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Bulletin No. 67. June, 1901.

OREGON AGRICULTURAL EXPERIMENT STATION,

CORVALLIS, OREGON.

THE SILO AND SILAGE.

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The Bulletins of this Station are sent Free to all Residents of Oregon who request them.

Oregon Agricultural College Printing Office.
GEO. B. KEADY, Printer.
1901.

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The Silo and Silage.

The growing tendency among our agriculturists to give more attention to dairying, brings frequent appeals for information relative to the construction of the silo; suitable crops to be grown for silage and methods of handling the same. Hence this bulletin is prepared more with the view of supplying this want of practical information as to the silo and silage, and less with the purpose of submitting at this time technical conclusions from the limited data at hand.

The success of winter dairying rests largely upon the ability of the farmer to secure a cheap succulent food for the herd. This class of feed will be found in silage or roots. The cost of production, however, is always a dominant factor when feeds are considered. From results of experiments thus far made, but a slight difference is indicated in the feeding value of good silage and roots. Silage is the cheaper food of the two, has the advantage of occupying much less space in storing, and is practically insusceptible to injury from freezing. The crops commonly grown for silage are usually removed when the soil is in a condition to best withstand the tramping and packing resulting from the operations of harvesting. The root crop is seldom ready to be gathered before the usual fall rains set in. The soil at this season is often saturated with water, and not infrequently serious injury to the land results from the horses and implements used in harvesting the crop.

The deeply rooted prejudice against the wholesomeness of silage so prevalent in the past has very largely been obliterated, and today it is generally recognized by all intelligent stock feeders as an economical food. The principal objections at present relates to the chemical or biological changes which take place, causing more or less serious loss of nutritive substances, and often resulting in the development of an excessive amount of organic acids. However the nutritive loss of silage in a well constructed silo should not necessarily be greater than the loss incident to the curing process of hay. In fact, when we take into account the almost total loss at times of a clover crop from rain, the silo will easily prove itself to be the more economical and surer method of preserving early cut forage crops.

The silo has passed the experimental stage, for the economy and practicability of this method of preserving fodder have been fully demonstrated. Domestic farm stock, however, cannot subsist upon silage alone, no more than man can hope to live on bread alone, hence a certain proportion of the farm crops should be cured as hay. One peculiar advantage the silo offers to the farmer is the almost absolute independence of weather conditions during the time of harvesting. In humid climates the loss of hay at times is very large, but with the silo this loss can often be reduced to the minimum. Dairymen experience more losses with clover than with any other hay crop. To prevent this it is suggested that the first cutting of clover, whenever practicable, be put into the silo, and the second cutting, or later maturing forage crops, be utilized as hay. While the silo is an indispensable adjunct to successful dairying, its use should not be confined to dairying alone; for it can be made to contribute equally as valuable service to the general farmer and stock grower. Silage is a valuable food, and is relished by all classes of farm stock, but is more particularly adapted for ruminating animals.

The efforts of the Station in this line of investigation during the past year have taken the direction of practical rather than scientific work. The object sought was to determine, if possible, what variations there are in the acidity of clover silage with clover ensiloed at different stages of ripeness; also the effect of water on the preservation of clover silage. For this work four moderate sized stave silos were constructed. Two being nine feet, and two ten feet in diameter. Each silo is twenty-two feet deep. Two by four inch dressed fir lumber was used in the construction of these silos. In the nine foot silos the two by fours were used with square edges. The staves of one of the larger silos were beveled so that they would fit snugly both at the inner and outer surfaces. The remaining silo was constructed with tongued and grooved staves. The two smaller ones and the one constructed with tongued and grooved lumber proved satisfactory, with results in favor of the latter. The one built with beveled staves was very unsatisfactory, as much of the silage in contact with the walls was spoiled, which was manifestly due to the admission of air. This was largely attributable to faulty workmanship in making the bevel.

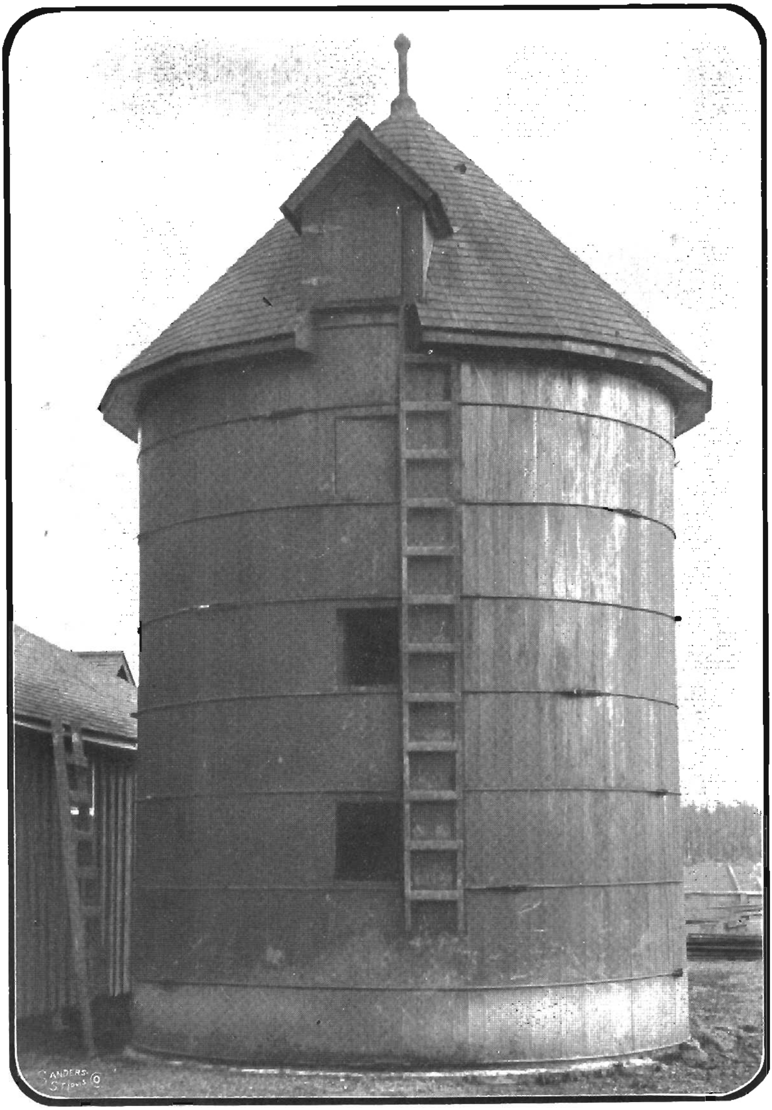

PLATE I.

THE LOCATION OF THE SILO.

The proper location of the silo for convenience in feeding should be given careful thought. While ensilage is not bulky it is exceedingly heavy, containing, approximately, eighty per cent of water. Hence, if it is to be conveyed any distance by manual labor, it means an unnecessary as well as an expensive expenditure of human energy. The silo may be constructed within the barn or on the outside, but wherever it is placed it should be convenient both for filling and for feeding. When the silo is constructed within the dairy barn, a good plan is to place a partition between the silo and the cows. This, in a measure, prevents the building from becoming permeated with the odor of silage, which has been thought in some instances to be responsible for objectionable flavors of the milk. This difficulty is entirely eliminated when the silo is located outside of the barn. A good arrangement is to have the silo constructed a few feet from the barn. The space between the silo and the barn may be enclosed, with a door leading into the barn. This door can be made sufficiently wide to permit a feed truck being placed immediately beneath a chute arranged for direct delivery of the silage. Thus the labor of feeding silage is greatly lessened. In removing silage from a silo located within the barn, care should be taken that none of it be permitted to remain on the floor after feeding. It is quite likely that this portion of the silage, even if it be a small amount, will give rise to more of the objectionable odor than the silo itself produces.

FORM OF SILO.

The consensus of opinion of those who have studied the silo problem, indicate that the circular form is preferable. There are, however, many square and rectangular silos in successful operation; especially is this the case with those having rounded corners. For the average dairyman and farmer in this state, the stave circular silo will prove entirely satisfactory. Where great strength and large capacity are demanded, the frame circular silo will best meet the requirements. This form of silo can be made quite durable by plastering the inside with cement. The pit silo in some localities can be used to advantage, and its merits are worth the consideration of agriculturists located in semi-arid districts where lumber and other material are usually expensive. These excavations, when practicable, should be made in sloping ground, with a trench dug for an approach, as well as serving the purpose of an opening for a continuous door. The walls of these pits could perhaps be cemented so as to keep them intact. When constructed after this method such silos should prove to be very durable. The circular stave silo, owing to its simplicity and economical construction, seems to fully meet the requirements of the farmer. With this form of silo properly erected, the waste of silage is reduced to the minimum. There are no corners, or bulging of walls to permit air to enter deeply into the silage.

MATERIAL FOR THE SILO.

Silos may be constructed from stone, brick, or wood; but owing to the abundance of excellent material, so easily procurable, and the entire satisfaction following, thus far, the use of the properly constructed stave silo, we recommend the wooden silo for general use at present. The staves are best made from common fir lumber, free from knots. These can easily be obtained up to twenty-five or even thirty feet in length. These staves can be used either rough or planed. They may be put into the silo with a square edge, so that the edges of the staves on the inner side of the silo will be pressed very tightly together, leaving a slight opening on the outer surface of the silo between each stave; or they can be beveled so that they will fit snugly both on the outer and inner surface of the silo. This, however, must be carefully done to obviate open spaces between the staves. While the planed, tongued and grooved stave increases the first cost of the silo, it is believed to be the cheapest and best in the end. There is practically no danger of collapse with these silos when empty and the walls can be made perfectly air-tight, thus ensuring a more perfect preservation of the silage.

For the construction of silos twelve feet or less in diameter, staves four inches wide would be most desirable; but for silos over twelve feet in diameter, staves six inches wide would be better. The larger silos will require a stave two inches in thickness, while those one and one-half inch thick will suffice for small silos.

FOUNDATION FOR THE SILO.

The foundation for the circular stave silo only, will be considered at this time. These silos are sometimes simply placed on the ground after the surface has been leveled. This, however, is not a satisfactory plan, as rodents not infrequently burrow underneath the walls and up into the silage, often resulting in much spoiled material.

The foundation may consist of lumber, which will probably prove as durable as the bottom portion of the staves of the silo. When lumber is used for the foundation, the ground should first be made level and well hammered down. Then lay two-inch plank, placed as close together as possible, and cover this with one-inch plank so as to break joints. A good foundation can be prepared with small rock or gravel. An excavation is first made from four to six inches deep, slightly larger than the contemplated silo. This is filled with the rock, which is to be well hammered down, and the whole can be covered with a thin layer of well puddled clay. The best, and erhaps the most economical foundation in the end, is that of concrete. Instead of using the clay after the rock or gravel has been firmly packed, the interspaces are filled with a thin mortar, consisting of one part of cement to four or five parts of sand. This should be well worked in so as to fill up all spaces between the rock or gravel and leave a level surface. After this sets, the whole should be surfaced with a thin mortar consisting of one part of cement to two or three parts of sand, over which a little dry cement can be worked in with a trowel. so as to give it a hard finish.

To facilitate the placing of the staves, a circle can be described by first driving a spike in the center of the foundation, before the cement becomes thoroughly set. To this attach a string one-half the length of the diameter of the proposed silo, and to the loose end fasten a file or some pointed instrument with which to strike the circle. A similar circle can also be described on a wooden foundation.

The material required for a concrete foundation of a stave silo twelve feet in diameter will be approximately one yard and two thirds of rock or gravel, four barrels of sand and one of good cement.

For large deep silos, where the weight of silage will be considerable, the excavation for the foundation should be somewhat deeper and the bottom covered with good sized flat surfaced rocks. Whatever class of foundation is adopted, care must be exercised to have it level and free from hydrostatic water.

SIZE OF SILO.

Perhaps more serious losses have resulted through lack of proportion between the size of the silo and the amount of silage fed daily, than from any other cause. The mistake is very generally made in having the exposed surface too large. An excellent rule is to so construct the silo that the horizontal feeding area for each cow will not exceed five, or the extreme limit of six square feet. When the silo is opened for feeding, a thin layer over the whole surface of the silo should be fed each day, so as to obviate the spoiling of any silage from too long exposure to the air. The approximate average weight of a cubic foot of silage is forty pounds, thus, five cubic feet will contain about two hundred pounds of silage. A cow will consume daily about thirty-five to forty pounds of silage, hence it requires a layer of about two inches thick, extending over five square feet, to supply the requisite amount. When the exposed surface of the silo exceeds five or six square feet per cow fed, the silage is removed too slowly, hence active decomposition ensues, which injuriously influences the quality of the feed.

It is doubtful if a silo less than six feet in diameter will be found practical, as the friction from the walls will be so great in proportion to the weight of the silage, that the contents will not settle properly.

The following table is offered as a guide in determining the proper diameter of a silo for a given number of cows:

Diameter of Silo. Feet.	Number of Cows.	Diameter of Silo. Feet.	Number of Cows.
6	5	14	25 to 30
7	6 to 7	15	29 to 35
8	8 to 10	16	33 to 40
9	10 to 12	17	37 to 45
10	13 to 15	18	40 to 50
11	15 to 18	19	47 to 56
12	17 to 22	20	52 to 62
13	21 to 26		

The depth of the silo is an important factor in its construction. Deep silos are preferable to shallow ones. The pressure from the silage in a deep silo will be greater than that in a shallow one, hence a deep silo will contain a greater weight of silage and less entangled air in proportion to the volume of silage than a shallow one. The diameter remaining the same, a silo 36 feet deep will store nearly five times the amount of feed that one 12 feet deep will. The silo should be at least 20 feet deep, while a depth of 30 feet would be better.

Since the capacity of the cylindrical silo is not as easily computed as that of the square or rectangular form, the following table is given, showing the approximate capacity of a circular silo for ordinary corn or clover silage:

PLATE II.

APPROXIMATE CAPACITY OF CIRCULAR SILO, IN TONS.

Depth of Silo. Feet.	Inside Diameter of Silo in Feet.*												
	10	12	14	15	16	18	20	21	22	23	24	25	26
20	26	38	51	59	67	85	105	115	127	138	151	163	177
21	28	40	55	63	72	91	112	123	135	148	161	175	189
22	30	43	59	67	77	97	120	132	145	158	172	187	202
23	32	46	62	72	82	103	128	141	154	169	184	199	216
24	34	49	66	76	87	110	135	149	164	179	195	212	229
25	36	52	70	81	90	116	143	158	173	190	206	224	242
26	38	55	74	85	97	123	152	168	184	201	219	237	257
27	40	58	78	90	103	130	160	177	194	212	231	251	271
28	42	61	83	95	108	137	169	186	204	223	243	264	285
29	45	64	88	100	114	144	178	196	215	235	256	278	300
30	47	68	93	105	119	151	187	206	226	247	269	292	315
31	49	70	96	110	125	158	195	215	236	258	282	305	330
32	51	73	101	115	131	166	205	226	248	271	295	320	346

* Professor Woll's Book on Silage, page 39.

In estimating the quantity of silage required for the feeding of a given number of cows for a certain period, a deduction should be made of about ten per cent from the amount of original fodder put into the silo. This unavoidable loss is due to an apparently uncontrollable fermentation of the silage. Hence a cow fed forty pounds of silage per day, for 180 days, will consume 7,200 pounds of silage, or about four tons of the original fodder. In making calculations as to the length of time a silo will supply feed on the basis of two inches being fed daily, about one-sixth should be deducted from the total height of the silo, as after two or three fillings the silage, when settled, will probably not occupy more than five-sixths of the silo.

A good crop of corn, clover, or vetch will furnish about ten tons of green fodder per acre. Hence one acre at this rate will give nine tons of silage, or sufficient to supply 450 rations for one cow. This estimated yield can be taken as a basis for calculating the area of land required to fill a silo of given capacity. For example, to fill a silo holding 100 tons of silage, the crop of 11 acres of land will be required. Much larger crops than this can be grown on land well cultivated and properly fertilized.

CONSTRUCTION OF SILO.

There are various modes employed in putting up the silo. If the silo is to be constructed within a building, the operation will be comparatively easy. In constructing a silo on the outside of the barn, as shown in Plate I, after the foundation is properly laid, it is best to erect a scaffold. This can be done by first setting up four 6 x 6 posts at the corners of a square sufficiently large to encompass the silo. To these nail securely 1 x 6 planks, horizontally, one near the bottom, one halfway up, and a third near the top on each side of the square. To these planks, at each angle of the square, nail 1 x 6 pieces so that the inner edge will just touch the staves when set up. Then place in position one stave and tack it to the 1 x 6 at the angle of the square. Care should be exercised to have the first stave perpendicular to the point where it rests upon the circle previously drawn on the foundation. As each stave is placed in position, it should be toenailed at the top. When a few staves have been placed, boards can be nailed across the top. They will serve both as a platform and as a support to the staves. To maintain an uniform circular outline during the time the staves are being put in position, an ordinary templet may be used. Prof. Clinton of Cornell University recommends old barrel staves for this purpose. For the small silo the stave of the sugar barrel is best adapted, and for the larger ones the stave of the cement barrel may be employed. These are tacked on horizontally with shingle nails, near the bottom and half way up on the inner side of the silo. The templet is easily made and will prove equally as satisfactory as the barrel staves. Drive a nail into the floor, to which attach a string one-half the length of the diameter of the proposed silo with a pencil or pointed instrument fastened to the loose end. Then lay a one by six inch plank on the floor in such a position that in describing a circle the plank will occupy the largest possible space. Start the saw upon the mark made and this will furnish a pattern for the rest. A sufficient number of these should be sawn out to reach around the silo. When a few staves are in position, tack a section of the templet horizontally at the bottom. This should be repeated as often as necessary until the silo is completed. After the staves are all in place the hoops should be put on; then remove the templet. When slightly beveled, tongued and grooved staves are used, no templet will be required. Simply place the staves on the circle and toenail at the top. Nothing should be permitted to project on the inner side of the silo, as it would interfere with the proper settling of the silage. The cleats for the doors are to be placed on the outer side, and the silo when completed ought to have a perfectly smooth surface on the interior.

HOOPS FOR THE SILO.

These can be made of any suitable material, such as half-inch, seven-sixteenth inch, or five-eighths inch round iron; one-eighth inch flat iron, two inches wide, or wire. The size of the hoops being governed by the capacity of the silo. For a silo twelve feet or less in diameter, seven-sixteenths inch round iron will be sufficient. The round hoops are more generally used and give good satisfaction. These can be put on in sections and held in position by means of lugs, or may be fastened in studding as shown in Plate II. The woven wire fence hoop is often used, since it is regarded as being very economical. It can be adjusted by wrapping the wire around and fastening it to two 4 x 4 pieces of wood, the latter to be drawn together by five-eighths inch bolts. The bolts to be placed near the ends of the four by fours and furnished with a long cut thread, so as to permit of being tightened. The wire to be cut so as to allow the four by four pieces to come within ten inches or a foot of each other. A couple of flat pieces of iron, curved to fit the outer surface of the silo, such as a piece of an old wagon tire, may be placed underneath the four by fours, so as to preserve the symmetry of the silo.

It is estimated that the pressure from silage when settling, at the time of filling, increases with the depth at the rate of 11 pounds per square foot for each 12 inches of depth. At a depth of 10 feet the lateral pressure is 110 pounds per square foot, at 20 feet it is 220 pounds, and at 30 feet 330 pounds.* Hence it will be seen at a glance that the hoops should be larger and stronger at the bottom of the silo than at the top, or their strength be augmented by placing them closer together. The first hoop may be placed six inches from the bottom, the next a foot above this, and increase the space six inches between each hoop untill the distance between them reaches four feet, which should be maintained to the top of the silo. A lighter hoop may be used towards the top, as the pressure from the silage there is comparatively small. In using the wire fencing, sufficient space between bands should be allowed for doors.

DOORS FOR THE SILO.

These may be simply sawed out, as shown in Plate I, or made continuous from the bottom to the top of the silo. The latter form

* King. Physics of Agriculture.

will slightly increase the cost of the silo, but is thought to possess sufficient advantages over the former to more than justify the additional expense. The sawed out doors may be ranged one above the other, with a stationary ladder placed alongside, running to the top of the silo, as shown in Plate I. A convenient size for the door is two feet wide and about two and one-half feet high. The lower door may be cut out between the third and fourth hoops, and the others in every other alternate space save the one at the top. The doors should be planned before setting up the silo, and when the joint is reached where the doors are required, the saw should be started at the top and bottom of each space alloted to a door, and run at an angle of 45 degrees to the inner surface of the stave. Hence the bevel is cut so that the opening will be larger on the inside of the silo. If tongued and grooved material is used, the tongue should be cut off where the edges of the door will come before the stave is fitted to its place. When the staves are all up in position, two cleats of two by three inch material, which have been prepared to fit the outer surface of the silo, should be nailed or bolted firmly to the doors before they are cut out. When plain edged staves are used, the short staves between the doors should be held in place by driving staples over the hoops. In filling the silo these doors are to be placed back just as they were sawed out, with a strip of tarred paper inserted at the top and bottom.

There are many patterns of the continuous door in use. The space for the door is usually about twenty inches wide, and the frame is made by bolting two strong pieces of timber firmly together. The door of the silo represented in Plate II is made by bolting two 4x6 pieces together with five-eighths inch bolts passing through short pieces of gas pipe between the frame to keep it apart. This frame is set up plumb, and braced, the inner side being placed on the edge of the circle. The first stave next to the frame is beveled, so as to make a close fit. When a sufficient number of staves are placed in position to complete about one-third of the silo, another 4x6 is erected, into which a double set of holes have been bored to receive the sections of hoops. The staves coming in contact on either side of this piece are beveled, so as to make a tight joint. On the completion of the second third, a similar 4x6 piece is let in, and when the staves are all in position, there are four of these 4x6 timbers, including the door frame. The edges of the door and frame are beveled to make a snug fit. The doors are made in sections about two and one-half feet long of the same material as the staves, and, as the silo is filled, they are placed one on top of the other with strips of tar paper around their edges. The door frame bolts are placed thirty inches apart and serve the purpose of a ladder. By using wider timbers for the door frame and placing a piece of canvass next to the bolts, a very convenient chute is formed to convey the silage into a truck or other receptacle. Another good door frame is constructed by bolting two 3x6 pieces together edgewise, about 20 inches apart with five-eighths inch bolts. If flat hoops are used, before the frame is set in place, grooves are cut to permit the hoops to pass between the frame and first stave. Two holes are to be made in the end of the hoop so that it can be fastened with nails or screws when looped around the door frame. The first stave on each side of the door is nailed or bolted solidly to the frame, about one inch from the inner edge. The doors can be made straight or curved to correspond with the silo, and may be hinged, with the top and bottom beveled so as to fit snugly, or the top and bottom may be left square and the doors placed one upon another as the silo is filled. A simple plan for the construction of a continuous door is to first make it in one piece, care being taken that the cleats are in proper position, then saw it into sections of the desired lengths for doors. These can be numbered so that they will occupy the same position when placed in the silo that they filled in the original piece. The doors can be made to correspond with the silo if the staves are beveled, and by having the cleats sawn with the proper curve. The hoops can be fastened in the rear of the silo with lugs, or square loops can be made at each end of a hoop and two 3x3 pieces of wood passed through the loops and tightened by bolts. When round iron hoops are used, these may pass through the door frame and be held securely by a double tap with a heavy washer. In the rear they can be fastened with lugs. In small silos with sawed out doors, a continuous hoop may suffice, but with large silos, hoops put up in two or more sections are better, as this insures a more uniform tension.

During the summer season, when the silo is usually empty, the hoops will probably need tightening; neglecting to do this may result in a collapsed silo.

PRESERVATION OF THE SILO.

The life of a wooden silo may be prolonged by using some preservative material to protect it from decay. Many different preparations have been recommended, but coal tar is the one generally used. This can be put on while hot or after dissolving in gasoline. In the latter mixture the proportions are about half a gallon of coal tar to two-thirds of a gallon of gasoline. This must be frequently stirred while it is being put on. Gasoline is highly inflammable; hence care must be exercised to have no fire in the vicinity when the mixture is applied.

Three of the Station silos are treated with preservative; one with hot coal tar; one with raw linseed oil, and a third with carbolineum avenarius. The edges of the staves should be thoroughly treated before putting the silo together, after which the inner surface of the silo may receive a similar coating. This treatment may be followed with an annual or biennial application of the preservative.

ROOF OF THE SILO.

When the silo is built on the outside of the barn a roof is needed. This may be simply a shed roof constructed with plank, or a neat inexpensive shingle roof as shown in plate II. The roof of this silo is supported by a 6x6 frame, set on the top of the silo. It is better to have a comparatively large door at the gabel end, rather than a small one, as considerable door space is desirable when the common elevator is used.

FILLING THE SILO.

The method usually employed in filling a silo consists of first passing the forage through a cutter, and then conveying it to the silo by an elevator, or a blower. To a small farmer the necessary outlay for this machinery is a question of vital importance; hence many, on this account, are deterred from adopting the silo. However, there are a large number of silos which have been operated successfully with uncut forage. It is generally conceded that passing the forage through a cutter before putting it into the silo has a decided advantage over the system of putting it in whole. From a close observation recently made as to the relative cost of the two methods, it was found that it required practically the same amount of labor to put whole clover into the silo as it did the cut clover, the only saving being in the engineer and the cost for use of machinery. The cut silage is in a much more convenient form for feeding and can be taken from the surface of the silo in layers of a uniform depth. It was also noted that much more cut than uncut forage could be gotten into the silo. In two silos of equal size it required 20.41 tons of cut clover to fill one of them on the first run, while only 10.64 tons of whole clover could be gotten into the other at the first attempt to fill. This ratio, however, is not liable to be maintained, as the whole clover will settle much more than that which is cut.

The addition of water to whole material while filling the silo, materially assists in making the silage more compact. This, however, is almost impracticable in the absence of a convenient water system. To elevate by hand the quantity of water required for this purpose, represents considerable labor. When whole material is used it should be handled in as fresh a condition as possible; so that by retaining its weight the settling of the silage is facilitated.

Also, in filling a silo with whole material, care should be exercised to have it kept level and thoroughly tramped. In small silos the material can best be thrown in with a pitchfork. This can be accomplished by putting up a light staging. The use of a derrick or hay fork in filling a small silo is not advisible, without very small loads are taken at a time, as it will be found almost impossible to properly spread a large load of tangled material when dumped into a small silo. With a large silo the use of the hay fork or derrick will be entirely feasible.

There need be no haste in filling a silo. If a few loads are put in each day until it is filled, the silage will be likely to become more compact than if it were filled hurriedly. If it is desirable to perform the work more rapidly, the silo can be filled and allowed to settle for two or three days, then refilled. This operation may have to be repeated three or four times in order to secure the maximum amount of silage in the silo. In case sufficient material is not ready to complete the filling of the silo, other material may be added at any time. It would be well, however, to first remove the covering, or spoiled silage on the surface of the silo.

When cut fodder is put into the silo the carrier should be adjusted so as to deliver the material in the center of the silo, thus facilitating its proper distribution. In filling with corn there is a tendency towards an uneven distribution of the ears; these, being heavier than the other portions of the plant, fall to the outside, resulting in the uneven settling of the silage. To obviate this, many devices are employed, the most simple of which is a long bag open at both ends and fastened to the end of the carrier. A small rope attached to this bag enables it to be manipulated so as to have the corn deposited in any part of the silo desired. There is no apparent necessity for these devices with other forage crops. The principal item to observe is to keep the contents of the silo level and well tramped. In small silos the tramping should be very thorough, so as to get the greatest possible weight of silage in a given space; for, as before stated, the friction and consequent resistence to the settling of the silage is greater in proportion in a small silo than in a large one.

DANGER IN FILLING SILOS.

During the period of active fermentation of the silage, carbon dioxid is generated quite rapidly; hence to guard against any possible accident, a lantern should be lowered before descending into the silo. If the light continues to burn at the bottom of the empty space it will be safe to enter. This precaution need only be taken when considerable closed space intervenes between the silage and top of silo. Cases are on record where people have been suffocated by going down into silos containing carbon dioxid. In the absence of a light to test for this gas, it would be a good plan to allow some material to be put in before entering the silo, as this will create circulating currents of air and eliminate all danger.

COVERING FOR THE SILAGE.

The original plan in the early period of the silo, was to cover the siloed fodder with boards which were heavily weighted with rock or earth. This custom, however, has been abandoned in recent years, as silage has been found to keep equally as well without the additional weight. The common practice of the present is to allow the material at the exposed surface of the silo to decompose, thus forming an impenetrable coat and excluding the air. This system, however, at times, results in a great waste of silage, as with clover or other spongy substances, decomposition extends downwards for some distance. A common practice is to put water on the surface of the silage at the rate of about one gallon to the square foot, then tramp down thoroughly. This causes a compact decomposed mass to form on the top of the silage which effectually excludes the air, and reduces the amount of spoiled silage to the minimum. Some siloists recommend a heavy sprinkling of grain, to be followed by an application of water every few days. This is supposed to form a very dense growth of roots, which, with a thin layer of decomposed material, affords a good protective coating for silage. When the op-

PLATE III—A Silage-fed Cow.

eration of filling the silo is completed, it is a good plan to cover the silage with at least six inches of cheap material, such as marsh grass or succulent weeds.

CROPS FOR SILAGE.

Corn, from the ease with which it can be converted into silage, is perhaps entitled to stand at the head of all forage plants for this purpose. The solid stems, flat leaf, and proper ratio between its liquid and solid constituents, seem to favor it for this work. The plant, however, is comparatively poor in protein; hence for western Oregon the leguminous crops will give better results to the general farmèr.

Of the legumes, clover is probably the most valuable plant, both for hay and silage. Its heavy yield, richness in protein and soil renovating qualities, will command the attention of all progressive agriculturists. Clover, with the possible exception of alfalfa, can probably be grown and placed in the silo at a lower cost than any other forage crop.

Vetch is another valuable legume and grows profusely in the western portion of the state. It will thrive in a greater variety of soils than clover and can be sown as a catch crop either in the spring or fall. It is very palatable to stock and about equal with clover in nutritive principles and adaptability for silage.

Alfalfa is also a good silage crop, and while it is only grown to a limited extent in western Oregon, it is very widely distributed in the eastern and southern portions of the state. This plant, under favorable conditions, will yield a crop representing perhaps a greater value per acre than any other forage crop grown. With the silo to preserve it in its succulency, this crop can be made of inestimable value to the dairying and stock growing industry in the semi-arid portions of the state.

The field pea makes a good silage crop. They can be grown under greatly varying conditions; are rich in protein, but stock do not relish them quite so well as clover and alfalfa.

There are other farm crops which are adapted for silage, but the ones mentioned are more generally grown and fully meet the requirements of the siloist.

Some unsatisfactory results have followed attempts to ensilo peas and vetch when grown with grain. While the grain will materially aid in holding the vetch and peas up, thus facilitating the harvesting of the crop, too large a proportion of grain is undesirable when the crop is to be ensiloed. The hollow stems of the grain carry more or less air into the silo, which is thought to accelerate fermentation and consequent deterioration of the silage. The best forage plants for silage are generally those with solid stems and which carry over twenty per cent of solid matter in their physical structure. Very succulent plants, such as cabbage, rape, and immature corn, clover, alfalfa, or vetch, when carrying much less than twenty per cent of solid matter, are unsuited for silage.

In recent experiments conducted at this Station with siloed immature clover, containing 79.14 per cent of moisture, it was found that a great quantity of its liquid constituents oozed out at the bottom of the silo. An analysis of this exudate showed that it contained 1.13 per cent protein. This is not large, but nevertheless represents a loss of valuable nutrients.

THE TIME FOR HARVESTING SILAGE CROPS.

Recorded results of a large number of experiments with silage warrants the conclusion that plants are in the best condition for silage when they are fairly well matured. Corn is seemingly in the best condition for the silo when the kernels are nicely glazed, just after the roasting-ear stage. In some seasons, corn suffers injury from autumn frosts. As a result of this injury, it becomes shriveled and dry, and the farmer usually concludes that it is not available for the silo. Frosted corn will make fair silage if the precaution is taken when putting it into the silo to add sufficient water to bring the moisture content up to what it would be under normal conditions.

Clover is in the best condition for the silo when it reaches the proper stage for hay; that is, when it is slightly beyond full bloom, and the first heads begin to discolor. It should be put into the silo as soon as possible after cutting. To permit it to wilt very much, will seriously interfere with its packing in the silo, unless water is added. It is quite probable that the reported failures with clover silage are largely due to the material not becoming sufficiently compact in the silo to exclude the air. This, in a measure, may be due to unnecessary wilting of the fodder before putting it into the silo.

Alfalfa is harvested for silage when in full bloom. Although failures have been reported with alfalfa as silage, there are, however, a great number of dairymen who have been eminently successful in siloing this crop.

Vetch is in the best condition for the silo when the first seed pods are nicely formed. In full bloom it is exceedingly succulent, carrying approximately eighty per cent of moisture. All classes of farm stock relish this forage plant; it is rich in flesh-forming substances, and useful for hay, soiling, or the silo.

Peas are ready for the silo when over fifty per cent of the pods are slightly advanced beyond the "green pea" stage. This crop seems to be especially well adapted for silage. Several tons were put into one of the Station silos last season, at the stage of ripeness mentioned, and came out in excellent condition. The silage possessed an agreeable aroma and the original color of the forage was well preserved.

With the various other forage crops suitable for silage, such as sorghum, grass, soja beans, millet, &c., a fair degree of ripeness before they are committed to the silo is indispensable to success.

METHODS FOR HANDLING SILAGE CROPS.

When large crops of corn are to be harvested for the silo, the modern corn binder is the thing. For the small crop, the corn knife will be a more appropriate implement. The corn knife, wielded by an active man, can be made to cut a surprisingly large amount of corn in a day. In using the knife the corn should be deposited in bunches of such a size that they may be taken up conveniently at one armful and loaded on the wagon. The work of loading will be facilitated by having the bunches of corn placed across the row so that they can be picked up easily. It has been suggested that low wagons be used for hauling the corn, with a portable platform attached at the rear, so that the loader can walk up into the wagon and deposit his armful of fodder. When the loading is completed, the platform is transferred to the next empty wagon. A very simple and effectual device for cutting corn consists of a sled with a cutting knife attached to the side near the front, at an angle of about forty-five degrees. The sled is hauled by one horse beside the corn row, and a man, kneeling on the platform, gathers the corn in his arms as it is cut off and deposits it in bunches on the ground. An ingenious device, operated on a somewhat similar plan when attached to a wagon, permits the corn to be loaded as it is cut. The platform is removable and may be attached to other wagons on the completion of the loading.

In harvesting the finer growing forage crops, the mower and rake answer all purposes. The plan followed by the Station, is to mow in strips and follow closely with the rake. We do not aim to cut more than one load at a time, and when the load is cut, the men operating the mower and rake assist in loading, making three loaders in the field a large portion of the time. Where the distance from field to silo is comparatively short, we find that two teams with three wagons will deliver as fast as the cutter will handle it. On cloudy, or showery days, it will do no harm to have several loads cut ahead; but in hot, clear weather, it is best to have the forage gathered up closely after the mower. If by accident the forage becomes much wilted, water should be added, either in the silo, or as it ascends the carrier. This item of moisture is an important one with clover and vetch silage. When these plants are in the best condition for silage, their moisture content is perhaps as low as may be safely risked in the silo. Forage carrying too large a percentage of solid matter in proportion to its moisture does not become sufficiently compact to effectually exclude the air. To allow clover, at the proper stage of ripeness, to go into the silo in a wilted condition, without adding water, invites failure. It is doubtful if adding water to unwilted fresh clover cut at the proper stage, will improve the silage. Hence the indiscriminate use of water, regardless of the condition of the clover, may not be good practice.

ACIDITY OF SILAGE.

The problem of sweet and sour silage continuously comes up and much theorizing has been indulged in. It is not our purpose to advance any new theory on this perplexing question. That some silage is exceedingly sour is a well known fact; but the cause or causes of this condition are not well known. The work of the Station on silage during the year just passed was more along practical lines than those of scientific research. However, the data obtained as the results of the work will be an aid in our efforts towards further investigations. The major portion of the work was with clover, and the object sought was to determine the effects of adding water to clover silage, both as to its influence on the acidity and protein content. The results obtained from these experiments seem to indicate that there are at least two conditions which favor the developmgnt of organic acids in silage, i. e. immaturity of the plant, and extreme compactness of the silage. A good example of the former is shown in the analysis of the immature corn silage.

It will be proper to mention that the chemical work of these investigations was done by Mr. F. E. Edwards, Assistant in Chemistry, who also supplied the tables.

IMMATURE CORN SILAGE.

	Original Substance.		Water-free Substance.	
	Green Fodder	Silage.	Green Fodder	Silage.
Moisture	75.18	80.09	....	....
Dry Matter	24.82	19.91	100.00	100.00
Ash	1.40	1.23	5.63	6.19
Protein	2.03	2.07	8.18	10.39
Crude Fiber	5.23	4.25	21.07	21.37
Fat	.63	.75	2.53	3.75
Nitrogen-free Extract	15.53	11.61	62.59	58.30
Acidity as Acetic Acid	....	1.94	....	....

The "silage" analysis above is from a composite sample made up of three partial samples taken at different depths in the silo. The "green fodder" was taken as the corn went into the silo.

1901.	Moisture.	Solids.	Acidity.		Water-Free Substance.		Orig. Subs.
			In 100 grams silage	As Acetic Acid.	Protein.	Nitrogen.	Protein.
April 30	77.91	22.09	370 c. c. N_{10} NaOH.	2.22	9.86	1.58	2.18
May 11	81.20	18.80	320 " "	1.92	10.26	1.64	1.93
15	81.16	18.84	280 " "	1.68	9.65	1.54	1.82
Average	80.09	19.91	323 c. c. N_{10} NaOH.	1.94	9.92	1.59	1.98

The corn for this silage was harvested when the kernels had reached what is known as the dough stage. The moisture content as represented by the green fodder is below what it should be. This is due to the fact that the composite samples of the fodder were collected in an open vessel which permitted of more or less transpiration, before moisture determinations were made. The amount of moisture found in the silage would perhaps more nearly represent that of the green fodder.

This corn silage, although very acid, as determined by the analysis, was exceptionally well preserved so far as general appearance and color were concerned. It possessed an agreeable acid odor, and, notwithstanding the 2.22 per cent of acid which some of it contained, the cows ate it with avidity. There were no appreciable harmful results from feeding this exceedingly sour silage. The period of feeding, however, was brief, only extending over two weeks.

With the clover the results were slightly different as the following tables will indicate:

ANALYSES OF PARTIAL SAMPLES, SILO No. 1.

1900.	Moisture.	Solids.	Acidity. In 100 grams Silage.	Acidity. As Acetic Acid.
Aug. 2	78.24	21.76		
13	66.39	33.61		
20	72.94	27.06	117.5 c. c. N_{10} NaOH	.71
25	74.80	25.20	102 " "	.61
29	71.05	28.95	112 " "	.67
Sept. 5	77.61	22.39	160 " "	.96
12	77.64	22.36	160 " "	.96
20	77.17	22.83	140 " "	.84
26	74.83	25.17	110 " "	.66
Oct. 6	76.14	23.86	130 " "	.78
13	76.98	23.02	160 " "	.96
19	77.05	22.95	150 " "	.90
27	66.88	33.12	120 " "	.72
Nov. 3	76.09	23.91	150 " "	.90
10	76.72	23.28	140 " "	.84
Average	74.70	25.30	134.7 c. c. N_{10} NaOH	.81

ANALYSES OF PARTIAL SAMPLES, SILO No. 2.

1900–1901.	Moisture.	Solids.	Acidity. In 100 grams Silage.	Acidity. As Acetic Acid.	Water-Free Substance. Nitrogen	Water-Free Substance. Protein	Orig. Subs. Protein
Nov. 19	82.17	17.81	180 c. c. N_{10} NaOH	1.08			
27	82.36	17.64	230 " "	1.38			
Dec. 4	79.43	20.57	150 " "	.90			
11	76.97	23.03	180 " "	1.08			
18	78.94	21.06	180 " "	1.08			
24	74.60	25.40	160 " "	.96			
Jan. 3	73.25	26.75	220 " "	1.32	1.99	12.44	3.33
9	74.25	25.75	260 " "	1.56	2.26	14.12	3.64
16	75.36	24.64	200 " "	1.20	2.06	12.88	3.17
25	75.78	24.22	200 " "	1.20	2.17	13.56	3.28
Feb. 4	76.02	23.98	160 " "	.96	1.87	11.69	2.80
Average	77.20	22.80	192.7 c. c. N_{10} NaOH	1.16	2.07	12.69	3.24

ANALYSES OF PARTIAL SAMPLES SILO No. 3.

1901.	Moisture.	Solids.	Acidity. In 100 grams Silage.	Acidity. As Acetic Acid.	Water-Free Substance. Nitrogen	Water-Free Substance. Protein	Orig. Subs. Protein
Feb. 9	81.68	18.32	160 c. c. N_{10} NaOH	.96	1.85	11.56	2.13
20	81.00	19.00	232 " "	1.39	1.73	10.81	2.15
26	82.25	17.75	140 " "	.84	1.89	11.81	2.10
Mar. 8	80.19	19.81	170 " "	1.02	2.04	12.75	2.53
15	75.65	24.35	180 " "	1.08	1.75	10.94	2.66
21	75.65	24.35	184 " "	1.10	1.70	10.61	2.58
April 1	76.39	23.61	180 " "	1.08	1.88	11.77	2.78
8	67.18	32.82	180 " "	1.08	1.85	11.27	3.70
22	75.78	24.22	160 " "	.96	2.11	13.20	3.20
Average	77.31	22.69	176 c. c. N_{10} NaOH	1.06	1.87	11.64	2.65

Complete analyses were not made of the samples at first; determinations only were made as to the solids and acidity.

The analyses were made with composite samples of the daily ration of the herd, taken from the silo on the dates given.

The following table will indicate the date of filling and the amount of clover placed in each silo:

Dates when fodder was placed in the silos. 1900.	Approximate weight of fodder, tons. Silo No. 1.	Silo No. 2.	Silo No. 3.
June 8	10.12		
9	6.75	4.50	
11	3.37	10.12	
12		3.37	
14	2.25	2.25	
15			14.62
19		1.12	9.00
22		4.50	7.87
Total	22.49	25.86	31.49

The clover cut from June 8th to June 11th, inclusive, was just in full bloom, or slightly too immature for hay. That which was put in Silo No. 3 had reached the proper stage of ripeness for hay. With the exception of about one gallon of water to the square foot of exposed area, put on to give a compact surface, the material in Silo No. 1 was put in as it came from the field, after passing through the cutter. The fodder in Silos Nos. 2 and 3 was watered at the rate of one gallon of water to every hundred pounds of material. These amounts are approximately correct only. Several loads of the forage were weighed and the average accepted as a basis of calculation for unweighed loads. The water was applied by means of a hose attached to an hydrant. Several determinations were first made as to the volume of flow for a given period, and the average of flow was taken as a basis of calculation for the period required to saturate a given weight of fodder. There is, however, some chance of error, as service elsewhere in the supply pipe at times would result in lowering the pressure and thus diminish the volume of flow.

Silos 1 and 2 are of the same capacity, but the silage in Silo No. 2 had settled much more than that of No. 1. The silos were all filled level full, at least three times. The effect of water upon the settling of silage is shown in the weight of silage per cubic foot. A number of determinations made at different depths in the silos gave the average weight of a cubic foot of silage in No. 1 as 33.65 lbs.; No. 2, 53.33 lbs.; No. 3, 54.63 lbs. Considerable rain fell during a part of the time when Silo No. 3 was being filled. As a result the forage was supersaturated, thus causing heavy seepage at the bottom. It was thought that the addition of such a large quantity of water to the green clover would have a tendency to wash out some of the protein compounds. This, however, did not seem to take place to any appreciable extent.

The following table represents the analyses made from composite samples of all the partial samples taken from each silo:

	Original Substance						Water-Free Substance.					
	Silo No. 1.		Silo No. 2.		Silo No. 3.		Silo No. 1.		Silo No. 2.		Silo No. 3.	
	Green Clover	Silage	Green Clover	Silage	Green Clover	Silage	Green Clover	Silage	Green Clover	Silage	Green Clover	Silage
Water	69.89	74.70	63.25	77.20	66.04	77.31	......	......	......	......	......	......
Dry Matter	30.11	25.30	36.75	22.80	33.96	22.69	100.00	100 00	100.00	100.00	100.00	100.00
Ash	2.23	2.18	2.67	1.99	2.42	1.89	7.39	8.62	7.23	8.73	7.13	8.35
Protein	4.10	3.27	4.54	2.96	3.97	2.69	13.62	12.93	12.36	13.00	11.69	11.84
Crude Fiber	9.48	8.41	11.22	7.97	10.70	7.91	31.48	33.18	30.53	34.92	31.49	34.84
Fat	.89	.84	1.08	.90	.98	.83	2.97	3.33	2.94	3.93	2.90	3.67
Nitrogen-Free Extract	13.41	10.60	17.24	8.98	15.89	9.37	44.54	41.94	46.94	39.42	46.79	41.30
Acid'y as acet. acid	.26	.81	.26	1.16	.26	1.06						

The same possible error occurs in the moisture content of the green clover as was noted in the corn.

It will be seen that the unwatered silage in Silo No. 1 retained a greater percentage of its original dry matter and developed perceptibly less acid than did the watered silage. If this loss of dry mat-

PLATE IV—Some Silage-fed Sheep. Average Weight, 255.83 Pounds.

ter is due to fermentation, this is significant, from the fact that it tends to show that greater fermentation takes place in silage saturated with water than with that carrying a moderate amount. The acidity is apparently the product of fermentation, and the loss in dry matter would indicate that more or less excessive fermentation had previously taken place. There is also a larger percentage of dry matter retained in the silage from Silo No. 3 than there is in that taken from No. 2; and, furthermore, the acidity is slightly less.

These experiments tend to show that acidity and loss of dry matter go hand in hand. This loss occurs in the carbohydrates and allied substances, the protein remaining practically constant. The rather unusual compaction of the silage in Silos 2 and 3 precludes an assumption that fermentation was due to large amounts of entangled air in the silage; for, if this were true, the fermentation would certainly be greater in the less compact silage of Silo No. 1. However, acidity and loss of dry matter may not both be due to fermentation. The acidity may represent the physiological products of the cell life of the plant; or may be due to a slower process of fermentation at a lower temperature. There is evidently a desirable mean between the ratio of dry substance and moisture, which gives the best results in the silo. If the fodder is too dry within certain limits, active oxidation will take place, thus destroying a large proportion of nutritive substances. If, on the other hand, it it is too heavily watered, acidity and loss of solid matter are the results.

The Station's work in silage the past year demonstrates thus far that clover, cut at the proper stage of ripeness and put into a properly constructed silo, will make good silage. There is no apparent need for the addition of water to green cut clover when passed through a cutter before entering the silo. Since within proper limits it does no especial harm, it may be used with profit when the clover is overripe, or unduly wilted.

Cost of Material for a Silo twelve feet in diameter, 24 feet deep. Capacity, 49 tons.

1⅔ yards of rock or gravel	$ 1.00
4 barrels of sand	.50
1 barrel of cement	4.75
2,260 ft. 2 x 4 tongued and grooved staves at $20.00 per M	45.20
72 ft. 3 x 6, 24 ft. door frames	1.44
358 ft. ⅝ round iron for hoops and bolts; weight, 465 lbs., at $3.20 per cwt.	14.88
9 lugs at 30 cents each	2.70
54 nuts at 8½ cents per lb.	.60
Preservative	1.50
Total	$72.57

These estimates are merely approximations and will be subject to variations in different localities. If the silo is constructed outside, the cost of roof and painting must be added.

Plate III taken May 1st, represents a dry Shorthorn cow which from January 1st to May 1st, was fed daily without grain 40 pounds of clover silage and what mixed clover hay she would eat up clean. This cow not only retained her excellent condition on the above ration, but made a satisfactory gain in live weight.

Plate IV represents six Cotswold ewes which were taken off of rape and clover pasture December 1, 1900, and put on clover silage, mixed hay and a light ration of grain. This was fed until March 15, 1901, when they were photographed for the plate.

These illustrations are introduced simply to show that silage has an important field of usefulness on the general farm.

LIST OF BULLETINS

(In print) published by the Oregon Agricultural Experiment Station to June, 1901.

Circular No. 1—Dairying in Oregon	Shaw, French and Kent
No. 6, 1890—Chemistry, Zoölogy	Washburn
No. 7, 1890—Small Fruits and Vegetables	Coote
No. 8, 1891—Varieties of Wheat and Flax	French
No. 10, 1891—Entomology	Washburn
No. 28, 1894—Pig Feeding, continued	French
No. 29, 1894—Horticulture, Pruning, etc.	Coote
No. 30, 1894—Potatoes and Roots, continued	French
No. 31, 1894—Codlin Moth, Hop Louse	Washburn
No. 32, 1894—Five Farmers' Foes	Craig
No. 33, 1894—Tent Caterpillar	Washburn
No. 34, 1895—Fruits and Vegetables	Coote
No. 35, 1895—Pig Feeding, continued	French
No. 36, 1895—Composition and Use of Fertilizers	Shaw
No. 37, 1895—Experiments in Cattle Feeding	French
No. 38, 1895—Fruit Pests	Washburn
No. 39, 1895—Grasses, Chemistry	Shaw
No. 40, 1896—Prunes, Apples and Pears	Hedrick
No. 42, 1896—Feeding Sheaf Wheat	French
No. 43, 1897—Flax Culture	French
No. 44, 1897—Review of Oregon Sugar Beets	Shaw
No. 47, 1897—Cheat and Clover	Shaw and French
No. 48, 1898—Spraying	Cordley
No. 50, 1898—The Fertility of Oregon Soils	Shaw
No. 51, 1898—Marketing Fruit	Craig
No. 52, 1898—Nut Culture	Coote
No. 53, 1898—Sugar Beets	Shaw
No. 54, 1898—Flax, Hemp, Dairy, etc.	French and Kent
No. 55, 1898—Chemistry of Cherries	Shaw
No. 57, 1899—Brown Rot	Cordley
No. 58, 1899—Rose Culture in Oregon	Coote
No. 59, 1899—Sugar Beet Experiments of 1898	Shaw
No. 60, 1900—Apple Tree Anthracnose	Cordley
No. 61, 1900—The Oregon Prune	Shaw
No. 62, 1900—Miscellaneous Investigations	Shaw
No. 63, 1900—Prevention of Smut on Oats—Preliminary Bulletin	Pernot
No. 64, 1901—Investigation of Diseases in Poultry	Pernot
Circular Bulletin concerning Acid Soils in Oregon—1900	Knisely
No 65, 1901—Creameries and Cheese Factories of Western Oregon	Kent
No. 66, 1901—The Grape in Oregon	Lake
No. 67, 1901—The Silo and Silage	Withycombe

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