U. S. DEPARTMENT OF AGRICULTURE.

OFFICE OF EXPERIMENT STATIONS.

FARMERS' BULLETIN No. 2.

THE WORK

OF THE

AGRICULTURAL EXPERIMENT STATIONS.

BETTER COWS. FIBRIN IN MILK. BACTERIA IN MILK. SILOS AND SILAGE. ALFALFA. FIELD EXPERIMENTS WITH FERTILIZERS.

THE BULLETINS OF THIS SERIES WILL BE SENT FREE ON APPLICATION.

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LOCATIONS AND DIRECTORS OF THE AGRICULTURAL EXPERIMENT STATIONS.

WASHINGTON, D. C.—*U. S. Department of Agriculture:* Office of Experiment Stations.

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STATISTICS OF THE STATIONS.

Under the act of Congress approved March 2, 1887, which provides for a grant of $15,000 per annum to each State and Territory for the purpose, experiment stations are in operation in all the States except Montana and Washington, and in the Territories of Arizona, New Mexico, and Utah. In each of the States of Connecticut, Massachusetts, New Jersey, and New York, a separate station is maintained entirely or in part by State funds, and in Louisiana a station for sugar experiments is maintained mainly by funds contributed by sugar planters. In several States branch or substations have been established. If branch stations are not counted the total number is 50; including them the number is 66. These stations, with this office, receive, the current fiscal year, $645,000 from the National Treasury, and about $125,000 from State governments and other sources. The agricultural colleges and other institutions with which the stations are connected in many cases supply buildings, ground, apparatus, and materials for experimental work. They employ about 400 specialists and others in the work of investigation. During the calendar year 1889 the stations published 45 annual reports and 237 bulletins. For further statements regarding station publications, see page 16.

THE WORK OF THE AGRICULTURAL EXPERIMENT STATIONS.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
Washington, D. C., May 29, 1890.

SIR: Farmers' Bulletin No. 1, of this office, describes the organization, purpose, and general character of the work of the agricultural experiment stations. Farmers' Bulletin No. 2, herewith transmitted for publication, contains a few illustrations of the results of their experimental inquiries selected in part from the report of this office for 1889.

Respectfully,

W. O. ATWATER,
Director.

Hon. J. M. RUSK,
Secretary of Agriculture.

ILLUSTRATIONS OF THE WORK OF THE STATIONS.

The following brief statements regarding the work of the stations in particular lines may help to an understanding of the nature and value of such experimental inquiries. Of course, only a very few of the points of interest or value, presented by the current work of the stations, are here given, the object being simply to indicate some of the ways in which the stations are endeavoring to aid the farmer.

BETTER COWS FOR THE DAIRY.

The need of better cows for the dairy is coming to be very generally appreciated. The dairy commissioner of Iowa is reported as saying that the average cow in that State gives but 3,000 pounds of milk annually, while good ones yield from 5,000 to 6,000 pounds. The director of the Vermont station states that the average yield per cow in that State is only about 130 pounds of butter per annum, while there are thirty dairies in the State that average over 300 pounds per cow.

The director of the New York station says:

> New York has 1,500,000 milch cows, probably producing on an average less than 3,000 pounds of milk per year, and the annual average butter product per cow for the State is undoubtedly less than 130 pounds. This should not be when there are whole herds averaging 300, and some 400, pounds of butter per year for each cow. Animals producing these by no means phenomenal yields are not confined to any particular breed, and are often grades of our so-called native or no-breed animals. Proper selection, systematic breeding, and judicious feeding have produced these profitable animals and herds.

The difference in the milk-producing qualities of different cows is brought out very clearly by a series of experiments conducted at the Massachusetts State station, of which Prof. C. A. Goessmann is director. They are especially interesting because the cows and their feed and care were such as are found on the better farms of Massachusetts, and the results, obtained with the appliances of a well-equipped experiment station, show in accurate and full detail the elements of actual profit and loss as they could not be found in ordinary farm experience.

These experiments have been made with twelve cows and have continued over five years. Grade Jersey, Ayrshire, Devon, Durham and Dutch, and native cows were used. They were secured for the experiments a few days after calving and fed until the daily yield fell below 5 or 6 quarts, when they were sold to the butcher. The length of the feeding period, *i. e.*, duration of the experiment with each cow, varied from two hundred and sixty-one to five hundred and ninety-nine days. Hay, fodder, corn, corn silage, green crops, roots, and corn meal, wheat bran, and other grain were used. The daily ration per head consisted of 18 to 20 pounds of dry fodder, or its equivalent of green fodder, and from 6½ to 9¾ pounds of grain. Careful accounts have been kept of the history of each cow, including breed, age, number of calves, length of feeding period, amounts and kinds of fodder, yield of milk, chemical composition of feed, milk, and manure, cost of cow and feed, and values of milk and manure.

The following is a recapitulation of the financial record of the cows. The milk was reckoned at the price paid for it at the neighboring creameries. The value of the manure produced is calculated by assuming that of the total amount of food 20 per cent would be sold with the milk, and the remaining 80 per cent saved as manure. As farmers in the region buy commercial fertilizers for the sake of their nitrogen, phosphoric acid, and potash, it was assumed that these same ingredients would be worth about as much, pound for pound, in the manure as in the better class of fertilizers, and accordingly the value of the manure was computed by taking the nitrogen as worth 16½ cents, phosphoric acid 6 cents, and potash 4¼ cents per pound. The return for feed consumed represents what the feeder receives for labor, housing of cattle, interest of capital invested, risk of loss of animal, etc.

The most profitable cow was bought for $60, fed five hundred and eighty-four days, and then sold for $28, making her actual cost $32; the feed cost $135.05, so that the total cash outlay was $167.05; the milk brought $203.37 at the creamery; the manure was estimated to be worth $56.93, making the total value received for feed consumed $260.30. Subtracting the total cash outlay of $167.05 from this, there remains $93.25 as net return for feed consumed. Deducting the estimated value of the manure, the remainder, "return in excess of estimated value of manure," is $36.32. In the average for the twelve cows, the net return was $50.43, and the return in excess of the estimated value of the manure only $15.13. With the least profitable cow the cash outlay for cow and feed exceeded the value of the milk and manure by $3.97; in other words, the net return for feed consumed was $3.97 less than nothing. Subtracting the value of the manure, the total loss was $34.25; that is to say, allowing for the value of the manure, the results with the twelve cows varied from a *gain* of $93 to a *loss* of $3.97. Or, if the value of the manure be left out of account, from a *gain* of $36.32 to a *loss* of $34.25.

It is noticeable that the profit or loss did not depend upon either the breed or the length of the feeding period. The most profitable cow, and the least profitable but one, were both of the same breed. Of the two most profitable cows, one was fed for five hundred and eighty-four days, and the other for only two hundred and seventy-eight days.

Two things, then, are brought out very clearly by these experiments. One is that in such localities as this, the value of the manure goes far to decide the profit in feeding dairy cattle. Another is that cows which would ordinarily pass for good ones may differ widely in product.

To the practical dairyman these experiments teach clearly the difference between cows which are profitable and those which are not, and the importance of selecting the best cows for his dairy and getting rid of the poor ones. In a larger sense they illustrate to every farmer the importance of knowing accurately the condition of his business. Upon this its success or failure largely depends.

FIBRIN IN MILK.

Besides feeding experiments with milch cows, a considerable number of the stations have made investigations on subjects relating to dairying, including analyses of milk, butter, and cheese; the devising of methods for testing milk, especially for butter fat; trials of methods of creaming and butter making, and the investigation of creameries. A brief account of two of these investigations is given below.

Dr. Babcock, of the Wisconsin station, has announced the discovery of fibrin in milk analogous to the fibrin of blood. Fibrin is formed in large quantities in blood after it is drawn from the veins and makes the clot. This consists of a dense network of minute threads or fibers in which the blood corpuscles are entangled. A similar clot occurs in milk, though in far smaller quantities. It may be that its formation is due to a ferment, like the fibrin of blood. The fibrin begins to form in the milk as soon as it is drawn from the cow, and the network of fibers entangles the fat globules and hinders their rising to the surface. Fibrin is therefore an important thing in the dairy, since it tends to hinder the separation of the cream. The creaming of milk is helped by anything which retards or prevents the formation of fibrin, and churning is aided by whatever breaks it up. Investigations indicate that in milk, as ordinarily handled, the coagulation of fibrin begins at the surface and in contact with the sides of the vessel; that it is hastened by contact with any rough surface, by agitation, and by exposure to air, and that it is retarded by heat, by cold, and by certain chemicals. Apparently if milk is stirred but little and set as soon as possible after making in a clean, smooth, metal vessel immersed in cold water, the creaming will take place most efficiently. Bright, smooth tin is excellent for the vessels and ice water for the cooling.

As we shall see beyond, it is probable that the "ripening" of cream is largely effected by the action of bacteria, in breaking up the fibrin which incloses the fat globules of the cream and in making it easier for them to collect into butter when the cream is churned.

BACTERIA IN MILK, CREAM, AND BUTTER.

The following statements have been collated from reports of an investigation on the bacteria of milk, cream, and butter, conducted in behalf of the Storrs station, Connecticut, by H. W. Conn, professor of biology in Wesleyan University.

What are bacteria?—The terms *bacterium* (plural *bacteria*) and *microbe* are used to designate a class of organisms found abundantly in air, water, soil, and in plants and animals. As popularly used the terms include a large number of organisms which the naturalists divide into three classes, bacteria, yeasts, and molds. Bacteria proper, which have most to do with milk and cream, are found in immense numbers everywhere, and play an important part in nature. They are all extremely minute. In shape they show three chief varieties, which may be compared to a lead pencil (*bacillus*), a ball (*coccus*), and a corkscrew (*spirilum*). With the highest powers of the microscope they appear as scarcely more than simple dots and rods. They are to be classed with plants rather than animals, in spite of the fact that many of them are endowed with motion.

What do bacteria do?—Bacteria multiply with the greatest rapidity. A single individual can in a few days give rise to countless millions. While thus growing they produce great changes in the substance in which they grow. Fermentation, such as raising of bread, fermenting of beer and cider, and the formation of vinegar; putrefaction and decay, such as rotting of potatoes and decay of wood, are produced by the bacteria, yeasts, and molds. They are of immense value as well as injury. Through their agency dead animal and vegetable matter is decomposed, and worked over so that plants can use it for food. It is doubtful whether vegetable life could long continue without their aid. On the other hand, many dangerous diseases—cholera, scarlet fever, typhoid fever, consumption, bovine tuberculosis, hog cholera, chicken cholera, etc.—are produced by the growth of micro-organisms in the body. Although bacteria are so very small, there are different species just as distinct as those of larger plants and animals. The disease germs are mostly parasites upon the animal body, and many of them are unable to live elsewhere. The species of bacteria which produce disease are called *pathogenic* bacteria. But there are many other species which live free in the air and do no injury to animals. It is with these non-pathogenic bacteria that we have to do in the dairy.

Bacteria in milk.—Bacteria collect in milk and cream that have been exposed to the air, grow readily, and multiply rapidly. While growing in the milk they cause it to sour and curdle, and induce other changes in it. Milk, as drawn from the healthy cow, is free from bacteria. Under ordinary conditions, however, it can not be kept free from them, for they will get into it from the hands of the milker, or the teats of the cow, or from the air with which the milk comes in contact. The vessels in which the milk is kept are the most common source of contamination. The bacteria collect upon the sides and in the joints of these, and here develop in the minute portions of milk, grease, or other matters from which it is difficult to free the walls of the vessels.

Effects of heat and cold—How to kill bacteria.—Within certain limits heat increases and cold retards their growth. Different species differ in regard to the temperature at which they grow best. Most species find the best conditions for growth at temperatures between 70° and 100° F. A few will grow quite readily at a temperature below 50° F. A temperature below freezing stops their growth. The heat of boiling water will kill the active forms, but several successive boilings are required to kill their spores (corresponding to seeds). It is not difficult to destroy bacteria after they have at once succeeded in getting into the milk. This may be easily done by heating the milk to the boiling temperature for ten minutes upon three successive days. Milk thus deprived of bacteria is said to be sterilized, and if we prevent the further entrance of bacteria by closing the vessel tightly with a plug of cotton, it will remain sweet indefinitely.

Rapidity of growth in milk.—The number of bacteria present in milk depends chiefly upon the length of time that the milk has been standing and upon the temperature. Estimates made upon milk under different conditions have shown from 300,000,000 to 600,000,000 per quart. The effect of temperature is shown by an experiment; a specimen of milk which had been standing for four days in a cold place was found to have about 10,000,000 bacteria per quart. The milk was then allowed to stand in a warm room for seven hours, and during this time the bacteria increased a hundred-fold. From this it appears that the most effective method of preventing milk from souring is to keep it cool. Milkmen sometimes find that the morning's milk in summer sours before the milk of the previous night. It is easy to see why this happens. Milk when drawn from the cow is at a temperature best adapted for bacteria growth. The night's milking is cooled over night. The morning's milk, however, is poured directly into the cans and the bacteria which have entered it are well started upon their growth before the night's milk is warmed by the air. The bacteria in the morning's milk actually get several hours' start, therefore, of those in the cooled milk of the night before. The immediate cooling of milk is thus of great advantage in preventing its souring.

Number of species in milk.—Between forty and fifty species of bacteria have been found in normal milk and cream. This large number is due to the fact that the milk may collect almost any kind of bacteria that may be floating in the air. The individuals of most of the species are few in number and ordinarily are of little significance. A few species are almost universal and extremely abundant.

Different effects of the different species—Souring of milk.—Many of the species cause curdling of the milk. Some of them do this by the production of an acid, and the milk sours. Others curdle the milk apparently by producing a ferment like that in rennet, in which case the curdled milk may not be sour. When a curd is formed it differs in character with the different species. Accompanying the curdling various odors are found, among which may be recognized odors of the cow, the barn-yard, and even the pig-sty. The souring of milk is thus more complex than has been supposed; and while it depends upon the action of bacteria, any of a number of species, or several combined may be the cause.

The ripening of cream.—Though the presence of bacteria is a nuisance to the milkman it is of positive advantage to the butter maker. The ripening of cream undoubtedly depends upon the presence of bacteria, though it is doubtful whether any one species can produce what is known as ripened cream. Ripened cream contains immense numbers of bacteria. Over 100,000 have been found in a single small drop. Dairymen let their cream ripen before churning, because their experience tells them that the butter separates ("comes") more readily, has a better flavor, and perhaps keeps better. A plausible explanation of the first fact is that the bacteria break up the albuminous matter connected with the fat globules, so that these globules are more easily separated from it and more easily shaken together into large lumps. The products of decomposition usually possess a prominent odor and taste and their presence in the cream probably gives the special flavor to butter made from ripened cream. Pure butter fat is tasteless.

Cleanliness in the dairy.—Few people understand what the thorough cleaning of milk vessels means. A great deal of milk is unnecessarily spoiled by lack of sufficient care to remove all material in which bacteria can grow. Vessels in which milk is kept can not be properly cleaned by pouring boiling water into one, allowing it to remain for a few minutes, and then pouring it into another, thus making one heating do for several vessels. The last ones thus treated will not be much cleaner, so far as bacteria are concerned, than if they were washed with cold water. The use of sal-soda in washing is advantageous, because it acts chemically upon fatty matters, and thus helps to remove these and other materials which adhere to the vessels. In like manner the use of "live steam" to "dry" vessels after washing has the advantage of sterilizing them, *i. e.*, killing the bacteria. As ordinarily used, however, the live steam does not completely sterilize the vessels, since its effects are not allowed to continue long enough. Two minutes' action of live steam is not sufficient to kill the spores of the bacteria that may be hidden in the cracks of the milk vessels.

Practical conclusions.—Three important points in the handling of milk and cream are brought out by these considerations.

(1) The importance of keeping milk so far as possible free from bacteria by the exercise of the greatest cleanliness.

(2) The importance of cooling milk immediately after it is drawn from the cow in order to prevent the souring as long as possible.

(3) The advantage of keeping cream under circumstances favorable to the growth of bacteria that induce ripening.

In brief, vessels in which milk is to be kept should be most carefully cleaned before milk is put into them. As cold retards and heat up to a certain limit favors the growth of bacteria, the advantage of keeping milk cold and cream warm is easily explained.

SILOS AND SILAGE.

Silage, or ensilage, as it is often called, is green fodder which has been more or less completely preserved in an air-and-water-tight pit or box, called a silo. A number of the stations have made investigations regarding methods of building and filling silos, varieties of crops best adapted for silage, growing of crops for this purpose, methods of feeding silage to different kinds of animals, and the chemical and other changes which take place in the fodder while in the silo.

Location and construction of the silo.—The Kansas, Ohio, and other stations have given especial attention to these details. They advise that the silo be as near the feeding place as practicable and on the same level. If, as is very often the case, the herd is fed in a long shed or barn, where the animals stand in stanchions in two long rows facing each other, with an alley between them, the best location for the silo is at one end of the building, with the door of the silo opening opposite the common alley. A root cellar already constructed near the feeding place may, in some instances, be economically converted into a silo, or a bank silo may be used, provided it is so arranged that the silage can be withdrawn at the lowest point. Experience seems to show that wood is the best material for silos. Brick or stone is much more expensive, and the results obtained where either has been used have been much less reliable than with wood. Portions of stone walls belonging to cellars or foundations of barns may be utilized, however, by covering them on the inside with wood. The method of construction which on the whole is to be recommended is in general terms as follows:

On a light foundation of stone set up a strong framework of studding (2 by 8 to 12 inch stuff). On the outside of this frame put a layer of stock boards, and on the inside two thicknesses of matched boards, with tarred paper between. The outside may also be battened and painted, though this is not necessary. A tight roof should be added. A dry and hard dirt floor will answer every purpose. The size of the silo should be proportioned to the number of cattle to be fed. It is better to have it too large than too small. A cubic foot of silage (about 40 pounds) per day per animal seems to be a sufficiently accurate calculation on which to base the size of a silo. From 12 to 15 by 13 to 18 feet, and 22 to 24 feet deep are common dimensions for ordinary silos. If built much larger they should be divided by a partition. The silo should be air-tight and strong enough to resist the great lateral pressure which results from compressing tons of material within a deep box. An experiment at the Kansas station with a silo 13 by 18 feet and 21 feet deep showed the lateral pressure to be about 55 pounds per square foot when the filling of the silo was completed. For about two weeks thereafter there was a small daily decrease in this pressure.

Silage has been successfully fed to a great variety of animals under different conditions, and is very generally considered a valuable substitute for dry fodder or roots. It seems specially adapted to cattle, but is also fed with good results to horses, swine, and poultry. "Silage," says Professor Johnson, of the Michigan station, "is excellent food for dairy cows, producing milk of the best quality."

From experiments at the Wisconsin station the conclusion was drawn "that dairy cows readily consume a sufficient quantity of corn silage to maintain a flow of milk and yield of butter fully equal to and rather more than that produced by feeding dry fodder corn." Besides its other advantages an important consideration is that a larger amount of food can be stored in a given space if silage is substituted for dry fodder. The idea that the small farmer can not afford the silo is strongly controverted by Professor Johnson. "The small farmer with limited area of land is necessitated to crop more continuously than his neighbor with a much larger acreage. He needs in every possible way to secure the fertilizing material that shall replace the drains that this closer cropping is making on his fields. How can he do it so cheaply, so surely, as by growing large crops of silage corn that will give him the main fodder necessary to enable him to feed for the market or the dairy through the winter much more stock than his acres will carry in the summer?" In a recent experiment in Kansas, "the actual cost of cutting up the corn, hauling it 50 rods to the silo, and storing it therein was 62 cents per ton. This includes fuel for the engine, but no charge is made for the use of machinery." Professor Shelton, under whose directions the experiment was made, has no doubt that this expense might be greatly reduced.

Corn silage is not a complete ration, but should be fed in connection with some hay or other dry fodder and grain, oil-meal, cotton-seed meal, wheat bran, or other nitrogenous food. This follows from the fact that corn contains an excess of carbohydrates (*i. e.*, substances which serve the body for fuel or are transformed into fat), and should, therefore, be combined with feeds containing more nitrogen to form a well-balanced ration. Silage alone, however, may in some cases produce better results with less expense than are obtained with hay as an exclusive diet.

It is generally agreed that corn is the best crop for silage in this country. Dent varieties are preferred in most cases, though Southern or silage varieties are recommended by some experimenters because of the large yields they give, and in the extreme North certain of the flint varieties may be used to the best advantage. In some localities, as in Kansas and other Southern States, sorghum is a very important crop for silage. The Kansas station recommends medium-growing saccharine and the non-saccharine varieties for silage, and especially Golden Rod, Late Orange, and Goose Neck. The sorghums have some advantages over corn. "They are less liable to damage by insects and they remain green far into the fall, usually until cut by frosts, so that the work of filling the silo may be carried on long after the corn plant has ripened its crop and the stalks have become worthless." Clover, alfalfa, cow-peas, and other forage plants have been successfully used for silage, but corn and sorghum will undoubtedly continue to be the principal crops used for this purpose.

Corn for silage should be planted early enough in the season to secure the proper maturity. The time of planting will vary from May 10 to June 15, according to locality, season, and variety of corn. The seed should be planted in drills 3 to 3½ feet apart. The Ohio station advises about twelve quarts of seed per acre for most cases, though with some of the larger Southern varieties fifteen quarts may be necessary. There is still considerable variety of opinion as to the proper time for harvesting the crop, though the recent investigations seem to favor greater maturity than was formerly thought desirable. Chemical analyses recently made at the New York station indicate "that for the greatest amount of nutriment, considered from a chemical standpoint, corn should not be cut before it has reached the milk stage of the kernel." In Ohio it is recommended by the station that "fodder corn should be cut when the corn begins to glaze and when the stalks begin to dry near the ground." But in Kansas, where intense heat and other climatic peculiarities hasten the ripening of the crop, it is thought that harvesting "should not be delayed after the corn is in the early dough state."

It is now quite generally thought better to put both stalks and ears in the silo than to use the stalks alone for silage. Before being placed in the silo the corn should be cut into small pieces. Some experimenters prefer one-half-inch lengths, as these will pack more evenly and solidly than longer pieces. It is a good practice to keep a man in the silo while it is being filled to see that the silage is packed as closely in the corners and along the sides as elsewhere. If the filling occupies much time, so that the silage becomes heated, some of the heated silage near the sides should be from time to time thrown into the center and replaced with the warmest silage, so as to keep the temperature of the whole mass as even as possible. It seems to make little difference whether the filling is continuous or extended over several days, provided the work is carefully and thoroughly done. There is no agreement among experimenters as to the necessity of weighting the silo. At the Ohio station a wooden cover made of flooring boards well fitted together was placed on the silo. On this was placed about a ton of sand in boxes, and round the edge of the cover next the silo walls a piece of inverted sod to prevent the entrance of air. After the silage had settled about 2 feet, a ton of grass was thrown over the boxes of sand. In Kansas a layer of tarred paper, covered about 18 inches deep with green grass, has been as effectual as weighting heavily with rocks.

Fermentation in the silo.—Recent investigations by Professor Burrill, of the Illinois station, emphasize and help to explain the fact that silage is necessarily a very variable product, requiring careful treatment. The corn or other material used for silage varies in maturity, in chemical composition, and in amount of moisture. Numerous and diverse chemical changes take place in the silo, and the fermentations due to the action of the minute organisms classified as yeasts, bacteria, and molds, are varied and complex. Until very lately people have had very little idea of the influence of bacteria and other ferments in the operations of the farm. On pages 6–9 of this bulletin a brief explanation is given of the nature and work of these organisms. Much remains to be found out concerning their action in the silo, for studies in this line are only just begun.

The kinds of ferments which cause changes in the silo include (1) yeasts, which cause the change of sugar into alcohol and other fermentations; (2) bacteria, which cause the formation of acids and the heating in the silo, and appear to aid in the destructive changes, notably the semi-putrid decomposition, accompanied by bad odors, which so often occurs in old silage; (3) molds, which also cause putrefaction. The yeasts found in the silo do not appear to be such as cause ordinary alcoholic fermentation, and it is doubtful if ordinary alcohol occurs in silage. The hot fermentation which often takes place soon after the silo is filled, though not yet fully explained, is not due to yeast. Two or more species of bacteria appear to be concerned in the raising of the temperature. These bacteria are similar to those which cause butyric fermentation, *i. e.*, the formation of butyric acid, which is found in rancid butter. The high temperature does not destroy the bacteria and molds which later cause acid fermentation and putrefaction. After the heating, however, the silage settles and the air is excluded. The initial high temperature which these bacteria induce is, therefore, probably most serviceable by causing this closer packing of the silage and the exclusion of the air, rather than by killing the germs of other ferments.

Ferments which induce the formation of acetic acid in vinegar and of lactic acid in milk are active in the silo, and if allowed to act produce much acid and make the silage sour. Silage from corn, however treated, contains the acid originally in the stalks. "Sweet silage" is that which has in addition only a small quantity of the acids formed by fermentation. What commonly passes for sweet silage is not always the same thing. It may be obtained either with or without heat. By the process of rapid filling and close packing, especially with the more mature and dry corn, the mass remains sweet, simply because little fermentation of any kind takes place in the silo. If, on the other hand, the silo is filled slowly, the mass soon becomes very hot. This high temperature is due to the action of bacteria. After the heating the silage settles and the air is excluded. In this way fermentation is largely prevented and the silage remains comparatively sweet. Since air and moisture favor the fermentations which injure silage, it follows that mature corn, containing less water than that cut earlier, and close packing in an air-tight silo are needed to produce the best silage.

ALFALFA.

Alfalfa or lucern (*Medicago sativa*) is a perennial forage plant resembling clover in its feeding value, habits of growth, and effects on succeeding crops. Under favorable conditions it will live from eight to fifteen years, and does not run out as clover does. It has long been cultivated in Europe, and is grown quite extensively in California and some of the Western and Southern States. It seems probable that it may be introduced with advantage into many parts of the Southern States east of the Mississippi, and over a wide tract of the more arid regions of the Southwest. It has been grown successfully for the past seven years at the station at Geneva, New York, but in recent experiments on thirty farms in different parts of Vermont it was very largely winter-killed. While a southern climate is more favorable to alfalfa, numerous experiments have shown that it will do well in many localities in the Northern States, and when established will produce from three to five crops each season for a number of successive years. "Alfalfa is especially adapted to dry climates, and withstands drouth much better than ordinary clovers." For this reason it is largely relied on in Colorado and California, especially where irrigation is used.

Soil.—Alfalfa prefers a light, sandy, or loam soil, with a subsoil through which its long roots can penetrate. In some cases its tap-root goes down 12 to 15 or even 20 feet. At the New York station, however, alfalfa has been successfully grown on a clay soil. On such a soil greater pains must be taken to secure a good stand, but when the plant is once established the character of the subsoil is of more importance than that of the surface soil.

Culture.—Use fresh and pure seed. Sow at any time when the ground is in suitable condition, and when there will be time for the plants to become well established before they are subjected either to drought or extreme cold. The soil should be thoroughly prepared, and the seed sown at the rate of 15 to 20 pounds to the acre. If sown broadcast, about the latter quantity will be required; if in drills, the former amount will be sufficient.

In regions where irrigation is necessary the Colorado station advises that the water should be applied to alfalfa before cutting, because thus the mower does its work more effectively and the growth of the succeeding crop is stimulated.

Harvesting.—Alfalfa should be cut during the first period of good weather after the blossoms begin to appear. If allowed to stand too long, its stalk becomes hard and woody and succeeding crops are likely to be diminished. If designed for hay, it must be carefully cured and housed, for otherwise its leaves will drop off and only a mass of bare stalks be left.

As a collector of plant food.—The mineral constituents of plants, such as phosphoric acid, potash, and lime, are derived solely and entirely from the soil. Nitrogen, on the other hand, may be taken into the plant from the air or from the soil. It now seems certain from experiments in Europe and by the Storrs station in Connecticut that alfalfa, clovers, peas, and many other plants belonging to the class called legumes gather a part of their nitrogen from the air. The plants which have this power may be called nitrogen collectors. The legumes contain large quantities of nitrogen in the form of protein. The protein compounds form blood, muscle, tendon, bones, and other nitrogenous tissues; hence the legumes are especially valuable for fodder. Furthermore, nitrogen is the most valuable constituent of manures, and is by far the costliest ingredient of commercial fertilizers. Plants which have the power of gathering nitrogen from the air have, therefore, a twofold advantage for the farmer. As fodder, they supply the protein which corn, corn-stalks, silage, straw, the poorer qualities of hay, and many other food materials lack for making meat and milk and giving animals strength for work. When they are plowed under or fed to stock and the manure returned to the ground they supply the nitrogen which other crops, such as wheat, rye, oats, grasses, root-crops, and potatoes are unable to acquire for themselves.

As a feeding stuff.—During a single season alfalfa furnishes a large amount of nutritious green forage, relished by all kinds of stock. It should be partially wilted or mixed with hay or straw. In the dry regions of the West it is much used for pasture, especially in the fall, but there is more or less danger that it will cause the cattle to bloat or that the plants will be killed by close pasturing. Cattle, sheep, and horses relish alfalfa hay and seem to thrive on it.

Chemical analyses and digestion experiments show that alfalfa compares very favorably with red clover both as green fodder and as hay. It may be used either for fattening or for milk. To secure a well-balanced and economical ration, alfalfa, which contains a large proportion of protein, should be fed with corn, wheat or oat straw, root crops, etc., which contain relatively large amounts of the other food ingredients (carbohydrates and fat). In many instances farmers might profitably raise alfalfa as a substitute for the wheat bran, cotton-seed meal, and other materials which contain large amounts of protein, and which they are now buying in order to utilize the excess of carbohydrates produced in corn and other crops.

Disadvantages of alfalfa.—(1) It is not easily established.

(2) It is less hardy than clover.

(3) If allowed to grow too long its stalks become hard and woody.

(4) Except in dry regions cattle can not be safely pastured on it.

(5) It requires peculiar treatment to make good hay.

Advantages of alfalfa.—(1) When established it does not run out.

(2) It withstands drought much better than clover.

(3) It grows rapidly and may be cut early in the season.

(4) It gathers a large amount of nitrogen from the air as well as from the soil, and is therefore very valuable as a fertilizing crop.

(5) It furnishes several large crops of green fodder each season.

(6) When properly cured it makes an excellent hay.

(7) It is relished and digested by all farm animals and is an excellent flesh and milk producer.

(8) It makes muscle rather than fat, and is therefore valuable to use with corn and other fat-producing crops to make a well-balanced ration for cattle.

In brief, experience at the stations and elsewhere indicates that alfalfa is valuable as a feeding-stuff and as a fertilizing crop, but that it requires peculiar conditions of climate and soil for growth, and careful culture and curing to make it a profitable crop. It is worthy of repeated and systematic experimental tests by farmers, even though in some regions and on some farms it should prove a failure.

FIELD EXPERIMENTS WITH FERTILIZERS—SOIL TESTS BY FARMERS.

Farmers in the older States are spending millions of dollars annually for commercial fertilizers. In this country, as in Europe, they have become an absolute necessity on worn-out soils; but to make them profitable it is necessary that they should fit the wants of the soil and crops for which they are used. If a farmer buys potash for land which abounds in potash but needs phosphoric acid, he of course loses. The fundamental principle in the use of commercial fertilizers is to select those materials which supply in the best forms and at the lowest cost the plant food which the crop needs and the soil fails to furnish.

In order to enable farmers to find out the wants of their own soils and the best ways of supplying them, and at the same time to get light upon the properties of soils in different sections of the country, a number of the stations are introducing soil tests with fertilizers, which are largely conducted both by the stations and also by individual farmers on their own farms. Of course, many of the experiments are failures, but many practical men who have engaged in this work have declared that they have thus learned a great deal which is practically useful and highly instructive. A general plan for such experiments may be found in Circular No. 8 of this office.

The results of these tests in general show that "soils vary greatly in their capabilities of supplying food to crops. Different ingredients are deficient in different soils. The best way to learn what materials are proper in any given case is by observation and experiment. The rational method for determining what ingredients of plant food a soil fails to furnish in abundance, and how these unfurnished materials can be most economically supplied is to put the question to the soil with different fertilizing materials and get the reply in the crops produced. The chief use of fertilizers is to supply plant food. It is good farming to make the most of the natural resources of the soil and of the manures produced on the farm, and to depend upon artificial fertilizers only to furnish what more is needed. It is not good economy to pay high prices for materials which the soil itself may yield, but it is good economy to supply the lacking ones in the cheapest way."

FARMERS AS EXPERIMENTERS.

A most gratifying outcome of these experiments is the demonstration they give of the capacity of our intelligent farmers for experimenting. Not only do many of them work with true scientific spirit, commendable accuracy, and marked success, but the results they obtain are of the greatest value for their communities as well as for themselves. It would be easy to cite a large number of cases in point. In the carrying of science to the farm and combining it advantageously with practice, in the development of talent for experimenting among farmers, and in thus making the experimenters teachers in their communities, are to be found some of the most satisfactory of the many encouraging features of the experiment station movement in the United States.

PUBLICATIONS OF THE STATIONS AND THIS OFFICE.

Each station issues bulletins and annual reports, which are sent free of charge to citizens of its own State and, so far as circumstances will allow, to applicants from other States. The work of the stations is also summarized in publications of this office.

The Office of Experiment Stations issues two classes of publications for general distribution: 1. Farmers' Bulletins, which are brief and popular in character, and are sent on application. 2. Experiment Station Bulletins and the Experiment Station Record, which are more or less technical. It is the practice to send to persons applying for them one or more numbers from which they may judge of their usefulness, but not to place any names upon the mailing list until after receipt of a special application on blanks furnished by the office.

Communications intended for this office should be addressed to the SECRETARY OF AGRICULTURE for the *Office of Experiment Stations, Department of Agriculture, Washington, D. C.*