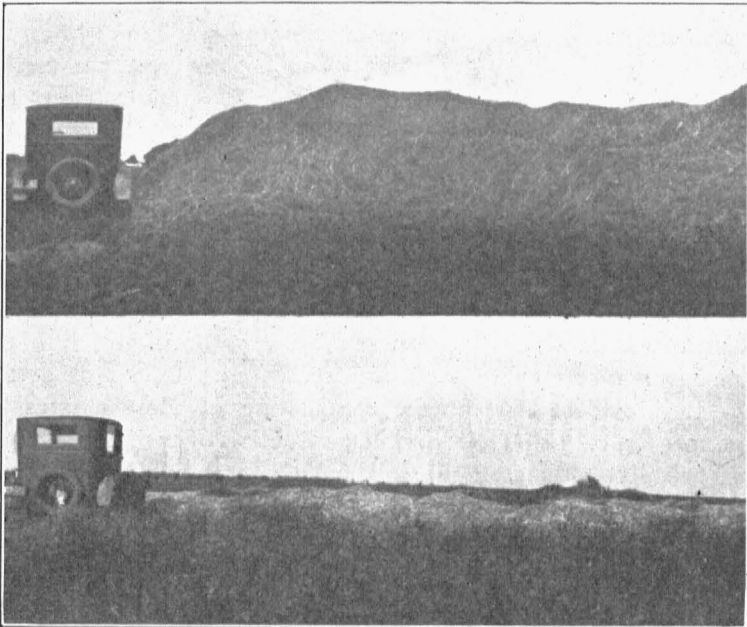


UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
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Artificial Manure Production on the Farm

W. A. ALBRECHT



July conditions (above) of straw treated during threshing to produce artificial manure. Late November condition (below) of the resulting manure when it was ready to be used as top dressing on winter wheat. (Poirot Farms).

COLUMBIA, MISSOURI

Summary

The need for organic matter in most soils should direct attention to artificial manure making from straws, corn stalks, cotton hulls and other organic residues, as a means of putting more of these organic materials back into the land. Such materials can be composted easily through mechanical means by adding a simple chemical reagent of $67\frac{1}{2}$ pounds of ammonium sulphate, 60 pounds of fine limestone, and $22\frac{1}{2}$ pounds of superphosphate per ton of dry matter, while the straw, for example is coming from the thresher. When piled to a height of 6 feet with flat top so as to take the rain, the decay will proceed as the moisture allows. Such composting may also be done by hand, but it is less laborious when the chemicals are applied through the machine, as the thresher, which mixes them more effectively.

Farm trials of the resulting manure warrant wide consideration of this process as a help in getting more organic matter into the soil on farms where there is surplus straw, corn fodder or cotton hulls. It is evident that proper composting of these wastes by simple mechanical helps will permit production of artificial manure which will give effects on the soil and the crop yields similar to those occasioned by farm manure. The artificial manure process deserves attention as a means of producing in larger quantities a product duplicating the farm manure of which the beneficial effects are so well known and whose decreasing supply has been fully appreciated.

Artificial Manure Production on the Farm

W. A. ALBRECHT

The well recognized value of barnyard manure for soil improvement and its decreased supply in this motorized age have aroused much interest in the possibilities of producing artificial manure from straw and waste materials on the farm. The production of manure artificially in England,* by methods savoring of those used long ago in making composts, gave impetus to the idea. Since the combine thresher leaves on the land straw that is often turned under with detrimental effects on the crops following, and since accumulated straw piles of many seasons often occupy valuable land while they rot so slowly as to waste their fertility in wheat farming regions, artificial manure making is a possible means of getting this much needed organic matter and plant food content back into the soil. Experimental studies have helped to learn the requisites of this process, to reduce its laboriousness, and to test the application of it under practical farm conditions.

Principles Involved in the Process

Since rotting of vegetable matter is simply a process in which certain materials serve as food for the unseen bacteria and other microorganisms, artificial manure making may be likened to an attempt to feed the straw, leaves, and other vegetable wastes to these smaller life forms. A proper ration for these must contain: (a) material supplying energy, (b) substances producing growth, (c) essential minerals, and (d) sufficient moisture and air. In addition, proper environmental conditions must prohibit the accumulation of excessive acidity, if these invisible life forms are to multiply rapidly and consume the ration or bring about its decomposition in the shortest time. Straw, leaves, cornstalks, and similar farm wastes consist mainly of cellulose and other carbon carrying compounds which serve for energy. They are deficient, however, in the element nitrogen, which is necessary for the growth of the microorganisms. Lacking sufficient nitrogen, such materials are poor bacterial rations and will decay but slowly without its addition. They do so rapidly, however, when balanced by the addition of nitrogen according to the requirements as determined

*The English method demands that the piles of waste material be built up by layers while a specially patented chemical and water are applied to each. Attention is called to patents Nos. 1471979 and 1619679 dealing with the manufacture of nitrogenous fertilizers and the utilization of nitrogen solutions. The Station can assume no responsibility in connection with any suits for infringement that may be instituted by the owners of these patents.

by various research workers and early suggested by the bacteriologist Omeliansky.

Cellulose and other carbon compounds must be balanced with nitrogen-carrying chemicals to give the proper ration for the microorganisms in a manner similar to that of balancing the rations for livestock by providing the proper amount of protein in purchased concentrates as supplement to the carbohydrate in corn or other grains. Thus nitrogenous chemicals are added to the straw to make it a balanced ration for the best growth and multiplication of the bacteria and to induce the consequent destruction of the straw by their rapid multiplication. Ground limestone is added to prevent the acidity, or the so-called "souring" type of rotting. The chemicals used in treating straw are fertilizer substances carrying nitrogen such as ammonium sulphate, sodium nitrate, calcium cyanamid, urea, and others, mixed with limestone. Since most farm manure should be supplemented with phosphate, this may well be added as superphosphate along with the other substances, though the process works equally well without it. Straw and other farm wastes given these supplementary chemicals and water, provide an excellent bacterial ration and conditions for the rapid decay of straw. It duplicates the manner in which animal urine acts on the bedding to produce farm manure.

Disastrous Effects From Turning Under Straw

The fact that straw is deficient in nitrogen as a bacterial ration is largely responsible for the disastrous effects on crops following closely on straw turned under. The straw in the soil begins its decay by serving as the carbon source for the microorganisms, but because of its nitrogen deficiencies they draw the soluble nitrogen from the soil. The incorporation of this into bacterial products makes it insoluble and thus reduces the soluble nitrogen supply in the soil to such a low level that crops suffer and fail. The composting of straw in the artificial making of manure escapes this danger by supplying the chemical nitrogen to balance the straw for bacterial use before it is mixed with the soil.

Various Wastes May Be Used

Straw, leaves, cotton hulls, and corn stalks, both chopped and unchopped, have been used. Many forms of vegetable matter as weeds, mature sweet clover, spoiled hays, accumulated garden refuse, and numerous other kinds of materials will serve. Almost any vegetable matter, whether green or dry, can be rotted by this process by adding the chemical mixture and water with care to pro-

vide air during decay. There are many forms of farm vegetable matter left to be scattered and their fertility value dissipated, when they might well be collected into piles, treated with chemicals and water, or left for the rainfall, to bring about their decay. By this process much of such wastes will help in restoring soil fertility and maintaining the soil organic matter. Areas as large as the farm may not be necessary, but even the city lot may be big enough for use of the artificial manure method.

Garden wastes as plant tops or pea vines, when the crops mature during the season, the accumulations after the frost kills them, and lawn clippings, or weeds may be built up with the reagent and water additions for manure production. Leaves, especially, should be disposed of in this manner. There seems scarce justification for burning them. If gathered when wet, the main trouble of wetting them in the pile will be overcome. When settled in a pile they compact in such a way as to turn water readily. They must be moistened while in a loose pile, but should be preferably gathered in the moist condition after a rain. If composted then with the reagent, repiled, and remoistened occasionally, they will make an excellent manure for the garden, for the lawn, or for mulching the landscape plantings. The vegetable wastes from even a city lot may do much through the artificial manure method toward providing a suitable home-made fertilizer for the city lot.

Artificial Manure May be Composted by Hand

The material to be used, such as straw, cotton hulls, corn stalks, and others should be built up into a pile, on a level area, by 4- to 6-inch layers with a sprinkling of water on each layer to moisten it, and then a dusting of the mixture of chemical reagents. The next layer is then added similarly and this continued until a pile about 4 feet high is made. The top of the pile should be level, or low in the center, so as to collect rainfall rather than shed it.

The pile so made will soon begin to heat, tending to dry out, and may need attention by the addition of water. Repiling to mix the reagent and refuse and to incorporate air, will likewise speed the decay. Piles may be so located that water may be brought from an eaves trough, or through some other means, to facilitate making this addition to keep the pile moist. The pile may also be built up with the material left in the dry state. Decay will begin at the top of the pile as the rainfall moistens it, and will travel downward as fast as the naturally added water permits. Trenching around the pile to prohibit the leachings from draining

away and to retain them in the base of the pile is advisable. This method is widely applicable where the amounts of vegetable wastes to be used are not large.

Artificial Manure Preparation from Straw During Threshing

As a means of reducing the laboriousness of making artificial manure from straw, the straw may be mixed with the chemical reagents during threshing and blown into a flat pile that will take the rain water and produce artificial manure. A mechanical attachment* fitted to the thresher, as illustrated in Figure 2, can be



Fig. 2.—Threshing machine attachment for artificial manure production as used on the Poirot Farms.

made for about \$5.00 and used to deliver the reagent into the blower or stacker and will thus mix this with the straw as it is blown into the pile. This mixing is done much more effectively than can be done by hand. This attachment as shown in the drawing of Figure 3 consists of a single section of a fertilizer drill fitted with a hopper and driven by a belt from one of the shafts on the thresher. By weighing a few loads of unthreshed grain and then

*This was designed by E. M. Poirot, Golden City, Missouri, whose help in many farm trials of artificial manure is hereby gratefully acknowledged. Blue prints for making one of these attachments may be had from the Agricultural Engineering Department, College of Agriculture, Columbia, Missouri, for the small cost of making and mailing. This attachment is given to and protected for public use by patent through the courtesy of Arthur Capper.

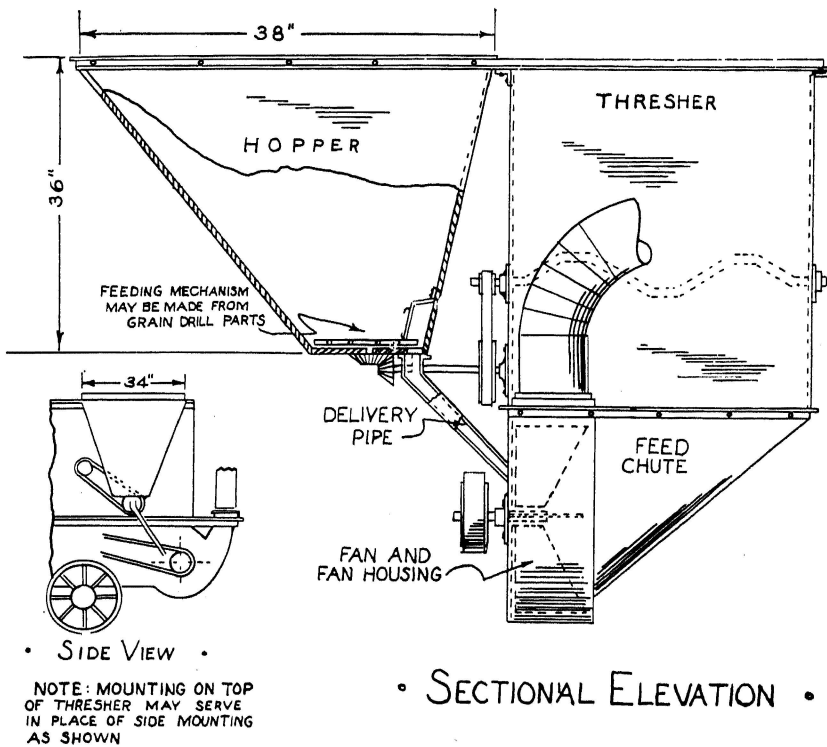


Fig. 3.—Mechanical attachment to threshing machine for treating straw with chemicals in making artificial manure.

noting the grain threshed therefrom—according to machine measure—the weight of straw per bushel of grain may be determined. The flow of the chemical reagent or mixture into the thresher may then be adjusted by the slide opening of the attachment so as to deliver 150 pounds of this reagent for the number of bushels representing a ton of straw.

This straw should be put into a flat pile usually not over 6 feet high, or the depth suited for the average rainfall of the late season in most parts of Missouri. With less rainfall, or greater depths of straw, more time must be allowed for the decomposition which occurs only as the moisture is provided. The straw pile can be made most receptive to rainwater by starting it as a ridge at maximum distances from the machine with the lowered and fully extended blower or stacker in a horizontal position. By starting a ridge of straw at maximum distance and blowing the straw against the top of this ridge so that it rolls down as the pile is

built toward the machine, the straw seems to be arranged in such a manner as to aid the pile in taking water rather than shedding it. This is an important item in the effective reception and use of the rainfall. With ample amounts of rainfall, decay of the straw should proceed rapidly enough to provide artificial manure for top dressing of winter wheat. Straw piles (see cover page) with abundance of rainfall, produced artificial manure in late November from wheat threshed in early July.

Chemical Reagents Recommended

The chemical reagent found to be effective and readily obtained, according to experimental trials, consists of the following:

Ammonium sulphate	45 parts	} per 100 parts of the mixture.
Finely ground limestone	40 parts	
Superphosphate	15 parts	

This mixture should be applied at the rate of 150 pounds per ton of dry straw or other wastes and will thus add

Ammonium sulphate	67½ pounds	} per ton of dry material.
Finely ground limestone ..	60 pounds	
Superphosphate	22½ pounds	

Other Reagent Mixtures May be Used

The reagent mixture may be made of ammonium sulphate and limestone only. These may be applied in amounts per ton of straw varying from the above figures. The use of 50 to 65 pounds of ammonium sulphate, and from 50 to 100 pounds limestone per ton of straw, will serve effectively to produce a good product. However, the lower amounts of ammonium sulphate may reduce the speed of decay. Since straw is low in phosphorus and since this element gives good returns on crops when used as fertilizer, the addition of phosphorus is recommended for regular use. Barnyard manure should regularly be reinforced with superphosphate, hence this fertilizer material should not be omitted from the artificial manure. Experiments suggest that some soluble potassium might be included to produce a better manure, but since straw is relatively rich in potassium, it is omitted from the reagent mixture.

Other nitrogenous materials, such as sodium nitrate, calcium nitrate, urea, or calcium cyanamid may replace the ammonium sulphate. In the case of calcium cyanamid, less limestone will be required. Trials of the different nitrogen carriers showed them to be effective in hastening straw decomposition. Complete fer-

tilizers, high in nitrogen, mixed with the limestone have been used successfully. A wide variation in the kinds of nitrogen carrier in the reagent is permissible. Since these latter reagent mixtures are more costly than ammonium sulphate, and since it has been found to give results equal to, and in most cases superior to, other reagents, the mixture of ammonium sulphate, limestone, and superphosphate is recommended.

The ammonium sulphate and superphosphate can be obtained through fertilizer dealers, and are the materials regularly used as fertilizers. The limestone is none other than the common, finely ground agricultural limestone distributed from many stone quarries. There should be no difficulty in obtaining these materials through the usual commercial channels handling them.

No Danger to Livestock Eating Treated Straw

Of the ingredients in the reagent used, limestone and superphosphate are not harmful to animals, but are even included in mineral feed mixtures. Ammonium sulphate might be injurious to livestock if consumed in large amounts. However, should the animals eat the treated straw, the amounts of ammonium sulphate consumed would be insignificant and there needs be no alarm about the possible danger. Animals tramping over the straw will not disturb the process, and may even help it by compacting it and thus increasing moisture retention. There should be no need in this connection for special fencing around straw piles, cornfodder, or other wastes treated for artificial manure production.

Index of Completion of the Process

When decay begins, the artificial manure pile will heat much in the same manner as does fresh barnyard manure. This heating may be excessive, and can be controlled by repiling or adding water. With shallower, less compact piles depending on natural rainfall, there is little danger that excessively high temperatures will result. When the decay process has run its course, there will be a decided decrease in volume, or collapse, of the pile (see cover page). No more heating will then occur. When this collapse has taken place, samples of the material twisted in the hand will break easily and the usual toughness of wet straw will be missing. The wet, strawy manure will resemble, in all respects, the strawy manure commonly produced in lots by livestock around the straw stack, or in barnyards where straw is liberally used as bedding and tramped down to form manure. The appearance of artificial manure made from straw is similar in almost every way to ordinary farm

manure and handles like it. The final product will not be mistaken by those familiar with strawy manure.

Occasional attention should be given to the pile during its decay, since repiling hastens the process. Addition of water periodically may be helpful. Whether such should be added at reasonable labor cost seems doubtful, except as an eaves trough from a building or similar simple means of watering may be used. Observations should be made on the process during decay to

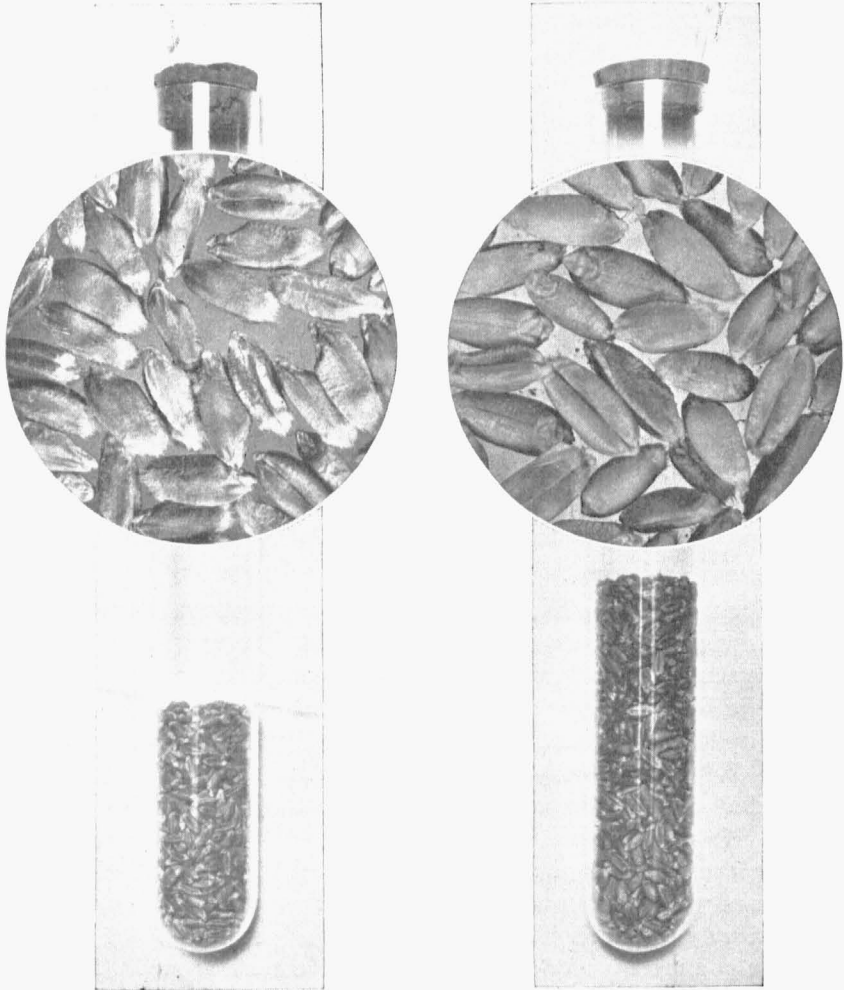


Fig. 4.—Differences in quality and yield in harvests of 40 wheat heads resulting from application of lime and acid phosphate (left) and from the application of lime, acid phosphate, and artificial manure (right) as a winter top dressing.

determine its completion. Premature use and plowing under will mean some temporarily injurious effects similar to those from plowing under straw.

The use made of the manure influences its value. According to the results from Sanborn Experiment Field (Missouri Experi-

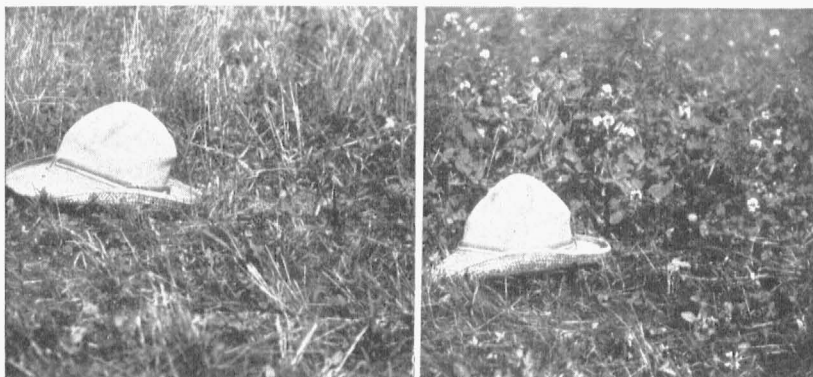


Fig. 5.—Stubble clover with lime and phosphate treatment (left) as compared with clover where this treatment was supplemented with artificial manure (right).

ment Station) lighter applications of manure give it greater value per ton. On wheat as a winter top dressing one ton of barnyard manure has been found to increase the wheat yields $4\frac{1}{2}$ bushels per acre as an average for a three ton application per acre. On timothy sod, the manure application has likewise been most profitable for applications of not over six tons per acre. Ahead of corn, manure also finds a good place. Its production artificially makes it possible to top dress winter wheat or sod in the late winter or early spring with decided improvement in grain quality as shown by farm trials, (Figure 4). In the former case it is especially helpful in establishing clover stands that might otherwise fail because of bad season or deficient fertility (Figure 5). Artificial manure will be more profitable as it is used in the more significant places in the crop rotation.

Economy of the Process

When manure is produced artificially by this method, its cost per ton may be taken at approximately \$0.60, when only the cash outlay is considered. This estimated cost is based on ammonium sulphate at \$45.00 and limestone at \$3.00 per ton, with both used at the rates in the formula of the mixture previously given, and on the general experience of this and other stations as well as of

farmers in producing three tons of manure from a ton of straw. This estimate of the cost of artificial manure includes no charge for the superphosphate that is introduced as a means of balancing it, since barnyard manure also should be similarly supplemented.

When measuring the cost of artificial manure, it is well to remember that such cash outlay results in the increased production of manure on the farm, the need of which is so commonly recognized. If one ton of wheat straw is produced per acre, three tons of artificial manure can be spread back for it. The use of artificial manure returns to the soil larger amounts of organic matter produced on the farm than are returned as barnyard manure. In addition it adds the amounts of nitrogen purchased in the ammonium sulphate. It carries additional phosphate so as to provide a more nearly balanced manure than the ordinary barnyard manure. Since manure can be produced by this process on any part of the farm, it is unnecessary to transport the straw to the barn and the manure back again. The artificial manure can be produced on remote parts of the farm and used there, thus manuring the neglected areas and reducing hauling costs. These and other economies must not be disregarded in estimating the economy of the process. The regular return of these larger amounts of better manure over the farm as a whole should result in an increased production and consequently more economy from the artificial manure production than cost figures might indicate.

The use of the Poirot attachment on the thresher with controlled delivery rate of reagent according to straw threshed or grain given, reduces the labor to a minimum. The costs of this cannot be estimated accurately but these will be less as one becomes more familiar with the process and brings about its better adaptation to farm conditions.