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Use of manure in crop production

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Quick Facts

Advantages:

1. The use of animal manure is an excellent way to improve crop yields, especially on eroded soils that have low soil nutrients and high lime levels (calcarious soils).
2. Manure improves soil physical properties and water retention.
3. Manure reduces the need for commercial fertilizer.
4. Compost made from manure is easy to apply, high in nutrients and free from weed seeds.

Disadvantages:

1. The chemical composition of manure varies considerably depending on the source and age of product.
2. Some lots of manure may be contaminated with common and/or noxious weed seeds.
3. Excessive manure applications can create high salt problems in the soil, which reduce seed germination, crop yields and result in excess nitrate-N (NO_3-N).
4. Manure must be incorporated as soon as possible after spreading to prevent nutrient losses.
5. Improper storage and application can cause ground water contamination.

Manure is a complex material that contains valuable nutrients and potential pollutants. Animal manure has been used as a fertilizer material for centuries. The value of animal manure to improve crop production has long been recognized. This source of essential plant nutrients and organic matter often is used to build and maintain soil fertility, improve soil tilth and increase the soil's water holding capacity. Environmental issues and the concern for sustainable agriculture has stimulated interest in "organic" crop production. With this approach, the use of commercial fertilizers and pesticides can be eliminated or reduced. Instead, advocates of low-input agriculture can substitute legumes in rotation to supply nitrogen, integrate livestock enterprises to supply manure as fertilizer for crops, and utilize mechanical-biological pest control.

Manure is an economical source of plant nutrients if it is close to the fields where it is applied. If hauled for a long distance, transportation costs may make its use uneconomical. However, producers should use manure at recommended rates whenever possible because of its general beneficial effect on the physical and nutritional characteristics of soils.

Manure Production

American farms produce a total of about 2 billion tons of manure each year. A portion of the total manure is deposited on pasture and range, but an enormous volume accumulates in feedlots, barnyards and stockpiles. This material must be collected, transported and utilized in an economical and non-offensive manner that is environmentally safe.

Over the last decade, there has been a shift toward confinement livestock operations that often result in the production of more manure than can be used within reasonable hauling distances. As a result, fields located near livestock operations

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often receive rates of manure far in excess of maximum-yield requirements. These excessive applications, in some cases, result in an accumulation of nutrients approaching toxic levels and the leaching of nitrate into the groundwater. Manure management is a major problem that faces agriculture. The estimated annual manure production by various types of animals is presented in Table 1.

Table 1: Annual manure production by various animals (wet weight).

Animal	Raw manure production per 1,000 pounds animal weight	
	tons/yr	gal/yr
Dairy cow	15.0	3,614
Beef feeder	11.0	2,738
Beef cow	11.5	2,884
Swine feeder	18.0	4,380
Swine breeding herd	6.5	1,533
Sheep	7.5	1,679
Poultry layer	10.0	2,336
Poultry broiler	13.0	3,139
Turkey	11.0	2,592
Horse	8.5	2,044

NOTE: Raw manure includes feces and urine. The wet weight of animal manures ranges between 8 and 9 pounds per gallon.
SOURCE: Vitosh, et al., 1988.

Manure Composition

The nutrient composition of farm manure varies widely even for the same species of animal. In the past, animal wastes were considered to be largely solids. Disposal was a problem because it required handling a large tonnage of low-analysis material. Today, an increasing amount of the waste is a fluid and the analysis is even lower because of the higher water content. The approximate fertilizer value for various manure handling systems is listed in Tables 2 and 3. These values are not absolute but serve as an aid indicating the amounts of plant nutrients that may be present. Animal wastes should be analyzed prior to land application if reliable local data are not available.

Moisture Content

Manure contains 10 percent to 80 percent water, depending on whether the material is stockpiled or taken directly from the feedlot. A simple method to determine water content is to weigh wet manure and then spread it on a sheet of plastic to air dry. When it dries, weigh it again and calculate its former moisture percentage as follows:

$$\text{Percent Moisture (wet basis)} = \frac{\text{Wet Weight-Dry Weight}}{\text{Wet Weight}} \times 100$$

Table 2: Composition of various solid manures.

Source of Manure	Bedding or litter	Dry matter	Ammonium N	Total N	P_2O_5	K_2O
		%	lb/ton raw waste			
Swine	No	18	6	10	9	8
	Yes	18	5	8	7	7
Beef	No	52	7	21	14	26
	Yes	50	8	21	18	26
Dairy	No	18	4	9	4	10
	Yes	21	5	9	4	10
Sheep	No	28	5	18	11	26
	Yes	28	5	14	9	25
Poultry	No	45	26	33	48	34
	Yes	75	36	56	45	34
Turkey	No	22	17	27	20	17
	Yes	29	13	20	16	13
Horse	Yes	46	4	14	4	14

NOTE: The nutrient value of manure varies with different feed and management systems. For the actual nutrient value of manure on your farm an analysis is necessary.
SOURCE: Vitosh, et al., 1988.

Table 3: Composition of various liquid manures.

Source of Manure	Waste handling	Dry matter	Ammonium N	Total N	P_2O_5	K_2O
		%	lbs/1,000 gal raw waste			
Swine	Liquid pit	4	26	36	27	22
	Lagoon*	1	3	4	2	4
Beef	Liquid pit	11	24	40	27	34
	Lagoon*	1	2	4	9	5
Dairy	Liquid pit	8	12	24	18	29
	Lagoon*	1	3	4	4	5
Poultry	Liquid pit	13	64	80	36	96

**Includes lot runoff water.*
SOURCE: Vitosh, et. al., 1988

Application rates usually are based on air-dried manure. Likewise, analytical results for chemical composition of manure also are reported on an air-dry basis. However, air-dried manure is not found in most storage systems. Factors to convert high-moisture manure to air-dry manure are given in Table 4.

Table 4: Factors to convert application rates for dry manure to feedlot manure with indicated moisture contents.

% Water	Factor	% Water	Factor	% Water	Factor
10	1.11	35	1.54	60	2.50
15	1.18	40	1.67	65	2.86
20	1.25	45	1.82	70	3.33
25	1.33	50	2.00	75	4.00
30	1.43	55	2.22	80	5.00

EXAMPLE: If the application rate for dry manure is 20 tons per acre, the application rate for manure containing 30 percent moisture is 1.43 x 20 = 28.6 tons per acre.

Composting of Beef Cattle Manure

Fresh beef cattle manure contains about 80 percent moisture. The moisture content of drylot manure depends on climate and length of exposure to drying. When composted, cattle manure changes from large sized masses that are difficult to spread uniformly, to small particles that can be applied almost as easily as commercial fertilizer. Marked changes also occur in the chemical composition of composted animal manure. During manure composting, cellulose and fiber are decomposed and water is lost. The total mass or volume of the waste is reduced. On the average, 4 to 6 tons of drylot cattle manure can be converted to 1 ton of finished compost (Chesnin, 1977).

Depending on the climatic conditions, composting drylot manure can take six to 10 weeks of periodic turning and aerating to develop a finished product. Compost piles should be turned or rolled over weekly for best results. This process can go on during the winter months because heat is generated. The typical temperatures recorded during the composting of manure ranges between 140° F and the thermophilic range of 176° F or higher. In general, these elevated temperatures effectively destroy most of the undesirable microorganisms and weed seeds.

Fresh drylot cattle manure has about 3.5 percent nitrogen. A considerable amount of this nutrient can be lost by improper management. Composting under controlled conditions will conserve and concentrate the nitrogen in the manure. If the compost pile is allowed to overheat, nitrogen can be lost as ammonia. Under these conditions, ammonia odor can be detected when the waste is turned. Other nutrients such as phosphorus, potassium, sulfur and zinc are increased or concentrated during the composting process.

Field Application

Proper, timely manure spreading and soil incorporation preserves nutrients and decreases potential pollution. Spreading should be as uniform as possible to prevent local concentrations of ammonium and other inorganic salts that can reduce germination and yields. Piles or windrows of manure in the field should be avoided. Incorporate manure into the soil as soon as possible to avoid loss of nitrogen by volatilization. Early incorporation also prevents rain or melting snow from washing manure pollutants into streams, lakes and domestic wells. This is particularly important on sloping land. Applications on frozen soil where manure cannot be incorporated is not recommended.

Ease of manure application depends largely on the physical condition of the manure. Friable material that is allowed to decay and dry and then stockpiled is much easier to load and spread than large chunks taken directly from a feedlot. However, some nitrogen and potassium is leached from stockpiles by precipitation.

Value Calculation

Calculate the value of the manure on the basis of the needed plant nutrients supplied plus some allowance for improvement of the soil's physical properties, i.e., tilth and water intake. The value of nutrients needed and supplied by the manure should be the price that the nutrients would cost as commercial fertilizer. If soil tests show need for nitrogen, phosphorus, potassium and/or zinc, the total value of these nutrients should be added. Additional value is obtained from manure in succeeding years by continued decomposition and nutrient release.

The additional cost to apply manure must be subtracted from its value. If additional herbicide applications are necessary to control weeds, the cost of the herbicide application also should be subtracted. Other added costs could accrue from additional tillage operations to incorporate the manure.

A survey of the loading, hauling and spreading costs in north central Colorado indicate that it costs about $15.00 per load for a 15-ton load if the distance is less than 10 miles. For every additional 10 miles, a $1.00 per ton hauling fee is charged. Some manure haulers charge by the hour. For example, one trucker quoted a fee of $40.00 per hour to haul and spread.

Hazards

Nutrients in manure can increase yields. However, continued heavy applications in one location can reduce yields. Heavy applications result in germination damage and growth reductions caused by high concentrations of ammonium and soluble salts of K, Na, Ca and Mg (potassium, sodium, calcium and magnesium). Salt buildup in the soil limits water uptake by plants. A measure

of the salt buildup (salinity) is the electrical conductivity of the soil water measured on the saturation extract from the soil. A soil that has a saturation extract with an electrical conductivity of 4 or more millimhos per centimeter (mmhos/cm) is classified as a saline soil. Heavy applications of manure can increase the electrical conductivity of the soil water saturation extract (Figure 1).

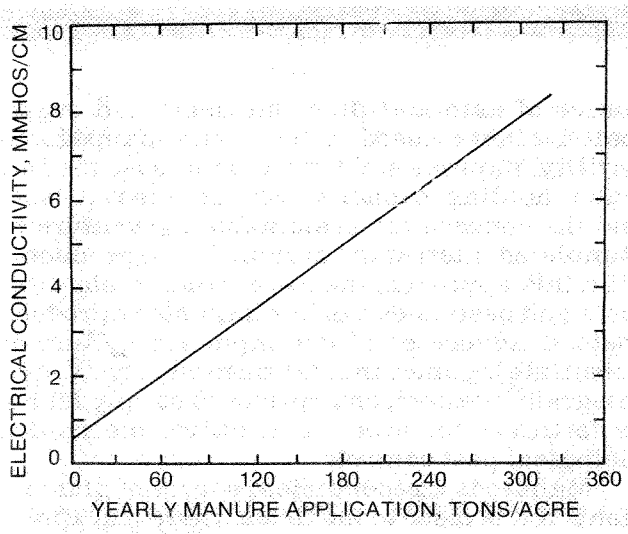

Figure 1: Salt buildup under irrigated forage corn as indicated by the electrical conductivity of the soil water saturation extract. Manure was added to the soil for three years. Rates are on the air-dry weight basis.
SOURCE: Powers, W.L., et. al., 1974.

The amount of soluble salt a crop can tolerate in soil varies. Proper plant selection is one way to moderate yield reductions caused by excessive soil salinity (Franklin and Follett, 1985).

When using the soil as a disposal medium for manure, an additional hazard might be the accumulation of nitrates in the soil. Excess nitrate nitrogen eventually can be leached to groundwater supplies (Gilbertson, et. al., 1979). Since groundwater is an important source of drinking water in Colorado, preventing its contamination is vitally important. In general, loading rates of 15 to 20 tons per acre of raw manure is acceptable to maintain water quality under normal conditions.

Summary

With all its pros and cons, manure is a product of considerable value and warrants consideration in the fertilizer program on farms. It should be spread or composted as soon as possible after it is produced. Even though at certain times of the year some loss of nitrogen may occur from this practice, it will probably be no greater than when the product is stored. The following conclusions as to the effectiveness of manure seem warranted:

- Farm manure is variable in composition depending on the kind, condition, and age of the animal and the ration fed.
- Manure is subject to important losses, especially nitrogen. Nitrogen is subject to volatilization, leaching, and runoff, both around the barns and in the fields.
- If the product is handled well and used on responsive crops, approximately 30 to 50 percent of the nitrogen and 80 percent of the phosphorus and potassium contained in the manure is effective for crop growth. In addition, appreciable quantities of the various secondary and micronutrient it contains also may be effective on some soils and crops.
- Since no precise estimate of manure contents can be made without chemical analyses, it is important to have manure analyzed by a testing laboratory for nitrogen, phosphorus and potassium.
- Manure may carry large numbers of weed seeds and in many cases is conducive to the growth of certain weeds. It should therefore be used in conjunction with a good weed control program.

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