertilization of agricultural crops. Nitrogen mineralization in sewage sludge is relatively slow compared with municipal effluents.

Sewage sludge is extremely variable in composition. The sewage sludge typically produces a plant yield response equal to that of a 5-5-0 chemical fertilizer. It also contains micronutrients and heavy metals. Supplemental applications of either manure or chemical fertilizers are necessary to provide the nutrient balance for good crop production.

The potential for adsorption of toxic quantities of heavy metal cations on the soil's exchange surfaces is one of the greatest hazards in using sewage sludge. When using residential sewage sludges this is not much of a problem. The best solution when applying sewage sludge in crop production is to monitor sludge and soil content of heavy metals, and prevent accumulation in the soil in toxic amounts.

Sludge decomposes in the soil much slower than plant residues and animal manures. When sludge is applied to the soil surface considerable N can be lost by volatilization either as NH_3 or through denitrification if high rates are applied, or if the material is very wet. To conserve N, farmers can inject the sludge into the soil or plow in at least part of the applied sludge rather than leaving it on the soil surface.

Heavy annual land applications of sewage sludge can increase the organic matter and N content of the soil. These increases are reflected most in complex organic compounds that are only slowly decomposed, but they do add to the large pool of organic matter and associated N, S, and phosphoric compounds which, through the years, can be recycled for plant and animal use.

Sewage sludge, when properly handled, is a highly desirable organic fertilizer. Sludge should be tested for heavy metal content prior to use on land destined to be planted to crops for human or animal (red meat) use. Guidelines for the application of sewage sludge to agricultural land are available from Alaska Department of Environmental Conservation.

MARINE BY-PRODUCTS

In Alaska, marine by-products can be a major source of nutrients. The forms are diverse, varying from fish to the shelled forms such as oysters, crabs, lobsters, and sea urchins. By-products used in agriculture are classified as liquid, dry, and fresh or frozen scraps.

Fish emulsions and oil are the main liquid by-products. To make fish emulsion, or fish hydrolysate, fish scraps are ground, digested with the enzyme papain, de-oiled, the bones screened out, and then the emulsion can be pasteurized in a dehydrator or spray-dryer to form spray-dried fish hydrolysate.

Fish soluble nutrients (FSN) are included in the "family" of fish emulsions, but are made as a by-product of fish meal. The basic FSN manufacturing process consists of cooking the fish, pressing out the liquid, extracting the oil, evaporating some of the liquid, and acidifying to stabilize the mass. Reduction of stress at time of transplanting is one beneficial plant response to the application of the family of fish emulsion products.

Bone meal and oil are often by-products of the emulsion process. Bones are dried and ground into a meal. Bone meal is also screened from coarsely ground, dried fish meal. Fish bone meal has shown promise as a fertilizer derived from a marine by-product as it contains Na for responsive crops, and micronutrients not present in standard commercial NPK fertilizers. Salmon bone meal and white cod bone meal are currently being used in Alaskan agriculture in small quantities. Research using salmon bone meal on potatoes and lettuce has been conducted by the University of Alaska. Analysis of Alaska salmon bone meal and white cod bone meal is given in Table 3.

Processed crab waste is a possible dried marine by-product with value as a soil amendment principally through its lime equivalence in the calcium carbonate chitin material.

Composting is another way to treat and utilize marine by-products. The composting process consists of mixing waste material with a bulking agent such as sawdust, and usually adding water. Different wastes including shark skins, crab shells, and fish frames decompose to form an enriched soil amendment or compost.

Seafood scrap is often considered a separate form of by-product and it has many uses. Land application on crops can be an inexpensive alternative to land filling. Chemical composition of fish scrap and other fish by-products is shown in Table 4.

Fish products are most often used in conjunction with other sources of nutrients to help maximize plant quality and production. They can be used to even out the rate of N release. Care must be taken at all times to incorporate (plow or disc) by-products into the soil to reduce odor and fly problems.

Table 3. Nutrient content of Alaska fish bone meal.

	Salmon bone meal*	White cod bone meal
Total N	8.23%	6.10%
P	4.20%	10.40%
K	0.45%	0.45%
Ca	8.43%	20.30%
Mg	0.29%	0.35%
S	0.89%	0.74%
Na	5,395 ppm	10,795 ppm
Cu	35	1
Zn	244	78
Mn	11	56
Fe	305	250
B	4	4

* Averages of ground and sieved salmon bone meal.

Source: Analysis performed in April-May, 1990 by the Agricultural & Forestry Experiment Station from samples obtained from Icicle Seafoods, Inc.

Table 4. Chemical composition of fish by-products used on agricultural crops.

Nutrients	Fish soluble nutrients	Fish hydrolysate[d]	Spray dried fish hydrolsysate[e]	Fish meal (menhaden)[a]	Crab meal[a]	Fish scrap (sole, dover raw offal)[f]	Sea urchin shells and viscera[g]	Fish compost[i]
Nitrogen (%)	5.04	2.38	12	9.79	5.15	1.87	0.11	0.6-1.2
Fat (%)	6.1[b]	2.7[b]	11.5	9.6[b]	2.2[b]	4.4	-	-
Ash (%)	10.1	4.1	6.5	19.1	41.1	3.5	40.1-47.9	-
Moisture (%)	50.	74.8	7.5	8	8	81.2	45.6-53.5	-
Phosphorus (%)	0.57	0.09	0.6	2.88	1.58	0.15[g]	0.04	0.1-0.5
Potassium (%)	1.64	0.25	1.3	0.7	0.45	0.32[g]	0.13-0.16	0.2-0.5
Calcium (%)	0.16	0.25	-	5.19	14.46	0.05[g]	13.72-15.99	-
Sodium (%)	2.45	-	1	0.41	0.88	0.09[g]	0.488-0.51	-
Iron (ppm)	280	-	45	550	4,350	-	-	-
Zinc (ppm)	43.2	-	15	144	-	-	9-16	-
Copper (ppm)	46.6	-	4	10.3	32.7	-	0.7-1.0	-
Boron (ppm)	3[c]	-	-	-	-	-	0.9	-
Magnesium (ppm)	300	-	100	1,500	9,400.	-	5,600-6,700	-
Chromium (ppm)	3[c]	-	-	-	-	-		1.9-3.8
Lead (ppm)	-	-	-	-	-	-		13-23
Cadmium (ppm)	-	-	-	-	-	0.09[g]	<0.05	0.2-1.3
Nickel (ppm)	-	-	-	-	-	-	-	1.1-4.8
Vitamin B_{12} (ppm)	506.6	-	140	122	437.6	-	-	-
Vitamin E (ppm)	-	-	700	6.8	-	-	-	-

a Ensminger et al., 1990
b Ether extract
c Miller, 1973
d Wyatt and Price, 1990
e California Spray Dry Co., Mariposa Road, Stockton, CA 95205-0035
f Sidwell, 1981
g Raw muscle
h Wyatt, 1989
i Frederick, 1989

Source: Wyatt, B. and G. McCourty. 1990. Use of marine by-products on agricultural crops. International By-Products Conference, April, 1990, AK.

SOURCES OF ORGANIC FERTILIZERS IN ALASKA

In Alaska, commercially dried or ground organic fertilizers imported from other states are expensive. Local, less expensive sources of organic fertilizers are desirable. The following list of some organic fertilizer sources is designed to provide Alaska growers with baseline information regarding the availability of local organic fertilizers.

Source	Materials
Mt. McKinley Meat 385 Outer Springer Road Palmer, AK 99645 (745-5232)	Blood in semi-liquid form - about 1,000 gal week available - pumpable Bones - approximately 300 lb day
(Other local meat processing or packing companies)	Manure - approximately 3 tons a month Arrangements for pick up and pricing may vary, contact Mt. McKinley Meat.
Marine by-products	Fish bone meal Fish meal Fish silage Crab meal Fish soluble nutrients Seafood scrap Availability and prices vary with current businesses operating.
Alaska Sea-Ag HCO1, Box 6930-D Palmer, AK 99645 (745-5725)	Salmon bone meal and white cod bone meal - 50 or 80 lb sacks
Manure	Any local animal producers in your area, as long distance transportation is not economically advantageous.
Landscape Companies	Blood meal, bone meal and compost can be purchased.
Seaweed	Available along the coast of Alaska.
Compost	Individuals can make their own compost or purchase it ready to incorporate in the soil.
School Districts	Food wastes, cardboard trays as composting materials.
Sewage Sludge	May be composted or applied directly to soil. Contact Alaska Department of Environmental Conservation for information concerning quantity, availability, application information and restrictions.
Alaska 1994 Food & Farm Products Directory Division of Agriculture PO Box 949 Palmer, AK 99645-0949	Provides names, addresses and telephone numbers where fertilizer and agricultural chemicals are available.

Organic fertilizers provide an agronomically acceptable alternative to manufactured materials. Organic fertilizers typically supply essential plant nutrients more slowly than manufactured materials, however, benefits derived from organic materials should be carefully weighed. The very different nutrient release rates of organic and manufactured materials requires attention to management techniques that are required to successfully use these materials.

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