Agricultural Experiment Station

BULLETIN NO. 75

WINTERING YEARLING CATTLE

a. Comparison of Different Coarse Fodders When Fed Alone, and when combined with a Limited Grain Ration

b. Influence of Winter Gains Upon Following Summer Gains at Pasture

c. Efficiency of Rations as Affected by the Season

COLUMBIA, MISSOURI

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COLLEGE OF AGRICULTURE AND MECHANIC ARTS

Agricultural Experiment Station

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WINTERING YEARLING CATTLE

By H. J. Waters, Director

SUMMARY OF RESULTS

In this bulletin are reported the results of seven years' work in wintering high grade yearling cattle on different forage crops and on different grain rations. The effect of these rations upon the gain in the winter and in a few cases upon the capacity of the animals to make gains at grass the following summer has been carefully studied.

Credit should be given to Chas. M. Conner, B. S., Professor of Agriculture, North Carolina Agricultural College; D. W. May, M. S., Director of the United States Government Experiment Station, Porto Rico; Thos. I. Mairs, M. S., Assistant Professor of Animal Husbandry, Pennsylvania State College; and Claude L. Willoughby, B. S., Animal Husbandman, Georgia Experiment Station, who at different times had charge of the details of the experiments here reported.

These experiments were begun in the winter of 1895-6, and have embraced four years of comparisons of the feeding value of various forage crops when used without grain, and four years of work when a limited amount of grain, chiefly corn, was added to the various sorts of coarse fodders under test.

In the experiments without grain, the following roughnesses have been compared:

1. Timothy Hay;
2. Whole Corn Stover;
3. Shredded Corn Stover;
4. Siloed Corn Stover;
5. Clover Hay;
6. Cowpea Hay;
7. A Combination of Whole Corn Stover and Clover Hay.
In the four years' experiments in which a limited amount of grain was used, the value of the following rations for wintering cattle was compared:

1. Shelled Corn and Timothy Hay;
2. Shelled Corn and Clover Hay;
3. Shelled Corn and Cowpea Hay;
4. Shelled Corn and Alfalfa Hay;
5. Shelled Corn and Millet;
6. Shelled Corn and Sorghum;
7. Shelled Corn, half Corn Stover and half Clover Hay;
8. Shelled Corn and Whole Stover;
9. Shelled Corn; Cottonseed Meal and Wheat Straw;
10. Shelled Corn, Cottonseed Meal and Corn Stover.

The principal results obtained in these experiments may be summarized as follows:

A COMPARISON OF VARIOUS COARSE FODDERS WHEN FED WITHOUT GRAIN

1. Timothy Hay Alone. Timothy hay of average quality was found to be nutritious enough to a little more than maintain the weight of yearling steers that were in thin condition to begin with. That is, steers of this class were wintered on timothy hay of fair quality without loss in weight, and, on the average, made a slight gain. The gain, however was very small, varying from a slight loss in one experiment, when the weather was particularly unfavorable, to a fair gain when the quality of the hay was good and the weather was dry, bright, and crisp.

Our experiments show that 18.25 pounds of hay were required to be offered daily to a steer weighing 750 pounds for these results. On this basis, it would require 3285 lbs. or slightly more than a ton and a half of hay to winter a steer of this size from November 1 to April 30—six months—and, according to our experiments, the steer would make a gain of about 50 pounds.

2. Whole Corn Stover Without Grain. Taking the average of our four years' work, it appears that whole field-cured corn stover, handled as in ordinary farm practice, would not quite maintain yearling steers moderately thin to
begin with. That is, the average of all of our trials shows a loss of 33 pounds per steer, on the basis of a six months' wintering period, or from November 1 to April 30.

In these experiments, we offered an average of 33 1/2 pounds of stover daily per steer, computed on the basis of 750 pounds live weight. This would require three tons of stover per steer for a six months' wintering period.

3. **Shredded Corn Stover Without Grain.** The results with shredded stover were slightly less favorable than with whole stover, although the difference was so small as to be easily within the limit of error. Clearly, so far as our experiments show, there was no enhancement of the feeding value of the stover by the shredding process.

Almost as much shredded stover was refused, or left uneaten, as of the whole stover. Shredding, therefore, would seem to be justified upon the ground of greater convenience in handling and the protection of the fields against injury by hauling stover out in muddy weather, etc., rather than upon that of the enhancement of its value as a feed.

4. **Siloed Stover Without Grain.** Siloed stover without grain produced very much better results than did field-cured stover, either fed whole or shredded, but the results are too meager to warrant a definite conclusion.

5. **Combination of Clover and Stover Without Grain.** In every trial, equal parts of clover hay and corn stover proved to be more efficient than did timothy. By combining stover with clover, therefore it is possible to bring its feeding value up to that of timothy hay, or, on the assumption that stover has little feeding value, the conclusion is justified that clover has practically double the feeding value of timothy.

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**A COMPARISON OF DIFFERENT KINDS OF ROUGHNESSES WHEN COMBINED WITH A LIMITED AMOUNT OF GRAIN**

1. **Shelled Corn and Timothy Hay.** This is the standard ration with which all others are compared, and is
chosen for the Standard because it more nearly approximates farm practice than any other single combination.

This combination proved very unprofitable in every trial, and was not to be compared in economy with the use of some legume hay with corn.

2. **Corn and Corn Stover.** This proved to be a much poorer combination than did even corn and timothy hay, as might be expected.

3. **Corn and Millet.** This was not as satisfactory a combination as was corn and timothy hay in either of the two years through which the trials extended.

4. **Corn and Sorghum.** This did not prove to be as efficient a ration as one would be led to expect, from the reputation this hay has throughout the State as a feed. The gains made on a limited amount of corn and all the sorghum hay the animals would eat were larger than from millet or stover, but less than from timothy and a like amount of corn.

5. **Corn and Clover Hay.** By substituting clover for timothy in these trials, the efficiency of the ration was practically doubled. That is, a bushel of corn when fed in combination with clover hay produced essentially double the number of pounds of gain that were produced on similar steers with the same amount of corn and good timothy hay.

6. **Corn and Cowpea Hay.** What was found to be true of clover applies almost identically to cowpea hay. That is, so far as our results go, cowpea hay of good quality with practically no peas on the vines has about the same feeding value as good clover hay, and like clover hay, when combined with corn, is capable of producing about double the amount of gain that can be obtained from timothy hay.

7. **Corn and Alfalfa Hay.** Our results do not indicate a material difference between the feeding value of alfalfa and good clover or good cowpea hay. It is safe to assume, however, that alfalfa of ordinary quality is fully equal to either of these hays in their best condition. Alfalfa in its best condition is without doubt more efficient than either clover or cowpea hay.
8. **Corn, Clover Hay and Corn Stover.** As was the case with this combination of roughnesses without grain, in every trial the combination produced larger gains than did good timothy hay. This means that with a large amount of coarse material like stover to be utilized, one of the most useful materials to feed in connection with it is a limited quantity of clover, cowpea, or alfalfa hay. To combine with this stover, food stuffs which do not remedy its chief defect, viz: low protein content, such as millet, sorghum, timothy or even corn, will not compare in economic results with the use of a legume hay.

9. **Corn, Cottonseed Meal and Stover or Straw.** In these experiments it was sought to supply the protein in cottonseed meal instead of in clover, cowpeas, or alfalfa. In other words, to attempt to utilize the low-priced roughage like stover or straw by combining cottonseed meal and a limited amount of corn with it.

The amount of gain secured was far less than when legume hay was used, such as clover or cowpeas, and in view of the high price of cottonseed meal, it would not be profitable to attempt to substitute this material for one of the legume hays for the wintering of cattle.

10. **Gains Made From Light Feeding are Relatively Costly.** In our feeding trials without grain, the cattle were but little more than maintained at best, and, therefore, practically all of the food consumed was wasted, when reckoned from the standpoint of gains made. As has already been pointed out, timothy hay very little more than maintained the cattle.

When we fed poorer material than timothy hay, such for example as corn stover, not only was all of the feed wasted when considered on the basis of the gains made, but to this expense must be added the cost of a slight loss in weight of the animal.

As the ration was increased in amount so that the rate of gain increased the cost of gains diminished uniformly. This seems to be true up to the full limit of the appetite of the animal, or to the point where the animal is on full feed or approximately on full feed. That is, other things being
equal, and considering only the cost per pound of gain, the cheapest gains are uniformly made when the animal is on full feed or approximately so.

11. Cattle, to Graze Well, Must be Thin. By grazing a portion of the cattle used in these experiments the following summer, it was found that there is a fairly definite relation between the gains made in winter and those possible to be made the following summer at grass. In other words, the gains made on grass are inversely proportionate to the amount of fat the animal carries, and are almost inversely proportionate to the gains made the previous winter.

If, therefore, cattle are to be grazed the following summer, it is important that they be wintered lightly, or in such a way as not to carry to grass any considerable amount of fat.

12. Circumstances Under Which Small Winter Gains May Be Justified. It will be impossible, therefore, to take advantage of the cheapest way of making gains in winter if the cattle are to be grazed the following summer. For, to reduce this gain to the lowest cost per pound as has already been pointed out, would necessitate full feeding or approximately full feeding the animal. This, in turn, would have the effect of storing up fat on the body, rendering the animal unfit to be grazed the following summer. In short, this would bring the animal to a marketable condition, or to a condition where it would be unprofitable to keep it longer for any purpose.

While it will probably be profitable under ordinary circumstances to feed in the winter up to the full capacity of the animal to grow without laying on fat, it will be justifiable in many seasons when the farmer has large quantities of cheap, coarse, material without an opportunity to market it, to bring the cattle through the winter in even thin condition, so that they may make the largest possible gains the following summer.

13. The Value of Cattle Enhanced by Wintering. The wintering process enhances the value of cattle, just as does the fattening process, although for another reason and to a much less degree. But this enhancement of
value due to the wintering process is necessary in order to make up the deficit that is practically inevitable when cattle are wintered lightly. This enhancement is due to the fact that the steer in the spring has the grazing season, which is the season of cheap gains and large profits, immediately before him, and is, therefore, worth more than in the preceding or the succeeding fall, when he has before him the wintering period, which is the period of expense. In the case of the fattening steer, the value is enhanced by reason of the animal being put in marketable condition. In the case of the animal that is being merely wintered, the enhancement is due mainly to a change of position rather than to a change in condition.

14. Seasonal Influence. A very large variation in the results of wintering cattle due to differences in season is inevitable. This may be a difference in the previous summer season as manifested in the quality of the roughage, as is strikingly illustrated by the high efficiency shown in the fodders and the hays grown in the dry season of 1901. Or it may manifest itself in the deterioration of the quality of the material during or after harvest, by storms, excessive rains, etc. Or the weather of the winter may affect the result, by influencing the animals directly. Cold, crisp, dry, bright, steady, weather furnishes ideal conditions for maximum returns. Then the appetite is sharp; the food is in good condition, and is eaten with the minimum of waste; the sheds and lots are dry, so that the animals follow a regular routine of eating, drinking, and lying down. Alternative warm and cold, rain and snow, intermingled with foggy, muggy, weather, with muddy lots, wet coats, and wet feed, when the animals eat irregularly and stand up most of the time for want of a comfortable place to lie, furnish the most adverse conditions for making gains or even maintaining weights.

DETAILS OF THE EXPERIMENT

Animals. The animals used in all of these experiments were high grade steers of the breeds designated, and were for the most part bred and raised in the vicinity of the Experiment Station.
After being assembled, they were either grazed or fed alike for as much as thirty days, to eliminate as far as possible the influence of any differences in previous treatment. This length of time was also employed in becoming familiar with the different animals, with a view to properly dividing them into lots that would represent the same quality, thrift, condition, etc.

**Live Weight.** The animals were weighed five days in succession at the beginning of the experiment, and the same number of days at the close of the experiment, at the same hour each day, and before being watered. The average of these weighings represents the initial and the final weights, and the difference in these figures is assumed to represent the gain or loss due to the feed or treatment involved. In addition to these initial and final weighings, the animals were weighed at the end of every ten day period throughout the experiment.

**Method of Feeding.** As a rule, the animals were fed twice daily—at 7 a.m., and at 5 p.m., and were given whatever amounts of roughage they would consume without undue waste.

A ton or more of loose hay or stover* was hauled in at a time from the field or stack, stored in a dry place in the feeding shed, and charged up to the lot of animals to which it was to be fed.

The animals were fed in a suitable manger under a dry shed, and were allowed the run of an open lot something like a tenth of an acre in area.

The mangers were cleaned each day, and the refuse material was stored in a dry bin provided for that purpose until it was weighed and sampled for water determinations and analysis.

When the fresh feed was weighed in, a 3000 gram sample was carefully drawn, enclosed in a tight pail and sent immediately to the chemical laboratory for the determination of moisture and subsequent analysis.

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*In this Bulletin, by “Corn Stover” is meant the plant after the ear is removed. By “Corn Fodder” is meant the entire plant, including the ear.
When the orts were weighed up, a similar sample was drawn for the same purpose.

**Water.** The animals had free access to fresh deep-well water in a trough under the shed.

**Salt.** In most instances barrel salt was kept in a box under the shed, where the steers had free access to it. In some of the experiments rock salt was used instead.

**FIRST TRIAL—1895-6**

**TIMOTHY HAY AND FIELD-CURED STOVER, FED WHOLE**

February 1st to March 21st, 1896.—49 days. Five Yearling Steers in each Lot.

The Timothy Hay used in this experiment was cut when the seed was in the dough, cured in the ordinary way, and put up in large stacks in the open field in the usual manner. Aside from the presence of considerable coarse weeds, the hay would be considered average quality.

The Stover was very coarse and large, the corn having yielded from 75 to 85 bushels per acre, was cut at about the usual time, set up in shocks sixteen hills square, husked at the usual time, set up again and allowed to stand until hauled in to be fed.

In other words, the common farm practice with respect to the handling of both of these feeds was imitated as closely as possible.

Excessive rains in the preceding December had very materially lowered the quality of the stover, so that, taken in connection with its coarseness, it was not up to the average in palatableness or quality, and no grain of any sort was fed.

Eleven high-grade Shorthorn Steers, about eighteen months old, averaging about 675 pounds in weight, in rather thin condition, were used in the experiment. They were divided so that Lot I, having Timothy Hay, contained six steers, and Lot II, receiving Whole Corn Stover, contained five steers.
TABLE 1. FOOD CONSUMED, AND GAIN OR LOSS IN LIVE WEIGHT PER LOT DURING THE EXPERIMENT
FEBRUARY 1ST TO MARCH 21ST, 1896—49 DAYS

<table>
<thead>
<tr>
<th>Lot I—6 Steers</th>
<th>Fresh feed lbs.</th>
<th>Dry matter lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy Hay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food offered</td>
<td>4176</td>
<td>3654</td>
</tr>
<tr>
<td>Food refused</td>
<td>968</td>
<td>868</td>
</tr>
<tr>
<td>Food eaten</td>
<td>3208</td>
<td>2786</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lot II—5 Steers</th>
<th>Fresh feed lbs.</th>
<th>Dry matter lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Corn Stover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food offered</td>
<td>6474</td>
<td>4710</td>
</tr>
<tr>
<td>Food refused</td>
<td>2246</td>
<td>1793</td>
</tr>
<tr>
<td>Food eaten</td>
<td>4228</td>
<td>2917</td>
</tr>
</tbody>
</table>

TABLE 2. DAILY FOOD CONSUMED PER STEER
FEBRUARY 1ST TO MARCH 21ST, 1896—49 DAYS

<table>
<thead>
<tr>
<th>Lot I—Six Steers</th>
<th>Fresh food lbs.</th>
<th>Dry matter lbs.</th>
<th>Average weight of live weight per steer lbs.</th>
<th>Gain or loss in live weight per steer lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy Hay</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food offered</td>
<td>14.2</td>
<td>12.40</td>
<td>26.42</td>
<td></td>
</tr>
<tr>
<td>Food refused</td>
<td>3.3</td>
<td>2.96</td>
<td>9.16</td>
<td></td>
</tr>
<tr>
<td>Food eaten</td>
<td>10.9</td>
<td>9.54</td>
<td>17.26</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lot II—Five Steers</th>
<th>Fresh food lbs.</th>
<th>Dry matter lbs.</th>
<th>Average weight of live weight per steer lbs.</th>
<th>Gain or loss in live weight per steer lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole Corn Stover</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food offered</td>
<td>12.2</td>
<td>11.93</td>
<td>26.26</td>
<td></td>
</tr>
<tr>
<td>Food refused</td>
<td>3.3</td>
<td>2.96</td>
<td>9.16</td>
<td></td>
</tr>
<tr>
<td>Food eaten</td>
<td>10.9</td>
<td>9.54</td>
<td>17.26</td>
<td></td>
</tr>
</tbody>
</table>

*Average of sixteen weighings—one every day for five consecutive days at beginning of trial, and one each week thereafter until the close.
TABLE 3. DAILY FRESH FOOD AND DRY MATTER CONSUMED PER STEER, COMPUTED ON THE BASIS OF 1000 POUNDS OF LIVE WEIGHT

<table>
<thead>
<tr>
<th></th>
<th>Food offered</th>
<th>Food eaten</th>
<th>Dry matter eaten</th>
<th>Per cent refused</th>
<th>Per cent food</th>
<th>Gain or loss in live weight in 49 days</th>
<th>Per cent water in food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot II—Whole Corn Stover</td>
<td>39.01</td>
<td>25.48</td>
<td>17.58</td>
<td>34.67</td>
<td>-2</td>
<td>34.69</td>
<td></td>
</tr>
</tbody>
</table>

SECOND TRIAL—1896-7

This season the experiment was enlarged so as to include Shredded Stover and Siloed Stover in addition to the Whole Corn Stover and Timothy Hay.

The number of steers was increased to twenty, and divided into four lots of five animals each.

They were high grade Shorthorn steers, about eighteen months of age, in thin condition, with an average weight of about 800 pounds.

The experiment was begun December 7, 1896, and continued until March 7, 1897, covering 92 days, exclusive of the preliminary period of some thirty days.

Feeds. No grain was fed. The Timothy Hay used was of fully average quality and comparatively free from weeds and other foreign substance.

Three kinds of Stover were fed viz:

Whole Stover—field cured—kept in 16-hill square shocks in the open field until needed for feeding, as is usual in farm practice.

Shredded Stover—field cured—shredded late in November, and put up in a rick in the open until used.

Siloed Stover. The details of its preparation are given below.

In the preparation of these three classes of Stover, the following precautions were taken:

At the time the corn was sufficiently mature to harvest for field curing, the field was divided into a series of plots of
five rows each. They were all harvested at exactly the same time, two sets of five rows being set up in shocks in the ordinary way and field cured, the third set, alternating with the other two, was put into the silo instead of being field cured, the ears being carefully removed before it was put into the silo.

The stage of maturity was approximately as follows:

The leaves below the ear, the outer husks and the upper sixth of the stalk were brown. The leaves above the ear were yet green and the coarser portion of the stalk was green. The corn was fully dented, but of course not even approximately dry enough to crib.

This method of making silage is clearly impracticable, as there would be no convenient and proper way of disposing of the grain, and it was not with a view to establishing a new practice that this particular phase of the experiment was undertaken, but it was made with a view of ascertaining what effect siloing would have upon the stover as compared with the field curing process.

In order to make a palatable silage sufficient water was applied to it at the time it was put into the silo to pack it well and to insure its keeping in good condition.

The corn was Leaming, a medium maturing Yellow Dent, producing about 75 bushels of grain per acre, the stalks being of medium size and height.

The season was reasonably favorable for the curing of the stover in the shock, it having been so tied as to stand up well, and at the proper time it was husked, care being taken to remove all of the ears, set up again in ordinary sized shocks, tied, and allowed to remain in the field until about the middle of November, when each alternate shock row field cured was hauled to the barn and shredded, made into a rick, covered with straw, and kept there until required for feeding. The other shock row remained in the field until required for feeding and was used as Whole Stover.

Thus, one of each set of three series of shock rows was put into the silo, another was field cured and shredded, and another was field cured and fed whole.

As indicated above, the experiment was begun December 7, 1896, and continued until March 7, 1897, 92 days, the
general method of feeding being as described in Trial I, the animals being fed in an open shed and being allowed the free run of bare, open, lots.

Samples of the fresh feed and of the orts were taken, as described in Trial I, and the dry matter as shown in the following tables is based on the results of the moisture determinations in these samples.

### TABLE 4. TOTAL AMOUNT OF FOOD EATEN, GAIN OR LOSS IN LIVE WEIGHT

**December 7, 1896, to March 7, 1897—92 Days**

*Five Yearling Steers in Each Lot*

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Kind of Food</th>
<th>Total food offered per lot, lbs.</th>
<th>Total food refused per lot, lbs.</th>
<th>Total food consumed per lot, lbs.</th>
<th>Total dry matter consumed per lot, lbs.</th>
<th>Total gain per lot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot I</td>
<td>Timothy Hay</td>
<td>10244</td>
<td>1906</td>
<td>8338</td>
<td>7031</td>
<td>161</td>
</tr>
<tr>
<td>Lot II</td>
<td>Whole Stover</td>
<td>15110</td>
<td>6918</td>
<td>8192</td>
<td>6368</td>
<td>-59</td>
</tr>
<tr>
<td>Lot III</td>
<td>Shredded Stover</td>
<td>11547</td>
<td>4485</td>
<td>7062</td>
<td>6019</td>
<td>-78</td>
</tr>
<tr>
<td>Lot IV</td>
<td>Silage</td>
<td>21730</td>
<td>180</td>
<td>21550</td>
<td>5453</td>
<td>54</td>
</tr>
</tbody>
</table>

### TABLE 5. DAILY FOOD CONSUMED PER STEER

**December 7, 1896, to March 7, 1897—92 Days. Five Steers in Each Lot**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot I</td>
<td>Timothy Hay</td>
<td>807</td>
<td>22.27</td>
<td>18.60</td>
<td>18.13</td>
<td>15.28</td>
<td>32.2</td>
</tr>
<tr>
<td>Lot II</td>
<td>Whole Stover</td>
<td>791</td>
<td>32.85</td>
<td>24.57</td>
<td>17.81</td>
<td>13.84</td>
<td>-11.8</td>
</tr>
<tr>
<td>Lot III</td>
<td>Shredded Stover</td>
<td>791</td>
<td>25.10</td>
<td>20.47</td>
<td>15.35</td>
<td>13.08</td>
<td>-15.6</td>
</tr>
<tr>
<td>Lot IV</td>
<td>Siloed Stover</td>
<td>811</td>
<td>47.24</td>
<td>12.02</td>
<td>46.85</td>
<td>11.85</td>
<td>10.8</td>
</tr>
</tbody>
</table>

*On basis of five steers*
TABLE 6. DAILY FOOD EATEN PER STEER, COMPUTED ON THE BASIS OF 1000 POUNDS LIVE WEIGHT

December 7, 1896 to March 7, 1897—92 Days. Five Steers in Each Lot

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Kind of Food</th>
<th>Daily food offered, lbs.</th>
<th>Daily food consumed, lbs.</th>
<th>Daily dry matter consumed, lbs.</th>
<th>Per cent total food refused, lbs.</th>
<th>Actual gain or loss in steer weight per 1000 lbs. of live weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Timothy Hay</td>
<td>27.60</td>
<td>22.46</td>
<td>18.93</td>
<td>18.6</td>
<td>32.2</td>
</tr>
<tr>
<td>II</td>
<td>Whole Corn Stover</td>
<td>41.50</td>
<td>22.50</td>
<td>17.49</td>
<td>45.78</td>
<td>-11.8</td>
</tr>
<tr>
<td>III</td>
<td>Shredded Corn Stover</td>
<td>31.79</td>
<td>19.41</td>
<td>17.80</td>
<td>38.69</td>
<td>-15.6</td>
</tr>
<tr>
<td>IV</td>
<td>Siloed Corn Stover</td>
<td>58.25</td>
<td>57.77</td>
<td>14.68</td>
<td>.82</td>
<td>10.8</td>
</tr>
</tbody>
</table>

THIRD TRIAL—1897-8

A third experiment along this line was made in the winter of 1897-8, beginning January 1st. and closing March 15, 1898, covering a period of 74 days.

This was an exact duplicate of the one of the previous winter, in that one lot was fed Timothy Hay alone, another, Whole Stover; a third, Shredded Stover, and a fourth, Siloed Stover.

To these was added a fifth lot, which was fed equal parts of shredded stover and clover hay.

As in the former trials, no grain of any sort was given.

The Timothy was harvested when the seed was in the dough, cured in the ordinary manner, and stored in a stack in the open field, as in previous trials, and was of average quality.

The Stover, whole, shredded, and siloed, was prepared in the same manner as described in the report of the second trial.

The Clover Hay was cut when about one-third of the heads were brown, cured in the usual way, stored in a rick in the field, and hauled in and fed as required.

As in former trials, samples of the fresh substance and of the refuse material were drawn regularly throughout the experiment for the determination of moisture.
The cattle used were yearling Herefords, in thin to moderate flesh, weighing from 675 to 775 pounds.

As in former trials, the cattle were fed under an open shed, had access to an open lot, and had deep-well water in a trough before them.

**TABLE 7. TOTAL AMOUNT OF FOOD EATEN BY EACH LOT DURING THE EXPERIMENT**

<table>
<thead>
<tr>
<th>Kind of Food</th>
<th>Number steers</th>
<th>Total food offered, lbs.</th>
<th>Total food refused, lbs.</th>
<th>Total dry matter consumed, lbs.</th>
<th>Total gain or loss in live weight, lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy Hay</td>
<td>4</td>
<td>5372</td>
<td>636</td>
<td>3892.10</td>
<td>123</td>
</tr>
<tr>
<td>Whole Corn Stover</td>
<td>5</td>
<td>13166</td>
<td>5582</td>
<td>5925.31</td>
<td>69</td>
</tr>
<tr>
<td>Shredded Corn Stover</td>
<td>5</td>
<td>8159</td>
<td>2682</td>
<td>4555.60</td>
<td>*-39</td>
</tr>
<tr>
<td>Siloed Corn Stover</td>
<td>4</td>
<td>14067</td>
<td>1167</td>
<td>3226.91</td>
<td>309</td>
</tr>
<tr>
<td>Clover Hay and Shredded Corn Stover</td>
<td>4</td>
<td>18044</td>
<td>2446</td>
<td>4964.00</td>
<td>234</td>
</tr>
</tbody>
</table>

*The minus sign denotes loss.
†Clover offered, 3600 lbs.; Clover refused, 312 lbs. or 8.66 per cent. Shredded Stover offered, 4444 lbs.; Stover refused, 1934 lbs. or 43.56 per cent.

**TABLE 8. DAILY FOOD CONSUMED PER STEER, JANUARY 1, 1898 TO MARCH 15, 1898—74 DAYS**

<table>
<thead>
<tr>
<th>Kind of Food</th>
<th>Average live weight per steer, lbs.</th>
<th>Daily food offered per steer, lbs.</th>
<th>Daily food refused per steer, lbs.</th>
<th>Daily dry matter consumed per steer, lbs.</th>
<th>Per cent food refused, lbs.</th>
<th>Gain or loss in live weight, lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy Hay</td>
<td>736</td>
<td>18.15</td>
<td>2.15</td>
<td>16.00</td>
<td>13.15</td>
<td>11.84</td>
</tr>
<tr>
<td>Whole Corn Stover</td>
<td>707</td>
<td>35.57</td>
<td>15.10</td>
<td>20.47</td>
<td>16.01</td>
<td>42.45</td>
</tr>
<tr>
<td>Shredded Corn Stover</td>
<td>667</td>
<td>22.03</td>
<td>7.25</td>
<td>14.78</td>
<td>12.31</td>
<td>32.91</td>
</tr>
<tr>
<td>Siloed Corn Stover</td>
<td>743</td>
<td>47.53</td>
<td>3.94</td>
<td>43.59</td>
<td>10.90</td>
<td>8.29</td>
</tr>
<tr>
<td>Shredded Corn Stover and Clover Hay</td>
<td>771</td>
<td>27.18</td>
<td>7.59</td>
<td>19.59</td>
<td>16.76</td>
<td>27.92</td>
</tr>
</tbody>
</table>

17
TABLE 9. AVERAGE DAILY FOOD CONSUMED PER STEER, COMPUTED ON THE BASIS OF 1000 POUNDS LIVE WEIGHT

January 1, 1898, to March 15, 1898—74 Days

<table>
<thead>
<tr>
<th>Kind of Food</th>
<th>Food offered per day, lbs.</th>
<th>Food consumed per day, lbs.</th>
<th>Dry matter consumed per day, lbs.</th>
<th>Actual gain or loss in live weight, lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timothy Hay</td>
<td>24.66</td>
<td>21.74</td>
<td>17.82</td>
<td>30.8</td>
</tr>
<tr>
<td>Whole Corn Stover</td>
<td>50.31</td>
<td>28.95</td>
<td>22.64</td>
<td>13.8</td>
</tr>
<tr>
<td>Shredded Corn Stover</td>
<td>33.03</td>
<td>22.13</td>
<td>18.46</td>
<td>7.7</td>
</tr>
<tr>
<td>Siloed Corn Stover</td>
<td>63.97</td>
<td>58.67</td>
<td>14.67</td>
<td>77.2</td>
</tr>
<tr>
<td>Shredded Corn Stover and Clover Hay</td>
<td>34.98</td>
<td>25.21</td>
<td>21.58</td>
<td>58.4</td>
</tr>
</tbody>
</table>

FOURTH TRIAL—1898-99

The fourth test of the value of Corn Stover and Timothy Hay for wintering yearling steers without grain was begun December 20, 1898, and continued until February 24, 1899, covering a period of 66 days, with yearling high-grade Hereford steers, weighing about 650 pounds. The cattle were what would be regarded as thin when the experiment began.

In all respects the conditions were essentially the same as reported in previous trials. The results are as follows:
### TABLE 10. TOTAL AMOUNT OF FOOD EATEN AND GAIN OR LOSS IN LIVE WEIGHT

December 20, 1898 to February 24, 1899—66 Days. Four Yearling Steers in Each Lot

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot II</td>
<td>Timothy Hay</td>
<td>649</td>
<td>4120</td>
<td>480</td>
<td>3640</td>
<td>11.6</td>
<td>3120</td>
<td>-30</td>
</tr>
<tr>
<td>Lot IV</td>
<td>Whole Corn Stover</td>
<td>627</td>
<td>8012</td>
<td>3238</td>
<td>4774</td>
<td>40.4</td>
<td>3398</td>
<td>-200</td>
</tr>
<tr>
<td>Lot V</td>
<td>Whole Stover and Clover Hay</td>
<td>666 <em>7208</em></td>
<td>1884</td>
<td><em>5324</em></td>
<td><em>26.1</em></td>
<td><em>4155</em></td>
<td><em>24</em></td>
<td>*</td>
</tr>
</tbody>
</table>

*Whole Stover offered, 4060 lbs.; eaten, 2560 lbs.; refused, 1500 lbs.; per cent refused, 36.9. Clover Hay offered, 3148 lbs.; eaten, 2764 lbs.; refused, 384 lbs.; per cent refused, 12.2.

†Dry matter consumed in Stover, 1813 lbs.; Dry matter consumed in Clover, 2352 lbs.

### TABLE 11. AVERAGE DAILY FOOD CONSUMED PER STEER

December 20, 1898 to February 24, 1899—66 Days. Four Yearling Steers in Each Lot

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Kind of Food</th>
<th>Food offered daily Per</th>
<th>Food eaten daily Per</th>
<th>Dry matter eaten daily Per</th>
<th>Per cent of total food refused.</th>
<th>Daily gain or loss in live weight.</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>Timothy Hay</td>
<td>15.61</td>
<td>13.8</td>
<td>11.82</td>
<td>11.6</td>
<td>-.11</td>
</tr>
<tr>
<td>IV</td>
<td>Whole Corn Stover</td>
<td>30.35</td>
<td>18.1</td>
<td>12.87</td>
<td>40.4</td>
<td>-.76</td>
</tr>
<tr>
<td>V</td>
<td>Whole Corn Stover and Clover Hay</td>
<td>27.3</td>
<td>20.2</td>
<td>15.78</td>
<td><em>26.1</em></td>
<td>.09</td>
</tr>
</tbody>
</table>

*Of the combination of Clover and Stover, 36.9 per cent of the Stover fed was refused, and 12.2 per cent of the Clover.
SUMMARY

It will be profitable to consider together the results of the four years' experiments with roughnesses of various kinds when fed without grain. Altogether fourteen lots of animals were involved, the experiments extended over four years, and included:

Four trials of Whole Corn Stover versus Timothy Hay.
Two trials of Shredded Stover versus Whole Stover.
Two trials of Siloed Corn Stover versus Whole and Shredded Stover.
Two trials of equal parts Corn Stover and Clover Hay versus Timothy Hay.

I. The Feeding Value of Timothy Hay Without Grain

On the basis of the results reported in the preceding tables it may be said that yearling steers when in thin condition and after having lost what the farmer terms "grass sap," which in practice usually occurs before the animals leave the pasture, may be wintered on timothy hay without any grain whatever and make a small gain in live weight. That is, timothy hay of average quality is nutritious enough to a little more than maintain animals of this class and in this condition.

The gain made, however, is small, varying from a slight loss in one experiment, when the winter was particularly unfavorable, to a considerable gain when the quality of the hay was good, and the winter was dry, bright and crisp but moderate.

The whole gain for the four years was 85 pounds for one steer in 281 days, or the equivalent of a gain of 54 pounds per steer for a six months wintering period, from November 1st to April 30th. It is believed that this is as high as would occur in actual practice.

To accomplish this, yearling steers weighing an average of 750 pounds will, on the basis of our four years' experiments, consume and waste an average of 18.25 pounds of hay per day. This is the actual average amount offered in our experiments covering four years, when computed on the
basis of steers weighing 750 pounds. It is true that some of this was wasted, mainly because of the presence of weeds, etc., but as the hay was of average quality and that portion refused was worthless except for bedding, it is fair to charge the entire amount fed, so long as it was not fed wastefully.

On this basis, it would require for a six months' wintering period, or from November 1st to April 30th, 3285 pounds of hay, for which, as has already been pointed out, we should have an increase of 54 pounds in the live weight of the animal. Estimating hay at $6.00 per ton, we have a charge of $9.85, and a credit, at 5 cents per pound, which is low enough for gains made in winter, of $2.70, due to gain in live weight, leaving a net deficit of $7.15 per head, chargeable to the cost of wintering, or practically $1.00 per hundred pounds of weight of the steer. This means that if the steer had been purchased at 4 cents a pound in the fall, and wintered on timothy hay alone, he would have to bring 5 cents a pound at grass to merely balance accounts. This is on the assumption that the labor saved by feeding the hay at home over baling and hauling it to a local shipping point would on the average fully offset the labor of feeding and caring for the animal.

In other words, as will be shown in more detail elsewhere in this bulletin, the making of gains in winter are expensive, even when what has always been supposed to be cheap material like hay is used exclusively, and that what the feeder calls the margin of profit, which is so essential in the fattening of cattle, is likewise essential in making profitable gains when animals are lightly fed in winter.

That this margin of profit is necessary to balance accounts in full feeding operations, has been clearly shown in a large number of feeding experiments and is well established in practical experience. It has not generally been emphasized, however, that this law applies in the case of cattle which are being wintered on what has been popularly supposed to be very cheap material, like coarse fodders and hays, or when given in addition to this coarse material a limited amount of grain, making what has always been popularly considered cheap gains.
II. The Feeding Value of Whole Corn Stover Without Grain

From our four years' study of this problem, it appears that yearling steers somewhat thin in flesh when fed all the coarse whole field-cured corn stover they would eat would scarcely be able to maintain their weight. The gain or loss per head on this ration for the different seasons is as follows:

First trial, loss ....................... 2 lbs.
Second trial, loss ..................... 12 "
Third trial, gain ....................... 14 "
Fourth trial, loss ..................... 50 "
Total loss in 281 days ................. 50 "
Loss in six months ................... 33 "

It will be observed that practically all of the loss occurred in the fourth trial, which was conducted under especially unfavorable circumstances. The stover was very coarse and badly leached out, and the weather during the trial was exceptionally unfavorable for all classes of live stock. It was during this period that the only loss in live weight which we had from feeding timothy hay alone occurred. In truth in this winter all of our lots of cattle on roughness alone, with the exception of one having a combination of clover and stover, showed a loss in weight. It is quite probable, therefore, that our results are low enough for stover. In fact, under ordinary management steers may be maintained without loss on field-cured corn stover, and under specially good management a gain equal to that reported for timothy hay will be possible. But to produce stover of a quality capable of making even a slight gain would entail some sacrifice of the yield of grain perhaps, by cutting it a little earlier than would be necessary where grain is the primary object sought, and it is not that class of stover which we desire to consider in this connection, but such stover as is produced under the average farm conditions in Missouri.

It will be interesting to note the amount of stover eaten and the amount of waste, as shown by our experiments, all computed on the basis of steers of uniform weight of 750 pounds, as was the case with timothy hay.
DAILY CONSUMPTION OF WHOLE STOVER PER STEER, ON BASIS OF 750 POUNDS LIVE WEIGHT

<table>
<thead>
<tr>
<th>Trial</th>
<th>Offered lbs</th>
<th>Eaten lbs</th>
<th>Refused per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>First trial</td>
<td>29.25</td>
<td>19.11</td>
<td>34.69</td>
</tr>
<tr>
<td>Second trial</td>
<td>31.12</td>
<td>16.86</td>
<td>45.78</td>
</tr>
<tr>
<td>Third trial</td>
<td>37.74</td>
<td>21.72</td>
<td>42.45</td>
</tr>
<tr>
<td>Fourth trial</td>
<td>36.30</td>
<td>21.63</td>
<td>40.40</td>
</tr>
<tr>
<td>Average</td>
<td>33.60</td>
<td>19.83</td>
<td>40.98</td>
</tr>
</tbody>
</table>

In other words, the average ration for the yearling steer weighing 750 pounds was 33.6 pounds of stover of which 19.83 was eaten, leaving 13.77 pounds, or 41 per cent. as refuse or waste material.

On the basis of the amount offered there will be required for a six months' wintering period 6048 pounds, or in round numbers, three tons per head. It is true that only 3570 pounds of this was eaten, and that 2478 pounds was refused, but as this refuse material is of value only for bedding and manure, it is fair to charge it as a part of the cost of wintering the steers.

At $2.00 per ton for this stover—about what it costs to cut and cure it, including the extra cost of husking the corn and not estimating anything for the diminution in the yield of grain due to cutting the corn instead of allowing it to fully mature on the stalk—we have a total cost per head for feed for six months wintering period at $6.00 per steer.

Inasmuch as each steer on the average in our experiment lost 33 pounds in live weight, we should add this to the cost, which, at 5c per pound, is $1.65, making $7.65 per head as the total cost of feed and loss in weight chargeable to wintering when whole corn stover is used.

On the basis of $6.00 per ton for timothy hay, and $2.00 for whole stover, when fed alone, the advantage in
economy of wintering is slightly in favor of timothy. The timothy steers showed a deficit of $7.15 per head, and the stover steers $7.65, or a difference of 50c per head for the winter. To equalize, then, the timothy would need to be estimated at about $6.20 instead of $6.00 per ton, assuming that the steers when eating timothy hay alone will gain 54 pounds each during the winter, and that those having whole stover alone will lose 33 pounds each.

Broadly speaking, therefore, it may be said that one ton of timothy hay is worth as much as three tons of whole corn stover, when each is fed as an exclusive ration.

As has already been pointed out, cattle of this sort may be wintered on stover of average quality, one year with another, with practically no loss of weight. This, then, would make a slightly better showing for stover than for timothy, although the difference is not large enough to be important.

III. The Feeding Value of Shredded Stover Without Grain

In two of the four years covered by these tests, a comparison between shredded stover and whole corn stover, with yearling cattle in thin condition was made.

The gain or loss in live weight from the two rations is shown in the following summary:

GAIN OR LOSS IN LIVE WEIGHT PER STEER ON WHOLE AND ON SHREDDED STOVER.

<table>
<thead>
<tr>
<th>Trial Type</th>
<th>Days</th>
<th>Whole Stover, loss</th>
<th>Shredded Stover, loss</th>
<th>Whole Stover, gain</th>
<th>Shredded Stover, loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Trial</td>
<td>92 days</td>
<td>12 lbs.</td>
<td>16 lbs.</td>
<td>14 lbs.</td>
<td>8 lbs.</td>
</tr>
<tr>
<td>Second Trial</td>
<td>74 days</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Both Trials</td>
<td>166 days</td>
<td>2 lbs.</td>
<td>24 lbs.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The surprise of the experiment was that the shredded stover was less efficient than the unshredded material, or that apparently, instead of enhancing its feeding value, shredding appeared to depreciate it.
Upon a moment's reflection it becomes apparent that this should be the case, for the following reasons:

The parts of the plant outside the ear which have a real nutritive value worth considering are the blades, the husks, and the finer portion of the stalk near the tassel when this has not been too badly weathered. All of these parts are more readily available to the animal and are in a form quite as convenient for consumption and utilization before being shredded as afterwards. The tearing into shreds of these parts of the plant does not in any way apparently improve their palatability, enhance their feeding value, or materially reduce the labor necessary to be expended by the animal in masticating and digesting them.

One other portion of the plant which, when finely ground, has considerable nutritive value is the hard shell or case surrounding the stalk. In its natural state, however, it is practically worthless, for the reason that animals, unless driven almost to the point of starvation, will not eat it. The tearing of it into slivers, as is the case when stover is shredded is not sufficient. The animals will, when nourished to the ordinary degree, still refuse to eat this part of the plant. To make this shell available, it is necessary to reduce it to something near the consistency of sawdust or bran. The cost of this process is of course wholly out of proportion to the value of the product obtained.

The portion of the plant encased by this shell, commonly known as the pith, is made very much more available to the animal by the shredding process. This pith, however, is almost pure cellulose, and is wholly unpalatable to animals except on the verge of starvation, and from every point is, to say the least, practically worthless as a feed, and the animal, if given the opportunity, will discard it. The shredding of the stover so intermingles the blades, husks, outer shell, and pith of the plant as to give the animal less opportunity for the selection of those portions which are palatable and for the discarding of the others than when the plant is fed whole. Therefore even against the wishes and perhaps welfare of the animal, it is forced to eat more or less of the pith.
That is to say, this pith possibly exerts a deleterious effect in two important ways, namely:

It swells enormously when moistened. On account of this fact, pure cellulose manufactured from this pith is used for the packing of war vessels, so that if the sides of the ship are punctured, the water as it flows into the vessel will moisten the layers of cellulose in the walls and this cellulose swells so rapidly and enormously as to close the opening and prevent the vessel from leaking further. The tendency among animals in consuming coarse fodders of this sort is to drink frequently and to drink immediately after eating. When they have, therefore, eaten even a small quantity of this cellulose, as they must when consuming shredded stover, and have taken a drink, the material swells to such an extent as to fill the paunch and the animal has no desire to eat more.

This is clearly brought out in our trials, for it will be noted that in the first trial the steers ate 22.50 pounds of whole stover per 1000 pounds of live weight and only 19.41 pounds of shredded stover. In the dry matter consumed in this case, however, there was practically no difference. In the second trial, when the difference in the effect of the two rations was much more marked than in the first, the whole stover steers ate daily per thousand pounds of live weight 28.30 pounds, as compared with 22.13 pounds for the shredded stover lot. In dry matter, the whole stover steers ate daily 22.64 pounds, as against 18.46 for the shredded stover lot, or 22.6 per cent more. This alone perhaps would be sufficient to account for the whole stover steers making a gain of 14 pounds each, while the shredded stover lot lost 8 pounds.

In another important way this pith may exert a deleterious effect. A certain amount of energy is required for the mastication, digestion and assimilation of any food stuff. In general, the concentrated food stuffs such as grains are much more easily masticated and digested than are the coarse feeds like hay, fodders, straws, etc. In fact, in the case of some of the poorer coarse fodders there is left almost no net available energy. That is, the small amount of energy supplied by the food may be entirely used up in
masticating, digesting and assimilating it, leaving nothing for production. In the case of this pith it is possible that it is even so poor as to have a negative value. That is, the amount of nutriment that the animal can derive from it is smaller than the energy required to get it out. Instead, therefore, of this material nourishing the system, it is not unreasonable to suppose that it is a tax upon it.

Relative Amounts of Shredded and Whole Stover Refused

It is commonly supposed by those who have had no experience in the matter that in order to induce the stock to eat the whole of the corn stover it is only necessary to shred it. Our results show that almost as much of the material was refused by the animals when shredded as when fed whole, notwithstanding the fact that the animals were offered a considerably less quantity of the shredded than of the whole material. In the first trial the per cent of whole stover refused was 45.78; of the shredded, 38.67.

In the second trial the per cent of whole stover refused was 42.45; of the shredded stover, 32.91.

In the light of these facts, it does not appear that the outlay of labor and money for the shredding of stover can be justified on the ground of enhancement of its feeding value. It is safe to say that this is too cheap a material in the corn belt to warrant the expenditure of much money in an attempt at increasing its feeding value. The investment of this extra money in cutting up and saving more stover will undoubtedly bring better returns than in attempting to improve the quality of the quantity that is now ordinarily harvested and saved.

It does not necessarily follow from this that shredding is an unwarranted practice. If the corn may be husked and the stover shredded at a very slight increase in cost over that of husking by hand, the practice must commend itself to every farmer, on account of the greater convenience with which the material may be handled and fed, and the ability to preserve the material from damage by rains, etc. Not only so, but the greatest single objection to the present
method of handling stover is the difficulty of getting it out of the field during the winter and early spring months without injury to the land and the growing wheat crop, which is often sown in the corn in autumn.

Moreover, shredding undoubtedly relieves the farmer of one of the most disagreeable tasks on the farm—the handling of the coarse stalks in bad weather, and relief from the necessity of digging this material out of the snow in winter. Likewise, it also makes it possible to feed the material under a shed or in the barn, using the portion refused by the stock for bedding, and still have the manure in a condition to be handled easily by a manure spreader.

In short, the shredding process may be justified on the grounds of greater convenience, rather upon that of the enhancement of its feeding value.

IV. The Feeding Value of Siloed Stover Without Grain

Two trials have been made with siloed stover. This should not be confused with silage made from the entire plant, including the ear.

The object in making this experiment was to ascertain whether the siloing process might in any way increase the palatability of this material to the extent of inducing the animals to eat larger quantities. This was on the theory that with a coarse and unpalatable material like corn stover the animals do not under ordinary circumstances eat enough to sustain them without loss in weight, much less to make a gain, and that if some cheap and satisfactory means might be discovered for increasing the palatability of the ration so that they would consume larger quantities the material might be much more efficiently used by the animal.

The results show that the animals ate the siloed stover with very little waste in the first trial, consuming practically the entire amount offered. In the second trial, when they were fed somewhat more liberally, they refused 8 per cent, as compared with 42 per cent for whole stover, and 32 per cent for shredded stover. To our great surprise, however, they consumed a smaller amount of dry matter daily than
did the animals receiving whole stover or shredded stover. Unfortunately, the amounts offered were not such as to make the comparison strictly fair. What would have been the result with respect to the dry matter consumed had the silage lot in each trial been fed as liberally as were the whole stover and shredded stover lots, that is, if they had been fed so that they would have shown the same percentage of refuse material, cannot be determined by our data. The value of silage for the wintering of cattle will be discussed in another Bulletin and in the light of subsequent and much more exhaustive trials.

V. The Feeding Value of a Combination of Stover and Clover Hay Without Grain.

Stover, when fed alone, is notably deficient in available proteids. In this respect it is considerably behind timothy. It was sought to determine what effect the addition of a limited quantity of clover hay would have on the efficiency of a corn stover ration as compared with stover alone, and as compared with timothy hay.

In both trials this combined ration produced much better results than did shredded or whole stover, and better results than were obtained from feeding timothy hay alone.

It will be observed that in the first trial with this combination, the gain per steer was 58.4 pounds, as compared with 30.8 pounds with timothy hay, and in the second trial the gain from stover and clover hay was 6 pounds per steer, as compared with a loss of 7.5 pounds with timothy hay alone.

In the second trial, the lot receiving this combined ration was the only lot receiving no grain that made a gain.

In the light of these results, it may be concluded that equal parts of corn stover and clover hay will produce materially better results than will clear timothy hay.

That the enhancement of the feeding value of stover by adding some material relatively rich in protein is feasible and profitable is, in the light of our results, evident. It will, however, be much more strikingly shown by the results of other experiments, where a small quantity of corn was given in addition to the coarse fodder.
COMPARISON OF DIFFERENT KINDS OF ROUGHNESS FOR WINTERING CATTLE, WHEN COMBINED WITH A LIMITED AMOUNT OF GRAIN

Under this head are presented the results of four years' work in wintering cattle on various coarse fodders when combined with a limited amount of grain.

The grain used in nearly all cases was shelled corn, and the amount given has varied from four to six pounds, or somewhat more than two quarts per day per head for a yearling steer weighing about 750 pounds. In all cases the animals were given all the roughness they would eat of the kind indicated.

The methods of conducting the test, weighing feed and cattle, and of drawing samples for the determination of moisture, etc., have already been fully outlined.

First Trial—1898-9

This trial began December 20, 1898, and was continued until February 24, 1899, therefore extending over 66 days. Four yearling Shorthorn steers of good quality, rather thin in flesh, constituted each lot. They had access to a shed open to the east and to open lots, with deep-well water accessible at all times. They were fed as follows.

Lot II. Timothy Hay, Without Grain.
Lot IV. Corn Stover, Without Grain.
Lot V. One-half Corn Stover; one-half Clover Hay, without grain.
Lot VI. Corn Stover and 4 lbs. Mixed Grain daily consisting of three parts Corn Meal, two parts Cottonseed Meal.
Lot VII. Corn Stover and 4 lbs. of Corn Meal daily.

The Stover was field cured and was set up in 16-hill square shocks and allowed to remain in the field until required for feeding, and was fed whole.

The Timothy and the Clover were of average quality, made without rain, and stored in ricks in the open field until used in the experiment.

The following table gives a summary of the results:
### TABLE 12. DECEMBER 20, 1898, TO FEBRUARY 24, 1899—66 DAYS. FOUR YEARLING SHORTHORN STEERS IN EACH LOT. FOUR POUNDS GRAIN PER HEAD DAILY. ROUGHAGE AD LIBITUM

<table>
<thead>
<tr>
<th>Lot</th>
<th>Ration</th>
<th>Average weight of steers</th>
<th>Grain consumed per lot</th>
<th>Roughage offered per lot</th>
<th>Roughage eaten per lot</th>
<th>Percent roughage refused</th>
<th>Total gain per lot</th>
<th>Average daily gain per steer</th>
<th>Cost of food offered per steer</th>
<th>Value of gain at 5c per pound</th>
<th>Profit or loss per steer</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Timothy Hay (No grain)</td>
<td>648</td>
<td>4120</td>
<td>3640</td>
<td>11.7</td>
<td>-30</td>
<td>.11</td>
<td>$3.09</td>
<td>$.37</td>
<td>$-3.46</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Whole Corn Stover (No grain)</td>
<td>627</td>
<td>8012</td>
<td>4774</td>
<td>46.0</td>
<td>-200</td>
<td>.75</td>
<td>$2.00</td>
<td>$-2.50</td>
<td>$-4.50</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>1/2 Whole Corn Stover, 1/2 Clover Hay (No grain)</td>
<td>666</td>
<td>7208*</td>
<td>5324*</td>
<td>26.1</td>
<td>24</td>
<td>.09</td>
<td>$3.41</td>
<td>$ .30</td>
<td>$-3.11</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>4 lbs. mixed grain.† Whole corn stover</td>
<td>687</td>
<td>1016†</td>
<td>7990</td>
<td>5362</td>
<td>32.9</td>
<td>204</td>
<td>$.77</td>
<td>$4.31</td>
<td>$ 2.55</td>
<td>$-1.76</td>
</tr>
<tr>
<td>V</td>
<td>4 lbs. corn meal. Whole corn stover</td>
<td>645</td>
<td>1016</td>
<td>7734</td>
<td>4470</td>
<td>42.1</td>
<td>-85</td>
<td>-.32</td>
<td>$3.74</td>
<td>$-1.05</td>
<td>$-4.79</td>
</tr>
</tbody>
</table>

*In the combination of Clover and Stover, 4060 lbs. Stover and 3148 lbs. Clover were offered, of which 2560 lbs. Stover and 2764 lbs. Clover were eaten, leaving as refuse: Stover, 1500 lbs., or 37 per cent, and 384 lbs. Clover, or 12 per cent of the whole amount offered.

†610 lbs. Corn Meal; 406 lbs. Cottonseed Meal.
The results of those lots which received no grain have been fully discussed under the fourth trial without grain in their bearing upon the various methods of wintering cattle in that way. Inasmuch as these animals were fed in connection with animals having a limited grain ration, it will be interesting to make some comparison of these two methods of wintering cattle and to compare two important sources of protein.

We have here, in other words, a comparison of stover alone and of stover and four pounds of corn meal daily, and of stover and four pounds of grain, consisting of 3 parts corn meal and 2 parts cottonseed meal daily. It will be seen that the cattle having stover alone lost 200 pounds, or an average of something like three-fourths of a pound daily per head. Those receiving all of the stover they would eat and four pounds of corn meal daily per head, ate very little less stover—some 300 pounds—out of a total of nearly 5000 pounds. Strange to say, however, this amount of corn meal, combined with stover, was not sufficient in the very severe weather during which this experiment was conducted to sustain the animals without loss of weight. By the addition of 4 lbs. of corn meal daily per head, however, this loss was reduced to 85 pounds per lot, as compared with 200 pounds for cattle on stover alone.

It will be noted, however, that when the mixed grain was substituted for corn meal alone, the mixture consisting of three parts corn meal and two parts cottonseed meal, the effect was very striking both in the amount of stover eaten and in the effect upon the live weight of the animals. Instead of diminishing slightly the amount of stover consumed as was the case when corn meal alone was given with stover as compared with stover alone, the addition of the cottonseed meal to the ration, with its available protein, had the effect, as is always the case, of stimulating the appetite. This as is usually the case has the effect of increasing materially the amount of roughness consumed. This is noted in the fact that the steers without any grain whatever consumed 4774 pounds of stover, while those with four pounds of corn meal daily and all the stover they would eat consumed 4470 pounds, or as has already been pointed out,
about 300 pounds less, while the lot of steers having a mixed grain ration consumed 5362 pounds of stover, or some 500 pounds more. Then, again, instead of losing 200 pounds, as did the steers without grain, or 85 pounds, as did those having four pounds of corn meal, the steers on this ration of mixed grain and corn stover gained 204 pounds.

Therefore by replacing two-fifths of the corn meal by that amount of cottonseed meal, and giving the steers all the stover they would eat a gain of three-fourths of a pound a day was made, while the steers on exactly the same amount of grain in the form of corn meal and with all the stover they would eat lost one-third of a pound daily. This means that the substitution of 1 2-3 pounds of cottonseed meal a day for an equal amount of corn meal made a total difference on the animal of more than a pound a day. Rating this gain or loss in live weight at 5 cents a pound, it is evident that each 1 2-3 pounds of cottonseed meal brought a return of 5 cents.

Attention has already been called to the influence that the protein in a cheap form like clover exerts upon the efficiency of the ration. It will be interesting to note in this trial that in the combination of clover and stover without grain the protein stimulated the appetite as it did in the case of the cottonseed meal, as shown by the fact that 5324 pounds of clover and stover were consumed, as compared with 4774 pounds of straight stover, and instead of the animals losing 200 pounds, as did those on straight stover, they gained, on a combination of clover and stover, 24 pounds per lot, or an average gain of something like one-tenth of a pound daily, as compared with a loss of three-fourths of a pound daily on stover alone. This will be referred to again at more length when the results of other experiments along this line have been presented.

It will be interesting to compare the results obtained from these various rations with that secured from timothy hay alone.

Note that a combination of a limited quantity of corn meal with stover was really not more effective than timothy without grain; but of more significance is the fact that a combination of clover with this stover was much more effective
than the timothy, and as has already been pointed out, materially more efficient than the small quantity of corn meal and stover.

This means that with stover as the chief food supply, and the farmer has the choice of adding a small quantity of corn or a half allowance of clover, in point of both efficiency and economy the stover-clover combination will be preferable. Such combinations as corn and stover, corn and straw, or millet, etc., should in the interest of economy be avoided.

Considering these results particularly in the light of those that are to follow, it is well to bear in mind that these experiments covered a period of the severest cold ever known in this latitude, when the mercury for some ten days was not above zero, and registered a minimum of some 26° below zero. The low efficiency of the food in comparison with other seasons is largely explained by this fact.

It will be interesting to compute these results on the basis of a six months' wintering period, from November 1st to May 1st. These data are, therefore, given in the following table:
TABLE 13. TOTAL FOOD CONSUMED AND GAIN OR LOSS ON STEERS, COMPUTED FOR A SIX MONTHS' WINTERING PERIOD, FROM NOVEMBER 1ST TO APRIL 30TH—180 DAYS

<table>
<thead>
<tr>
<th>Lot</th>
<th>Ration</th>
<th>Average weight of cattle</th>
<th>Cost of grain eaten per steer</th>
<th>Cost of roughage offered per steer</th>
<th>Total cost of food per steer for 180 days</th>
<th>Total gain in wt. per steer for 180 days</th>
<th>Value of gain in weight at 50¢ per lb.</th>
<th>Profit or loss in wintering process</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>Timothy Hay (No grain)</td>
<td>648</td>
<td>8.42</td>
<td>8.42</td>
<td>- 20.0</td>
<td>$ -1.00</td>
<td>$ - 9.42</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Whole Corn Stover (No grain)</td>
<td>627</td>
<td>5.46</td>
<td>5.46</td>
<td>-125.0</td>
<td>$ -6.25</td>
<td>$ -11.71</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>½ Whole Corn Stover; ½ Clover Hay (No grain)</td>
<td>666</td>
<td>9.24</td>
<td>9.24</td>
<td>16.4 $</td>
<td>.82</td>
<td>$ - 8.44</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>4 lbs. Mixed Grain;* Whole Corn Stover ad libitum</td>
<td>687</td>
<td>6.29</td>
<td>5.44</td>
<td>11.73</td>
<td>139.0 $</td>
<td>6.95</td>
<td>$ - 4.78</td>
</tr>
<tr>
<td>VII</td>
<td>4 lbs. Corn Meal; Whole Corn Stover ad libitum</td>
<td>645</td>
<td>4.95</td>
<td>5.27</td>
<td>10.22</td>
<td>- 57.6 $</td>
<td>-2.88</td>
<td>$ -13.08</td>
</tr>
</tbody>
</table>

*Mixed Grain consisted of 3 parts corn and 2 parts Cottonseed Meal.

In the above computations, the following values for feed are used, which are approximately the prices that prevailed at the time the trial was conducted: Corn, 40¢ per bushel; Hay, $6.00 per ton; Stover, $2.00 per ton; Cottonseed Meal, $24.00 per ton.
Second Trial—1899-1900

Twenty yearling grade Hereford steers, of moderate flesh, were divided into five lots of four animals each, and the experiment was begun December 30, 1899, and continued until April 10, 1900—101 days. The cattle were fed as follows:

Each steer in every lot (except Lot VII.) received four pounds of shelled corn daily, and in addition:
- Lot II. Timothy hay.
- Lot IV. One-half corn stover; one-half clover hay.
- Lot VI. Cowpea hay.
- Lot VII. Cowpea hay (No grain).

The animals were fed in a shed open to the east, had free access to open lots, with deep-well water before them constantly.

There was a preliminary period of some 20 days preceding the opening of the experiment.
<table>
<thead>
<tr>
<th>Lot</th>
<th>Ration</th>
<th>Average weight of cattle</th>
<th>Corn eaten per lot</th>
<th>Roughage offered per lot</th>
<th>Roughage eaten per lot</th>
<th>Per cent of roughage refused</th>
<th>Total gain per lot</th>
<th>Average daily gain per steer</th>
<th>Cost of food offered per 100 lb. gain</th>
<th>Value of gain per steer</th>
<th>Profit or loss per steer</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>4 lbs. Shelled Corn; Timothy Hay ad libitum</td>
<td>765</td>
<td>1612</td>
<td>7058</td>
<td>6743</td>
<td>4.4</td>
<td>262</td>
<td>.65</td>
<td>$12.44</td>
<td>$8.17</td>
<td>$3.25</td>
</tr>
<tr>
<td>IV</td>
<td>4 lbs. Shelled Corn; 1/2 Stover, 1/2 Clover</td>
<td>767</td>
<td>1612</td>
<td>9352*</td>
<td>7224*</td>
<td>—</td>
<td>357</td>
<td>.88</td>
<td>$7.90</td>
<td>$7.05</td>
<td>$4.45</td>
</tr>
<tr>
<td>VI</td>
<td>4 lbs. Shelled Corn; Cowpea Hay ad libitum</td>
<td>783</td>
<td>1612</td>
<td>8008</td>
<td>7757</td>
<td>3.0</td>
<td>622</td>
<td>1.54</td>
<td>$5.71</td>
<td>$8.89</td>
<td>$7.75</td>
</tr>
<tr>
<td>VII</td>
<td>Cowpea Hay (No grain)</td>
<td>788</td>
<td>—</td>
<td>8318</td>
<td>8048</td>
<td>3.3</td>
<td>228</td>
<td>.56</td>
<td>$10.94</td>
<td>$6.24</td>
<td>$2.85</td>
</tr>
</tbody>
</table>

*In the combination of Stover and Clover, 5684 lbs. Stover and 3668 lbs. Clover were offered, of which 3631 lbs. Stover and 3593 lbs. Clover were eaten, leaving as refuse: Stover, 2053 lbs., or 36 per cent of the amount offered, and Clover, 75 lbs., or 5 per cent of the amount offered.

†For prices of foods see foot note to Table 13, p. 35.
The results of this trial seem to be in all respects trustworthy. The experiment was begun December 30, 1899, and continued until April 10, 1900. In other words, it began at a time when in ordinary farm practice the grass held over from summer is exhausted, when the stalk fields have been eaten out, and when the farmer is obliged to feed his cattle from the hay and grain produced the previous summer. It closed at the earliest moment (April 10) that in this latitude could be depended upon, even in unusual seasons, for good pasture. That is to say, the experiment covered the precise period of the year that the farmer must feed his stock cattle.

It will be observed that there was a very striking difference in the gains made on the different rations. For example, 4 pounds of shelled corn, when combined with timothy hay, made an average gain of about two-thirds of a pound daily per steer, while the same amount of corn, when combined with cowpea hay, produced more than 1½ pounds daily. In other words, the combination of cowpea hay and shelled corn was more than twice as efficient as was the combination of timothy hay and corn.

In passing, it may be well to note that the animals ate more cowpea hay than they did timothy. The average daily consumption of timothy hay per steer was 16.7 pounds, while the steers having cowpea hay ate 19.2 pounds. Attention has already been called to the fact that whenever the protein content of a ration is increased over a basal ration of corn and timothy, the appetite is stimulated and a larger consumption of feed is the result.

It will be noted that four pounds of shelled corn and one-half clover and one-half corn stover produced a total gain of 357 pounds, as compared with 262 pounds for corn and timothy hay. Here, as in all previous trials, a mixture of one-half clover and one-half corn stover for roughness, either fed alone or in combination with grain, has been more efficient and necessarily considerably cheaper than straight timothy.

It is interesting to note the gain of the lot having cowpea hay without grain, in comparison with other lots which had four pounds of shelled corn and different sorts of roughness. It will be recalled that this limited grain ration
when combined with cowpea hay produced 622 pounds of gain, whereas the steers without the grain and eating all the cowpea hay they would, made a gain of 228 pounds. The average daily gain for four pounds of corn and cowpea hay was 1.54, and for cowpea hay alone was .56.

Considering the winter period of feeding alone, and disregarding entirely the behavior of the cattle in the following summer on grass, or assuming that they would gain equally well the following summer, it paid handsomely to add corn to the ration, even though the steers went through the winter in a thrifty condition and made a fair gain on the hay alone. That is to say, the difference between the gain of the two lots was 394 pounds. The difference in the feed was 28.8 bushels of corn. To state the case absolutely accurately, the lot of cattle having the corn were offered 310 pounds less hay, worth, at the current market price, approximately $1.00. Disregarding this, however, we have an extra gain of 394 pounds, worth, at 5c a pound, $19.70, which may be fairly attributed to the use of 28.8 bushels of corn. This means that the corn brought practically 70c a bushel, as compared with the returns from feeding the hay without grain.

Stating the case differently the cost per 100 lbs. of gain was $5.71 on corn and cowpea hay and $10.94 or almost double on the hay ration alone. Here, as in general, when the ration is made nutritious enough to insure large or rapid gains the cost of the gain is reduced and vice versa. This as has already been pointed out appears true even when coarse and so-called cheap fodders are used for the small gains and the larger gains are made from the so-called high priced grains.

It is interesting to note that the steers gained almost as much, however, on cowpeas alone as did those having 4 lbs. of shelled corn and a full ration of good timothy hay, the gain for cowpea hay alone being 228 lbs. per lot and for corn and timothy 262 lbs.
Third Trial—1900-1901

This trial was made with grade yearling Shorthorn steers, and was begun January 29, 1901, and continued until April 19, 1901, covering 80 days, with four steers in each lot.

The steers were well bred native cattle of excellent quality, had been roughed until this time, and were in what would be considered ordinary or thin condition.

As before, the steers were fed in a shed, open to the east, with free access to open lots which were not at all times dry.

Each steer was given 6 pounds of shelled corn daily, and in addition the roughnesses fed to the various lots were as follows:

Lot III. Timothy hay.
Lot IV. Clover hay.
Lot V. Millet.
Lot VI. Sorghum hay.
Lot VII. One-half corn stover; one-half clover hay.

The hays of the various kinds were of average quality, and had been preserved without injury by the weather.

The millet had been cut and harvested before the seed passed into the dough state.

The sorghum had been sown thickly and produced little or no grain, and few of the stems were larger than an ordinary lead pencil. It was cut at the usual time, field cured, and allowed to remain in large shocks until required for feeding.

It is well known that the best quality of sorghum hay is not produced by this method of growing or handling, but this was the only kind that could be purchased in the neighborhood at the time the experiment was conducted.

The following is a summary of the results:
TABLE 15. TOTAL AMOUNT OF FOOD EATEN, AND GAIN IN LIVE WEIGHT, FROM JANUARY 29, 1901 TO APRIL 19, 1901—80 DAYS. FOUR YEARLING SHORTHORN STEERS IN EACH LOT, EACH STEER RECEIVING SIX POUNDS SHELLED CORN DAILY

<table>
<thead>
<tr>
<th>Lot</th>
<th>Ration</th>
<th>Average weight of corn eaten per lot</th>
<th>Roughage offered per lot</th>
<th>Roughage eaten per lot</th>
<th>Per cent roughage</th>
<th>Total gain per lot</th>
<th>Average daily gain</th>
<th>Cost of food offered per 100 lb. gain</th>
<th>Cost of food per steer</th>
<th>Cost of food at 5c per pound</th>
<th>Value of gain per steer</th>
<th>Profit or loss per steer</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>6 lbs. Shelled Corn; Timothy Hay ad libitum</td>
<td>814</td>
<td>1920</td>
<td>4600</td>
<td>4523</td>
<td>1.7</td>
<td>318</td>
<td>1.00</td>
<td>$8.66</td>
<td>$6.88</td>
<td>$3.97</td>
<td>$-2.91</td>
</tr>
<tr>
<td>IV</td>
<td>6 lbs. Shelled Corn; Clover Hay ad libitum</td>
<td>900</td>
<td>1920</td>
<td>5908</td>
<td>5719</td>
<td>3.2</td>
<td>641</td>
<td>2.00</td>
<td>$4.61</td>
<td>$7.86</td>
<td>$8.00</td>
<td>$0.14</td>
</tr>
<tr>
<td>V</td>
<td>6 lbs. Shelled Corn; Millet Hay ad libitum</td>
<td>792</td>
<td>1920</td>
<td>4184</td>
<td>3941</td>
<td>5.7</td>
<td>119</td>
<td>.37</td>
<td>$22.08</td>
<td>$6.57</td>
<td>$1.48</td>
<td>$-5.09</td>
</tr>
<tr>
<td>VI</td>
<td>6 lbs. Shelled Corn; Sorghum Hay ad libitum</td>
<td>693</td>
<td>1920</td>
<td>5232</td>
<td>4727</td>
<td>9.4</td>
<td>166</td>
<td>52</td>
<td>$14.57</td>
<td>$6.05</td>
<td>$2.07</td>
<td>$-3.98</td>
</tr>
<tr>
<td>VII</td>
<td>6 lbs. Shelled Corn; ½ Stover, ½ Clover Hay</td>
<td>833</td>
<td>1920</td>
<td>7128*</td>
<td>5917*</td>
<td>*</td>
<td>533</td>
<td>1.67</td>
<td>$5.31</td>
<td>$7.03</td>
<td>$6.67</td>
<td>$- .36</td>
</tr>
</tbody>
</table>

*Of the combination of Stover and Clover Hay, 3494 lbs. Stover and 3634 lbs. Clover were offered, of which 2298 lbs. Stover and 3619 lbs. Clover were eaten, leaving as refuse: Stover, 1196 lbs., or 31 per cent of the amount offered, and Clover, 15 lbs., or .4 per cent of the amount offered, making daily roughage consumption per steer 7.2 lbs. Stover and 1.3 lbs. Clover.

†For prices of feed used in these computations see foot note to Table 13, p. 35.
Here again the season of the year covered by the experiment was essentially that in which, under ordinary farm conditions, cattle are a direct expense to the farmer, by reason of having to be fed. While the length of the period was only 80 days, extending from January 29 to April 19, yet the results agree in detail with those of longer experiments in previous and subsequent years.

In all of our trials the low efficiency of timothy as a feed in comparison with its cost has been very striking, and this experiment is no exception. Note that the gain from six pounds of shelled corn and clover hay is just double in amount that obtained from exactly the same quantity of corn and all of the good timothy hay they would eat. In one case the average gain was two pounds per day; in the other it was one pound per day.

As was the case in former trials, clover and stover combined showed a high efficiency, not so high as clover alone, but in excess of timothy, and in consideration of the fact that this stover must be utilized in some way, and of the further fact that in ordinary farm practice it is difficult, in fact almost impossible, to secure enough clover hay to winter all the stock to be kept on the farm as an exclusive roughage, this combination has proven to be exceptionally advantageous.

In order to use the stover to the best advantage, it is necessary to combine it with a limited quantity of clover, cowpeas, or some such leguminous hay.

The poor showing made by millet and by sorghum was a surprise. Owing to their low content of protein, it was expected that they would fall below clover and cowpea hay, but that they should fall so far below timothy, we were not prepared to believe. This remark applies especially to sorghum.

**Fourth Trial—1901-02**

The general experiment was again repeated in the winter of 1901-02, with grade native yearling Hereford steers of good quality and in moderate flesh. They were all fed alike, on Stover, Alfalfa Hay and a limited amount
of corn, for a period of three and a half weeks, until they became thoroughly accustomed to their new quarters and until we had had the opportunity to study carefully each individual and divide them into lots of uniform quality, thrift, etc.

This winter the experiment was conducted in a shed open to the south, with access to small lots without grass.

The experiment began December 26, 1901, and continued until April 24, 1902, or 120 days. There were four steers in each lot.

Each steer was fed six pounds of grain daily, which in all lots except one was shelled corn. In lot VIII, it was a mixture of four pounds of corn and two pounds of cottonseed meal.

The various roughnesses fed were as follows:

Lot I. Timothy Hay.
Lot II. Clover Hay.
Lot III. Alfalfa Hay.
Lot IV. Cowpea Hay.
Lot V. Sorghum Hay.
Lot VI. One-half Corn Stover, one-half Clover Hay.
Lot VII. One-half Wheat Straw, one-half Clover Hay.
Lot VIII. Wheat Straw.

It will be recalled that the summer of 1901 was exceptionally dry, practically no rain having fallen from the middle of April until the end of the summer season. The quality of the forage produced that year was, therefore, exceptional. Having a very small content of moisture at the time of harvest, it was cured readily, necessarily without rain, and with a minimum of bleaching by the sun. Owing to the very limited amount of moisture in the ground, the yield was light, which means that the material was very fine, and had presumably the minimum amount of woody fiber. In short, wheat straw in a season like this had almost if not quite as much quality as timothy hay has in seasons that are exceptionally wet and when it is subjected to drenching rains in the process of curing.

In view of the further fact that the weather of the winter was uniformly dry, with temperature cold enough
to give a stimulus to the appetite, and yet steady, so as to interrupt the appetite and activities the least, the quarters were dry, and the weather bright in the main, so that the animals were induced to remain out of doors a great deal, all of which furnish the best conditions for large gains. It is to be expected, therefore, under all these circumstances, that the feeds would be used with small waste and with most excellent results.

The timothy hay was cut when the seed was in the dough, cured without rain, and kept in a large rick until required for feeding. The quality was good.

The clover was cut when one-third of the heads were brown, stacked immediately, and when fully cured, was baled and stored in a barn until required for feed. Quality excellent.

The alfalfa, first cutting, fine texture and good color, was stacked, then baled, and stored in a barn until required for feeding. Quality good.

The cowpea hay was cut when an occasional pod had been formed, cured in shock until dry enough to bale, then stored in a barn. Fully one-third crab grass. Otherwise the quality was good.

The corn stover, small, fine, was cut when the few ears that formed were fully glazed, set up in shocks sixteen hills square, where it remained until required for feeding. All ears and nubbins carefully removed. Bright, sweet and good.

Sorghum. Grown in rows 44 inches apart, with perhaps plants about 4 inches apart in the row, stalks rather coarse, and all produced seed. Harvested when about one-half of the heads were ripe, set up in shocks, and preserved in good condition until required for feeding. Quality good.

In the table below will be found a summary of the results:
| Lot | Ration | Average weight of 
| | | corn eaten per lot | roughage offered per 
| | | steer | lot | roughage eaten per 
| | | | | lot | total gain per lot | average daily gain | cost of food offered 
| | | | | | per steer | per 100 lbs. gain | value of gain 
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>at 5c per lb.</th>
<th>profit or loss per steer</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>6 lbs. Shelled Corn; Timothy Hay</td>
<td>288.0</td>
<td>858.0</td>
<td>815.2</td>
<td>658</td>
<td>1.37</td>
<td>$7.02</td>
</tr>
<tr>
<td>II</td>
<td>6 lbs. Shelled Corn; Clover Hay</td>
<td>288.0</td>
<td>937.1</td>
<td>912.3</td>
<td>929</td>
<td>1.84</td>
<td>$12.42</td>
</tr>
<tr>
<td>III</td>
<td>6 lbs. Shelled Corn; Alfalfa Hay</td>
<td>288.0</td>
<td>829.6</td>
<td>814.8</td>
<td>782</td>
<td>1.63</td>
<td>$5.35</td>
</tr>
<tr>
<td>IV</td>
<td>6 lbs. Shelled Corn; Cowpea Hay</td>
<td>288.0</td>
<td>868.0</td>
<td>847.9</td>
<td>621</td>
<td>1.29</td>
<td>$5.81</td>
</tr>
<tr>
<td>V</td>
<td>6 lbs. Shelled Corn; Sorghum Hay</td>
<td>288.0</td>
<td>168.41</td>
<td>163.87</td>
<td>626</td>
<td>1.30</td>
<td>$7.50</td>
</tr>
<tr>
<td>VI</td>
<td>6 lbs. Shelled Corn; ½ Stover, ½ Clover</td>
<td>288.0</td>
<td>969.3</td>
<td>854.6</td>
<td>743</td>
<td>1.55</td>
<td>$5.43</td>
</tr>
<tr>
<td>VII</td>
<td>6 lbs. Shelled Corn; ½ Wheat Straw, ½ Clover</td>
<td>288.0</td>
<td>759.8</td>
<td>733.5</td>
<td>628</td>
<td>1.31</td>
<td>$5.63</td>
</tr>
<tr>
<td>VIII</td>
<td>3/4 Shelled Corn; 1/6 Cottonseed Meal; Wheat Straw</td>
<td>288.0</td>
<td>574.5</td>
<td>556.2</td>
<td>451</td>
<td>.94</td>
<td>$6.39</td>
</tr>
</tbody>
</table>

†Of combination of Stover and Clover, 4662 lbs. Stover and 5031 lbs. Clover were fed, of which 3568 lbs. Stover and 4958 lbs. Clover were eaten, leaving as refuse: Stover, 1094 lbs., or 21 per cent., and Clover, 73 lbs., or 1 per cent. of whole amount fed, making daily roughage consumption per steer 7.4 lbs. Stover and 10.3 lbs. Clover.

† Of combination of Clover and Straw, 3360 lbs. Straw and 4298 lbs. Clover were fed, of which 3126 lbs. Straw and 4209 lbs. Clover were eaten, leaving as refuse: Straw, 234 lbs., or 7 per cent., and Clover, 27 lbs., or .2 per cent. of total amount offered, making the daily roughage consumption per steer 6.5 lbs. Straw and 8.8 lbs. Clover.

*1920 lbs. Corn; 960 lbs. Cottonseed Meal.
The results are essentially the same as have already been reported for former trials.

The superiority of clover over timothy is again marked.

The superiority of a combination of stover and clover over timothy is still to be observed.

The high feeding value of the timothy in this trial is easy to be accounted for by the exceptional quality already referred to.

It is interesting to note the excellent gains made this season by the use of shelled corn and one-half wheat straw and one-half clover. In other seasons, when the straw is not so bright, clean and palatable, it is hardly to be expected that these results could be duplicated.

In Lot VIII, having shelled corn, cottonseed meal and wheat straw, an attempt was made to supply the protein in cottonseed meal instead of using clover hay for this purpose. It will be observed, however, that the results would not justify the adoption of this as a practice. In other words, the average daily gain on shelled corn, wheat straw and clover was 1.31 pounds, or a total of 628 pounds for the entire experiment, as compared with .94 of a pound daily, or 451 pounds for the entire experiment on two-thirds shelled corn, one-third cottonseed meal, and wheat straw. In short, the gains made on the steers receiving clover hay and wheat straw lacked $1.00 per head of paying for all the feed they consumed, while those receiving corn, cottonseed meal, and straw, lacked $9.90 per head of paying out.

RESIDUAL EFFECT OF DIFFERENT FEEDS

At this point it will be well to consider the effect of the gains made in winter upon the capacity of the animal to make gains the following summer at pasture, or, to consider the effect of the condition of the animal in the spring upon its capacity to graze profitably.

Fortunately, all of the cattle used in the experiments in the winter of 1899 and 1900 were turned to pasture together as soon as the trial closed, and grazed together from April 30 to December 24. During the last 30 days of the pasture sea-
son, they were fed a limited quantity of grain, but were all treated exactly alike in that respect. Thus we have the opportunity to ascertain whether these different feeds have any residual effect, or whether the amount of gain made in winter affects the gain to be made at grass during the following summer.

These cattle were weighed five days in succession before being turned to grass in the spring, and were weighed on five successive days when brought to the sheds in the fall. The difference in these is considered to be the gain in weight at pasture. The following table shows the gains made in summer in relation to the gains of the previous winter, ranked in the order of winter gains:

<table>
<thead>
<tr>
<th>Winter Ration</th>
<th>Winter gain per steer.</th>
<th>Following Summer gain per steer.</th>
<th>Total of Summer and Winter gain.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn and Cowpea Hay</td>
<td>155</td>
<td>345</td>
<td>500</td>
</tr>
<tr>
<td>Corn Stover and Clover Hay</td>
<td>118</td>
<td>357</td>
<td>475</td>
</tr>
<tr>
<td>Corn and Timothy Hay</td>
<td>65</td>
<td>422</td>
<td>487</td>
</tr>
<tr>
<td>Cowpea Hay alone</td>
<td>57</td>
<td>364</td>
<td>421</td>
</tr>
</tbody>
</table>

It will be noted that in general the larger the gain in winter, the less the gain the following summer on grass.

Considering the three lots having equal quantities of grain and different roughnesses, their summer gains are in inverse ratio to their previous winter gains. This means that the thinner the animal in the spring, provided it be strong enough to graze well, the greater the gain it is capable of making at grass during the summer. Conversely, the fatter the animal, the less capacity it has for making large gains on grass. That this will be true of fat animals is self-evident. It is easy to conceive of animals going to grass so fat from having been grain fed for a considerable length of time that
they will be, incapable of maintaining even their weight on grass alone, but will actually lose in weight. This probably means that the appetite and the general activity of the animal have been so affected by excessive fat, or by the prolonged grain feeding, that the animal will not eat enough grass to even maintain its weight. It is self-evident that the fat steer has a materially higher total maintenance requirement, by reason of the fact that he is much heavier, and this extra weight has in no way increased his appetite or his capacity for grazing. In other words, his appetite and his capacity for grazing have at the very least stood still, while his weight and, therefore, his maintenance cost have, through the fattening process, been considerably increased. It is safe to go even farther, and say that if the animal be made fat, i. e. approximately in marketable condition, the appetite and the ability to graze well will both become very materially reduced at the same time that the maintenance cost per steer has been increased. At this point, certainly, the steer would be incapable of eating enough grass to maintain its weight.

It frequently occurs that yearling cattle winter well, and carrying to grass considerable fat, will weigh little if any more the following fall than they did in the spring. They will be considerably larger but much thinner. Fat has in this process been displaced by growth.

SECOND TRIAL OF RESIDUAL EFFECT

The steers used in the third trial of a limited grain ration, or in the winter of 1900 and 1901, were grazed together the following summer. They had been fed alike from the time the experiment closed, April 20th, to May 10th, on six pounds of shelled corn daily per head, as during the experiment, and a mixture of the various roughages used in the experiment. In the summer they had the run of the same pasture, and during the last 60 days were fed ear corn at pasture, all being fed together.

They were weighed five days in succession at the end of the experiment, and had been weighed 5 days in succession just previous to being turned out. The following table shows the gains made by each lot, and the relation that these gains bear to those made in the previous winter.
Here again there is a fairly definite relation between the gains made in winter and those made the following summer at grass or, as has already been pointed out in a previous trial, the gains in summer are in inverse ratio to the gains made the previous winter. Or, perhaps more accurately stated, the summer gain is inversely proportionate to the amount of fat the animal carries to grass.

**CATTLE TO GRAZE WELL MUST BE THIN**

It is evident therefore that if cattle are to be grazed the following summer, advantage cannot be profitably taken of the cheapest way of making gains, in winter namely, by full feeding, inasmuch as the animal would in a short time under this treatment be carrying so much fat that it would not make good gains at grass, and the only profitable disposition to make of it would be to continue the fattening process until it was ready for market. This makes the cost per pound of gain in merely wintering cattle excessively high. This, however, is not a fair measure of the cost of wintering as a rule, inasmuch as the number of pounds of gain is very small. For example, a steer gaining 50 pounds during the winter and costing 10 cents a pound for this gain, or a total of $5.00 for the entire wintering period, would be a comparatively inexpensive animal to take through a six
months' wintering period, whereas, viewed from the standpoint of cost of gain, 10 cents a pound would look like an excessive price and it would look like the animal had been wintered disadvantageously. As a matter of fact, however, he would probably be in a condition in the spring to very quickly pay back this deficit of $2.50 in the rapid gains he he would make at grass.

In ordinary practice, cattle are kept on the farm in winter to eat the surplus coarse forage, to clean up the stalk fields, and to eat the surplus grass left from summer, and if they pay expenses during the winter the farmer considers himself fortunate.

CIRCUMSTANCES UNDER WHICH SMALL GAINS MAY BE JUSTIFIED

Then, if the farmer should be possessed of a large quantity of coarse fodder and only a limited quantity of grain, and should likewise be possessed of considerable cheap grass to be utilized the following summer, the most profitable way in which steers could be wintered would be to run them through comparatively thin, so that the pasture might be utilized to the greatest advantage. As has already been explained by making the gain larger in winter the deficit in wintering could be reduced somewhat, but the probabilities are that by fall the account would be squared, or this excess deficit due to light winter feeding would be overcome by the increased gains the steers would make at pasture because of their thin condition.

GAINS FROM LIGHT FEEDING RELATIVELY COSTLY

It has already been pointed out that the gains made from light feeding are relatively expensive. The old notion that light feeding makes cheap gains will not bear investigation. The truth is, other things being equal, the cheapest gains are made on full feed or approximately full feed. As the ration is decreased from this point, the food required per pound of gain increases uniformly until a maintenance ration is reach-
ed, when, of course, all of the food given is wasted when con-
sidered from the standpoint of gains made. Reducing the
feed even below the point of maintenance, so that the ani-
mals actually lose in weight, as is often done in unapproved
farm practice, the deficit to be met is not only the total
cost of the feed used, but the value of the loss in weight as
well.

All of this means that the use to which a steer is to be
put the following summer, whether to be grazed or full fed,
will influence in a large measure the way in which he can be
most profitably wintered. If to be grazed alone, there is a
very definite limit to the amount of grain that can be fed
without seriously affecting the capacity of the animal to make
profitable use of the pasture the following summer. Or, to
state it differently, there is a very definite limit in the amount
of fat that it will be profitable to put on a steer in winter that
is to be grazed the following summer.

On the other hand, as a general proposition, the smaller
the gains, the more costly they are, and, within certain limits,
the more expensive the wintering operation becomes, or the
larger the deficit from wintering.

THE AGE AFFECTS THE WAY IN WHICH
CATTLE SHOULD BE WINTERED

In general, the age of the animal will affect materially
the kind, quality and amount of feed that may be profitably
used in wintering. In other words, the age will determine
largely whether they are to be fed liberally on palatable and
nutritious feeds, or to be roughed through on coarse fodders
of the cheapest sort. Young cattle will require the former
class of feeds in more liberal quantities, while the older cat-
tle will be able to utilize to advantage the poorer and coarser
grades. This is principally true because it is more important
to keep the animals gaining steadily at the age of 6 to 18
months than later. Checking the rate of gain after 24 months
of age, when the rate of growth has naturally declined and
when the tendency of the animal to lay on fat begins to as-
sert itself, will make much less difference than if it be check-
ed in the earlier stages when the tendency to grow and not
to fatten is much more marked.
It is believed that to make growth at the natural or proper time, that is, when the animal is young, and when the tendencies of the entire organism are to convert food into growth, and when it may be made with the least expense of food, room, labor and investment, will be highly advantageous as compared with so feeding the animal as to restrict the growth at this age and depend upon making up this deficiency by liberal feeding later.

In fact, it is believed that, from birth until the steer goes to grass at the age of twelve months, there should be sufficient food of a palatable and nutritious character to supply the requirements of the maximum growth of which each individual is capable, without laying on any considerable quantity of fat. This is, of course, on the supposition that they are not to be fed out as baby beef. In case they are to be made into baby beef, naturally the quicker they are made fat, the greater the profit in the feeding. The first winter, between the ages of 6 and 12 months, is not the time to attempt to utilize cheap coarse fodders extensively, like stover, etc. These materials should be used chiefly on older cattle.

It goes without saying that from 12 to 18 months of age the cattle should receive an abundance of nutritious grass, so as to promote a uniform and rapid growth or to approximate the full capacity of the animal for growth and to lay on as much fat as possible, for gains at pasture are cheap, and all the fat it is possible to make here will be made at the very minimum of expense.

As to the winter treatment from the ages of 18 to 24 months, all will depend upon what the immediate future of animal is to be. If it is to be grazed the following summer as a two year old, it should be made to utilize the cheap fodders on the farm, eat out the stalk fields, etc. In any case, it should not be permitted to lose in weight, but should be made to gain liberally, so long as it does not lay on any fat.

The laying on of fat at this juncture is unprofitable if the animal is to be grazed, for two reasons.

First. It is unnecessarily expensive to make fat by partial feeding. As has already been pointed out, gains made on anything less than full feed are made at a cost that increases directly as the quantity of food is decreased.
Second. Fat on an animal affects its ability to make rapid and economical gains the following summer at grass, as has been clearly shown by our results where cattle had been made to gain different amounts in winter and were grazed together the following summer.

**WINTERING, LIKE FATTENING, ENHANCES THE VALUE OF CATTLE**

Gains made in winter, whether made by full feeding or otherwise, are relatively expensive.

Gains made in summer on grass, while cheap, do not ordinarily enhance the value of the animal above the market value of the gains actually made.

It is only on account of the extreme cheapness with which gains may be made in summer on grass, therefore, that the grazing of cattle is profitable.

It is on account of the enhancement of the value of the animal by making it fat or in marketable condition in addition to the value of the gains put on that makes full feeding under any circumstances profitable. That is to say, the food required to make the gain in full feeding costs more than the gains made will sell for. Were it not, therefore, for the enhancement of the value of the carcass already produced in a cheap way on grass, the fattening operation would be uniformly conducted at a loss.

By the process of wintering cattle their value is enhanced to a less degree, it is true, than by the fattening process, but the enhancement of value is necessary to make up the deficit in the wintering process. This enhancement is due to the fact that the steer in the spring has the grazing season, which is the season of profit, immediately before him, and he is therefore worth more to his owner than in the preceding fall, when he faced the wintering period, which is usually a period in which a deficit occurs. The enhancement of value in this case is one mainly of position, whereas in the case of the fattening steer it is one of condition.