Fertilization of Annual Rangeland with Chicken Manure[1]

CYRUS M. McKELL,[2] VICTOR W. BROWN, ROBERT H. ADOLPH, AND CAMERON DUNCAN

Professor of Agronomy, University of California, Riverside, California; Director, and Farm Advisor, University of California Agricultural Extension Service, San Diego County; and Laboratory Technician, Agronomy Department, University of California, Riverside.

Highlight

Changing patterns of land use caused by urban expansion may bring poultry operators into foothill areas and thus provide a cheap source of plant nutrients for rangeland fertilization. Research results with chicken manure applied to annual range indicate that application may be made in any season, with forage responses lasting into the third year after application. Forage quality and palatability are increased but the initial abundance of legumes is decreased by increased rates of chicken manure. Additional first year feed obtained from fertilization can be obtained for a cost of between $1.56 and $2.18 per AUM.

Fertilization of annual rangeland in California has been shown to be both biologically necessary and economically profitable. Various reports have outlined the need for fertilizer elements such as nitrogen, phosphorus and sulfur, the amounts required, season and methods of application, and the plant species which give the best responses. The work of Martin and Berry (1955, 1956) provides a practical guide for rangeland fertilization on a pasture basis.

A large factor in deciding whether commercial fertilizers should be used on rangelands to increase forage production has been the cost of the fertilizer. However, changes in markets, land use, and production levels have made large volumes of animal manures available to many rangeland operators. For example, a considerable portion of the estimated 80,000 tons (about 200,000 yards) of poultry manure produced annually in San Diego County, California was purchased by vegetable crop growers along the coast. Recent subdivision of the vegetable croplands, movement of the poultry industry into the foothills along with expanding urbanization and health department regulations which require frequent pen clean-out but prohibit stockpiling the manure forced the poultry industry to look for new avenues of manure disposal.

Application of poultry manure to rangeland appeared to be an excellent solution to the problem but before range operators could be induced to adopt fertilization as a regular practice they wanted to know the optimum time and rate of manure application, how much forage could be expected from fertilization with manure as contrasted with commercial fertilizer, how long the fertilizer effect would last, how forage quality would be affected, what effect the manure would have on forage legumes, and would fertilization be profitable. Therefore, a series of experimental plots were established to answer such questions.

Methods

An area of approximately 10 acres 2 miles north of Santa Ysabel, San Diego County, California, was fenced to provide an experimental area.[3] The site is on a gentle alluvial slope from the chaparral-covered hills to the east. The soil is classified as a clay loam. Preliminary soil tests indicated a deficiency in nitrogen, a deficiency in phosphorus, and adequate potassium. Annual precipitation is approximately 10 to 20 inches and occurs generally from October to May in a pattern typical of a Mediterranean climate.

Resident forage species include filaree (*Erodium botrys*), ripgut (*Bromus rigidus*), red brome (*Bromus rubens*), soft chess (*Bromus mollis*), annual fescue (*Festuca megalura*), native annual legumes, and broad leaf forbs. Prior to laying out the plots the entire area was drill-seeded with bur clover (*Medicago hispida*), rose clover (*Trifolium hirtum*), soft chess, hardinggrass (*Phalaris tuberosa* var. *stenoptera*), and smilo (*Oryzopsis miliaceae*) at rates of 2, 2, 5, 1, and 1 pounds per acre, respectively.

Seven treatments were replicated four times: (1) no fertilization, (2) 1 ton chicken manure per acre, (3) 2 tons chicken manure per acre, (4) 4 tons chicken manure per acre, (5) 70 lb. N plus 40 lb. P per acre, (6) 140 lb. N plus 80 lb. P per acre, and (7) 280 lb. N plus 160 lb. P per acre. Nitrogen was applied as ammonium nitrate and P was applied as trebble superphosphate in amounts calculated to be approximately equal to their concentration in the volumes of poultry manure used. A plot size of 30 ft × 30 ft allowed sufficient size for subsequent reapplication of fertilizer to one-half of the plot.

To evaluate the seasonal effect of the fertilizer on forage response and on the efficiency of the fertilizer, a new set of the seven treatments was applied fall, winter, and spring for four growing seasons. Winter-fertilized plots were treated each year before late winter temperatures began to increase. The spring-fertilized plots were treated after forage maturity so that the manure would be subject to summer temperatures and not available to plants until the subsequent growing season.

In October 1965 all fall-treated plots were split and refertilized to provide an interval of reapplication of 1, 2, and 3 years.

Forage production was estimated from 3 ft × 27 ft strips harvested from each plot at the full bloom state of rose

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[2] Present address, Head, Department of Range Science, Utah State University.

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Table 1. First-year forage yields in pounds per acre of annual rangelands fertilized with chicken manure vs. comparable rates of inorganic fertilizer.

Fertilizer treatment	Date of fertilization, date harvested: Oct. 1962 May 1963	Mar. 1963 May 1963	June 1963 May 1964	Oct. 1963 May 1964	Jan. 1964 May 1964	June 1964 May 1965	Mean yield in excess of check
Check	650_{a}[1]	700_{e}	2710_{h}	3100_{l}	2450_{q}	3020_{u}	—
Chicken manure							
1 ton	1880_{b}	1240_{ef}	4260_{i}	5030_{m}	3490_{r}	5260_{vw}	1422
2 tons	2690_{bcd}	2260_{g}	5680_{ij}	5610_{mn}	4260_{r}	5710_{vw}	2263
4 tons	2900_{cd}	2690_{g}	7420_{k}	6780_{o}	6580_{st}	7460_{w}	3533
Inorganic							
$N_{70}P_{40}$	2310_{bc}	1560_{f}	3550_{i}	6000_{no}	5190_{rs}	4200_{uv}	1697
$N_{140}P_{80}$	2850_{cd}	2690_{g}	7030_{jk}	7870_{p}	6840_{st}	6270_{vw}	3487
$N_{280}P_{160}$	3550_{d}	2580_{g}	7870_{k}	7610_{p}	8070_{t}	7520_{w}	4095

[1] Values followed by the same letters do not differ significantly (5% level).

clover. *Bromus rigidus* was generally in the soft dough state at this time. A subsample of herbage was collected for moisture determination, separation into species components, and chemical analysis. Each fall soil samples from the top 6 inches were obtained for chemical analysis[4] and samples of the chicken manure remaining on the soil surface were returned to the laboratory for chemical analysis.

After the plots were sampled, cows were turned into the experimental area and allowed free-choice grazing of the dry feed. In 1963 a visual rating of the degree of utilization was made. Animal droppings were removed before the initiation of each new growing season.

Data obtained in the study were statistically analyzed according to a randomized block design. The Duncan Multiple Range Test was applied for mean separation within seasonal blocks.

Results

Fertilization with either chicken manure or inorganic fertilizer significantly increased first-year forage yields at the study site (Table 1). In all but one season of application (March 1963) the average response to 1 ton of chicken manure per acre (or $N_{70}P_{40}$) was significantly greater than the average yield for the check plots. On the average, 1 ton of chicken manure resulted in a first-year forage yield increase of 1420 lb., 2 tons of chicken manure increased yields by 2260 lb., and 4 tons of chicken manure resulted in forage yields of 3530 lb. per acre more than the check plots.

Yield increases resulting from either type of fertilizer were statistically equal at all rates studied with only two exceptions such as with the October 1963 application (Table 1). Even though there appeared to be a slightly higher yield from plots fertilized with inorganic fertilizer than with the chicken manure such differences were not statistically significant.

Variation in forage yield during the 5-year study was large (Fig. 1). Yields as low as 670 lb. of forage per acre were obtained from check plots in 1963 in a year of 18.5 inches precipitation. In 1967 the precipitation was over 21 inches and yields of 3590 lb. of forage per acre were harvested from the check plots. This latter figure is approximately equal to the average yield resulting from fertilization with 1 ton of chicken manure during the 5-year study.

Timing of fertilization throughout the year does not appear to be of critical importance. The additional forage produced over that of the check plots for the first 2 years after fertilization was approximately equal in the fall, winter, or spring. There appears to be a greater advantage for the application of chicken manure in the fall than in the spring and summer. Concern that there would be a loss of ammonia N from fertilizer left lying in the sun during the summer does not appear to be justified. Because of the shorter period available for

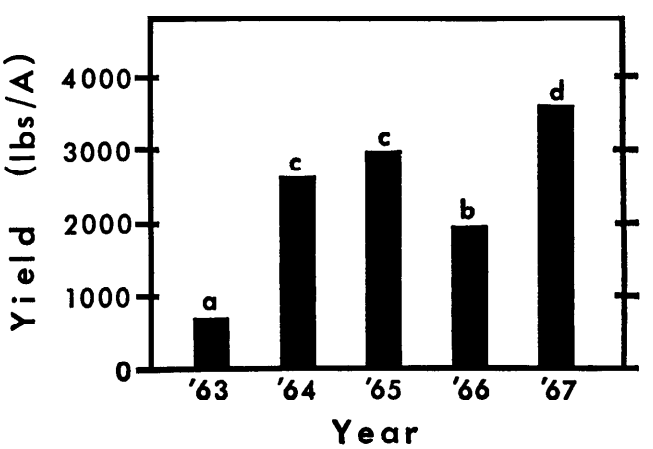

FIG. 1. Average annual variation of annual-range forage production as indicated by yields of check plots during a 5-year period (Santa Ysabel, California). Bars labelled with the same letter are not significantly different at 5%.

[4] Dr. Jack Rible, Extension Soils Technologist, University of California, provided the chemical analyses of the soil samples.

Table 2. Forage yields (lb./acre) for the first, second, and third years after fertilization. Data are averaged over time of season of application.

Treatments	First year[1]	Second year[2]	Third year[3]	Total yield in excess of check
Check	2304	2513	3030	
Chicken manure				
1 ton	3732	2825	3579	2289
2 tons	4462	3000	3649	3264
4 tons	5577	3045	4144	5859
Inorganic				
$N_{70}P_{40}$	3997	2413	2854	1417
$N_{140}P_{80}$	5264	2757	3510	3184
$N_{280}P_{160}$	5636	4308	3848	5940

[1] Each value is an average of 36 plots.
[2] Each value is an average of 28 plots.
[3] Each value is an average of 16 plots.

Table 3. Crude protein and phosphorus content (%) of annual range forage from fertilizer test plots harvested at maturity. (Fertilized fall 1963)*

Treatment	Crude Protein	Phosphorus
Check	6.6	.33
Chicken manure		
1 ton	7.0	.34
2 tons	7.7	.39
4 tons	8.9	.43
Inorganic		
$N_{70}P_{40}$	7.1	.38
$N_{140}P_{80}$	9.7	.45
$N_{280}P_{160}$	12.6	.54

* Figures are the mean of four observations.

the beneficial effect of the fertilizer it appears that winter fertilization with chicken manure is slightly less beneficial than fall application. This does not appear to be the case when inorganic fertilizer is used.

Cumulative forage yields for the first 3 years after fertilizer application indicate a beneficial carry-over effect from fertilization into the third season (Table 2). Yields from applications of chicken manure and inorganic fertilizer appeared to be equal for 3 years regardless of year to year variations. First-year yields were generally higher with the inorganic fertilizer, but the yields from chicken manure application appeared to hold up better in the second and third year and thus the cumulative totals for both types of fertilizer were about equal by the end of the third season. The low rate of chicken manure was more effective than the low rate of inorganic fertilizer during the second and third growing seasons.

On the basis of cumulative yields in excess of forage production from check plots for a 3-year period after fertilization it appears that each 50 lb. of N plus 21 lb. of P stimulated an additional 1000 lb. of forage yield.

Reapplication of fertilizer appears necessary after the third season to continue a high level of forage production. Fourth-year yields from the plots started in fall 1962 were generally no greater than check plots. No visual response to the fertilizer was discernible in the fourth year on plots fertilized early in the experiment.

Forage yields on nonreplicated plots, which received rates of chicken manure as high as 8 and 10 tons per acre, were only slightly higher than yields from the 4-ton rates. Plots were difficult to harvest and were usually later than the check plots to mature. No "burning" of the forage plants was noted although the physical presence of the large amount of chicken manure had a retarding effect on plant growth when applied in the winter or early spring.

Chemical composition of forage was altered by fertilization. Crude protein and P were both increased in the harvested forage (Table 3). Without any fertilizer applied the average protein content was 6.6%. At the highest rate of chicken manure fertilization the crude protein percentage was 8.9% as compared with 12.6% for inorganic fertilizer. The P content of forage was also increased proportionately. With no fertilization the forage contained .33% P, and on plots fertilized at a rate of 4 tons of chicken manure the P content was .43%. Forage from plots receiving the highest rate of commercial fertilizer contained .54% P.

Palatability increase is a commonly observed result of range fertilization, and in this study there appeared to be a relationship between the degree of animal use and the level of fertilization (Fig. 2). When the first year forage was grazed, cows preferred the commercial-fertilized forage over the chicken manure fertilized forage. Fertilized forage at all rates was preferred over the unfertilized forage.

In the years following fertilization there was a large increase in legume percentage all over the experimental area—including the check plots (Table 4). Legume response to fertilization was inversely proportional to the amount of N applied. Of the seeded legumes, Rose clover was the dominant species. Other legumes such as lupine (*Lupinus* spp.) and bur clover also increased in abundance during the years after fertilization. Legumes made up about ⅓ of the forage on the fertilized plots by the end of the fifth year after seeding and fertilization. In contrast, legumes made up almost ½ of the forage on the check plots after 5 years.

Nitrate values in the harvested forage were well below the range of toxicity to livestock. Even when

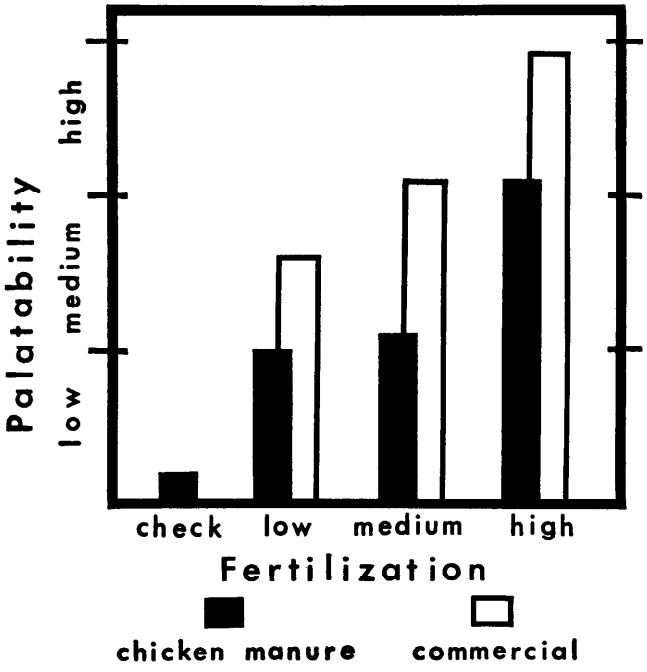

FIG. 2. Palatability of non-fertilized, commercial fertilized, and chicken manure fertilized annual range as determined from the degree of utilization.

plants were fertilized at high rates of chicken manure during the growing season nitrate values were not in the dangerous range. High application rates of inorganic fertilizer produced values as high as .12% NO_3-N but were still within the safe level for nitrate (Kendrick et al., 1955).

The breakdown rate of the chicken manure in the field was relatively slow but sufficient to stimulate plant growth equal in magnitude to the inorganic fertilizer. After 3–4 months in the field the N content of the surface-applied chicken manure decreased about 42% (Table 5). Further N decreases were much slower. Several months after application a considerable amount of chicken manure was still evident on the surface of the plots. Phosphorus changes in the chicken manure were considerably slower than N and appeared to be associated with a physical breakdown of the manure rather than with liberation by leaching.

Table 4. Legume abundance (% by weight) in hand-separated samples from the first block of fertilized plots (1964 to 1967).

Treatments	1964	1965	1966	1967
Check	1	14	19	49
Chicken manure				
1 ton	1	19	23	41
2 tons	1	16	29	31
4 tons	1	17	9	24
Inorganic				
$N_{70}P_{40}$	0	26	40	26
$N_{140}P_{80}$	1	13	31	36
$N_{280}P_{160}$	0	12	31	21

Table 5. Fertilizer value (N,P) of chicken manure when applied in the field and 3 months later.

Date of application	Original fertilizer value (%)		Fertilizer value after 3 months (%)	
	N	P	N	P
November 1962	4.28	2.35	1.84	2.19
March 1963	4.59	2.28	3.31	3.18
June 1963	4.22	3.43	2.62	3.47
October 1963	5.40	2.89	2.88	3.00
Mean	4.62	2.74	2.66	2.96

The level of available P in the soil approximately doubled as a result of fertilizer application (Table 6). At the beginning of the study the P content of the soil of the site was about 5 ppm. One year after fertilization with the 4-ton rate of chicken manure the average P content was 13.1 ppm. Two years later the P level was 13.9 ppm and after 3 years 24.4 ppm. The value after 4 years was 15.1.

Discussion and Conclusions

Fertilization of annual rangelands with chicken manure appears to hold considerable promise as a range improvement practice in areas close to a source of supply. Inasmuch as poultry operators are obligated to frequently clean the manure from under the chicken cages and dispose of it, rather than stockpile it they are often willing to give it away to insure prompt removal. Thus, the cost to the range operator is for loading, hauling, and spreading. Results shown in these studies indicate that minor differences in forage yields from application at different times in the year are not significant. This allows the rangeland operator to spread

Table 6. Phosphorus increases (% P in fertilized plot—% P in check)[1] in soil samples from annual range as a result of fertilization. Plots fertilized October, 1962.

Treatment	Sampling Date				Mean
	Nov. 1963	Nov. 1964	Dec. 1965	Aug. 1966	
Chicken manure					
1 ton	4.4	3.2	5.0	2.3	3.7_a[2]
2 tons	7.1	8.4	8.6	4.6	7.2_{ab}
4 tons	8.1	9.0	14.1	10.0	10.3_b
Inorganic					
$N_{70}P_{40}$	4.6	7.5	4.9	3.7	5.2_a
$N_{140}P_{80}$	10.0	7.2	7.4	5.9	7.6_{ab}
$N_{280}P_{160}$	23.9	20.1	12.0	14.3	17.6_c
[1] Check	5.0	4.9	10.3	5.1	

[2] Values followed by same letters do not differ significantly (5% level).

poultry manure on his fields anytime during the year that weather and field conditions permit.

Weather variability from year to year is large in a mediterranean climate. Forage production varies considerably in response to favorable or unfavorable rainfall and temperature patterns. During the 5 years of this study forage production on check plots averaged from a low of 670 lb. per acre to a high of 3590 lb. per acre. Fertilization is more effective in producing additional forage in years of favorable weather than in years of unfavorable weather. However, the additional feed produced in a low rainfall year may be highly valuable to a rangeland operator because of feed scarcity. McKell et al. (1958) showed a 300% increase in the efficiency of precipitation for forage production on fertilized annual range. Martin and Berry[5] generally recommend rangeland fertilization with nitrogenous fertilizers in areas which receive an average of from 12–30 inches of precipitation.

As is the case with range fertilization in general, fertilization with chicken manure produces forage of a higher quality and palatability. Protein and phosphorus content were significantly higher in forage from fertilized plots. Other benefits of fertilization include a longer period of forage availability. Fertilized range is ready to use earlier in the season and, because of its higher palatability as dry feed, may be used with greater efficiency for grazing in the dry summer months.

The results from this study show that the fertilizer value of chicken manure is equal to equivalent rates of commercial fertilizer. There appears to be a slower release of fertilizer elements from the chicken manure than the inorganic fertilizer but over a 3-year period the net forage response was nearly equal.

Annual forage legumes do not appear to benefit initially from the application of chicken manure. The high rates of nitrogen cause a proportionately greater stimulation of grasses than the legumes. In subsequent years following fertilization when the high levels of N have been utilized by the grasses or lost by leaching the legumes appear to thrive on the increased level of available P and may be expected to make a substantial contribution to forage yield and quality.

In rural San Diego County operators of manure spreader trucks will spread poultry manure on land for $3.10 to $4.35 per ton, depending upon distances from poultry farm to areas using the manure.

A general average of 1600 lb. of extra feed was obtained for each ton of chicken manure. The value of this added feed may be expressed in animal unit months (AUM) or its equivalent (1 AUM = 800 lb. of hay for a 1000 lb. steer). Thus, the 1600 lb. of extra feed is equal to 2 AUM's and has a value of $5.00, using a local average of $2.50 per AUM. (Considerably higher values of an AUM are reported for other annual range areas). A net profit is, therefore, possible based on local prices of $3.10 to $4.35 per ton (2.5 yards per 1 ton) of poultry manure applied on the range.

[5] Proceedings of XI International Grassland Congress, 1970. (In press)

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