Use Animal Manure Effectively!

Bulletin A-55

Agricultural Experiment Station and Cooperative Extension Service

The University of Arizona

Contents

Summary

To realize profit from the use of manure on cropland:

1. Buy high quality manure — low in moisture, salts, and sand content.
2. Buy aged manure in preference to fresh manure spread directly from the lot. If possible, buy on the basis of analysis of manure to be spread from a specific stockpile.
3. Apply 5 tons of dry manure (or its equivalent) annually, or 10 tons per acre in alternate years.
4. Apply before plowing or disk thoroughly into the soil.
5. Irrigate thoroughly to leach excess salts below the root-zone.
6. Allow about a month after irrigation before planting, to enable soil microorganisms to begin decomposition of manure.
7. Do not apply where downward movement of water is not good, or where irrigation water is very salty or inadequate to move salts down in the first irrigation, and thereafter to keep them well below the surface soil.
8. Apply commercial nitrogen only when and if needed. About half of the nitrogen and phosphorus applied in manure is available to plants immediately, or throughout the season. Application of potash is not necessary.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U. S. Department of Agriculture George E. Hull, Director of Extension Service, The University of Arizona College of Agriculture, Tucson, Arizona.

3M — September 1968 — Bulletin A-55

Use Animal Manure Effectively!

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A possible $90-per-acre return for a $20-per-acre investment is being overlooked by many Arizona farmers. In recent years, the use of cattle manure has been much less than the supply available in Arizona, although the benefits to both soils and crops have been shown.

In 1964, Stubblefield and Smith (5) estimated the yearly production of feedlot and dairy manures in the Phoenix area at 412,000 tons. This was then about 75 percent of the total manure production in the state. They cited two problems in marketing manure facing Arizona cattle feeders: (1) location of the feedlot in relation to the farms on which the manure can be used, and (2) stimulation of the demand for manure.

Had manure been applied to one-sixth of Maricopa County's 511,000 acres of irrigated farmland at the rate of 5 tons per acre, manure use would have equaled manure production. More important, income of both livestock raisers and crop farmers probably would have been increased substantially.

Some feedlot operators not only fail to receive income from the sale of manure, but pay to have it removed. The cost of applying manure today is mainly the cost of hauling and spreading. This service is competitive, and may range from less than $2 to $4 per ton for up to a 40-mile haul. The fertilizer value of manure is at least $2 per ton for available nitrogen and phosphorus.[1] The value of organic matter applied in manure must account for the balance in cost.

"Animal manure is an excellent source of organic matter. Its value on the farm is often not appreciated," writes University of Arizona Professor of Soils Wallace H. Fuller (2). This value is difficult to estimate, but in desert soils, organic matter disappears very rapidly. Ten tons of manure added to 6 acre-inches of soil would increase the organic matter by 0.3 percent before decomposition. This increase would be roughly equivalent to the initial increase in organic matter from the crop residue of a 150-bushel-per-acre corn crop, or 3½ tons of alfalfa hay.[2]

The greatest value of manure may result from the indirect effects of the organic matter contribution on the physical condition of the soil and in maintaining the availability of certain soil nutrients.

Table 1 (page 5) summarizes what may be expected in the quality of manure that may be purchased. Manure is a variable product, and as yet no system for classification is available that assures the buyer of high quality. However, the careful buyer will find that there is much quality manure available.

Table 2, (page 6) compares the value of feedlot manure as fertilizer with a commercial nitrogen fertilizer. The data are from reports for four years of the field experiment described below. In the first two years, manure alone was equal in value to 100 lbs. of commercial N. In the third and fourth years, cotton yields for manure alone exceeded those for commercial nitrogen. For the four-year period, manure would have been more profitable than commercial N had it cost twice as much as it did.

In an experiment conducted from 1960 through 1965 at the Cotton Research Farm at Phoenix, cotton was grown each year, with and without 10-ton-per-acre annual applications of manure (6). Until the build-up of **Verticillium** wilt became severe on high nitrogen and manured plots, the manured cotton without additional nitrogen out-yielded or equaled yields of the unmanured cotton, even when adequate commercial nitrogen was applied. In the fourth year, additional nitrogen decreased the yield on manured plots.

Plots receiving manure alone out-yielded all other treatments, including those planted to sesbania for green manure in alternate years. The fact that plenty of nitrogen and phosphorus remained in the manured soil was obvious in the growth of oats

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[1]Using the average of analyses for nitrogen (N) and phosphorous (P_2O_5), Table 1 (page 5), delivered prices for N and P_2O_5 in solid commercial fertilizers @ 11¢ a pound for each, and conservatively assuming the availability for both at 50%:

Nitrogen: 23.5 lbs. X $0.11 X 0.50 =	$1.29
Phosphorus: 16.3 X $0.11 X 0.50 =	0.90
Per ton value of manure, as fertilizer:	$2.19

[2]Using the average figure (from Table 1) of 668 lbs., or 6,680 lbs. per 10 tons per 2,000,000 pounds soil (six acre-inches) = 0.33% initial increase in organic matter.

Table 1. Characteristics of Six Recently Sampled Manures

Dry weight percentage and pounds (per ton) on moist basis. Analysis percentages on oven-dry basis.

													Soluble Cations[5]					
	Dry Weight		Organic[1] Matter		Sand[2]		Nitrogen[3]		Phosphorus[4] (P_2O_5)		Soluble[5] Salts		Calcium & Magnesium		Sodium		Potassium	
Sample	%	Pounds	%	Pounds	%	Pounds	%	Pounds	%	Pounds	%	Pounds	%	Pounds	%	Pounds	%	Pounds
Dairy	80	1,600	49	790	26	420	1.6	26	1.2	18	8.9	142	0.15	2.4	1.1	18.2	2.3	36.8
Feedlot A	48	960	62	590	22	210	1.8	17	1.3	13	10.6	102	.08	0.8	0.6	6.0	3.8	36.8
Feedlot B	69	1,380	53	725	29	400	1.9	26	0.8	12	8.0	110	.27	3.8	0.8	10.8	2.2	30.8
Feedlot C	75	1,500	40	600	38	570	1.6	24	1.4	20	9.5	143	.13	2.0	1.2	18.6	2.4	36.3
Feedlot D	80	1,600	44	700	41	660	1.6	26	1.2	19	4.2	67	.06	1.0	0.5	8.0	1.2	18.9
Feedlot E	76	1,520	38	575	47	710	1.4	22	1.0	15	7.2	109	.10	1.5	0.8	12.2	2.0	30.4
Average	71	1,430	48	668	34	496	1.65	23.5	1.14	16.3	8.1	112	0.13	1.9	0.85	12.3	2.3	31.7

[1]Oven-dry weight less weight of ash.

[2]Ash not soluble in hydrochloric acid.

[3]Total, not including ammonia, etc. lost upon drying at 75°C.

[4]Total, by ashing 16 hours at 450°C.

[5]Determined in 1:20 manure:water extract.

Table 2. A comparison of returns per acre from 100 pounds of commercial nitrogen vs. 10 tons of feedlot manure for the first 4 years of a cotton experiment conducted at the Cotton Research Farm.

	Control (No Fertilizer)	100 lbs. N/A	10 tons manure applied annually
Year:	Pounds seed cotton per plot		
1960	18.1	19.5	19.4
1961	11.7	15.7	15.2
1962	9.3	14.2	19.9
1963	13.2	17.9	20.7
4 year average yields	13.08	16.83	18.80
Average increase over control as percentage	0	28.7%	43.8%
Average pounds of lint per acre	806	1,038	1,159
Increase in lint, pounds per acre	0	232	353
Return over control, @ 32¢/lb. lint	0	$74.24	$112.96
Cost of 100 pounds N @ 11¢/lb., applied	—	11.00	—
Return over cost of fertilizer	—	63.24	—
Cost of 10 tons manure @ $2.00/ton, applied		—	20.00
Return over cost of manure		—	92.96
Increase return for manure over commercial nitrogen			47%
Return if applied cost of manure were:		$3.00/ton	82.96
		$4.00/ton	72.96
		$5.00/ton	62.96

Table 3. Yields of Hopicala seed cotton as influenced by manure and nitrogen, 1966.

Manure Treatment	No Nitrogen		75 lbs.N/A		150 lbs. N/A	
	Yield	% of Control	Yield	% of Control	Yield	% of Control
	lbs./A	%	lbs./A	%	lbs./A	%
Control — no manure	1,820	100	2,300	126	2,230	122
Manure; per acre:						
10 T. in 1965, 10 T. in 1966.	3,280	180	3,130	172	3,000	165
10 T. in 1965, none in 1966.	2,615	144	3,045	167	2,815	155
10 T. in 1965, 5 T. in 1966.	2,820	155	2,860	157	3,020	166

planted in the field in 1966 without additional manure or nitrogen.

Another experiment in progress at the Cotton Research Farm compares the effects of rates and frequency of manure applications upon cotton yield and **Verticillium** build-up. In 1965, the first year of this experiment, manure increased yields by one-third, and adding nitrogen with manure did not cause any significant effect. Seed cotton yields for Hopicala, a **Verticillium**-resistant variety, are shown for 1966 in Table 3, (above). Results to date indicate that favorable effects of manure will be evident the second and third years following manure application.

Manures may be shown by future research to be a better source of plant-available phosphorus than commercial phosphate for some desert soils. Response attributed to the nitrogen in manure when applied to desert soils may be at least partly a response to plant-available phosphorus added in the manure, and soil phosphorus made available by increased biological activity. Herron and Erhart (3) found that high quality manure from a commercial feedlot was a satisfactory source of nitrogen for irrigated grain sorghum on a calcareous soil in Kansas. However, they did not attribute any value to the manure's phosphorus content because an application of phosphorus and nitrogen from fertilizers failed to produce yields equal to those from manure and nitrogen.

They did find a substantial increase in available phosphorus in the soil, and in phosphorus content of forage and grain of sorghum grown on manured plots. Chemical analyses showed 31 pounds of nitrogen, 21 pounds of

P_2O_5 and 16 pounds of potassium in each ton of the feedlot manure. They found that over a 3-year period one ton of manure was worth an average of 20 pounds of commercial nitrogen, with one-half of it available the first year. California and Arizona research has shown that good feedlot manure contains about 25 pounds of P_2O , with phosphorus availability at least as good as availability of nitrogen in manure (1).

Good management is essential if the best results are to be obtained from a manure application. Any practice which allows the salts added in manure to accumulate near the surface of the soil is dangerous to germinating seeds or young plants. It is easier to leach out the soluble salts if the manure is applied before plowing.

It is sometimes possible to successfully apply a heavy application of manure — 10 tons or more per acre — to plowed land which is then disked, furrowed out for a row crop, planted dry, and "watered up." However, this must be considered a risky practice if the manure applied is high in soluble salts, particularly if the soil has a moderate to high salt content. Soluble salts from soil, manure, and irrigation water may accumulate at the top of the bed around the seeds and result in a poor stand.

A better practice for a row crop is to pre-irrigate, knock off the top 4 inches of soil, and plant in moist soil. This has been the practice on the clay loam soil of the Cotton Research Farm, where manure has been applied either before or after plowing — with no injury to stands of cotton. But the furrows were well filled during pre-irrigation. This practice leached most of the excess salts well below the seedling root-zone.

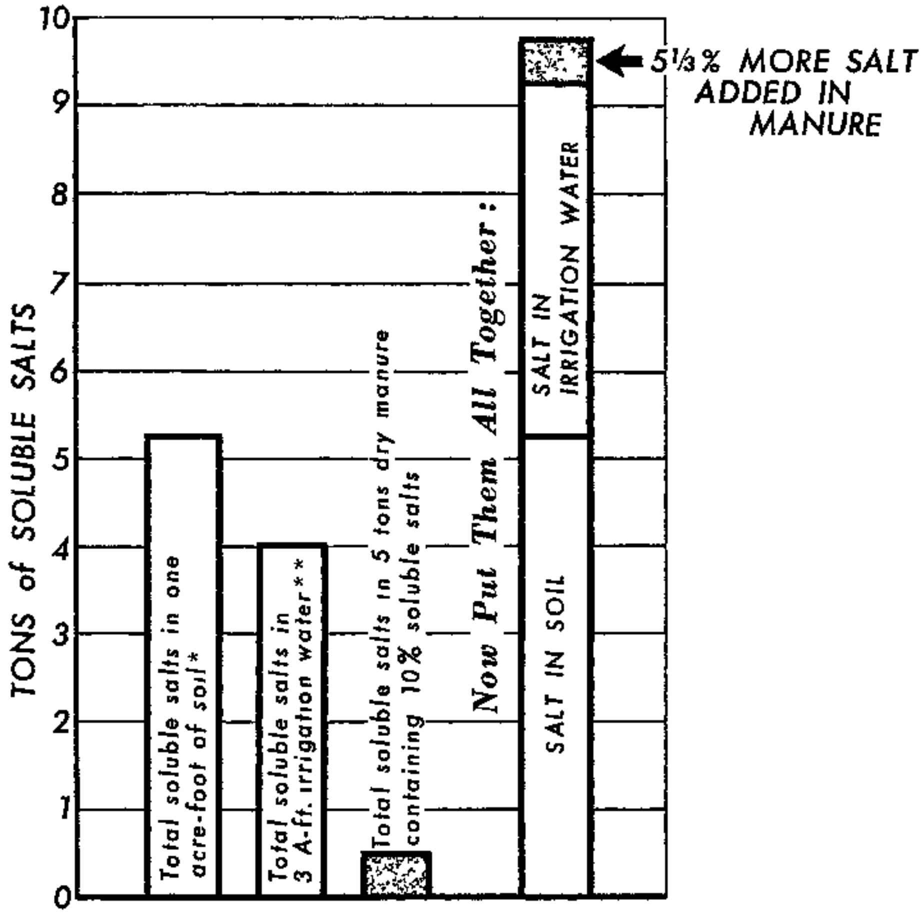
Time and moisture are needed for the action of microorganisms upon the organic matter in the manure. This biological process should be started about a month before planting if possible. Organic compounds in manure contain both nitrogen and phosphorus. These are made available to the crop throughout the season as the organic matter decomposes in the soil. These nutrients are not all leached out by the irrigation water which moves the soluble salts downward.

Because the accumulation of soluble salts in manure is unavoidable, this factor must be taken into consideration. The prospect of increasing the salinity of his soil may make a farmer wary of applying manure. But the experience of homeowners who have killed grass and plants in their yards with manure need not worry the typical farmer applying manure to cropland, because their situations are very different. The homeowner who killed his grass may have applied 30 times as much manure, and less than half as much water as the farmer does in good management of a comparable area of land.

The soluble salts in manure commonly range from 5 to 10 percent on a **dry** basis. But **dry** manure is seldom applied to farmland (see Table 1, page 5). Most of the soluble salts in manure are likely to be those of sodium and potassium, both capable of causing an unfavorable soil structure. In extremely high concentration they are toxic to plants.

Seldom, however, does manure applied at moderate but profitable rates cause any noticeable detrimental effect. This is because the soil and irrigation water used in a crop season on most of our farms already contain considerably more soluble salts than is added in 5 or 10 tons of manure per acre. (See Figure below.)

How Much Salt Does Manure Add?



*A moderately saline soil, $EC_e \times 10^3 = 6$ — below salt tolerance of cotton, sugar beets, small grains, grain sorghum, field corn, castorbeans. (See Bulletin A-43, Water, Soil, and Crop Management Principles for the Control of Salts. 1965. Wallace H. Fuller, University of Arizona. P. 21.)

**An average quality water, containing 1,000 parts per million total soluble salts (2,718 pounds per acre-foot). (See Bulletin A-36, A Survey of the Production and Marketing of Cattle Manure in Arizona. 1964. Thomas H. Stubblefield and Arthur H. Smith, The University of Arizona. P. 6.)

Frequent **heavy** applications of manure might contribute to this bad effect. For this reason — and the unnecessary cost for heavy applications — recommendations for manure are seldom for more than 5 tons per acre annually, or 10 tons per acre applied in alternate years. The regular addition of organic matter in manure will benefit soil structure, needed plant nutrients will be supplied, and commercial fertilizers, when needed, will be more effective.

A field experiment comparing a number of soil amendments including feedlot manure at per-acre rates of 10 and 20 tons was conducted in 1954 and 1955 by the Department of Agricultural Chemistry and Soils. The location was on a saline soil high in replaceable potassium located near Gilbert, Arizona (4). These plots were leveled and bordered, planted flat, and received equal amounts of water.

While the heavy applications of manure did not improve the existing conditions of slow water penetration and salt accumulation, neither did the manure treatments significantly slow the penetration of water into the soil. Chemical analyses of the surface soil showed replaceable sodium and potassium, and total soluble salts were no greater for the manure-treated plots than for the untreated plots. Plant emergence counts and yields of sorghum grown on the manured plots were as good as on the untreated plots. Emergence counts for the barley which followed the sorghum crop were higher on the manured plots, and yields of grain were equal.

Do not apply manure if the following conditions exist in a field:

1. Downward movement of water is slow.
2. A barrier to vertical drainage, such as a hardpan or high water-table, causes excessive soluble salts to accumulate near the surface.
3. Available irrigation water is very salty or in short supply.

If the vertical drainage can be restored by subsoiling, deep plowing, leveling the field, or by other means, the amount of soluble salts added to a saline field by a moderate application of manure will be manageable. Sandy, well-drained soils can benefit more from heavier applications of saltier manure than can fine textured soils. Increased crop yields are possible into the second and third years after a heavy application of manure to a sandy soil.

Aged, or "composted" manure, delivered from a stockpile, differs from manure spread directly from the lot in the following ways:

1. Moisture content is reduced, resulting in higher actual value per ton.
2. Total plant nutrient content is increased.
3. Total soluble salt content is increased.
4. Resulting soil organic matter is increased because the readily decomposed organic

materials (straw and partly digested feed) have been greatly reduced. The organic matter remaining in aged manure is more like the form of organic matter which persists in the soil after microbial decomposition.

5. Viable weed seeds will be fewer because of the effects of heating which occurs in the stockpile during aging.

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This publication is issued by the Cooperative Extension Service and the Agricultural Experiment Station of The University of Arizona. See your local County Extension Agent for additional information.

For further information see Bulletin A-36, "A Survey of the Production and Marketing of Cattle Manure in Arizona." It is available from your local County Extension Office. Or write to Publications Editor, College of Agriculture, The University of Arizona, Tucson, Arizona 85721.

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