

# SOILS AND MANURES.

## ARTIFICIAL FARM-YARD MANURE.

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Artificial Farm-yard Manure experiments have been carried out for a number of years on the Experimental Stations and on Estates with various materials. All experiments were carried out in consultation with the Government Agricultural Chemist by whom all analyses were done. The first set of experiments were conducted at Sidapur in 1922 while the Government Agricultural Chemist carried out similar experiments at Coimbatore. The material used in both cases was paddy straw 1,500 lb. and 6·7 per cent. Calcium Cyanamide as starter. The manures rotted well and a really good stuff resembling Farm-yard Manure was obtained in both cases. The loss of nitrogen at Sidapur was 29·5 per cent. and 13·66 per cent. at Coimbatore.

The method followed at Sidapur was as follows:—

Experiment began:—2nd February, 1922.

1,400 lb. Paddy Straw stacked 10 ft. x 6 ft. x 6 ft.

Straw piled loosely and at every foot 5 watering cans of water sprinkled over the layer; 30 cans of water being used altogether.

When the stack was complete, 10 cans of water were added from the top to thoroughly moisten it and 56 lb. of Calcium Cyanamide were spread on the top in the two applications; and, after each, 10 cans of water were added to wash this into the stack.

Total water added 60 cans = 160 gallons.

Daily watering was carried out as follows:—

7 a. m.	..	3 cans	} 12 cans = 32 gallons.
Noon	..	6 cans	
5 p. m.	..	3 cans	

One pound of dry straw was sent for analysis and represented the materials started with.

Climatic conditions dry and hot with drying winds. Stack in open and full sun.

5th day	...	Fermentations began in the middle of the heap with development of heat. Colour change noticed.
6th	..	Straw black in centre of heap.
9th	..	Stack reduced in height to 4 feet. Very hot.
10th	..	Fumes arising from the centre.
13th	..	Smell of ammonia noticed.
14th	..	Heap fuming.
16th	..	Watering reduced to 16 gallons per day.
17th	..	Colour yellowish black: smell of ammonia strong. Wet in centre.

- 19th ,, ... Height of stack reduced to 3 feet getting compressed.  
Great heat still developed.
- 31st ,, ... Still hot. Stuff in centre rotting and stinking.
- 32nd ,, ... Watering stopped.
- 36th ,, ... Stuff mixed and sampled.

Water added:—

Initial watering	..	160	gallons
Daily watering	..	152	"
Total		<u>312</u>	<u>gallons</u>
Weight of final material	...	3,402	lb. 14 oz.
Weight of sample sent	...	2	lb. 4 oz.

Throughout the sides of the stack were dry, as they dried out soon after watering. Fermentation does not appear to have reached the sides to any extent.

The Government Agricultural Chemist's report is as follows:—

"The sample of analysis was found to contain 78.65 per cent. moisture and 0.335 per cent. nitrogen. As the heap at the time of sampling weighed 3,403 lb. the total amount of nitrogen at the end of the experiment was 11.4 lb.

"The total amount of nitrogen at the beginning of the experiment was:

		lbs.
In straw	..	6.3
In Nitrolim	..	9.9
Total		<u>16.2</u>

"There was therefore a loss during the experiment of 4.78 lb. or 29.5 per cent. of the original nitrogen.

"The straw was not so much rotted as was expected, and different methods will have to be tried. In view of the high temperature in this country it is possible it may be desirable to reduce the amount of soluble nitrogen added. The Farm Manager's note would appear to indicate a too rapid formation of Ammonium Carbonate."

In view of the results of the 1922 experiments, it was decided to carry on some experiments in pits in order to try and slow down the rate of fermentation and avoid such big losses of nitrogen. The results of experiments in 1923 are as follows:—Lemon grass was used and Calcium Cyanamide as starter.

	Percentage loss Nitrogen	Percentage loss dry matter.
Mr. J. J. Murphy's Estate (Yendayar, Mundakayam), with dry weeds and grass and nitrolim as starter. Heap on surface .. .. .	40.07	35.23
Mr. J. R. Vincent's Estate (Kuttikal and N e n n e n e y) Lemon grass from which oil has been distilled, starter nitrolim .. .. .	37.96	60.52 (very high)

<i>Peermade</i> :—Wild lemon grass and nitro-			
lim. Heap on surface	..	54.94	71.23 (abnormal)
Pit .. .. .	..	57.2	50.79
Heap on surface. Wild lemon grass			
and lantana in equal proportions	..	42.0	65.5
<i>Tenmalai</i> :—Lantana and nitrolim			
Heap on surface	.. ..	41.50	26.20

It may be noted that the heap on Yendayar had a thatched roof over it, while on Kuttikal there was no roof. As the rainfall was high (141.5 inches in five months) there was probably a considerable amount of seepage and loss of nitrogen from this source.

In experiments carried out at Coimbatore in the same year the loss of nitrogen from the pits was less in every case than from the heaps, but at Tenmalai it was slightly more. The losses of nitrogen and air-dry material at Peermade and Tenmalai are also larger than was found at Coimbatore; showing that fermentation had gone further.

Coimbatore results are shown below:—

	Per cent.
The losses of nitrogen from surface heaps	26.46
The losses of nitrogen from pits	16.34
The loss of dry matter in the surface heaps	36.46
The loss of dry matter in pits	27.33

In all these experiments the loss of nitrogen was still very high, and it was thought that some of the nitrogen losses might be due to portion of the liquid seeping into the soil and carrying some nitrogen with it. It was also decided to reduce the amount of starter used in order to try and fix the exact amount that could be usefully employed. The amount of starter was therefore reduced from 100 lb. per ton to 50 lb.

In 1924, experiments at Peermade were carried on pit and heap systems. Details of experiments are as follows:—

1. Surface Heap System :	Started on April 7, 1924. Closed on October 3, 1924.
Quantity of air-dry lemon grass taken for experi- ment	... 1,750 pounds.
Nitrolim added	... 39.1 pounds (at 50 lb. per ton of grass).
Water used for experiment at commencement	... 50 rose cans or 137½ gallons.
Dimensions of the stack	10 ft. x 6 ft. x 6 ft. or 360 c. ft.
Total quantity of water used including the 50 gallons used at commencement	... 481½ gallons.
Dimensions when the stuff was unstacked	... 9 ft. 4 in. x 6 ft. x 1 ft. 9 in. or 98 c. ft.
Total quantity of stuff obtained	... 2,664 pounds.

2. Pit System :	...	Started on April 7, 1924. Closed on October 4, 1924.
Quantity of air-dry grass taken to start the experi- ment	...	1,750 lb.
Nitrolim added	...	39 1 pounds.
Water used while starting the experiment	...	50 rose cans or 137½ gallons.
Dimensions of the stack	...	10 ft. x 5½ ft. x 5 ft. or 275 c. ft.
Total quantity of water used until the hot season and the water used at stacking		120 rose cans or 467½ gallons.
Dimensions of the stack when removed	...	10 ft. x 5½ ft. x 3 ft. or 165 c. ft.
Total quantity of stuff obtained	...	3,420 pounds.

Fermentation started on the fifth day of the experiment, and continued till the end of June in the first experiment. During the heavy rains, there was no warmth in either of the stacks. From about the middle of August, the one under the pit system again began to ferment, and the stuff was quite warm even when it was removed while the other one had stopped all decaying. The latter was well rotten throughout except a little on the surface. The stuff was jet black in colour. The stuff under the Surface Heap System had not decayed uniformly and the sides and the top were quite dry.

The big difference in weight in the second experiment (Pit system) is due partly to the soil particles deposited within the pit during the heavy rains—when the shed over it was blown down by the wind and rain.

The pit system manure was decidedly better than the other and looked very like cattle manure.

Analyses and remarks are as follows:—

Analyses:		Pit system	Heap system
		%	%
Moisture	..	73'03	78'39
Loss on ignition	..	13'53	14'68
Insoluble mineral matter		7'81	4'31
Soluble mineral matter		5'63	2'62
	Total	<u>100'00</u>	<u>100'00</u>
Nitrogen	..	0'30	0'22
Phos. Acid ( P O )	2 5 { Total Citrate soluble Water soluble	0'95	0'073
Potash (K <sub>2</sub> O)		0'047	0'034
Lime (C a O)			

**Remarks:**

The insoluble matter (of which the 'Pit' manure contains more) is mostly sand. Eliminating this and the moisture in the two samples, the values

for organic matter and nitrogen calculated on the residual dry matter are :

	Pit.	Heap..
Organic matter ..	70.63	84.87
Nitrogen ..	1.57	1.27

which point to the 'Pit' manure having reached a more advanced stage of decomposition. On the other hand neither appears to have reached the limit of rotting, the Nitrogen value (on dry basis) for well rotted manure should be about 2 per cent. This is also evident from the still fibrous conditions of the samples.

The time for this experiment was just about 6 months.

In 1925, experiments were carried out both at Peermade and Tenmalai. A pukka floor was built for the heap system in order to avoid any loss by seepage.

#### Peermade :

A ton of dry lemon grass was taken for each of the experiments. The grass obtained for the experiment was still young and not old or matured. Though air-dried for some time the grass still contained a considerable amount of moisture when the experiment was started—owing to dew and drizzling rains then experienced. The stuff was loosely spread layer after layer and sprinkled with Nitrolim at 50 pounds per ton and sprinkled with water every layer.

The water used was just the quantity required to allow the nitrolim to form into a solution to soak through every bit of grass. Fifty rose cans of water were used to each heap, when the stacking was finished. The fermentation started on the third evening in both stacks; and at the end of the period the stuff was fairly well decomposed in both, although it was more uniform in the pit.

#### Heap System :

Started May 7, 1925.

Closed October 26, 1925.

Quantity of lemon grass taken for the experiment ...	2,240 pounds.
Nitrolim added ...	50 pounds.
Water used at the commencement ...	50 rose cans or 137½ gallons.
Dimensions of the stack ..	10 ft. x 8 ft. x 6 ft. or 480 c. ft.
Total quantity of water used ...	218 rose cans or 599½ gallons.
Dimensions of the stack when removed ...	10 ft. x 6 ft. x 2 ft. or 120 c. ft.
Total quantity of stuff obtained ...	3,260 pounds.

#### Pit System :

Started on May 7, 1925.

Closed on October 26, 1925.

Quantity of dry lemon grass taken for the experiment ...	2,240 pounds.
Nitrolim added ...	50 pounds.
Water used at the commencement	50 rose cans or 137½ gallons.
Dimensions of the stack ..	10ft. x 8 ft. x 6 ft. or 480 c. ft.
Total quantity of water used ...	183 rose cans or 503½ gallons.
Dimensions of the stack when removed ...	10 ft. x 6 ft. x 1¾ ft. or 105 c. ft.
Total quantity of stuff obtained ...	3,673 pounds.

**Tenmalai :****Artificial Farm-yard Manure on Pukka Floor.**

1. Place ... Tenmalai—Travancore.
2. Date of commencement ... Stacking started on December 9, 1924.  
Stacking finished December 10, 1924.
3. Material used ... Forest grass. The grass has flowered and stalks 10 to 12 feet long—fairly thick were used.
4. Weight of material ... One ton. Partly dry.
5. Analysis of material ... Original moisture—9·0 per cent.  
Total nitrogen—0·4432 per cent.
6. Name of starter ... Nitrolim.
7. Quantity of starter ... 50 lb. (50 lb. per ton.)
8. Quantity of water at different times ... 1001·6 gallons.
9. Approximate cost of manure ... Rs. 16-13-6 or Rs. 17-13-3 for a ton of manure.
10. Experiment finished on ... February 10, 1926.
11. Manure obtained ... 2,116 lb.

**Pit System :**

1. Place ... Tenmalai—Travancore.
2. Date of commencement ... Stacking began December 9, 1924.  
Finished on December 10, 1924.
3. Material used ... Forest grass partly air-dried. The grass had flowered and stalks 10 to 12 feet long and fairly thick
4. Weight of material ... Two tons grass.
5. Analysis of grass ... Original moisture 9·0 per cent.  
Total nitrogen 0·4432 per cent.
6. Name of starter ... Nitrolim.
7. Quantity of starter ... 100 lb. (50 lb. per ton of grass).
8. Quantity of water at different times ... 1,870 gallons.
9. Approximate cost of the manure ... Rs. 31-14-0 or Rs. 16-4-4 a ton of manure.
10. Experiments finished on ... February 10, 1926.
11. Manure obtained ... 4,389 lb.

The Government Agricultural Chemist's analyses and remarks on the finished product are shown below :—

**Peermade**

	A. F. Y. Manure. Heap System	A. F. Y. Manure. Pit System	Lemon grass for A. F. Y. M.
1. Moisture	4·11	5·125	2·09
2. Phosphoric acid (P <sub>2</sub> O <sub>5</sub> )	0·72	0·80	0·195
3. Potash (K <sub>2</sub> O)	0·28	0·19	0·01
4. Nitrogen	1·26	3·30	1·83
5. Per cent. loss of nitrogen	75·99	19·87	—
6. Per cent. loss of dry matter	58·52	47·68	—
7. Original moisture	75·06	71·81	12·3

## Tenmalai

	Artificial F. Y. Manure. Pit System	Artificial F. Y. Manure Pukka Floor System
Moisture	2'86	5'09
Loss on ignition	35'07	50'54
Insoluble mineral matter	44'04	24'25
Soluble mineral matter	18'03	20'12
Total	100 00	100'00
Nitrogen	0'87	1'52
Phosphoric acid (P <sub>2</sub> O <sub>5</sub> )	0'18	0'33
Potash (K <sub>2</sub> O)	0'79	1'42
Original moisture	66'35	70'24
Per cent. loss of nitrogen	61'32	42'97
Per cent. loss of dry matter	62'32	68'84

" The loss of nitrogen in the four experiments conducted in the two places is in agreement with the results obtained in the pot experiments conducted in this Laboratory. Not only almost all the nitrogen added in the form of starter is lost, but in some cases even a portion of the nitrogen of the basic material also disappears. This loss is further accentuated when fermentation is allowed to proceed beyond a certain limit, *i.e.*, when the loss in dry matter exceeds 50 per cent. of the original dry matter, and this loss of nitrogen is not strictly proportional to the loss of dry matter. This fact is observable by comparing Peermade figures, in which loss from heap which has exceeded the limit of fermentation is more than three times the loss from pit which is very near the fermentation limit.

" At Tenmalai both systems have exceeded the limit and hence the loss is considerable."

On scrutinizing last year's results obtained at Peermade and Tenmalai, the following points may be noted:—

The pit system at Peermade has given much the best results with a nitrogen content of 3.3 per cent., a loss of nitrogen of 19.87 per cent., loss of dry matter 47.68 per cent. The amount of water used was 503½ gallons for the whole period of 5 months and 20 days. From 1 ton of air-dry material lemon grass with 50 lb. starter (Nitrolim) the outturn of manure was 3,673 lb., *i.e.*, 1 ton 12½ cwt.

The Heap System gave much poorer results. Nitrogen content is 4.26 per cent. and loss of nitrogen amounted to 75.99 per cent. and loss of dry matter 58.52 per cent.

The total quantity of water used was 599½ gallons nearly 20 per cent. more than was used in the pit system. The outturn of manure was 3,260 lb. or 1 ton 9 cwt. from 1 ton dry material.

Turning to Tenmalai results, it is found that results are much poorer than at Peermade even with a pukka floor in the heap system. The experiment was carried on for nearly 14 months and the amount of water used was

1,000 gallons per ton of material on the pukka floor heap system and 935 gallons per ton in the pit system.

In this case the content of nitrogen in the pukka floor heap system is higher than in the pit system being 1.52 per cent. as against 0.87 per cent. The nitrogen losses amount to 42.97 per cent. and 61.32 per cent. respectively while the loss of dry matter amounts to 68.84 per cent. in the heap system and 62.32 per cent. in the pit system.

The outturn of manure in this case was actually less than was put in as dry material, viz., 2,194 lb. per ton of dry material in the pit system and 2,116 lb. per ton in the heap system. In Peermade experiments the outturn was 1 ton 12½ cwt. in the pit system and 1 ton 9 cwt. in the heap system.

This shows that at Tenmalai, fermentation had proceeded much too far and the losses of organic matter were much too great. The amount of water used was too high and probably caused considerable loss of nitrogen by seeping.

Taking the results as a whole the two main facts which emerge are:—

1. Too much starter should not be used.
2. The rate of fermentation should be controlled.

(1) Even with the reduction in amount of starter (Nitrolim) used from 100 lb. per ton of dry material to 50 lb. per ton large losses of nitrogen still occur. Later experimental work by the Government Agricultural Chemist has gone to show that very little starter especially in the case of green material is required. It is found that as little as 200—300 lb. cattle manure in suspension or 50—100 lb. fine Bone Meal is sufficient starter per ton. With the latter material the phosphate percentage is also considerably increased and there is no fear of the loss of the phosphate so supplied. For green material, the rate may be about  $\frac{1}{4}$  of the above amounts.

As very little nitrogen is added—only sufficient to start the fermentation,—there can be practically no loss of Nitrogen from this source. While the manure thus made may be lower in nitrogen content than one to which larger quantities of starter are added, yet as loss of nitrogen is eliminated and nitrogen is expensive to buy it serves the purpose.

The main thing is to get a bulk manure at reasonable cost. If it is a little lower in actual food materials, Nitrogen, Phosphoric Acid and Potash, these can be augmented *after* the manure has been made and just before application to the soil or the bulk manure or the artificial may be applied separately. Once in the soil there is much less risk of loss than seems to be the case when the nitrogen is added as starter. The content of the manure, therefore, will depend almost wholly on the nitrogen content of the original material.

Jungle grass of which there is a plentiful supply in a number of the Planting Districts should be cut before it seeds. If cut about July and August when crops are short any way and made up in the usual way, application of bulk manure could be made in December—March during the dry weather when crops are again short. It could thus be worked into present estate practice and better use made of the labour force.

(2) The rate of fermentation should be controlled. The pit system on the whole offers better opportunities than the heap system. When the heap

is on the surface there is greater trouble in keeping the sides and top of the heap thoroughly moist as is necessary, and while the centre of the heap may be thoroughly rotted the sides are not. The pit system obviates this as it prevents evaporation to the same degree as in the heap; and so less water is used and a more even fermentation obtained all through the heap. The rate of fermentation is also controlled and lowered so that there is less chance of loss of Nitrogen.

The pit may be dug about 3 feet and the soil from it should be thrown up on the sides and consolidated to form a low wall all round to a height of 3 or 4 feet. The walls need not have perpendicular sides, but may slope from both sides towards the centre, as owing to the shrinkage of the material on rotting, the heap will sink even though it is broader at the top than at the bottom. The heap can be made a foot or two higher than the mud wall to allow for settling down. The wall so made prevents any surface water from entering the pit.

Generally speaking 20—30 cubic yards of air-dry material represent 1 ton; and 7—10 cubic yards of green material, depending on the degree of wetness or dryness. The heap is made layer by layer taking care that all sheaves are broken up and evenly spread. Each layer is watered and the necessary amount of starter added. The amount of water required varies but generally runs about 500 gallons per ton. Most of this water is supplied when the heap is being made and the remainder as and when it is necessary to keep up the moisture content which should be kept between 75—80 per cent.

It should be used when the loss of dry matter has not exceeded 50 per cent. Roughly the individual stalks should be so rotted that while still retaining their shape, the slightest pull will break them and practically no resistance is given, when a forkful of the manure is pulled out of the heap.

The total cost incurred at Tenmalai amounted to Rs. 16-6-0 per ton of dry material and the cost of the finished manure works out at Rs. 17 per ton. On the same basis which is comparatively high, the cost of the finished article at Peermade would amount to Rs. 10 per ton for the pit system and Rs. 11-4-0 per ton for the heap system. With a moisture content of 75 per cent. and a nitrogen content of 1 per cent. on dry matter the manure should contain 0.25 per cent. nitrogen. Valuing the manure on the same basis as Groundnut Poonac containing 7 per cent. nitrogen at Rs. 120 per ton, the unit cost works out at Rs. 17 and on this basis the Artificial Farm-yard Manure is worth Rs. 4-4-0.

If, however, as at Peermade the nitrogen content increases to over 3 times the amount calculated above, the value of the manure increases to Rs. 12-12-0 per ton on nitrogen content alone; and it becomes an economic proposition as the actual cost of production amounted to only Rs. 10.

With this reduction in the amount of starter advocated the manure will cost still less; and could therefore be produced economically.

This method of making Artificial Farm-yard Manure will no doubt appeal to many who have large areas of jungle grass near by and it should prove a useful and easily worked source of the all-important organic matter for soils which are in need of it. Urine would make an excellent starter; and if it were possible to utilize this source of nitrogen large amounts of grass and other organic material could be turned into bulk manure with a high nitrogen content at low cost. For those having cattle the obvious thing to do is to use as much bedding as possible to soak up all the urine, and soak it well with water before putting it into the manure pit.—*The Planters' Chronicle*, Vol. XXI., Nos. 38 and 39.