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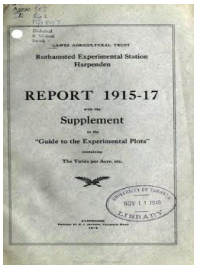
Report 1915-17 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



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Farmyard Manure

Rothamsted Research

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INVESTIGATIONS ON FARMYARD MANURE.

XIV. "*The Changes taking place during the Storage of Farmyard Manure.*" E. J. RUSSELL and E. H. RICHARDS. Journal of Agricultural Science, 1917. **8**, 495-563.

The changes in a manure heap are at a minimum under anaerobic conditions, and they are as follows :—

In the laboratory experiments as much as 17 per cent. of the dry matter may be converted into gas, in the heap the proportion is less.

The non-nitrogenous constituents are particularly affected, one quarter of the pentosans may disappear during the process and other constituents break down in like proportion. The gas evolved contains carbon dioxide, marsh gas and hydrogen.

The nitrogenous compounds also break down, part of the complex compounds giving rise to ammonia. In the laboratory experiments more ammonia is found at 26° C. than at 15° C ; in the only heap where we were satisfied that the conditions were anaerobic there was no accumulation of ammonia.

No nitrates are formed.

There is no loss of nitrogen during the process ; the whole of the initial nitrogen being recovered within the error of the experiment.

The aerobic changes are as follows :—

The loss of dry matter is greater and the temperature rises higher than under anaerobic conditions. The gases evolved contain no hydrogen or marsh gas. The loss of dry matter shows some relationship to the aggregate rise of temperature.

There is almost always a larger decomposition of complex nitrogen compounds than under anærobic conditions. Usually no ammonia accumulates in the laboratory experiments, and in the heap there is invariably a loss. Nitrate is found in the dry outer portion of the heap, but not in the moister interior, nor was it found in the laboratory experiments where the manure remained moist ; the necessary conditions appear to be dryness and sufficient air.

Under conditions of perfect aeration no loss of nitrogen occurs. Under ordinary conditions of incomplete aeration, however, there is an evolution of gaseous nitrogen.

The loss of ammonia shows some relationship to the maximum temperature attained.

Exposed heaps lose more dry matter than sheltered heaps and also more ammonia, if any appreciable quantity is present ; but the loss of total nitrogen is not always greater. Field experiments show that the loss of crop producing power caused by exposure is greater than the analytical figures indicate.

The loss of nitrogen is not a necessary accompaniment of the loss of dry matter, since, as already stated, it does not occur under purely aerobic or purely anaerobic conditions, although other constituents are lost. But the loss of nitrogen that takes place in the mixed aerobic and anaerobic conditions occurring in practice varies under comparable conditions with the loss of dry matter, all constituents of the heap apparently breaking down simultaneously. An exception occurs when the temperature has risen high, *e.g.*, to 70° C., after which decomposition of dry matter and loss of nitrogen proceed more slowly than loss of dry matter, so that there is an actual concentration of nitrogen in the heap.

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Similarly also in exposed heaps the loss of dry matter is usually proportionally greater than that of nitrogen.

The loss of nitrogen might occur by

(*a*) washing away of soluble nitrogen compounds,
(*b*) volatilisation of ammonia,
(*c*) evolution of nitrogen,
(*d*) other ways.

From the sheltered heap (*a*) is excluded.

It is further shown that (*b*) can hardly account for the observed losses in the heap, and certainly not for those in the laboratory experiments, where the extent of volatilisation was measured and found to be only small. An evolution of nitrogen has been demonstrated in the laboratory experiment and presumably a similar change goes on in the heap.

In the laboratory experiments decomposition never proceeded very far, the maximum losses being 17 per cent. of dry matter, 30 per cent. of complex nitrogen compounds, and 33 per cent. of total nitrogen.

In our heap experiments we find this last fraction of complex nitrogen compounds, representing 50 to 60 per cent. of the original total nitrogen, only decomposes very slowly indeed.

XV. "*On Making and Storing Farmyard Manure.* E. J. Russell and E. H. Richards. Journal of the Royal Agricultural Society, 1917. 77, 1-35.

In this paper the above results are applied to the practical problem of storing farmyard manure.

The objects to aim at in a manure heap are to secure

(*a*) as much dry matter,
(*b*) as much ammonia, and
(*c*) as little loss of nitrogen as possible.

The laboratory experiments show that these objects can all be attained by storing the manure heaps under anaerobic conditions (*i.e.*, with complete exclusion of air) at about 26° C. Under these circumstances there is a formation of ammonia and no loss of nitrogen, although some loss of dry matter occurs.

The farm experiments, on the other hand, show that these desirable results are not attained in manure heaps, no matter how well put up. However compact the heap some nitrogen is always lost and there is never an accumulation, but commonly a loss of ammonia.

Apparently the requisite conditions can only be attained in a water-tight pit or tank that could be closed so as to keep out oxygen and keep in the carbon dioxide produced by fermentation. This would be the ideal method for storing farmyard manure. But as this ideal method presents practical difficulties, we must see how nearly the best methods of practice approximate to it, and whether any further improvements can be suggested.

Two cases arise :

1.—Manure left undisturbed under the beasts, *e.g.*, manure made in covered yards or stalls by fatting beasts.

2.—Manure thrown out daily, *e.g.*, manure made from dairy stock or from the horse stables.

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1.—All experiments show that the manure left under the beasts suffers a loss of about 15 per cent. of its nitrogen ; there is no accumulation of ammonia, but, on the contrary, less ammonia than corresponds with the digestible nitrogen in the food. This method is far from being perfect ; but in comparative experiments it has always come out better than any heap, and if the buildings are good and the manure is well made there is probably little scope for improvement.

Further losses set in as soon as the beasts are removed or the manure is hauled out into a clamp ; in particular, there is always a loss of nitrogen.

The losses become more serious if the heap is not properly compacted or if it is left exposed to the weather. Compacting only delays, and does not prevent loss, especially in the heaps stored over summer. Shelter from rain proved distinctly effective in conserving the crop-producing power of the manure.

2.—Manure thrown out daily. From the outset the conditions are aerobic, involving marked losses of dry matter, of ammonia, and to a less extent of total nitrogen, and the losses are aggravated when the heaps are thrown out into the open and exposed to the washing of the rain and the drying of the sun. Improvement can be effected by carrying the manure into a sheltered place, such as the Cheshire dungstead or the Oxford manure house, but even the best dungstead still retains some of the imperfections of the clamp.

We think the best prospect of dealing with manure from dairy cows is to aim straight away at storage in a pit or tank, and experiments to this end are being carried out on the farm of the Hon. Rupert Guinness at Hoebridge, Woking.

The practical conclusions are :—

(*a*) The method of leaving manure under the beasts in boxes or covered yards until it is wanted remains the best that we can suggest where it is practicable.

(*b*) If the manure has to be stored it should be under anærobic conditions (*i.e.*, complete absence of air), and if possible at a temperature of about 26° C.

(*c*) No heap, however well compacted or sheltered, fully satisfies these requirements. Probably the making of the heap has been developed to as perfect a pitch as possible, and we have no further improvements to suggest.

(*d*) The best hope for improvement lies in storing the manure in watertight tanks or pits, so made that air can be completely excluded and the proper temperature maintained.

We are hoping the experience gained in the new Woking experiments will indicate a method whereby this end can be achieved in practice.

XVI. "*The Fixation of Nitrogen in Fæces.*" ERIC HANNAFORD RICHARDS. Journal of Agricultural Science, 1917. 8, 299-311.

During the course of the preceding investigations gains of nitrogen were occasionally recorded instead of losses, and on examination it was found that horse fæces contain material which can be utilised by the free-living nitrogen-fixing organism *Azotobacter* in presence of sufficient moisture and calcium carbonate. The amount of nitrogen that can be fixed depends on the diet, and is much reduced when the horses are fed on grass alone, instead of corn and hay.

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Under the most favourable conditions, four mgms. of nitrogen is fixed per gram of dry matter present in the fæces.

Nitrogen fixation also takes place in bullock fæces, but to a smaller extent than in horse fæces. Here also it depends on the diet, as it occurs only when animals are fed with cake, and not when they receive grass alone.

Evidence is adduced to show that fixation is brought about by a mixed culture of *Azotobacter* and *B. lactis aerogenes*. Of these the latter is normally present in fæces; *Azotobacter* is not, but readily comes in by infection. Both organisms are present in the soil.

XVII. "*Some Experiments on the House Fly in relation to the Farm Manure Heap.*" H. ELTRINGHAM. Journal of Agricultural Science, 1916. 7, 443-457.

The possibilities of the manure heap as a breeding ground for flies were investigated. Heaps were made up and left for a certain period to allow of infection; they were then covered over completely with gauze frames fitted with fly traps, and the flies as they emerged were collected, identified, and counted.

Manure heaps near to dwelling houses form a prolific breeding ground for the ordinary house fly; heaps remote from the house, however, are but little frequented, and then only later in the season when the flies have become numerous and widely dispersed. It is shown that the flies do not live in the heap, but only use it as a convenient breeding place; they travel backwards and forwards to the house for their food. Care should be taken, therefore, to place the manure heap so far from the kitchen that it is no longer possible for them to continue feeding in the kitchen and breeding in the manure heap.

Even when this is done, the heap may still remain a prolific source of the biting fly, *Stromoxys calcitrans*, a blood sucking insect, harmful to man and beast, and of *Musca autumnalis*, which closely resembles the house fly, but swarms in the open and only enter houses in autumn. Where these are sufficiently numerous they are harmful, and the heap should be treated with an insecticide.

PLANT NUTRITION PROBLEMS.

XVIII. "*Studies of the Formation and Translocation of Carbohydrates in Plants.* I.—"*The Carbohydrates of the Mangold Leaf.*" WILLIAM ALFRED DAVIS, ARTHUR JOHN DAISH and GEORGE CONWORTH SAWYER. Journal of Agricultural Science, 1916. 7, 255-326.

Starch is entirely absent from the leaf after the very earliest stages of growth and disappears entirely as soon as the root begins to develop and receive the sugars formed in the leaf. Maltose is entirely absent from the leaf, mid-ribs and stalks at all stages of growth and at all times of night and day.

During the early stages of growth of the mangold, when leaf formation is the principal function, saccharose is present in the leaf tissues in excess of the hexoses. The reverse holds good later in the season, when sugar is being stored in the root; hexoses then largely predominate in the leaf.

In the mid-ribs and stalks the hexoses always predominate and they vary widely in amount during day and night and throughout the

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