Animal Manures What are they worth today?
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ANIMAL MANURES

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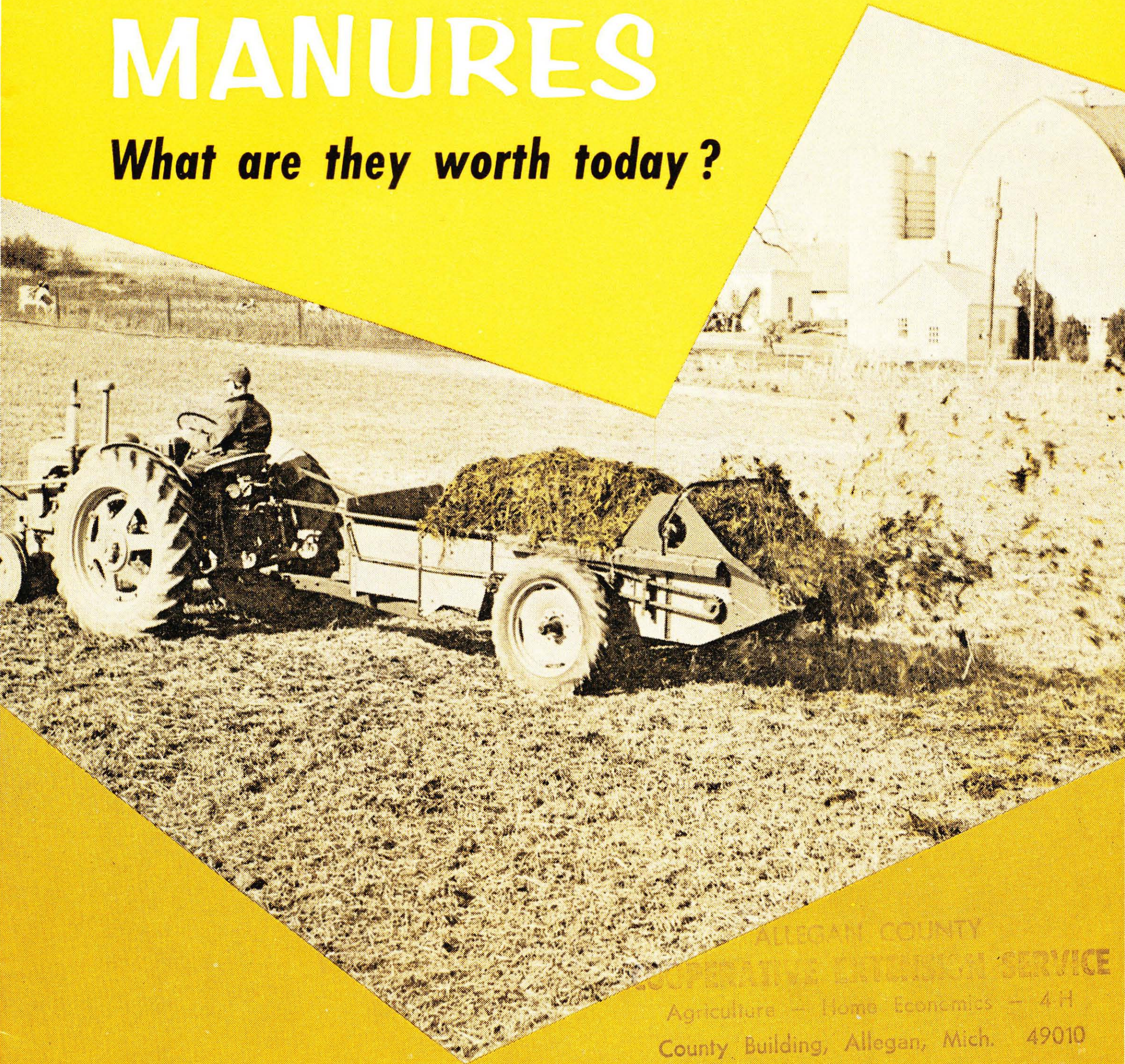

By E. J. Benne, C. R. Hoglund, E. D. Longnecker, R. L. Cook

MICHIGAN STATE UNIVERSITY

Agricultural Experiment Station
Cooperative Extension Service
EAST LANSING

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ANIMAL MANURES
What Are They Worth Today?

By

E. J. Benne[1], *C. R. Hoglund*[2], *E. D. Longnecker*[3], *and R. L. Cook*[3]

INTRODUCTION

Animal manures have long been regarded as valuable by-products of livestock farming, but with today's plentiful supply of commercial fertilizers and the high cost of labor and equipment, the question has been raised whether it is still profitable for farmers to collect and use manures for fertilizing purposes. This study was undertaken to answer that question.

The results indicate that manures are still valuable as a source of plant nutrients and as soil conserving materials. The by-products of soil microorganisms are responsible for soil aggregation, a condition essential for high productivity of clayey soil. These organisms require organic matter as a source of energy for their life processes, and animal manures are one of the best sources of food for them, especially where use of green manure crops may not be practicable. Light applications of manure, added frequently, are inducive to continued microorganism activity in the soil.

After the composition of manures is determined by chemical analysis, the value of the nutrients they contain can readily be calculated. This furnishes one way of determining whether or not one can afford to use them for fertilizers. At present day fertilizer prices, the nitrogen, phosphorus, and potassium contained in manures will more than pay the cost of handling and spreading them. The secondary and minor nutrients add to this value on the soils where they are needed. Modern fertilizers contain very small amounts of these extra plant foods, so manures may be even more valuable than when the older, low-grade materials were used.

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Field experiments have furnished another way of arriving at manure values. The Michigan data, showing values greater than is accounted for by the value of the nutrients, are typical of those published elsewhere. The extra value no doubt results from the addition of the organic matter, a substance very important in fertility maintenance.

Composition of Manures

The value of manures depends on the plant nutrients they contain and on their effectiveness as soil-amending agents. It is difficult to place a generally applicable dollar value on these qualities because manures vary widely in composition.

Plant nutrients in manures come entirely from the feeds consumed by the animals excreting them and from the beddings used. The animals themselves do not create nor add fertility. They merely excrete part of the nitrogen and some of the minerals and organic matter contained in the feeds they eat. The proportions of the fertilizing constituents originally present in feeds that are excreted, vary with the kinds of animals, their ages, and their condition. In general, young, growing animals absorb and store in their bodies considerably greater proportions of plant nutrients present in their feeds than do mature animals, and their excrements accordingly contain lesser amounts of these nutrients. Likewise, manures from milking cows contain less nutrients than those from cows not milking, since the former must replace nutrients excreted in the milk.

On a general farm, where the livestock population includes both young and mature animals of different kinds, it seems reasonable to assume that on the average about three-fourths of the fertilizing constituents in the feed are excreted in feces and urine. However, on a dairy farm, where most of the animals are milking cows, the figure is lower.

Furthermore, manures from different kinds of animals vary considerably in the percentages of fertilizing constituents they contain. Manures from chickens, horses, and sheep usually contain less water than those from cattle and hogs, and partly because of this their percentages of plant nutrients are higher.

Nitrogen, Phosphorus, and Potassium

However, in spite of these sources of variation in the composition of manures, some fairly accurate general values relating to the plant nutrients they contain were arrived at by chemically analyzing samples from different kinds of animals. Table 1 gives average figures thus obtained for the nitrogen, phosphorus, and potassium in manures from several kinds of common farm animals and their combined value per ton. This is based on what they would cost if purchased in the form of commercial fertilizers at current retail prices. Obviously, these values will fluctuate with fertilizer costs.

TABLE 1—Average amounts and combined value of nitrogen, phosphorus and potassium in manures from different farm animals

Kind of manure	Per-cent water	Pounds per ton of manure			Value per ton(*a*)
		Nitrogen	Phos-phorus	Potas-sium	
Chicken—					
a. From dropping boards, without litter	54	31.2	8.0	7.0	$7.06
b. With old floor litter(*b*)	61	33.8	12.4	12.8	8.95
Dairy cattle	79	11.2	2.0	10.0	2.73
Fattening cattle	80	14.0	4.0	9.0	3.61
Hog	75	10.0	2.8	7.6	2.63
Horse	60	13.8	2.0	12.0	3.22
Sheep	65	28.0	4.2	20.0	6.33

(*a*) Calculated on the assumption that the present retail costs in cents per pound are as follows: nitrogen 14.5; phosphorus, 26.8; and potassium, 5.7.
(*b*) Probably contained some feed residues.

Minor Elements

In addition to nitrogen, phosphorus, and potassium, manures also contain numerous other essential plant nutrients. Among these are boron, calcium, copper, iron, magnesium, manganese, molybdenum, sulphur, and zinc. All are required for plant growth. Consequently, crops grown on soils deficient in these elements would definitely benefit by the amounts supplied in generous applications of manures.

Table 2 gives amounts of these constituents found in several kinds of manures and in several common feeds. Comparison of these values shows that a ton of manure might contain several times the quantities in a ton of certain of the feeds. This suggests the potential of manure as a source of these needed elements for plant growth, provided that all could be made available for this purpose.

TABLE 2—Other essential elements in manures from different animals and in several common livestock feeds

Kind of manure or feed	Percent water	Pounds per ton								
		Boron	Calcium	Copper	Iron	Magnesium	Manganese	Molybdenum	Sulphur	Zinc
LIVESTOCK										
Chicken—										
a. From dropping boards, without litter	54	.12	74.0	.03	.93	5.8	.18	.011	6.2	.18
b. With old floor litter(*a*)	61	.03	28.0	.02	.31	2.4	.08	.005	3.3	.10
Dairy cows	82(*b*)	.03	5.6	.01	.08	2.2	.02	.002	1.0	.03
Fattening cattle	78(*b*)	.04	2.4	.01	.08	2.0	.01	.001	1.7	.03
Hog	72(*b*)	.08	11.4	.01	.56	1.6	.04	.002	2.7	.12
Horse	73(*b*)	.03	15.7	.01	.27	2.8	.02	.002	1.4	.03
Sheep	69(*b*)	.02	11.7	.01	.32	3.7	.02	.002	1.8	.05
FEEDS										
Alfalfa hay	11-12(*c*)	.03	23.8	.03	.27	6.1	.09	.002	5.0	.08
Corn grain	11-12	.01	.4	.01	.10	3.0	.02	.0002	.7	.05
Mixed hay	11-12	.03	11.6	.03	.27	3.1	.13	.003	3.1	.05
Oat grain	11-12	.01	1.4	.03	.14	3.6	.17	.0005	2.3	.06
Soybean seeds	11-12	.01	2.8	.05	.28	5.3	.09	.022	5.8	.12
Wheat grain	11-12	.01	1.0	.02	.07	2.4	.08	.0004	1.6	.06

(*a*) Probably contained some feed residues.
(*b*) Represent different batches of manure than those in Table 1.
(*c*) Estimated average for air-dry feeds.

Mineral and Organic Matter

Besides the plant nutrients already mentioned, manures also supply considerable mineral and organic matter. Table 3 provides some general information on amounts of mineral and organic matter, as well as some of the major constituents of organic matter, found in different kinds of manures.

Value of Manures in Farming Practices

Increases Yields

The organic matter value of manure is reflected in increased crop yields. Research work by Robertson *et. al.*[4] showed that even on the best soils, such as the Sims clay loam in the cash-cropping, Thumb area of Michigan, organic matter was deficient. Green-manure crops plowed down markedly increased yields. Mixed legumes were seeded with wheat and plowed under for the next year bean crop and with barley to go under for the next year corn. This meant two green-manure additions in a 5-year rotation. Average increases in yield per acre during the period 1941 to 1951, attributable to the green-manure, were corn, 11.2 bushels; sugar beets, 0.73 tons; wheat, 4.0 bushels; and beans, 1.3 bushels.

Other experiments by Guttay, *et. al.*[5] showed that manure and sweetclover green-manure caused increases in yields of row crops and small grains and improved soil aggregation. The soil was a Tappan-Parkhill loam handled from 1936 to 1953 under a 2-year grain-row-crop rotation with sweetclover seeded with each grain crop as one treatment. Cow manure at 10 tons an acre applied for each corn crop was another treatment. A third treatment consisted of sweetclover with the grain and manure for the corn. This meant that on those plots sweetclover green-manure and stable manure were both plowed under for the corn. Superphosphate (0-20-0) was applied on all plots at 200 lbs. per acre each year.

Yield results, shown in Table 4, are significant. During most of the 17 years, starting with 1937, the plots receiving sweetclover green-manure produced higher yields than did the control plots. The same may be said regarding the application of manure and combinations of

[4]Robertson, L. S., R. L. Cook, P. J. Rood, and L. M. Turk (1952). Ten years' results from the Ferden rotation and crop sequence experiment. Proc. Amer. Soc. Sugar Beet Technologists 7: 172-179.

[5]Guttay, J. R., R. L. Cook, and A. E. Erickson (1956). The effect of green and stable manure on the yield of crops and on the physical condition of a Tappan-Parkhill loam soil. Soil Sci. Soc. of Amer. Proc. 20: 526-528.

TABLE 3—*Mineral matter and organic matter contained in different kinds of manures with varying moisture contents*

Kind of manure	Pounds per ton(*a*)							
	Water	Total mineral matter(*b*)	Total organic matter(*c*)	Carbohydrates			Crude fat(*d*)	Crude protein
				Total	Difficultly-digestible	Easily-digestible		
Chicken—								
a. From dropping boards, without litter	1,080	332	588	392	140	252	7	189
b. With old floor litter(*e*)	1,220	134	646	416	159	257	14	216
Dairy cattle	1,640	38	322	266	113	153	7	49
Fattening cattle	1,560	45	395	330	120	210	7	58
Hog	1,440	161	399	297	107	190	9	93
Horse	1,465	149	386	327	170	157	6	53
Sheep	1,370	63	567	470	224	246	14	83

(*a*) Based on results from the analysis of only one sampling of each manure.
(*b*) Ash remaining after ignition.
(*c*) Loss from ignition of the water-free material.
(*d*) Materials soluble in dry ether.
(*e*) Probably contained some feed residues.

TABLE 4—Average yields of crops, 1936-53, as affected by stable manure and sweetclover green-manure, Tappan-Parkhill loam

Dates	Crops	Check	Sweet-clover(*a*) every 2 years	Manure(*a*) every 2 years	Sweetclover and manure(*a*) every 2 years
1936	Small grain.........bu./A.	44.5	52.4	55.2	57.9
			c	m	cm
1937	Corn...............bu./A.	47.7	56.6*	48.5	56.0*
1938	Small grain.........bu./A.	53.1	49.7	53.9	56.7
			c	m	cm
1939	Pea beans..........bu./A.	32.9	35.4	33.4	37.3*
1940	Small grain.........bu./A.	80.2	80.6	82.9	78.1
			c	m	cm
1941	Sugar beets........tons/A.	11.5	16.2*	11.9	15.9*
1942	Small grain.........bu./A.	50.2	65.1*	61.8*	69.2*
			c	m	cm
1943	Pea beans..........bu./A.	28.5	32.7*	29.6	34.2*
1944	Small grain.........bu./A.	54.2	61.1*	57.8	63.3*
			c	m	cm
1945	Sugar beets........tons/A.	10.7	13.7*	11.6	14.9*
1946	Small grain.........bu./A.	41.0	51.6	48.1	56.9*
			c	m	cm
1947	Corn...............bu./A.	30.1	42.4*	31.9	40.1*
1948	Small grain.........bu./A.	35.6	49.9*	41.0	51.9*
			c	m	cm
1949	Pea beans..........bu./A.	43.7	45.3	50.7	57.4*
1950	Small grain.........bu./A.	70.9	78.5	74.7	84.8*
			c	m	cm
1951	Pea beans..........bu./A.	24.4	30.1	28.8	33.0*
1952	Small grain.........bu./A.	34.4	33.5	33.7	33.9
			c	m	cm
1953	Pea beans..........bu./A.	27.8	25.6	23.8	27.6

(*a*)c = sweetclover green manure; m = 10 tons manure per acre.
*Statistically different from check at 5% level.

sweetclover and manure. In all, 22 of the differences were statistically significant.

Improves Soil Structure

Stable manures add nitrogen and other plant foods to the soils. These furnish food for the soil microorganisms which leave certain structure-forming by-products in the soil. Some of the difficultly-digestible organic constituents eventually assume the form of humus and improve the physical properties of the soil.

The actual aggregating effects of these treatments are indicated by the data in Table 5. This is shown by the increase in the perecentage of large water stable aggregates, 20.8, compared to 8.2, for the

TABLE 5—The effect of sweetclover and stable manure added every 2 years on water-stable aggregate size, as determined by wet-sieving,(a) Tappan-Parkhill loam

Aggregate size	Water-stable aggregates	
	Check	Sweetclover+manure every 2 years
mm.	Percent	Percent
4	8.2	20.8
4 to 2	7.6	12.0
2 to 1	9.3	11.8
1 to 0.5	12.4	15.8
0.5 to 0.25	23.7	17.5
0.25 to 0.10	4.1	2.5
Total 0.10	65.3	80.4
Total 0.5	37.5	60.4

(*a*) Samples were taken from 6 to 12 mm. dry aggregate fractions.

greater than 4 mm. size. Considering all aggregates greater than 0.5 mm., the comparison is 60.4 with 37.5. These differences are very significant. Water and air movement through the more stable soil was surely facilitated by the improved aggregation. This probably was responsible for some of the beneficial results.

Conserves Soil

In the 1957 U.S.D.A. Yearbook on Agriculture in an article on page 229, Myron S. Anderson reported that two corn plots were located on a 12-percent slope of Muskingum silt loam. One was topdressed with manure, while the other was not. Soil loss from the untreated plot was 41 tons an acre between late June and harvest. During the same period, the loss from the manured plot was 1.4 tons an acre. Thus, manure applied to the soil surface furnished valuable protection to the soil.

Responses Vary with Crops and Soils

Certain crops, including corn, potatoes, wheat, and numerous vegetables, are highly responsive to applications of animal manures. However, in the case of potatoes, manure should be applied 6 months to a year in advance of planting in order to avoid the tendency of freshly applied manure to encourage potato scab. The true grasses are more responsive to manure, particularly the nitrogen, than are legumes.

However, light top dressings greatly increase the probability of successful legume seedings in small grain crops, particularly on unfavorable locations.

Since few farmers have as much manure as they would like to use, careful selectivity in its use will return high dividends. In addition to the variation in responsiveness of different crops to manure, as previously mentioned, its application to soils low in organic matter should prove more profitable than its use on soils with relatively high contents of organic materials. Crops on low fertility areas, such as light sandy locations or clay knolls, will respond more to manure than those on more fertile lands.

Returns from manure applied to puddled, poorly aerated soils will be greater than returns from applications to soils in good physical condition. Other management factors being similar, the greater the lapse of time between the legume in the rotation and the application of manure, the greater the crop response to manure. On soils where there is a history of responsiveness to nitrogen and/or potassium, manures are likely to be especially valuable.

Calculating Cost and Return for Manures

The net value of manures is represented by the difference between their fertilizing value and the costs involved in loading and spreading them. Costs for these operations vary widely among farms. Where the volumes of manures are large, and power machinery can be used advantageously, less hand labor is required. However, the upkeep, operation, and depreciation of the machines add to operational expenses. Some buildings do not lend themselves to the use of manure loaders and gutter cleaners, and this adds to the cost for labor.

Dairy Cattle

In a recent study of labor requirements for different milking systems, information was obtained on the size of crew, equipment used, and hours required to remove and spread manure from loose-housing barns. These farms averaged 52 cows. On two-thirds of them, manure was hauled out twice a year and on the balance, only once a year. Two men using two tractors, two manure spreaders, and a manure loader constituted the average crew.

An average of 160 hours of man labor and 120 hours of tractor time was used per farm in loading and hauling the manure to the field.

The two manure spreaders were valued at $850 and the manure loader at $500. In calculating the costs of handling the manure, it is assumed that half of the labor was extra, hired for the purpose, and that the regular dairy crew provided the remainder.

The calculated costs of handling and hauling manure from the loose-housing barns were as follows:

Man labor hired	80 hours at $1.25	$100.00
Tractor hours used	120 hours at $1.50	180.00
Spreaders—$850 x 15% depreciation and repairs		128.00
Manure loader—$500 x 15% depreciation and repairs		75.00
	Total Costs	$483.00

These figures do not include fuel, oil, and depreciation in the operation of a tractor and scraper blade in keeping outside concrete areas cleared of manure and in hauling this manure. This is usually a daily or twice-weekly chore. Of course, these operations must be carried out whether the manure is salvaged or not.

Various estimates have been made of the annual tons of manure produced by different kinds of livestock. Van Slyke reported a production of 13.5 tons of excrement per 1000 lbs. of cattle. A figure of 10 tons per cow has often been used. This is considered conservative. On this basis, 520 tons of manure per farm was hauled out on the farms in the Michigan study. This manure, when credited at $2.73 per ton (Table 1), had a total nutrient value of $1,420.00, or three times the cost of hauling and handling it.

Beef Feeders

As part of a study of automation in beef feeding, information was obtained on the equipment and labor used in hauling the manure. Twenty-two beef-feeders fed an average of 218 cattle. These feeders used about the same equipment and number of men as did the dairy farmers for the same job. Investments for two spreaders and loading equipment averaged $1,450 per farm.

It required an average of 30 man days in hauling manure during the year. It is estimated that two-thirds of the labor needed for manure hauling was hired. On the basis of an 8-hour day, this was a total of 160 hours of hired help.

The calculated costs of handling and hauling manure for the 200 fattening cattle were as follows:

Man labor hired	160 hours at $1.25	$200.00
Tractor hours used	180 hours at $1.50	270.00
Spreaders—$950 x 15% depreciation and repairs		142.00
Manure loader—$500 x 15% depreciation and repairs		75.00
	Total Costs	$687.00

For 200 steers fed to gain 600 lbs. to a finished weight of 1,000 lbs., it is estimated that 800 tons of manure were hauled out. Fattening cattle tend to rest or otherwise spend more of their time away from covered shelter than do dairy cattle. It is expected that nutrient losses in manure were higher for steers than for dairy cattle since more of the manure was subject to weather losses. When the 800 tons of manure are valued at $3.61 per ton (Table 1), we have a total value of $2,888. Deduction of the total cost of $687, leaves a balance of $2,201, the net return from the manure used.

Other Considerations

The value of increased crop yields resulting from the application of manure may far exceed the fertility value of the manure. If used judiciously with respect to crop and rate of application, returns should exceed the fertility value and cost of loading, hauling and spreading combined. Weidemann and Millar[6] in a 12-year study, where cattle manure was applied directly in advance of corn in a 3-year rotation of corn, barley, and wheat, obtained results as follows:

Rate per acre every 3 years	Value of crop increase per ton of manure
5 tons	$4.46
10 tons	3.82
15 tons	3.02

Crop values used in this calculation are based on November 18, 1959 prices paid to farmers in Central Michigan — barley, $0.82/bu.; corn, $0.92/bu.; and wheat, $1.85/bu.

It should be remembered, of course, that the cost of removing the manure from the barn or yard just to get rid of it might be as great as the cost of spreading it in the field. For instance, burning would require an expenditure for fuel.

[6]Weidemann, A. G., and C. E. Millar (1951). Results from long-time field experiments. Mich. Agr. Expt. Sta. Spec. Bul. 366, 53 pp.

Another factor to be considered in calculating cost and return for manures is the loss of plant nutrients. From 20 to 60 percent of the original plant nutrient content of manures may be lost when they are stored in the open for several months. Since nearly half of the nitrogen and three-fifths of the potash are in the liquid portion of the excrement, much of this may be lost by drainage during storage.

Where manures are spread in the field or piled in the yard, large proportions of the nutrients are unevenly distributed or lost. These are practices often followed during the winter feeding period on Michigan dairy farms with stanchion barns. Higher proportions of these nutrients are undoubtedly preserved when cattle are kept in loose-housing barns and manures are hauled out directly before they are plowed under.

ANIMAL MANURES ARE WORTH MONEY
DON'T THROW THEM AWAY

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NITROGEN, PHOSPHORUS, and POTASSIUM

in manures

from	are worth
Chickens	$7.06 per ton
Dairy cattle	2.73 per ton
Fattening cattle	3.61 per ton
Hogs	2.63 per ton
Horses	3.22 per ton
Sheep	6.33 per ton

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As a BONUS they supply
ESSENTIAL MINOR ELEMENTS
and ORGANIC MATTER and improve
SOIL STRUCTURE
USE MANURES WISELY!

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